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THE APOLLO 17 LUNAR SURFACE JOURNAL

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The Apollo 17 Lunar Surface Journal

Prologue: The End of the Beginning

Never in the history of exploration has there been an undertaking quite like Apollo. Driven by wounded pride and the military threat implied by early Soviet space achievements, particularly the stunning flight of Yuri Gagarin, the Kennedy Administration and the Congress opened the public purse so that America could demonstrate its technological prowess to the world by achieving a lunar landing before the end of the 1960's and, more importantly, before the Russians. "No single space project," Kennedy said, "will be more impressive to mankind, or more important in the long-range exploration of space; and none will be so difficult or expensive to achieve." At the program's budgetary peak in 1965, fully a half million skilled people worked on the project, all of them eager to make the first lunar landing a reality. Many of them believed that Apollo was the most important thing they would ever do and they put in long hours to make sure of its success. Few of the half million ever had a chance to travel in space and fewer still walked on the Moon; but most were deeply dedicated and, for them, working on Apollo was much more than a job. And if, from their perspective, the program ended too soon and, at that, on the sour note of missions canceled for lack of money, they still had the satisfaction of having been part of an historic undertaking.

Changes in human perspective usually come in small steps and, Apollo was a rare and extraordinary opportunity to make a purposeful leap. For many people in the program, Apollo was more than a race to beat the Russians; it was the start of an even grander enterprise. Commentators compared the first landings with the first steps by sea creatures onto the land and there were few in NASA who believed that Apollo was an end in itself.

Apollo 17 was the sixth and last of the Apollo landings and Mission Commander Eugene A. Cernan often called his flight "the end of the beginning", the end of the first phase of humanity's lunar adventure. The spotlight of history which had shone so brightly during Apollo 11 had long since dimmed and, outside the NASA community, there were few people with the time or inclination pay much attention to what Cernan and his crewmate, geologist Harrison H. Schmitt, did on the Moon. Fortunately, the long-term importance of Apollo 17 was not to be determined by the size of the television audience. After only five brief missions, there was still plenty to be learned about the Moon and about doing useful work in so novel a place.

As with the ancient colonization of the dry land by creatures from the sea, the long-term potential of the Moon and the rest of the Solar System can only be realized through a lengthy process of learning how to live and work in these new environments. Minute by minute, each of the Apollo crews

enlarged the body of lunar work experience and added to the collection of geology samples. After Apollo 17, it was going to be a long time before anyone would make another trip to the Moon and it will be longer still before we are ready to build a permanent base, or to establish industries and settlements; but, in the interim, the geology samples and experiences of the astronauts are invaluable to those making plans for the next phase of lunar development - whenever it may come.

In the years since Apollo, the geologic samples have told us a great deal about the local materials we will use for construction on the Moon and as feed stock for future lunar industries. And, as we think about designs for a lunar base, the experiences of the Apollo astronauts have much to tell us about the things that are difficult about working on the Moon and, as well, about the ways we can take advantage of lunar conditions - particularly the weak gravity field - to make the work easier.

Beyond the symbolism of the first landing, Apollo was, above all, a learning experience and, from mission to mission, the learning curve was steep. On Apollo 11, Neil Armstrong and Buzz Aldrin spent only two and a half hours outside their landing craft, proving that they could walk and work in the stiff pressure suits and in the vacuum and weak gravity that are the dominant features of the lunar environment. They set out three experiments, collected about 20 kilograms of rocks and soil and, as befitted the occasion, went about their work with considerable caution.

However, mission after mission, NASA as a whole - and the astronauts, in particular - gained confidence in themselves and in the equipment and learned how to get the work done more efficiently. By the time of the last three missions, crews were spending three days on the Moon and, out of each twenty-four hours, were staying outside and working hard for six to seven hours at a time. On Apollo 17, Cernan and Schmitt set records for the longest work day (7 hours, 37 minutes); the longest total amount of time spent outside the spacecraft (22 hours, 4 minutes); the greatest quantity of samples brought back to Earth (110 kilograms); the farthest excursion away from a landing craft (7.5 kilometers); and the greatest total distance driven (35 kilometers). And, at least in Jack Schmitt's case, they may have even snatched the record for the longest and soundest sleep from the previous holders of all of these records - the crew of Apollo 16.

As a measure of the confidence they had in their suits and in their own agility while wearing them, Cernan and Schmitt were about as active as the suits would permit. Like the Apollo 16 crew before them, they leaned on low rocks and on their tools; and, like John Young, the Apollo 16 commander, Cernan sometimes even knelt in front of his work. Getting up took a little bit of effort but, then, Cernan and Schmitt got plenty of practice. Because they were so active, they fell down a lot and had plenty of chances to perfect the

art of getting up. Above all, they had fun; and they sang and joked and laughed a good deal of the time.

Had a high level of funding for the space program continued past the mid-1960's, NASA probably would have built a cargo-only version of the lunar lander and, perhaps by the mid-1970's, would have established a permanent base camp on the Moon. However the reality is that Apollo was a very expensive undertaking for its time and, as Arthur C. Clarke suggested in an essay published during the week of Apollo 11, we had made such a great leap into space during the 60's that we needed a time of "consolidation", a period in which to assimilate the new technologies and the new perspectives. We needed to understand what it was we had done and what we had learned. That "we" didn't necessarily include NASA and the astronauts; but it certainly included most of the people - politicians and voters, alike - who would have to pay for the next stages.

Twenty-five years later, the debate over spending priorities continues and what is clear is that political support for a resumption of lunar operations has yet to emerge. But, as we prepare for the eventuality of a lunar base, of lunar industries, and of lunar settlement, there is much we can learn from the experiences of the Apollo crews. This Apollo 17 Lunar Surface Journal has been prepared in the interest of making the experiences of the last, the longest, and the most productive of the missions accessible to the people who will undertake the next stages.

The Apollo 17 Lunar Surface Journal, Part 2
Contents of the Journal

During the Apollo 17 mission, Gene Cernan and Jack Schmitt spent about 72 hours on the Moon and, on three separate occasions, put on their spacesuits and went outside to deploy scientific instruments and to study the geology the beautiful lunar valley in which they had landed. In addition to more than 100 kilograms of rock and soil samples that they brought back to Earth, the permanent record of their investigations consists of more than 2000 photographs, more than 12 hours of recorded video transmissions, more than 30 hours of recorded voice transmissions, and a large number of post-flight reports and technical papers. And then, too, there are the memories that the crew brought back, memories which have faded a bit with time but which, even after the passage of nearly a quarter of a century, still contain much of value.

The material included in the Apollo 17 Lunar Surface Journal has been assembled so that an uninitiated reader can understand, in some detail, what happened during Apollo 17 and why and what was learned, particularly about living and working on the Moon. At its heart, the Journal consists a corrected mission transcript which is interwoven with commentary by the crew and by Journal Editor - commentary which, we hope, will make the rich detail of Apollo 17 accessible to a wide audience. To make the Journal even more accessible, this CD-ROM publication contains virtually all of the Apollo 17 audio, a significant fraction of the photographs and a selection of drawings, maps, video clips, and background documents.

The text portion of the Apollo 17 Journal is divided into twenty-one sections. Most of these are introductory chapters designed to put Apollo 17 into historical context and to give uninitiated readers a running start at the rich detail of the transcript and commentary. The twenty-one sections are

1. Prologue: The End of the Beginning
2. An Introduction to the Contents of the Journal
3. Preparation and Structure of the Annotated Transcript - contains a description of the detailed mission reviews performed by the Journal Editor and the crew and, also, discussions of such matters as transcription conventions and access to the photographs and other supporting material.
4. Engineering Aspects of Apollo - contains descriptions of the Lunar Module (LM) "Challenger" in which Cernan and Schmitt landed on the Moon and then lived for three days; the spacesuits which they wore during their three excursions outside; and the Lunar Rover, the battery-powered exploration buggy which they drove to geology stops as much as 7.6 kilometers (4.5 miles) away from the LM.
5. Building on Experience - contains a short history of the U.S. space program, with an emphasis on the robotic and manned missions that paved the way for the first lunar landing.

6. Apollo 11: - contains a summary of the first landing mission. Although the surface activities conducted on this mission were secondary to the primary goal of landing and then returning safely to Earth, Neil Armstrong and Buzz Aldrin spent two and a half hours out on the surface collecting geology samples and demonstrating that it was possible to do useful work.

7. Apollo 12: A Visit to the Snowman - contains a summary of the first precision landing mission. As planned, Pete Conrad and Al Bean landed their spacecraft a mere 183 meters from a robotic probe, Surveyor III, which had landed on the Moon 31 months previously. Conrad and Bean performed two 4-hour EVA's (periods of Extravehicular Activity) during which they deployed scientific experiments and made a roughly circular geology traverse that covered about a mile of ground and took them up to 400 meters from their LM. during this traverse, Conrad and Bean walked down into the large crater in which the Surveyor had landed and retrieved parts of the spacecraft so that engineers back on Earth could study the effects of long-term exposure to the lunar environment.

8. Apollos 13/14: The Frustrations of Frau Mauro - contains summaries of two successive missions targeted for a landing site from which geologists hoped to collect ejecta from the giant impact that created the Imbrium Basin. The Apollo 13 mission was aborted because of an explosion in an oxygen tank in the Service Module. The explosion crippled the Command Module and forced the crew to use the LM engines to get them back to Earth. Fourteen months after the accident, the Apollo 14 crew successfully landed at Frau Mauro and, like the Apollo 12 crew, conducted two 4-hour EVA's, including a 1.4 kilometers walk virtually to the rim of Cone Crater. This mission marked the only use of a handcart which gave the astronauts the ability to carry more tools and samples than was possible on the prior missions, albeit without any significant increase in mobility.

9. Apollo 15: Rovers and the Cost of Drilling - contains a summary of the first three-day mission, in which Dave Scott and Jim Irwin explored a stunningly beautiful landing site at a place called Hadley Rille. Scott and Irwin were the first crew to have the advantage of three long EVA's and the use of the Lunar Rover. The Rover gave them even greater cargo capacity than the handcart had provided on Apollo 14 and, more importantly, gave them much greater mobility and, while they were driving to place to place, a chance to rest. In all, Scott and Irwin did 28 kilometers of driving, did geology at eight widely separated spots, and brought home some 78 kilograms of samples. They were the first crew who were able to devote a significant portion of their training to geology and the high productivity of their mission demonstrated the value of that training. The only notable shortcoming of the mission was a series of problems that Scott experienced while trying to drill three holes into the lunar surface - problems caused by poorly designed equipment and procedures. Because Scott had to spend far

more time than had been planned for the drilling, he and Irwin ultimately were forced to shorten their final geology traverse and to drop two significant geology stops.

10. Apollo 16: Descartes Surprise - contains a summary of the second 3-day mission during which John Young and Charlie Duke performed humanity's first exploration of the lunar highlands, the rugged, mountainous type of terrain that covers most of the Moon's surface. Young and Duke landed in an area where some geologists had expected to find signs of relatively recent volcanism. Like the Apollo 15 crew, Young and Duke were well trained as field geologists and, although there proved to be no signs of volcanism at the Descartes landing site, the astronauts described and sampled the geologic realities of the site in sufficient detail that, after the mission, the geologists back home could characterize the impact processes that had formed this part of the highlands. Characteristically, John Young was the first person to get a really good night's sleep on the Moon.

11. Apollo 17 - contains a summary of the Cernan/Schmitt visit to the valley of Taurus-Littrow. As was the case at Hadley Rille, Taurus-Littrow offered the crew an opportunity to investigate both mare and highland features and, with Schmitt being a professional geologist and Cernan being as well trained in geology as any of the other pilot-astronauts, they performed what was probably the most productive of all the Apollo missions. Cernan and Schmitt pushed themselves and their equipment about as hard as was possible. Often working under tight time constraints, they were able to capture the essence of each of the geology stops with a minimum amount of wasted effort. The highlight of the mission was the discovery of orange soil - a product of ancient volcanic fire-fountaining - at Shorty Crater. Because they had to make sure that they had enough cooling water and oxygen that they could walk back to the LM if the Rover failed, the astronauts only had about 20 minutes to spend at Shorty before driving closer to the LM for their next stop. At Shorty, Cernan and Schmitt provided what may have been the finest demonstration just how efficient and productive a well-trained crew could be.

12. The Cast of Characters - contains biographical sketches of the Apollo 17 crew and of the astronauts who served as their CapComs (Capsule Communicators), the only people talked with them while they worked on the Moon.

13. The Valley of Taurus-Littrow - contains a description of the Apollo 17 landing site, with emphasis on the geologic features which were the focus of their explorations.

14. A Running Start - contains a summary of the Apollo 17 mission from Earth launch up to the moment when Cernan and Schmitt fired the Lunar Module engines for the descent to the surface.

15. Landing Day and EVA-1 - contains the transcript and commentary covering the first day's activities, which were

devoted primarily to the deployment of the Apollo Lunar Surface Experiments Package (ALSEP).

16. EVA-2 - contains the transcript and commentary for the second day of exploration. The focus for the second day was a 6.4 kilometer drive westward from the LM to the foot of a 2.1-km-high mountain called the South Massif. The stop and Shorty Crater was made during the drive back to the LM

17. EVA-3 - contains the transcript and commentary for the third day of exploration. On this EVA, Cernan and Schmitt drove north from the LM and up onto the lower slopes of the North Massif and spent over an hour studying a large split boulder that had rolled down from a prominent outcrop higher up the mountain. After this stop, they drove eastward, spending most of the day working on the slopes of the mountains.

18. Launch day - contains the transcript and commentary for Cernan and Schmitt's return to lunar orbit.

19. The Trip Home - contains a summary of the remainder of the mission, including Ron Evans' EVA to retrieve film from the Scientific Instrument Module (SIM) and also including a day that the Apollo 17 crew spent in lunar orbit making visual observations mapping of orange deposits that Evans had spotted elsewhere on the Moon.

20. Epilogue: When will we return - contains a discussion of the future of lunar exploration and of the Moon's potential role in large scale space development.

21. Acknowledgments and Bibliography

22. Background and Supporting Material

The Apollo 17 Lunar Surface Journal, Part 3

Preparation and Structure of the Annotated Transcript

The only major difficulty in putting the lessons of Apollo to work - other than a chronic shortage of funds - is the simple fact that, during the twenty-five years since Apollo 17, most of space community's energies have been devoted to the Shuttle and Space Station programs and, consequently, collective memories of the Apollo experience have begun to fade. Information that will be of importance in the lunar base program - and of interest to historians and future lunar workers and settlers - is becoming less and less accessible.

Constant use, alone, keeps experience fresh and, by now, relatively few people remember much more about the Apollo missions than where they were when they watched Neil Armstrong step down onto the lunar surface for the first time. Outside of the small cadre of people who were actually involved in the conduct of the missions and, as well, a small band of people who have been dedicated to lunar development throughout the long hiatus that continues into the 1990's, the detail of what was done is little remembered. The first steps and other highlights of the missions are well recorded; and the astronauts themselves are still much in demand as public figures. Rubbing elbows with an astronaut, particularly one who has been to the Moon, has never lost it's appeal. But when, eventually, earnest work does begin on lunar base designs, it will be the details of the Apollo experience that will matter to engineers and planners trying to decide how best to design equipment and procedures. They will need to know what worked, what didn't work - and why. And they would do well to pick up where Apollo left off.

Apollo was, above all, a learning experience. On Apollo 11, Armstrong and Aldrin only had the hatch open for two and a half hours and never ventured more than about sixty meters from their spacecraft. Their job was to land and then return home safely; and it was a bonus that they were able to collect forty-four pounds of rocks and soil, deploy a few scientific instruments and, in the process, prove beyond a shadow of doubt that it was possible to do useful work on the Moon. Tentatively and cautiously, from mission to mission, NASA increased the demands placed on the astronauts and their equipment; and, by the end of Apollo 14, for example, enough was known about walking on the Moon that, during each of the three remaining missions, the crew could drive several kilometers away from the LM and be confident that, in the event of a Rover failure, they could walk back long before their oxygen and cooling water ran out. Mission by mission, NASA and it's contractors learned how to design equipment and procedures appropriate to lunar conditions. As Gene Cernan notes in this Journal, there is always an easy way to do things in 1/6th gravity and sometimes it took a bit of trial-

and-error and a bit of adaptation to lunar conditions before the easy way became apparent.

The NASA archives are full of reports, manuals, transcripts, photographs, audio tapes, and video tapes vital to an understanding of the Apollo missions. Each year, as people clean out their desk drawers, storage cabinets, and garages, the central collection grows more and more complete. However, because memories fade with time and people retire and die, by the time we start lunar base planning in earnest, putting the Apollo experience to work will be no easy task. To illustrate the effort involved, after a couple of years of half-time work, and with considerable help from Gene Cernan and Jack Schmitt, I acquired a fair working knowledge of what happened during their three days visit on the lunar surface. Five years into the preparation of the Journal, many of the spacecraft systems are still something of a mystery to me but, with regard to the EVA's, I am probably as alert to important details as anyone can be without having been intimately involved with the mission at the time it happened. And, clearly, anyone with an eye for detail could also spend a couple of years of digging through the archives and get up to the same level of expertise. However, as a practical matter, few lunar-base design engineers will have the time or inclination to make a thorough search for relevant detail and even fewer will have ready access to the astronauts and/or knowledgeable members of the support teams.

With the needs of lunar-base design engineers in mind - and with the interests of historians, space enthusiasts, and future lunar citizens in mind as well - Gene Cernan and Jack Schmitt and I have prepared an annotated transcript of the communications recorded during their three-day stay on the lunar surface. We have been conscious of the role that such "journals" have played in the past and note the example of Roald Amundsen, the great Norwegian polar explorer who was first to sail the Northwest passage in 1905 and then was first to reach the South Pole in 1911. Amundsen approached polar exploration in much the same way that NASA approached the lunar missions. He spent many years in preparation, learning the art of polar-region survival from the native peoples of Greenland and Northern Canada, learning about clothing and especially about handling dogs. And yet, although he was by far the best prepared of the early Antarctic explorers, during the months he spent voyaging toward the ice and during the months he spent waiting in winter camp for the arrival of the Antarctic spring, Amundsen and his companions spent endless hours reviewing, critiquing, and discussing the accounts of previous expeditions, searching for insights or, at the very least, circumstances to be avoided.

There is, of course, at least one important difference between the Apollo 17 Lunar Surface Journal and it's historical counterparts. Entries in the journals of Amundsen, Robert Falcon Scott, Lewis and Clark, Captain Cook and the others were usually a few paragraphs of summary

written at day's end. On some days, there was little to record but the routine of the journey, little more than a series of events familiar to anyone who had spent much time at sea or on an extended overland journey. For such days, the journal entries usually were only a few lines to record the weather and the progress made. In preparing the Apollo 17 Lunar Surface Journal, we have had, of course, almost an embarrassment of riches. Except for intervals when Cernan and Schmitt were inside the Lunar Module Challenger with their microphones turned off, virtually every word they spoke on the Moon was broadcast to Earth and recorded. Similarly, their Rover carried a television camera which could be operated remotely from Earth and, therefore, except for the times when they were driving or when Ed Fendell, the camera operator, was doing a TV panorama, at least one of them was on camera and, therefore, a substantial proportion of their activities were recorded on video tape. Never before in the history of exploration has there been so detailed a record. But then, too, never in the history of exploration has so much expensive and unfamiliar activity been crammed into so short a span of time.

Bonestall drawings here

Because of the Kennedy deadline and the overall cost of the project, NASA necessarily designed the sparest set of spacecraft that would let astronauts land on the Moon and then return safely to Earth. When, in the early 50's, Werner von Braun and his colleagues described their vision of the first lunar landing, they imagined a fleet of three vessels carrying a total of fifty people and nearly three hundred tons of cargo. There was equipment enough for the assembly of a permanent lunar base and, indeed, Von Braun had the members of the first expedition spend six weeks on the Moon before returning to Earth. Clearly, Von Braun and his colleagues were a bit optimistic about the scale of operations that would be possible on the first lunar voyages and, at least in the context of Apollo, all that was really possible was a series of one-day, two-day, or three-day visits by crews of two. Although NASA had hopes of developing an unmanned, cargo-only version of the Lunar Module, a vessel which would have permitted the accumulation of supplies and equipment at a base camp, political realities prevented Apollo from developing into a lunar base program and short stays were necessarily a fact of life. Except for the hours the astronauts spent resting and trying to sleep, they were constantly working, trying to maximize the return from these all-too-brief opportunities for exploration. In all, the Apollo crews spent about 24 man-days on the Moon and, although some activities were repeated from day-to-day and from mission-to-mission, the learning curve was steep and the frequency of novel experiences was high.

Consequently, we have decided to incorporate the entire transcript in the Journal; and, indeed, as we have reviewed the transcript and tapes, we have found the series of sometimes similar events to be helpful in jogging memories

and in establishing the richness of the experience. Many things were done at one geology station that had been done at others and, certainly, the preparations for the EVA's were, in considerable detail, repeated from day to day. But always the context was different. A couple of days of experience, a few hours of hard, fatiguing work, or the excitement of an unexpected discovery could make a world of difference in how the "routine" went and, as a record of a work experience and as tutorial in lunar operations, we believe the Journal benefits from completeness. The relatively recent development of CD-ROM technologies also permit a level of completeness that would have been impossible to achieve - at a reasonable cost - in print.

Preparation of the Journal

During each of the Apollo missions, NASA recorded all of the audio and video transmissions and, virtually in real time, prepared transcripts for use by reporters. According to Brian Duff, then with the Manned Spaceflight Center's Public Affairs Office, a crew of typists was stationed behind the curtain in the main auditorium - the only spare room available at the time - and, as segments of recorded conversation were delivered, they prepared typescript for immediate distribution, usually within an hour.

Given the circumstances, it is not surprising that the original typescript contains errors. Mis-identifications of speakers are common errors in the original transcript; and the reason for such errors is simple. The quality of the recorded transmissions are generally good but, because the crew's microphones picked up high frequencies better than low frequencies, some distinguishing voice characteristics were blurred. Indeed, during our reviews of the tapes, even Cernan and Schmitt occasionally had trouble figuring out who was speaking. Usually we were able to come to agreement on an identification, using context, speech patterns, and word choices to guide us. We believe that relatively few mis-identifications remain. We also believe that most of these occur during the periods of EVA preparation in the cabin and are relatively unimportant to an understanding of the mission. The original typescript also contained errors in the transcription of what was actually said and the cause of these errors is also easily understood. The astronauts were performing complicated tasks under tight time constraints and were talking either with each other or with another member of the Astronaut Corps serving as Capsule Communicator (CapCom). The natural tendency to use professional jargon was heightened; and there are passages full of what might be called "tech-speak". The astronauts also tended to speak rapidly, cramming a great deal in information into short periods of time. Under the circumstances, the frequency of mis-transcriptions is surprisingly low.

The original transcripts form the core of the Apollo 17 Lunar Journal and, as a first stage of preparation, an

optical scanning device was used to convert the typescript into computer files which could be manipulated with word-processing programs. After the scanning was complete, I then compared the transcripts with copies of the original audio tapes in order to correct obvious errors. In addition, I added a "mission elapsed time" at the start of each utterance. For the earlier missions, NASA had included such timing information throughout the transcripts; but, for Apollo 17, NASA included only occasional time marks. Because time marks are useful for cross referencing and for analyses of work efficiency, the addition seemed warranted. And, finally, for those parts of the mission for which video records exist, I also reviewed the TV tapes and added commentary about crew actions.

When I began my review of the tapes and transcripts, my ignorance of mission details was nearly complete; and, consequently, background material supplied by Cernan and Schmitt, by Janet Kovacevich and Joey Kuhlman of the Johnson Space Center's History Office, and by Judy Allton of the Lockheed Engineering and Science Company was essential to progress. References of particular importance are included in the Bibliography which can be found in Part 21 of the Journal - Acknowledgments and Bibliography.

With these documents and a selection of Apollo 17 photographs at hand to fill in gaps in memory, I met with Schmitt and with Cernan to review the tapes and transcripts. At intervals through 1989, 1990, and 1991 I met with one or the other of the astronauts for a day or two at a time. Usually, we were able to complete about three mission hours per working day. Jack Schmitt and I started our review in May 1989, before I had acquired copies of the video tapes or the majority of the background material. Consequently, it took us about 13 working days to complete a review of the first 2 1/2 days of the lunar stay.. Gene Cernan and I started working together in January 1990 and, having the video tapes and a significant amount of background material available when we started, were able to complete our review of the first two and a half lunar days in only ten working days. For our final review of the third EVA and the launch, the three of us met in Santa Fe in mid-September 1991 and finished in two additional days.

As we worked, we each had a copy of the rough-edited transcript and, as we listened to the audio tapes or watched the video tapes, recorded commentary designed to give the uninitiated reader a good chance of understanding exactly what was happening, why it was happening, and what - from the prospective of a lunar base engineer - the consequences of a particular action or set of circumstances might have been. Later, I transcribed and edited these comments for inclusion in the Journal. In addition - and with the permission of the crew - I did a small amount of editing of corrected mission transcripts. Usually, I added (in parentheses) words and phrases needed for easy readability. In some places, unimportant verbal stutters have been removed without note;

in other places, verbal stutters have been retained where they are important in illustrating thought processes.

Structure of the Journal

The body of the Apollo 17 Lunar Surface Journal (Parts 15 to 18) consists of the corrected, edited transcripts together with interpolated comments. Each transcribed statement begins with a estimated mission elapsed time. As we discuss in greater detail in Part 14 of the Journal, the launch of Apollo 17 was delayed by 2 hours and 40 minutes. During the trip outbound from Earth orbit, the crew performed trajectory corrections so that they arrived in lunar orbit at the originally scheduled time and, in conjunction with those maneuvers, all mission clocks on board and in Houston were reset to show time elapsed since the planned moment of launch. For each utterance, we include the hours, minutes and seconds of the elapsed time and identify the speaker. Because these times are interpolated between the occasional times given by NASA in the original typescript, they are subject to errors introduced by the slightly different operating speeds of the copying and playback tape machines. Readers should also note that there are obvious discrepancies in some of the times given by NASA - for example, sudden jumps of ten or even twenty seconds between sections of the original transcript. These jumps probably represent shifts from one typist to another; and I have made some adjustments in the times to smooth over these discrepancies. Over short intervals of the transcript - say a few minutes - I believe that relative timing errors are no worse than two or three seconds. Generally, the times of major events - hatch openings and closings, for example - agree with times given in the mission reports to within ten or twenty seconds.

Commentary by the Cernan and Schmitt is indicated by enclosing brackets and quotation marks and are printed in standard type. When appropriate, the commentary is sometimes inserted between two halves of what was originally a single utterance. All sentence-length and paragraph-length editorial comments are also enclosed in brackets, but without attribution or quotation marks. Some brief editorial comments - particularly those indicating laughter and conversational pauses - have been inserted into the dialog and are indicated by enclosing parentheses.

With regard to breaks in communications, a pause of ten seconds or less is indicated by the insertion "Pause". "Long Pause" indicates a break of ten to sixty seconds. "Comm Break" indicates one to three minutes of radio quiet. "Long Comm Break" indicates a hiatus of three to ten minutes. And, "Very Long Comm Break" indicates a radio silence of more than ten minutes. In this CD-ROM publication of the Journal, we have included virtually all of the radio communications between the Challenger crew and Houston.

Julian/Jim Here, I thought we might say something like "In the interest of saving space on the CD-ROM for more interesting material, all radio quiet periods of ten seconds or more - all the Long Pauses and Comm Breaks - have been edited out of the audio track. However, in order to preserve the flavor of the communications breaks, we have chosen to insert automatic stops at each Long Pause and Comm Break. At each of these places, the audio track can be started again by clicking on the audio restart button." If we wanted to use the computer clock to insert automatic resumption after the actual interval, we could do that, or even offer options for automatic resumption after, say, 10 seconds. We probably ought to include a general start/stop audio button so that people can take time to read the commentary if they want to.

Conversational overlaps are a normal part of human dialog, particularly so when one adds the effects of the two-and-a-half-second, round-trip communications delay between the Earth and the Moon. Readers should note that the transcripts represent conversations recorded on Earth and, therefore, while comments by the CapComs were recorded virtually as they were spoken, anything Cernan or Schmitt said was recorded after a one-and-a-quarter-second delay. For hearing impaired readers, I have tried to capture the flow of the conversation by using ellipses to indicate either a break in thought or the start and/or continuation of an overlapped remark. In the following example, we imagine CapCom Bob Parker giving Gene Cernan instructions on parking the Rover. Before Cernan hears Parker, he starts to make a comment about where he is parked. He then stops talking, listens to Parker (who doesn't stop talking), responds, and then continues with his comment.

Parker: Gene, just a reminder that we want a Rover (garbled)...

Cernan: Bob, we've stopped next to...(Hears Parker)

Parker: ...(heading) of 045; and, when you get out, we'll need readouts.

Cernan: (Responding to Parker) Okay, Bob. We've parked next to one of the fresh craters that shows up on the map.

Generally, when someone's utterance ends with ellipses and his next utterance begins with ellipses, the reader should infer that the speaker kept talking under the overlapping remark. When someone's utterance ends with ellipses but his next utterance does not begin with ellipses, the reader should infer either a break in thought or a pause to listen. Unintelligible dialog is indicated by the editorial comment "garbled". Unintelligible dialog is often associated with overlapping conversations and in this illustration, on the continuation of Parker's utterance I have indicated the likely missing word.

The Apollo 17 Lunar Surface Journal, Part 4 Engineering Aspects of Apollo

Because some sections of the Journal contain a high density of technical dialog- in particular, the landing sequence with which the transcript begins - we think it important to give the uninitiated reader an introduction to the basic hardware: the Saturn V launch vehicle, the Command-and-Service Module (CSM), the Lunar Module (LM, pronounced "lem"), the LM Environmental Control System (ECS), the Apollo Suit, and the Lunar Rover.

The Kennedy deadline placed a number of constraints on the engineers and planners who had to decide how the landings would be accomplished and then had to design and build the actual flight hardware. The process of deciding how to get to the Moon has been thoroughly documented elsewhere - for example, in Roger Bilstein's "Stages to Saturn" and, at a less technical level, in NASA's Apollo: Expeditions to the Moon, edited by Edgar Cortright, and in John Wilford Noble's "instant" New York Times book, We Reach the Moon. There were a variety of proposals floating around as how one might accomplish a lunar landing but, in the end, only one concept offered any plausible chance of success by the end of the 60's. The technique was called Lunar Orbit Rendezvous and, in some senses, it involved the use of two separate sets of spacecraft.

The Apollo Spacecraft

The first set of Apollo spacecraft consisted of the multi-stage Saturn V launch vehicle - which boosted the whole Apollo stack on its way to the Moon - and the Command-and-Service Module (CSM). It was in the Command Module that the astronauts entered lunar orbit and then, when the landing mission had been accomplished, it was in the Command Module that they left lunar orbit for the trip home to Earth. By itself, the Saturn V/CSM combination was only capable of performing missions to lunar orbit and, indeed, during the 1968 Christmas season, the crew of Apollo 8 performed just such a mission.

Conceptually, the hardware for the landing mission comprised a separate system - albeit one that was carried as cargo by the Saturn V/CSM. The landing systems allowed the Mission Commander and the Lunar Module Pilot (sometimes referred to as the CDR and LMP, respectively) to descend from lunar orbit to the surface while the Command Module Pilot (CMP), the third member of the crew, waited for their return. For Apollos 15, 16, and 17, there were four major elements of landing-mission hardware: (1) the Lunar Module (LM) Descent Stage which contained the engines and propellant for the actual landing, (2) the LM Ascent Stage which contained the crew cabin and the engines and propellant for the return to lunar orbit, (3) the suits which allowed the crew to work

outside the pressurized cabin, and (4) the Rover which they drove to the various geology stops.

The LM Descent Stage

At the heart of the Descent Stage was the engine which the astronauts fired in lunar orbit to slow themselves through the twelve-minute descent to the surface. At the moment Cernan first fired the Descent Engine, the total weight of the Apollo 17 LM Challenger was 36,686 pounds and, of that total, slightly more than half (19564 pounds) was descent propellant. The fuel and oxidizer were, respectively, hydrazine and nitrogen tetroxide. Because these burned on contact once they were introduced into the reaction chamber, there was no need for an ignition system. In addition, Cernan could control the fuel and oxidizer feed rates so that he and/or the on-board computer could control the thrust level and, therefore, fly a descent path tailored to minimize propellant use. At the moment of engine shutdown, Cernan had 1315 pounds of propellant left.

(Put Descent Stage plan view here)

In plan view, the descent stage had an octagonal cross section, with the engine, the associated propellant tanks, and also tanks of water and oxygen for use by the crew and the spacecraft systems occupying the central portion. Around the periphery, landing struts were attached at the center of every second section of the octagon. The intervening sections were used for stowage of the Rover, the scientific equipment packages, and such things as replacement batteries, spare lithium hydroxide canisters for the removal of carbon dioxide from the cabin and suit air, and even a two-day supply of food. Anything that could be stowed in the Descent Stage meant a savings in the weight and volume in the Ascent Stage and, thereby, a savings in fuel needed for the return to orbit. Stowage in the Descent Stage also gave the astronauts more elbow room in the cabin.

LM Ascent Stage

At liftoff from the Moon, the Apollo 17 Ascent Stage weighed 10997 pounds, including about 240 pounds of rock and soil samples. Again, about half (5261 pounds) of the total weight was propellant. The main Ascent Stage propulsion engine also burned hydrazine and nitrogen tetroxide; however, because the most efficient return to orbit is one in which velocity is built up as quickly as possible, the ascent engine had no throttling capability. Fine tuning of the LM attitude and trajectory - both during descent and ascent - was accomplished through the use of sixteen small rockets mounted on the Ascent Stage in clusters of four. These steering engines comprised the Reaction Control System (RCS) and could be started, stopped, and restarted repeatedly. Used in various combinations, the RCS engines allowed the Commander to rotate the LM about any axis and to perform small translational (side-to-side, forward-and-aft) adjustments in any direction.

(LM Ascent Stage diagram here with cabin, engine and tanks)

When the LM was sitting on the Moon, the cabin was essentially a stubby cylinder laying on its side, with the flat ends pointed forward and aft. The cabin was surrounded laterally and at the back by tanks for propellants, water, and oxygen. There were hatches on the front face and at the top. The cabin had a diameter of 92 inches and an fore-to aft length of 92 inches, as well; however, much of the cabin volume was taken up by instrument panels, the environmental control equipment, storage compartments, and the ascent engine cover. In effect, the cabin was just barely big enough to hold two suited astronauts. When the LM crewmen were getting ready to go outside and had their suits pressurized and were wearing their backpacks, even turning in place required careful coordination.

The LM Cabin

LM cabin interior diagrams

In the interest of minimizing the LM weight, there were no seats of any kind; and, except when the astronauts were stretched out in their hammocks, they stood at the front of the cabin. The Commander stood on the left side and the LMP stood to his right. Each of them had a triangular-shaped window which was inwardly canted and gave a view out the front and to the side. They had armrests for use during the descent; and they also had restraining cords with which they tethered themselves to the floor. Metal decking provided about a five-foot width of level floor across the cabin; and, at a point midway between the windows, there was about six and a half feet of vertical space available. A square hatch, 42 inches across and hinged on the LMP's side, was mounted at the center of the forward bulkhead with its bottom flush with the floor. This forward hatch swung inward and gave access to a small porch at the top of the westward-pointing, forward landing strut and thence to the strut-mounted ladder. Overhead in the cabin, and with it's center above the ascent engine cover, there was an upper hatch which the crew used in orbit when they were docked with the Command Module. In addition, there was a small window over the Commander's position on the left side of the cabin which he used primarily during the rendezvous and docking maneuvers after returning to orbit.

Rear cabin view

Toward the rear, the cabin was even more cramped than it was from side to side. At eye level, the cabin was a full seven and a half feet deep; however, from about knee height down, the aft portion of the cabin was filled with the ascent engine cover and, forward of that, the floor space was only three feet deep. In addition, the side bulkheads in the aft portion of the cabin were covered with storage compartments on the Commander's side and the environmental control equipment on the LMP's and, in effect, the aft portion of the cabin was only useful as a place for temporarily stowing such things as the suits and helmets and, at night, as a place to hang the Commander's hammock. Readers should also note that, contrary to what is shown in the accompanying drawings, the

crews of the extended missions (Apollos 15, 16, and 17) did not wear their suits during the rest periods and, rather, slept in their underwear. The suits were stowed on the ascent engine cover and further reduced the usable space in the cabin.

Hammock diagram here; then control panels

From about waist height up, the forward wall and the bulkheads to either side of the forward section of the cabin were covered with gauges, switches, and circuit breakers. There was also a panel running across the front of the spacecraft at about waist height and, on it, each of the astronauts had a pistol-grip attitude controller at his right hand and a thrust controller at his left. In between these on the Commander's side, there was a manual start/stop button with which he could back up the computer and, in a similar position on the other side of the cabin, the LMP had readouts and a data entry pad for the Auxiliary Guidance System (AGS), the back up navigation-and-guidance computer. On the waist-height panel between the two astronauts and above the hatch, they had a Display and Keyboard Assembly or DSKY - pronounced "diskey"- which was used for input and output of the Primary Guidance-and-Navigation System or PGNS - pronounced "pings". Because the DSKY was over the hatch and extended about a foot out into the cabin, the astronauts had to be careful not to catch their backpacks on it as they crawled in and out of the spacecraft. The final piece of navigation instrumentation was a small, one-power, optical telescope or sextant with which the astronauts could make star sightings either while they were in orbit or once they were down on the surface. This Alignment Optical Telescope (AOT) was hung from the ceiling over the DSKY and had an aft-pointing eyepiece at about eye level.

Environmental Control System (ECS)

ECS general diagram

All of the aforementioned instrumentation was devoted to the flight phases of the LM mission and, once the astronauts were on the Moon and were sure that their spacecraft was in good shape, most of this equipment was powered down for the three-day stay. Thereafter, the systems with which the astronauts were most concerned were those with which they controlled the electrical supply, communications, and the cabin environment. The Environmental Control System (ECS) took up most of the right bulkhead, the one aft of the LMP's station. This ECS compartment contained most of the equipment which controlled cabin heating, cooling, humidity, oxygen pressure, and carbon dioxide content - all of it packed in a space about a meter high, a meter deep, and about a half meter thick. Most of the ECS controls were located behind the LMP's station and, as can be seen in the transcripts, some of the controls were hard to reach when both astronauts were suited, pressurized, and wearing their backpacks.

Almost all references in the transcript to the Environmental Control System concern the settings of various

ECS switches and valves. Consequently, in the next few paragraphs we will go into some detail about the relevant parts of the ECS.

Pressure Relief valves and Other Cabin Pressure Controls

At sea level, the Earth's atmosphere is a mixture gases - primarily of nitrogen (78% by volume), oxygen (21%), water vapor (varying amounts depending on temperature and humidity), and traces of carbon dioxide and other gases. Oxygen is, by far, the most important component of what we breath and, indeed, the Apollo astronauts breathed almost pure oxygen laced with controlled amounts of water vapor. With the nitrogen eliminated, the cabin pressure could be considerably less than sea-level pressure on Earth - about 4.8 psi (pounds per square inch) versus 14.7 psi - and, consequently, the cabin walls could be relatively thin and, therefore, light in weight.

(put air stream figure here)

Fresh oxygen had to supplied more or less continuously because, as the astronauts breathed, they took in oxygen and exhaled carbon dioxide. Lithium hydroxide canisters (described below) were used to extract excess carbon dioxide from the cabin and/or the suits and, had fresh oxygen not been added, the cabin and/or suit pressures would have slowly decreased. Except when the astronauts were using the oxygen supplied from their backpacks, they used oxygen supplied to the cabin and/or the suits through a pair of oxygen demand regulators - usually referred to in the checklists and in the transcript as "Press(ure) Reg(ulator)'s A & B". Upstream of the demand regulators, various valves and switches allowed the crew to select the tank from which fresh oxygen would be drawn (two tanks in the descent stage and one in the ascent stage), allowed them to refill the tanks in their backpacks, or, after a period of Extravehicular Activity (EVA), allowed them to repressurize the cabin. Also to be found upstream of the demand valves were various relief valves, burst diaphragms, and high pressure regulators which protected the ECS from the high (2700 psi) pressures of the descent stage storage tanks.

ECS control diagram with Demand reg detail

The two demand regulators were hooked up in parallel so that the system would still function if one or the other of them failed. The controls were located on a panel behind the LMP's station. They were positioned at about waist height and each had four possible settings. With the control set in the Closed position, no oxygen would flow through the regulator while, in the Cabin position, enough oxygen was supplied directly to the crew compartment to maintain a pressure in the range of 4.6 to 5.0 psi. When set in the Egress position, the regulators maintained a pressure of 3.8 psi (plus or minus 0.2 psi) in the Suit Circuit described below; and, finally, the Direct O2 setting produced unregulated flow of oxygen into the Suit Circuit. Some readers may want to note that, with the demand regulators set in Direct O2, pressure in the Suit Circuit could, in

principle, be controlled through use of the Suit Circuit Relief valve which also described below.

repress valve control detail

As already mentioned, the ECS included a cabin repressurization valve. Its control was located on the same panel as the demand regulator controls and it had three settings. In the Closed position, there was no possibility of flow through the valve while, in the Manual position, oxygen would flow into the cabin until the setting was changed. With the control in the Auto position - and the repressurization circuit breaker closed - valve openings and closings were determined by a solenoid which was enabled whenever either of the demand regulators was set in the Cabin or Direct O2 position. With the solenoid activated and the repressurization control in the Auto position, a drop of pressure below 3.7 psi would activate the flow of oxygen until the cabin pressure built back up to about 4.5 psi.

Although the repressurization valve never had to respond to an emergency during any of the Apollo missions, it was designed to maintain cabin pressure at 3.5 psi for at least 2 minutes following a 5-inch-diameter hull puncture. The only times when a puncture was at all plausible was during landing and during launch and rendezvous; and, at these times, the astronauts always wore their suits, albeit unpressurized so that they could move their arms with relative ease. Consequently, in the event of a puncture the astronauts would only need cabin pressure maintained for long enough that they could get their suits inflated. Two minutes gave plenty of margin. Because there was never any repressurization emergency during any of the Apollo missions, the repressurization valve was only put to use following the EVA's (three on Apollo 17) and various scheduled jettison operations (two on Apollo 17).

Dump valve diagram here

In order to depressurize the cabin for an EVA or to jettison trash (empty food packs, expended batteries, and the like), the astronauts could use one or both of two dump valves: one was built into the forward, or "EVA", hatch and the other into the overhead, or "docking", hatch. As indicated in the accompanying figure, each of the dump valves had two lever-type handles. One was on the outside of the spacecraft so that, if for some reason pressure built up in the cabin and was holding the hatch closed, the astronauts could use the external handle to dump the pressure. (There were never any unplanned cabin pressurizations during the Apollo missions and, consequently, the external handle was only used as a means of pulling the hatch partially shut for cabin thermal control during the EVA's.) The internal handle could be set and locked in any one of three positions. In the Closed position, no cabin gas could get through the valve. In the Open position, the valve was fully open and gases in the cabin could freely escape to the lunar vacuum. And, in the Auto position, the valve served as a pressure relief valve, and would have opened had the cabin pressure

ever exceeded 5.4 psi. In the Open position, the overhead valve could reduce cabin pressure from 5.0 psi to 0.08 psi - a value low enough that an astronaut could pull the hatch open against the remaining pressure - in about 180 seconds. The corresponding time for the forward dump valve was 310 seconds.

The Suit Circuit

Between the time Cernan and Schmitt undocked from the Command Module in preparation for the descent and the time that they redocked once they were safely back in orbit, they spent about 58 hours inside the LM and 22 hours outside on the surface. Because the backpacks were cumbersome and had only limited oxygen storage capacity, they were used only during the EVA's. For virtually all of the time the astronauts were in the LM, they used the ECS Suit Circuit to provide them with oxygen which was temperature controlled and scrubbed of excess carbon dioxide, excess water vapor, extraneous dust and smells.

As noted previously, oxygen was added to the Suit Circuit when either of the pressure demand regulators was set in the Egress or the Direct O2 positions. In Egress, enough oxygen was added to maintain the Suit Circuit pressure at 3.8 psi while, in the Direct O2 setting, the flow was unregulated, albeit at a modest 7 pounds of oxygen per hour. For comparison, the cabin repressurization valve supplied 6.6 pounds of oxygen in two minutes.

Beyond the point where fresh oxygen was added to the Suit Circuit flow, the gas stream first passed through a heat exchanger where, depending on the setting of a control located behind the LMP's right foot, more or less heat was added.

Suit Isol detail

The oxygen stream next entered two Suit Isolation valves - one for each crewman. The controls for these valves were located behind the LMP's station at about knee height and each had two settings. In the Suit Flow position, the valve let oxygen flow from the Suit Circuit into the hoses and then back again. In the Suit Disconnect position, the valve was closed to flow. The prime position of the valve was Suit Disconnect and, indeed, the valve was equipped with a solenoid-activated, spring-operated Override which would cut off the flow if a sensor detected a suit circuit malfunction. If the actuator had ever been tripped, the astronauts would then have hooked up to the backpacks or the Oxygen Purge Systems described below.

diagram of Suit Circuit Relief and other colocated controls

Beyond the Suit Isolation valves, the oxygen flow next encountered the Suit Circuit Relief valve. This control was located on the inboard face of the ECS cabinet, a position which was relatively hard to reach when the astronauts were wearing their backpacks and had their suits pressurized.

Indeed, the only time they had to change the Relief valve setting while they were pressurized was just prior to the backpack jettison at the end of the last EVA - at a mission elapsed time of 171:48:42. The transcript indicates at that point, with his backpack off, Schmitt had enough freedom of movement that he could reach the control without notable trouble. The Relief valve had three settings. In the Open position, oxygen flowed freely out of the Suit Circuit into the cabin; while, in the Closed position, no flow could occur. Because both the Open and Closed positions represented a slightly increased risk in the operation of the Suit Circuit, microswitches were used to produce a telemetry signal whenever the control was in either of those settings. The normal setting was Auto. Usually, this meant that the valve was closed but, when the Suit Circuit pressure exceeded 4.3 psi, the valve would open to relieve the excess into the cabin. The only time during Apollo 17 when the Suit Circuit Relief valve was not in the Auto position was during a brief period prior to depressurization for the backpack jettison. For these few minutes, the Relief valve was Closed and one of the Pressure Demand Regulators was set to Direct O2, thereby permitting suit/suit circuit pressurization for an integrity check. Once the suits had been pressurized, the regulator was reset to Egress; and, then, a short while later when the integrity check was complete, the Relief valve was reset to Auto. Thereafter, pressure in the Suit Circuit was maintained at 3.8 psi by the Demand Regulators.

Put Diverter valve diagram here

Next downstream from the Suit Circuit Relief valve was the Suit Gas Diverter valve - located behind the LMP's station, just to the right of his head. This control was a push/pull-type handle. The fail-safe position was Pull/Egress which closed the valve and prevented the flow of oxygen out of the suit circuit, through the valve, and into the cabin. The alternative position was Push/Cabin which permitted free flow of oxygen out of the suit circuit into the cabin. Under normal conditions, this setting was used only when the astronauts were out of their suits and wanted to maximize the interchange of air between the Suit Circuit and the cabin and/or they wanted to dry the suits. Had the cabin pressure ever fallen with the Suit Gas Diverter set in Push/Cabin, a solenoid would have released a spring and returned the valve to the Egress position.

Cabin Gas Return Valve detail

Oxygen flowing out of the Suit Gas Diverter valve returned to the suit circuit through the Cabin Gas Return valve. This control was also located on the inboard face of the ECS cabinet. As with the Suit Circuit Relief valve, its setting was never changed when the astronauts had their suits pressurized. The control could be set in one of three positions: Open, Auto, and Egress. The Open setting, of course, permitted a free return of cabin gas to the suit circuit and the Egress setting prevented such flow. In Auto, the flapper-type valve was allowed to respond to pressure

differences between the cabin and the suit circuit - closing when the cabin was at lower pressure than the suit circuit and opening in response to the reverse condition.

Beyond the Return valve, oxygen in the suit circuit flowed through one or the other of two carbon-dioxide/odor-removal canisters, the choice of canister depending on the settings of selectors mounted on the in-board face of the ECS cabinet. The canisters each contained beds of lithium hydroxide (LiOH) for carbon dioxide removal and beds of activated charcoal for odor control. The larger Primary canister had a capacity of 41 person-hours while the smaller, Secondary canister, identical to the canisters used in the backpacks, had a 14-hour capacity. Replacement LiOH cartridges - along with backpack replacements - were stored outside the cabin in the Modular Equipment Storage Assembly (MESA). On Apollo 17, replacement of the Primary ECS cartridge were done after wake-up on Day 2 of the lunar surface stay and then, a second time, about 35 hours later at the end of EVA 3. We note that the astronauts were outside the spacecraft during two 8-hour EVA periods during the time between the first changeout and the second. Consequently, the cartridge was used for about 38 person-hours, a figure close to the design lifetime. As a back up, there was a carbon dioxide sensor in the Suit Circuit which, if the CO2 partial pressure exceeded 7.6 mm of mercury, would have turned on warning lights. And, finally, because of the heavy - if relatively brief - dust load anticipated following the EVA's, the Primary canister was protected with a dust filter which, if it became clogged, could be bypassed by changing a valve setting.

CB11, CB16, and other ECS controls at the front of the cabin ECS

Oxygen flow through the Suit Circuit was achieved primarily through the operation of one or the other of two suit-circuit fans. The circuit breaker for fan No. 1 was located on breaker panel 11 on the Commander's side of the cabin while the circuit breaker for the other fan was located on panel 16 on the LMP's side. A selector switch was located on a panel on the forward cabin wall, right next to the ECS caution lights and just to the LMP's side of the centrally-mounted Alignment Optical Telescope (AOT). Generally, Fan No. 1 was used during the landing and launch phases while Fan No. 2 was used during the pre-and-post EVA periods. A sensor called Suit Fan Delta-P measured the pressure differential across the fan assembly. It was operated with a circuit breaker on the LMP's panel and, when the breaker was closed, lit a warning light if the pressure difference across the fan assembly was less than 9.0 inches of water (about 0.3 psi). Obviously, the warning light would come on as the fan was turned on and, by going out, would indicate that the fan had come up to speed. Backflow across an inoperative fan was prevented by flapper-type check valves.

Beyond the fans, oxygen in the suit circuit flowed through a sublimator where excess heat was removed and then

through one of a pair of water separators where excess water was removed and transferred to the waste management system. A selector switch was located near the LiOH canisters on the in-board face of the ECS cabinet.

The Apollo Suits

Each of the suits, together with the backpack comprised an independent spacecraft. To get from place to place, the suited astronaut still had to rely on muscle power but, otherwise, the suit-and-backpack combination - called the Extravehicular Mobility Unit or EMU - kept him safe from the lunar vacuum, kept him cool by getting rid of excess body heat, provided him with oxygen for breathing, removed the carbon dioxide he exhaled, and gave him the means to talk with his crewmate and, through relays in the LM and on the Lunar Rover, the means to talk with Earth. The suit was also designed so that, despite the tendency of internal pressure to make it a rigid, unyielding balloon, the astronaut could move his arms and legs and flex his fingers. Necessarily, moving the suit against the internal pressure was hard work. Forearm fatigue from the constant use of the hands inhibited productivity, but at least it was possible to get work done. LCG picture or drawing

Next to his skin, the astronaut wore a Liquid-Cooled Garment (LCG), a pair of long-johns embedded with a network of thin plastic tubes. During the EVA's, water was pumped through the tubes where it picked up excess body heat. The water then flowed out of the LCG, through a connecting hose, and into the backpack where it was cooled before flowing back to the LCG. This supply of LCG cooling water flowed in a closed-loop system and there was never any appreciable loss during the course of the mission. Inside the backpack, there was another supply of water called the feedwater; this was fed at a controllable rate through a heat exchange coil where it extracted heat from the LCG water. After being heated in the coil, the feedwater was then allowed to sublime into the lunar vacuum and, thereby, carried away the excess heat. Each of the backpacks could hold about twelve pounds of feedwater, enough to provide cooling for about eight hours of fairly strenuous activity.

Sublimator drawing

The suits were made of an inner bladder covered by several layers of insulating aluminized mylar which, collectively, not only held pressure but also provided thermal protection when the astronauts were out in the direct sun. In addition, the outer layers of the suits were strong enough to resist tearing and abrasion as the astronauts crawled in and out of the LM, carried equipment, jumped onto their Rover seats, brushed up against rocks, sometimes even fell. At stomach and lower chest levels, the suit was equipped with connectors for water hoses, oxygen hoses, and a communications cable. The hose connectors each had a ring lock and, embedded in it, a ring-locking mechanism

ingeniously called a "lock-lock". There were also dust covers over each of the connectors.

suit connectors and lock-locks, PLSS cutaway

The hoses ran from the connectors around to the backpack or PLSS (Portable Life Support System) - pronounced "pliss" - which contained communications and telemetry gear, tanks of oxygen and feedwater, a fan to move the oxygen through the suit, a pump to move the closed-loop water through the Liquid Cooled Garment, a lithium hydroxide canister to remove carbon dioxide, a battery for electric power, and assorted subsystems which allowed the astronauts to recharge and refill the tanks for multiple forays out onto the lunar surface. For Apollo 17, each of the PLSS's could hold enough oxygen (1.8 pounds), feedwater water (12 pounds), and battery power (25 amp hours) to see an astronaut through seven to eight hours of Extravehicular Activity (EVA). The exact length of an EVA depended on the astronaut's level of exertion and, therefore, the rate at which he used his supplies of "consumables". The nominal eight-hour capacity - with about an hour's worth of cooling water in reserve and even more of oxygen and battery power - meant that the astronauts got back in the LM at about the time when prudence would suggest getting out of the suits for a period of rest anyway. Indeed, the astronauts could divide their lunar stays into something resembling three normal 24-hour days - four hours of EVA preps, eight hours of work outside the spacecraft, four hours of post-EVA activities, and eight hours of rest - and, thereby, minimize the fatigue and stress with which they had to cope.

For its time, the PLSS design represented an amazing engineering achievement: a complete life-support system in a reliable, manageable, 80-pound package. However, the fact that crew safety was so dependent on PLSS operation dictated that backup systems be available.

OPS photo or diagram

On top of their PLSS's, each of the astronauts wore a forty-pound Oxygen Purge System (OPS) which provided backup oxygen. The purge system contained about a thirty-minute supply which could be used in the event of a PLSS failure, a suit puncture, or exhaustion of the primary oxygen supply. Because the OPS's could not be recharged and, in addition, were intended to serve as sources of emergency oxygen in case the astronauts could not dock with the Command Module and, therefore, had to make a spacewalk, there was never any thought given to use of the OPS's to extend an otherwise normal EVA. However, if oxygen were needed in an emergency, the astronaut could pull an actuator mounted on the Remote Control Unit (RCU) on his chest and the OPS would supply whatever oxygen was needed to keep the suit pressure at 3.8 pounds per square inch. In the case of a suit puncture, oxygen would flow out of the OPS, into the suit, and out through the hole; and, if it was a PLSS failure that caused the problem rather than a suit puncture, the astronaut could open a purge valve fitted on the right side of his chest in

order to create a pressure difference and, thereby, initiate the emergency flow. The purge valve had two settings. If the LCG/PLSS cooling system was still working, the astronaut would put the purge valve in the Low Flow setting (4 lbs/hour) and would be able to get oxygen for about an hour. If the cooling systems was inoperative, he would use the High Flow setting (8 lbs/hour) and would have about 30 minutes to climb back in the cabin and get hooked up to the LM oxygen supply.

Because the astronauts planned to drive for up to an hour to get to their most distant work stations, if they were going to make it back to the LM in the event of a PLSS failure they had to be able to operate the OPS in Low Flow. Consequently, it was essential to have a backup to the cooling system. This was provided by the Buddy/Secondary Life Support System (BSLSS) which consisted of a set of water hoses and fittings which would allow the astronauts to share cooling water from the good PLSS. Because the astronauts could not have walked very far or very quickly tied together with hoses, the BSLSS was only of practical value if the Rover was still working. However, the risk of a simultaneous PLSS/Rover failure was considered to be acceptably low.

RCU controls photo

The various PLSS controls were located on either the chest-mounted Remote Control Unit (RCU) or, the lower, right corner of the front of the PLSS. Switches for the oxygen fan and the LCG pump were located on the RCU along the comm switches, a volume control, an oxygen quantity gage, and an assortment of warning flags which would indicate PLSS malfunctions. The gage and the flags were located on the top surface so that, in principle, the astronaut could merely look down and see them. Sun glare and dust sometimes made the reading a little difficult. The switches on the bottom of the PLSS were located far enough forward that, in principle, the astronaut could reach back and turn the sublimator on, switch from the primary feedwater tank to the auxiliary tank, or adjust the amount of cooling he was getting by changing the rate of feedwater flow through the sublimator. Each of the switches was shaped differently from the others so that they could be distinguished by feel. However, the stiff suits made the act of reaching the switches a bit difficult. When the astronauts were inside the LM, reaching the switches was particularly difficult - especially for the shorter-armed astronauts - and many had to help each other get their cooling water turned on or off. Outside, the stiff suits forced most of them to first move their right arms up and forward so that they could get some momentum in a downward swing as they reached back for the control.

LRV cartoon

The Lunar Rover

The last of the Apollo "spacecraft" to be designed and flown was the marvelous Lunar Rover, designed and built by the Boeing Company and NASA's Marshal Spaceflight Center.

The Rover was a lightweight vehicle, weighing only 462 terrestrial pounds empty - 70 pounds on the Moon. It was battery-powered and had a potential range of about 50 kilometers. On level ground, the Rover was capable of about 10 - 12 kilometers per hour and, when one added to the driving time the time spent on Rover deployment and housekeeping chores, the savings over a walking traverse was not particularly impressive. However, because the astronauts used far less oxygen, feedwater, and physical energy when they were riding than they did when they were walking, use of the Rover meant that they arrived at the geology stops rested and refreshed and with a far greater stock of consumables than they would have had otherwise. In addition, the Rover could carry up to 970 terrestrial pounds of payload and, when one subtracted about 600 pounds for the astronauts and their life-support gear, there was still plenty of capacity for communications equipment and a generous assortment of scientific paraphernalia.

LRV wheels

The four Rover wheels were each made of a strong wire mesh and had a chevron-shaped, metal tread that covered about fifty percent of the traction surface. When fully loaded, the Rover chassis had a clearance of about 14 inches. Rocks bigger than that had to be avoided, of course and, indeed, Cernan tried to avoid as many rocks as he could to avoid damage to the wheel. Inevitably, he couldn't avoid all of the six-inch rocks and ran over quite a few and, by the end of the third EVA, had collected a number of golf-ball-sized dents in the mesh. The dents did not noticeably degrade the Rover's performance and, indeed, because each of the wheels was driven by a separate motor and because the vehicle had, as well, both front and rear steering systems, there was little chance of a complete Rover breakdown.

The Rover was equipped with a navigation system which used counts of wheel rotations to measure the distance driven since the system was last reset. More importantly, when the wheel-rotation data were combined with heading information provided by an internal gyro, the nav system provided a range and bearing to that last point of initialization - always a point near the LM.

The "problem" of getting back to the LM from some distant geology station was actually a trivial one. There were outbound Rover tracks to follow and, even if the astronauts weren't retracing their outbound course, there were plenty of landmarks to lead them close enough to see the 23-foot-tall LM. For obvious reasons, the astronauts always landed in the middle of a large area of relatively flat terrain and, even if the LM was in a local low spot, all one had to do was find a bit of high ground and the glint of sunlight off the LM's foil covering would immediately catch the eye. Certainly, there was no chance of mistaking the LM for a rock and, if it was in the line of sight, it could be seen from a considerable distance. The only exception to this general rule was when the astronauts had to look

directly into the low, early-morning Sun - in the direction called "up-Sun". In such a case, even had they been able to see into the bright glare, they would have been looking at shadowed surfaces on the spacecraft and might have had trouble spotting it. However, it wouldn't have taken much of a detour to get a good viewing angle and, all in all, there was virtually no chance of getting lost.

Because even the "flat country" is rolling and hummocky and everything but the LM is some shade of grey, the problem of finding anything else - say a specific crater - could be challenging. As an extreme example, on Apollo 14 Alan Shepard and Ed Mitchell walked to within twenty meters or so of the rim of Cone Crater and then, after a tiring climb and a fruitless search, eventually had to head back toward the LM without ever having actually looked into the crater. With the Rover, the problem of finding geology stops was much less dramatic.

Because the nav system measured distance and bearing relative to the LM, finding a specific crater meant that the astronauts had to know exactly where they had landed. On each of the three Rover missions, there was some initial confusion about the absolute location of the LM; but, after a while, the crews were able to unambiguously identify a crater or two. Navigation readouts at those places then helped the support people back in Houston to pin down the landing site and, thereafter, the crews could use the nav systems to drive with confidence from one place to another. The nav system was only accurate to about 100 meters; but, if there was a little remaining confusion when the crew got close to their target, they could always spend a minute or two driving around, seated comfortably, until they found the crater they were looking for.

The Apollo 17 Lunar Surface Journal, Part 5

Building on Experience

For three days in December, 1972, while astronaut Ronald E. Evans orbited overhead in the Command Module America, Gene Cernan and Jack Schmitt explored a spectacular lunar valley called Taurus-Littrow. The Apollo 17 landing site is bounded by massive, rounded mountains that rise eight thousand feet and more above the valley floor; and, as Cernan and Schmitt went about the business of setting out scientific equipment and collecting samples, the massifs formed a breath-taking backdrop.

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Taurus-Littrow is located on the southeastern rim of the great circular basin called Mare Serenitatis and, within an hour's drive by Lunar Rover, Cernan and Schmitt had access to a wide variety of geologic materials. These included ancient, shattered, impacted derived rocks that make up the massifs, younger lavas that constitute the valley fill, avalanche materials which had slid off one of the massifs about 100 million years ago, and even orange-colored traces of volcanic fire-fountains which had flared from time to time while the last of the lavas were being laid down. In many ways, the rich returns of Apollo 17 were due to the happy (and intentional) choice of a complex landing site.

And there was another factor which contributed to the productivity of Apollo 17 and that was the complementary skills of the two-man landing crew. Gene Cernan was a skilled pilot, a veteran of more than 200 aircraft carrier landings and of two prior space missions. His main job was to fly the Lunar Module, Challenger but, like many of the other pilot-astronauts, he had taken advantage of years of training to learn enough about field geology and about the scientific goals of the mission that, even on his own, he would have done a first-rate job making observations and collecting the significant samples that Taurus-Littrow had to offer. In much the same manner, Jack Schmitt was a professional geologist and, while he had been deeply involved in scientific planning for all the Apollo missions and had helped tailor the geology training program to fit the needs of the pilot-astronauts, he had also learned the spacecraft systems so well that Cernan considered him to be an "outstanding" co-pilot. In flight and in matters of Lunar Module and Lunar Rover operations, Cernan was the expert and Schmitt was his assistant. And in matters of geology and the rest of the scientific program, Schmitt took the lead. Cernan and Schmitt worked well as a team and it showed in the amount of productive work they were able to cram into their three-day visit to the lunar surface.

Run-throughs and Rehearsals

In greatest measure, of course, the success of Apollo 17 was due to lessons learned and experiences gained during the missions that preceded it. Robot spacecraft like the Rangers and Lunar Orbiters provided close-up, map-quality images of the lunar surface; and, then, beginning with Russia's Luna 9 in 1966 and continuing through the Surveyor series of that same year, soft-landers determined something of the chemical, mechanical, and bearing properties of the surface layers and, as well, provided ground level views of crater-and-rock-strewn lunar terrains.

In the very early years of the Space Age, cautious planners had demanded unmanned demonstration flights to prove that humans could survive, at least, the rigors of spaceflight; but, after a few launches of canine and primate stand-ins, it wasn't long before the Mercury and Gemini astronauts demonstrated that they could control and maneuver a spacecraft and, also, could perform the critical maneuvers necessary to rendezvous and dock with a passive target.

Learning the Basics in Orbit

As mentioned previously, the tight deadline that Kennedy had established for accomplishing the first landing dictated the design choice of having an astronaut stay in lunar orbit in the Command-and-Service Module while a two-man landing crew flew the LM down to the surface. This choice minimized the amount of mass that had to be launched from Earth and, indeed, for almost any other mission mode, NASA would have been faced with the choice of either designing a bigger booster than the Saturn V or making multiple Saturn V launches to accomplish a single mission. Neither alternative was really acceptable and ultimately, NASA realized that only with the design choice of a CSM/LM combination could they meet Kennedy's challenge. However, the choice also meant that, when a LM crew lifted off from the Moon, they would have to rendezvous and dock with the CSM and, while theoretical studies of orbital rendezvous were reasonably well developed, it took the ten-mission Gemini program to prove that it could be done. Of the ten Gemini crews, five crews had rendezvous targets available on orbit and all five conducted successful rendezvous. And to crown the success of the program, the last two crews were able to rendezvous and dock with their targets during their first orbit of Earth.

pix of Gene outside on Gemini IX

The Gemini program provided opportunities to prepare for Apollo in other ways as well. The crews of Gemini 5 and 7 spent eight and fourteen days in space, respectively and, although they had far less elbow room than the Apollo crews, they proved beyond any doubt that there were no physiological or operational barriers to the conduct of a ten-day lunar mission. Five of the Gemini astronauts (among them, Gene Cernan on Gemini IX) ventured outside their spacecraft and, when they tried to do strenuous work, discovered that the air-cooling system used in the Gemini suits wasn't going to be adequate for Apollo. An astronaut sitting inside a

cramped capsule simply couldn't work hard enough to generate much body heat and, consequently, could be kept cool by oxygen flowing through the suit. But when he got outside and flexed his arms and legs against the internal pressure of the suit, the extra heat load quickly overwhelmed the air-flow cooling system. What was needed was a system which could carry away the excess heat; and, as a result of the Gemini experience, NASA and its contractors developed a system for circulating cooled water through tubes woven into an undergarment worn next to the astronaut's skin.

Testing the Spacecraft

pix of Mercury, Gemini, Apollo capsules

Although much of the design work for Gemini and Apollo was carried out by independent teams, both programs used design features which had been tested during Mercury and were further validated during the Gemini flights. In many ways, the Apollo Command Module was a large, complex cousin of the Mercury and Gemini capsules. It was designed for orbital flight and for the return to Earth. Like its predecessors, it was equipped with a blunt heat shield to protect both the spacecraft and the crew inside during the final, fiery descent through the Earth's atmosphere toward a splash landing in the ocean. Perhaps not surprisingly, the Command Module was the first major piece of the Apollo flight hardware ready for flight testing.

The first manned flight test was delayed for twenty months because of the tragic launch-pad fire that took the lives of Gus Grissom, Roger Chaffee, and Ed White in January 1967. By October 1968, however, the CSM design had been modified to eliminate the fire hazard - and to incorporate a number of essential upgrades - and the crew of Apollo 7 (Wally Schirra, Donn Eisele, and Walter Cunningham) put the CSM through its paces in low orbit around the Earth. Two months later, the crew of Apollo 8 (Frank Borman, Bill Anders, and Jim Lovell) made an epochal Christmas voyage to lunar orbit. In part, they flew this early voyage to the Moon - leap frogging CSM/LM tests in low and high Earth orbits - for the simple reason that development of the LM was lagging behind the rest of the program by five months and there wasn't a spacecraft ready to fly. And, more importantly, the Russians had sent unmanned Zond spacecraft to lunar orbit in September and November and then had brought them back to Earth. The Zond missions were generally seen as precursors to a manned orbital mission and, in large measure, Apollo 8 was flown to prevent a Russian first which would have greatly diminished the psychological impact of the first landing. Global politics aside, however, Apollo 8 also provided a fortunate opportunity to prove out flight control procedures at lunar distances. It gave NASA vital experience in tracking a spacecraft orbiting the Moon and also provided an opportunity to expand the photographic coverage of potential landing sites. It was a great confidence builder

for the entire Apollo team; and it was shared with an international audience of hundreds of millions of people. Few who witnessed it will ever forget the crew's Christmas Eve reading from Genesis that accompanied the TV pictures of the lunar surface passing below. And, as well, there were the still photos the crew brought home, the stunning pictures of the Big Blue Marble, our home planet Earth, rising above the limb of the Moon. It was a taste of other stunning moments and pictures yet to come.

By March 1969, a LM was finally ready for a manned test flight in Earth orbit. The crew for this flight - Jim McDivitt, Dave Scott, and Rusty Schweickart - originally had been scheduled to fly Apollo 8 when that mission was slated as a LM test in low Earth orbit. Because of the delays in LM development and the change in plans for Apollo 8, McDivitt opted to swap places with Borman and his crew. McDivitt had been training for the first LM flight for a long time and he didn't want to give it up.

The LM was like no other vehicle that had ever been flown. It was a new sort of beast; and it is, perhaps, not surprising that it was the last major piece of Apollo hardware to be ready for flight test. It was a two-stage vehicle, one-stage for the descent from lunar orbit to the landing, and the other for the return from the surface. Because the LM would never have to fly on its own through Earth's atmosphere, it didn't need the structural strength or aerodynamic shape of the CSM. What the LM had to be was lightweight and reliable and, although NASA successfully tested the propulsion and guidance systems during an unmanned, earth-orbital flight in January 1968, it was excess weight and other design problems that delayed the first manned test. There was no room in the weight budget for much sophistication and, indeed, every kilo that could be shaved from the spacecraft gave the crew another tenth of a second or so to find a safe landing spot, another half hour to spend on the Moon, or the opportunity to bring a few more priceless samples back to Earth. The search for weight savings and improved engine performance continued virtually until Apollo ended and the payoff was not only a flawless series of LM missions - nine of them in all - but also a dramatic increase in productivity with each succeeding flight.

Because of the tight deadline that Kennedy had set, the final rehearsals for the lunar landing mission came in rapid-fire order. As hardware became available for flight test, it was immediately pressed into service. During Mercury, NASA had conducted a flight on the average of once every four months and then, during Gemini, had increased the rate to one every other month. But, while each of the crews built on the successes of their predecessors, at no time during Mercury or Gemini was so much new equipment or so many new procedures brought on line so rapidly as during Apollo. At three month intervals, Apollo crews made great strides along the road to the lunar surface and it was a combination of determination,

plentiful resources for design and testing, and also a good measure of luck that made it all possible.

The Apollo team did its best to make sure that equipment and procedures would work the first time they were tried in flight; and the successes of the unmanned test series and of Apollo 7 and Apollo 8 continued unabated into the final year of the decade. For the first time, on Apollo 9, a crew performed the delicate maneuver of separating the Command Module from the Saturn V, then moving away and turning around to dock with the stowed LM and pull it free of the Saturn. On the second day of the flight, they fired the big Command Module engine, much as later crews would do to enter lunar orbit, and tested the bond between the two spacecraft. On the third day, in what would later prove to have been a rehearsal for the Apollo 13 rescue, they test fired the LM's Descent Engine for six minutes while still docked with the Command Module. On the fourth day, Schweickart spent nearly an hour outside on the LM's front porch, testing the Portable Life-Support System or PLSS - the backpack that the lunar surface crews would wear. And then, finally, on the fifth day of the mission, McDivitt and Schweickart pulled away from the CSM and fired the Descent Engine to boost themselves to higher orbit around Earth. This was about as close a simulation of the lunar descent that could be flown in Earth orbit; and, once the maneuver was complete, McDivitt fired the Descent Engine for a third and final time to position the LM for a simulated ascent back to lunar orbit. Then, all that remained was to jettison the Descent Stage and fire up the Ascent Engine for a rendezvous with Scott. It all went flawlessly

The crew of Apollo 9 demonstrated the readiness of all of the major components of Apollo; however, the margins for error in the first landing mission were very tight and, once again, it was a weight problem with the LM that forced a change of plans. When the crew of Apollo 10 - Commander Tom Stafford, Command Module Pilot John Young, and Lunar Module Pilot Gene Cernan - was announced on November 13, 1968, the NASA press release listed possible missions ranging "from Earth orbital operations to a lunar orbit flight." However, Gene Cernan says that there was always the possibility that fate could hand them the first landing and, it wasn't until March 24th - eleven days after the Apollo 9 splashdown - that the Apollo Program director, General Sam Phillips, decided that Apollo 10 would be flown as a rehearsal mission to lunar orbit.

A lunar landing was a complex undertaking and, although the procedures had been reviewed and practiced countless times in simulations, there was nothing quite like going to lunar orbit and then flying almost down to the surface to make sure that everything - the propulsion systems, the guidance, radar, and communications systems - was ready for the actual landing. Twenty-plus years after the fact, Jack Schmitt says that he has no doubt that a final dress rehearsal would have been flown, no matter what it might have

meant in terms of meeting the Kennedy deadline. However, in his excellent book, *Carrying the Fire*, Michael Collins says that, had it been his decision, he would have delayed Apollo 10 until a landable LM was ready for Stafford and Cernan to fly. Certainly, there was a good deal of talk and debate before a final decision was made to fly one last rehearsal.

According to Gene Cernan, "When I got assigned to Apollo 10, I remember Stafford telling me, 'You know, it depends on how the hardware flows, but we may be the first guys to land on the Moon.' And we went into that flight not knowing whether we would or would not. Apollo 10 was not designed to be a dress rehearsal until LM-5 began to have problems. LM-5 was the lighter weight LM that would have flown on Apollo 10 had Apollo 8 not flown without one and which eventually flew on Apollo 11. It was at least two months behind and it was at that time that there were discussion of 'Do we wait for the LM and take Apollo 10 all the way to the surface of the Moon? After all, if we're going to go through the risk of launch and TLI, and go a quarter of a million miles away, and go down to some distance above the surface, why not take the rest of the risk and land. Let's wait for the LM that's going to be able to do that.' And the other theory was 'Well, let's take it step by step. Let's put it through all those risks, but let's just not take "the big risk" and put them down on the surface.' And we, the crew, were in discussions - Stafford in particular - as to what direction this should head. And I think Tom tended, once LM-5 was slipping and the opportunity to go on Apollo 10 came, to think that that was the thing to do. Tom was not so adamant about being first on the Moon. He never looked at it that way. He wanted to do what was the best thing to do to have a coordinated, planned program. And when he got involved in those discussions, I think he tended to agree with the people that said 'Let's go to the Moon, but not land.'"

Stafford, Young, and Cernan were launched from Earth on May 18, 1969; and, after spending a couple of hours in Earth orbit checking out all the spacecraft systems, they fired the Saturn V's third stage engine to send them toward the Moon. As with Apollo 8, they flew what is known a "free return" trajectory, one that would take them around the backside of the Moon and then, if the Command Module engine failed to fire, directly back to Earth. However, as it did on all of the Apollo missions, the Command Module engine worked perfectly. As the crew swung around the back of the Moon, flying only 60 nautical miles (110 kilometers) above the center of the lunar Farside, they fired the engine for about four minutes and entered lunar orbit. Twenty minutes later they came around the eastern limb of the Moon and regained radio contact with Earth. The timing of their re-appearance was all that was needed to confirm that they were in the planned orbit.

For the next several hours, Stafford and Cernan checked out the LM. Then, after a night's rest, they separated from Young and, over the Farside, fired the Descent Engine for

thirty seconds and put themselves in an orbit which would take them down to 47,000 feet over a point 300 miles east of the planned Apollo 11 landing site. As they approached the low point of their orbit, they got close enough to the ground to check out the LM radar and to make a visual examination of the area in case it was needed as a backup site for the first landing. Then, rather than fire the Descent Engine against their forward motion for a landing, they fired it in the opposite direction and boosted themselves into a new orbit which would take them out to 190 nautical miles above the Farside and then back down for a final pass, this time over the planned Apollo 11 site.

Two hours later, at the end of another lunar orbit, Stafford and Cernan were ready to rehearse the ascent and rendezvous. Once again passing low over the southwestern corner of the Sea of Tranquillity, they jettisoned the Descent Stage and fired the Ascent Engine for about 15 seconds and, soon thereafter, made a perfect rendezvous with Young. Almost everything had gone perfectly. There had been one anxious moment when, at the moment of staging, the Ascent Stage began to spin and pitch. As it turned out, a control switch for the small steering rockets had been improperly set and it took Stafford eight long seconds to regain control of the spacecraft and then fire the Ascent Engine.

"I saw the lunar horizon go by about seven or eight times in ten seconds," Cernan says. "That's a hair-raising experience. That's when I said 'Son-of-a bitch, what the hell happened?'"

"Now, this story applies to some things we're going to talk about later, so it's worth going into it in some depth. Although I was the Lunar Module Pilot on 10, I prided myself that I could fly the Command Module. Not as good as John Young; because I didn't understand all the systems in the depth that he did. But I had trained in the Command Module simulators, especially for the rendezvous, and I certainly understood how to operate it. It was my nature to do that. I wanted to know what John was doing so that, if we had a problem, I'd understand what his problem was and I'd know what our problem was. And in the Lunar Module simulators, sometimes I would fly on the left seat, just so I would know what Tom was doing. I'd flown with Tom before, so I knew him pretty well. I know how he acts and reacts pretty well. And I felt I knew the lunar module on both sides, very well. Including handling the PGNS (Primary Guidance and Navigation System, pronounced "pings"), as well as anybody. I also had the responsibility of operating the AGS (Abort Guidance System, pronounced "ags"). And a lot of times on Apollo 10, I would operate the PGNS as well as the AGS.

And this is what happened on Apollo 10, to the best of my recollection. When we staged (separated the Ascent Stage from the Descent Stage), there were a number of things we had to do, including changing programs in the PGNS and changing switch positions. At this late stage, twenty five years after it happened, neither Tom or I can be sure but, when it

came time to stage, some program change blipped up on the PGNS (display) and I acknowledged it from my righthand seat - or there was some switch (actually, the AGS Mode Control Switch) that had to be changed, and I changed it. And I'd be willing to bet that, if we could recreate that moment in history - and I think Tom would say the same thing - I put the switch in the new position and Tom went ahead and moved it back to the old one. His action was to move the switch. I had already done it for him. But he didn't know that and, when he moved the switch, he just moved it back where it was. And, in effect, we created the problem.

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"When the spacecraft began to gyrate, neither one of us realized what the other had done. And so we looked at failed software, we looked at stuck thrusters, we looked at all kinds of things. It happened right at the moment of staging and, my god, it was not a passive moment, it was an active moment. And we did do some wild gyrations (maximum rates of motion were 19 degrees per second in pitch and greater than 25 degrees per second in yaw and roll). I think Tom probably damped it out in less than twenty seconds (actually, within eight seconds of staging). Pretty quick. He handled it extremely well. But maybe this is one area we didn't train enough on, And I was going through the procedures and I moved the switch. And I don't remember whether I should have or not. And that's what happened.

"Now, that problem could not and would not have happened on the lunar surface because, had we been ready to stage on the lunar surface, we would have looked at all the switches. We were very meticulous. On Apollo 17, we were ready 30 minutes to an hour ahead of time. We went over the checklist more than once. We would have verified all the switches. So that problem was not relevant to staging on the surface. But, when we came to Apollo 17, there was an invisible line at the righthand edge of the PGNS and I said to Jack, 'Don't ever - don't ever, ever, ever, ever, ever, ever - touch anything to the left of that line, unless I know about it.' And the reason I said that is because I was on his side once and I touched a switch. Tom and I operated a little bit more interdependently, maybe, than Jack and I did, and I didn't want Jack to get ahead of me, throw a switch and the same thing happen to us that happened to Tom and me. And that was my unwritten rule. And that had nothing to do with Jack's abilities, because Jack knew the computer, he knew the systems. He was an outstanding Lunar Module Pilot. It was just that, in times of dynamic action and reaction and people trying to help each other, they can overhelp each other. Like on Apollo 10. And so the rule was, 'Jack, don't touch anything left of the righthand edge of the PGNS.' And it worked out perfectly."

Once Stafford and Cernan regained control of the LM, they fired the Ascent Engine and, two orbits later, rendezvoused and docked with Young in the Command Module. Another orbit later, after Stafford and Cernan were safely

back in the Command Module, they jettisoned the LM which Houston then sent into a solar orbit with a final firing of its engine.

After a good night's sleep and a day in orbit to do landmark tracking, the crew of Apollo 10 headed back to Earth. Although the crew of Apollo 10 encountered problems during the mission, they were the sort of problems that inevitably plague test flights. the important point is that there had been no showstoppers, and the net result of the Apollo 10 rehearsal was that the stage was now set for a try at for a landing on Apollo 11.

Apollo 11: Giant Steps and Baby Steps

In his commentary on the Apollo 17 transcript, Gene Cernan says that, in his experience, landing a jet on an aircraft carrier at night is more difficult than landing the LM. Certainly, in the LM he had plenty of help from Earth; visibility was good; and there were no winds or waves to move the target around. Still, the LM was an experimental craft and the vehicle that Neil Armstrong and Buzz Aldrin landed was only the fourth that had ever been flown. And, of course, no carrier landing had ever had quite the historic overtones of Apollo 11; nor had any carrier landing ever been performed before so large an audience. Literally billions of people listened as it happened.

Down to 50,000 feet above the Moon, Apollo 11 was little different from 10. Armstrong, Aldrin, and Command Module Pilot Mike Collins had a flawless launch from Earth, a long, uneventful coast out to the Moon, and a nominal engine burn to put themselves into lunar orbit. As they crossed over the Sea of Tranquillity for the first time, Armstrong remarked that "the pictures and maps brought back by Apollo 8 and 10 have given us a very good preview of what to look at here. It looks very much like the pictures; but, like the difference between watching a real football game and watching it on TV, there's no substitute for actually being here." On that first orbit, the planned landing site itself was still enveloped in pre-dawn darkness and it wasn't until their fourth pass - during the LM checkout - that Aldrin reported seeing it from the LM windows.

In his excellent book "To a Rocky Moon", geologist Don Wilhelm's discusses the process by which Apollo landing sites were chosen. After Apollo 12, scientific considerations were given considerable weight but, for the very first landing, the site was chosen entirely for operational reasons. During the Lunar Orbiter missions, the high resolution cameras had been focused on promising sites strung out along a 10-degree-wide band straddling the lunar equator. Equatorial sites were of interest because they could be reached with a minimal expenditure of fuel. Sites were also sought at least 45 degrees west of the east limb of the Moon - the right edge as seen from the northern hemisphere on Earth - because the landers were going to orbit from east to west and Houston was going to need several minutes of tracking data so that the landing computer could be updated prior to the descent. As Jack Schmitt related during a review of this introduction, "The targeted point for Apollo 8 was picked as the easternmost site that the Flight Control Division thought they could handle, the easternmost certified (acceptably smooth) site for which they thought there would be enough time after AOS (Acquisition of Signal) to track the Lunar Module, update it's state vector, and get a successful landing. So Apollo 8 was targeted for that site (designated as Apollo Landing Site 1) and, when it came time for Apollo 10, they targeted it to the same site, because they already

had a rough data package (that is, data on orbits and the timing of events during the mission) that they could refine based on the relative positions of the Earth and Moon at the planned time of launch. (Launch times were picked in part, so that, at the time of landing, the Sun would be between 5 and 13 degrees above the landing site horizon, low enough to give good shadow definition of the terrain and not so low that everything would be obscured by overly-long shadows. Lighting conditions at the Cape and at abort recovery sites were also factors.)

"When I heard that they were going to target Apollo 10 for the Apollo 8 target site, I went to Tom Stafford and said, 'Tom, you know, this is really not the most efficient way to prepare for Apollo 11. First, we've already seen the Apollo 8 site, admittedly from high orbit (60 miles altitude), and we came away with some confidence that it was acceptable. Second, if we target Apollo 10 for the next certified site west (certified landing sites were spaced about 12 degrees apart - about the distance the sunrise line moves in 24 hours - in case there was a launch delay and you didn't want to have to wait a whole month), the fact that Apollo 10 is going to spend an extra day in orbit means that, by the time you're ready to leave, the Sun will have risen on the third site. So, by the end of Apollo 10, we will have three options for Apollo 11.' That was my basic argument. And Tom liked the idea.

"So I worked out more of the detail and began to raise the idea up the chain of command. One of the people we briefed was Jerry Hammack, the Recovery Chief, who was in charge of recovery back here on Earth. We had stuck something in our arguments to get his attention because, had we maintained the Apollo 8 target for Apollo 10, we would have had a pre-sunrise, quasi-nighttime splashdown. And he'd been nervous about that. We didn't know how nervous, but it didn't seem like a good idea to us and, by retargeting to the next site, you ended up with a post-sunrise splashdown in the Pacific. And when we briefed Chris Kraft, the discussion went back and forth and, just as I paused, Jerry said 'All that and a daylight landing, too!' And that impressed Chris and I think he became an advocate then.

"But then we took it up to the next level, late one night, to George Low and Sam Phillips, who were in town (Houston), and gave them the whole presentation. And when we left the room, George had indicated that he didn't think it was a good idea. Sam had not indicated one way or the other, but did say that we were just too far down the line to change the data pack. So, when Tom and I left, we were sort of discouraged. But the next morning, Tom called me and said that George had changed his mind. And I said, 'I think Sam Phillips changed George's mind.' But, whatever the reason for it, they said go ahead and target for the next landing site. And that ended up being Tranquillity Base. When we got to Apollo 11, there was no question. We knew we had plenty of time after coming around the limb, the tracking had

been done (on Apollo 10), and we'd seen the sight close up (from 9 miles rather than 60). And even I couldn't argue that we ought to go further west."

Eighty six hours and five-and-a-half lunar orbits into the mission, the crew of Apollo 11 settled down for their last rest period before the landing. As Jack Schmitt relates in his Apollo 17 commentary, six hours of intermittent sleep in orbit can be as restful as six hours of uninterrupted sleep on Earth and, during the outbound trip from Earth, the Apollo 11 crew had been getting between 9 and 10 hours during each of the rest periods. The final rest before the landing was necessarily a short one, but the three of them each got six hours of deep sleep. When the wake-up call - answered by a very groggy Mike Collins - came at ninety-three hours into the mission, they were rested for the historic day ahead.

For the next eight hours, Armstrong, Aldrin, and Collins got ready for the descent. By the time they disappeared behind the Moon for the fourteenth time, they were suited and undocked, and just minutes away from the 30-second burn that would put the LM on the Apollo 10 descent trajectory down to 50,000 feet. Collins would remain in a circular orbit 60 nautical miles above the Moon and, because of his higher altitude and greater speed, it was he who was first to regain radio contact with Earth. Everything had gone well. The LM would be coming around the corner in just a moment and right on time.

There were no seats in the LM. Armstrong and Aldrin were standing, held in place by elastic cords attached to the flooring. For sixteen minutes they looked out the windows and timed the passage of landmarks below them (across a scale marked on Armstrong's window) to confirm the tracking data that Houston was getting. With Houston's help, they also checked and double checked the health of the LM.

When the twelve-and-a-half-minute descent burn finally began, they had the spacecraft oriented so that they were flying with their feet and the engine forward. They were also flying with the windows facing the Moon so that they could do some post-ignition landmark timing; but then, as planned, three minutes into the burn Armstrong rotated the spacecraft to a face-up position. Now, he and Aldrin needed to fly with their backs to the Moon so that, as they approached the landing site and the LM began to rotate upright, Armstrong would be able to see the ground ahead and pick out a good, clear landing spot. As they flew, they monitored the LM's performance and the readouts of the guidance computer. All of the data indicated that they were flying very close to the planned trajectory.

If, as Cernan suggests, landing on the Moon was easier than landing on an aircraft carrier at night, one of the many advantages was the fact that the LM was equipped with what was - for the time - a sophisticated on-board computer that did much of the routine work of flying the spacecraft. During all but the final moments of the approach, flying the proper trajectory was a matter of analyzing navigation data

from inertial and radar systems and then subtly adjusting the thrust and pointing of the LM engine. It was a labor-intensive task and a job well suited to computer control. Not until after an event called pitchover - when the spacecraft rotated from 60 degrees off vertical to 20 degrees - did the astronaut's roles become more than that of monitor-and-backup.

Several times during the descent, the computer flashed alarms. The trajectory looked good but the "1202" message - like a later "1201" - wasn't one that the crew recognized and there were a few tense seconds until Houston radioed "We're GO on that alarm." As it turned out, parts of the computer memory were being overloaded with extraneous data from the rendezvous radar and, fortunately, not only had the computer been programmed so that it could continue to handle high priority tasks but, also, the person who knew the computer best - engineer Steven Bales - needed only a few seconds to diagnose the problem and recommend that the landing continue. Bales later stood beside the crew at a White House ceremony and was decorated for his singular contribution to the success of the mission.

The on-board computer handled a variety of tasks during the descent and, in addition to the unanticipated flood of data from the radar, there were also annoying, computer-related losses in communications with Earth. The LM was equipped with a pair of broad-beam, "omni-directional" antennas, but a high rate of data transmission could be achieved only through use of a narrow-beam, steerable antenna. It was the computer's job to maintain proper spacecraft orientation so that the high-gain antenna could maintain a lock on Earth. The computer had been instructed to avoid certain spacecraft orientations which would force the antenna to look through the LM and, thereby, lose enough signal strength that the "lock" on Earth would be lost. However, the computer had been given an inaccurate "map" of the LM and loss of signal was a recurring problem throughout the descent. Because the precise landing spot was not critical on this first mission, all that Houston needed was enough information to be sure that the spacecraft was operating properly and, through the combined use of the omni antennas and voice relays through Collins in the Command Module, adequate communications was maintained.

The program alarms and the communications dropouts were annoying but in all other respects, the LM computer and the navigation system performed beautifully. Eight minutes and thirty seconds into the burn, the computer pitched the LM nearly upright and Armstrong got his first close-up view of the place to which the computer was taking them. He was about 5000 feet above and about 20,000 feet east of it. As planned, he had fuel enough for five more minutes of flight. Each of the astronauts had a small, double-paned, triangular window in front of him. On the inner surface of each pane in Armstrong's window, there was a long vertical scale marked in degrees and, at right angles to it, a similar but shorter

horizontal scale. At pitchover, Armstrong positioned himself so that the vertical scales were aligned; and Aldrin read a computer output to him that indicated just where he should look on the scale to see find the computer's intended landing point. In principle, if he didn't like the spot, he could pulse the pistol-grip hand controller forward or back or to either side and, thereby tell the computer to move the target a small amount in the indicated direction. According to plan, Aldrin was to give Armstrong an "angle" every few seconds until, at an altitude of about five hundred feet, the window targeting lost its usefulness and Armstrong took over complete manual control for the final descent.

However, once Aldrin had given him an initial target angle, Armstrong realized that, although the site selection team had picked a smooth patch of ground, the state of the guidance art at the time of Apollo 11 wasn't nearly as refined as it would be for the later missions, and fate and the computer were taking the LM into a field of boulders on the northeast shoulder of a crater the size of a football field. Nowhere on the Moon are craters of that size more than a few kilometers apart and, for this first landing, the NASA flight engineers were not yet ready to fine-tune the approach trajectory to much better than about eight kilometers east or west of the target point and about two kilometers north or south. The Apollo 11 "landing ellipse" contains dozens of craters a hundred meters across or more, and the important point is that the LM had plenty of range so that Armstrong could avoid even the largest of them.

There was no doubt in Armstrong's mind about landing in the boulder field. It wasn't essential that he land the LM perfectly upright. A tilt of up to fifteen degrees would cause no particular problem with a launch. However, if he hit the engine bell or one of the landing struts on a large rock, there would be a real chance of sustaining structural damage. Two minutes after pitchover and about two minutes prior to the landing, Armstrong took action. He decided to follow an old maxim: "When in doubt, land long." To do that, he would have to overfly the crater and land well to the west of it; and there was clearly no point - nor really much time - to give the computer enough of an update via the hand controller. The Landing Point Designator (LPD) was designed for fine tuning and what Armstrong needed was a big change. So he switched to manual control, pitched the LM forward, and began to fly it like a helicopter. Within seconds, he had slowed his rate of descent from about twenty feet per second down to about three and flew the LM about 1100 feet west beyond the craters and the boulders.

Even with the computers to help, landing a LM was a tricky operation, one that required countless hours of training in indoor simulators and in an ungainly "flying bedstead" called - more formally - the Lunar Landing Training Vehicle. According to Cernan, the LLTV was actually harder to fly than the LM. It was equipped with a big jet engine which provided enough thrust to counteract 5/6th of the pull

of Earth's gravity and that big engine - firing more or less straight down - made the trainer more unstable than the LM. Indeed, during training, Armstrong had to eject from one of the LLTV's. His was the second of three trainers that went unstable and crashed and, as Cernan relates, the trainer he flew in preparation for Apollo 17 was the only survivor of an original fleet of four. The long hours of training paid off, of course.

While Armstrong flew the LM toward a good landing spot, his attention was totally focused on the job at hand. Aldrin did virtually all the talking; and he, too, was all business. He read the computer output to Armstrong, giving him their altitude, their rate of descent and their forward speed. Back in Houston, Flight Director Gene Kranz and other members of the support team in the Mission Control Room were watching telemetry from the LM. They did not know about the crater yet - Armstrong wouldn't discuss it until well after the landing - but it was obvious that the landing was taking longer than planned. Indeed, with each passing second there was mounting concern about how much fuel remained. Because of uncertainties in both the gauges in the tanks and the estimates that could be made from telemetry data on the engine firing, the amount of time remaining until the fuel ran out was uncertain by about 20 seconds. If they got too low, Kranz would have to order an abort.

Drama was the last thing that any one had wanted for the first landing. The event itself was exciting enough. Finally, Armstrong found a place that he liked and he began to kill his forward velocity and let the LM ease down toward the surface. As they came down through 75 feet, Duke radioed that they had sixty seconds of fuel left and, in the cabin, Aldrin had already seen a warning light that was telling him the same thing. But they were close now and it was just a matter of easing themselves down. Armstrong had killed almost all of their forward velocity and now, as they began to kick up dust with the engine exhaust, he asked Aldrin to confirm that they were still moving forward a little. He wanted to land on the surface he could see in front of them, rather than on ground he couldn't see behind them. Aldrin gave him the confirmation that he wanted and, eight seconds later, they saw the contact light. The ten-foot-long probes that dangled from the landing gear had touched the Moon. A second or two later they were down and had the engine shut off. Forty seconds had passed since the sixty-second warning, but they were down.

(Post-mission analysis indicated that they actually had about 45 seconds of fuel left, rather than 20. Nonetheless, it the smallest margin of all the Apollo landings. Note, also, that, in the interest of reducing uncertainty, the fuel gauging system was improved for Apollo 12.)

Despite the drama of the moment and the enormous feelings elation and relief that they both felt, Armstrong and Aldrin had little time for anything but getting the LM ready for an immediate departure. No one expected that they

would have to launch right away but, just in case a problem did develop - say a leak of the high pressure helium that they would use to pressurize the propellant tanks in the Ascent Stage, they wanted to be ready. However, despite being very busy with things in the spacecraft for nearly two hours after they landed, from time to time they stole glances out the window and described the scene for the radio audience back on Earth.

put an Apollo 11 window photo here, showing the flat terrain

In all directions, the land was West Texas flat. The circular horizon was broken here and there by the subtle rims of distant craters. In the middle distance, Armstrong and Aldrin could see boulders and ridges, some of the latter perhaps 20 or 30 feet high. Close at hand, a hodgepodge of craters pockmarked the surface; and there were small rocks and pebbles scattered everywhere. It was a flat, level site but, as with Australia's Nullarbor (Latin for "Treeless") Plain, small variations gave the surroundings a subtle beauty of its own. And, of course, because this was the very first landing on the Moon, everything was of enormous interest. However, before Armstrong and Aldrin could pay much attention to the view or think about going outside themselves, they had to be sure that they had a healthy spacecraft and that the navigation computer was properly loaded with the information needed to get them back to orbit for a rendezvous with Collins. Finally, two hours after the landing, they and the NASA engineers were satisfied that the LM was ready to come home and, therefore, that it was safe to stay for a while.

According to the flight plan, Armstrong and Aldrin were scheduled to take a five-hour rest break before getting ready to go outside. However, it came as no surprise when they suggested to Houston that, after a scheduled hour-long meal, they prepare for what was called, in the NASA jargon, an EVA - a period of Extravehicular Activity. Normally, the EVA preps were supposed to take about two hours but, because this was to be the shortest of the Apollo EVA's no one -except, perhaps, the waiting, worldwide TV audience - was bothered when the EVA preps actually took three and a half hours.

Finally, about six and a half hours after the landing, they had the hatch open and Armstrong crawled out onto the porch - feet first and on his hands and knees. Moments later he was on the top rung of the ladder and pulled a lanyard to release a work bench / stowage area that was attached to the side of the LM. The Modular Equipment Storage Assembly or MESA was pivoted at the bottom so that, when Armstrong pulled the lanyard, the MESA swung down into a horizontal position. The most important piece of gear on it was undoubtedly the black-and-white TV camera. It was mounted in such a way that, when the MESA swung down, the camera was pointed directly at the foot of the ladder. For the astronauts, the landing had been the big moment of the mission. But, for the waiting world, the big moment was still to come - the first footstep.

From the bottom rung of the ladder, Armstrong had to make a three-foot jump down to the footpad - a contingency against a less than gentle landing that might have compressed and shortened the landing strut. From the footpad, he had only a couple of inches to step down to the surface itself. He stood on the pad for a moment or two, testing the soil with the tip of his boot before he made the epochal "small step".

The soil was very fine grained and had a powdery appearance and, once he stepped down, his boot sank perhaps a couple of inches, making a sharply defined print. Because of the Moon's relatively weak gravity field (one-sixth as strong as Earth's), Armstrong's total weight - half astronaut, half suit and backpack - was only about sixty pounds. Movement wasn't particularly tiring but because of the dramatic upward-shift in his center of mass caused by the backpack, he had to lean forward to keep his balance and it took a few minutes before he could walk comfortably. Just in case he had to end the EVA suddenly, Armstrong used a long-handed tool called the Contingency Sampler to scoop up a bit of rock and soil into a Teflon bag. He then removed the bag from the Sampler, folded it, and stored it in a shin pocket.

Aldrin joined Armstrong out on the surface about fifteen minutes later and then, for the next hour and forty minutes, the two of them examined the LM, moved the TV camera out about 50 feet, deployed a pair of scientific instruments, and collected more samples. One important set of questions to be addressed, of course, concerned the crew's ability to get the work done. If all went well, following crews could stay longer on the Moon, venture farther from the LM, and undertake more ambitious sets of tasks. For the first half hour or so, neither Armstrong nor Aldrin did more than a shuffling walk as they went about their work and it was planned, after this initial period of familiarization, for Aldrin to try to take advantage of the 1/6th gravity and try to run. Starting from near the LM, he first ran toward the TV camera, rolling from foot to foot in a loping or, as Jack Schmitt calls it, a cross-country skiing stride. Then as he turned and ran back toward the LM, he used the same gait again but twice changed direction by sticking a foot out to the side and pushing off of it, rather like an American football running back. Coming back toward the camera for a second time, he tried a kangaroo hop but decided that it didn't give him as much fore/aft stability as he got with the loping gait. It looked as though a crew that ventured a few hundred meters away from their LM would be able to run back in just a few minutes if the need arose.

In general, the crew of Apollo 11 went about their work with appropriate caution. However, as with later crews, as time passed, their confidence grew. Generally, they walked without bounding and, compared with later crews, their movements seem fairly stiff and restricted. However, toward the end of the EVA, the TV audience got a glimpse of Armstrong running back from a brief visit to a crater 60

meters east of the spacecraft. There was even one moment - a bit earlier in the EVA when Aldrin was lifting the scientific instruments down from its storage compartment - when Armstrong appeared to bob down on one knee, a difficult maneuver in the stiff spacesuit. Clearly, it was possible to get work done and to move with relative ease. Later crews would have more time to adapt and, building on the Apollo 11 experience, would do their work with greater and greater confidence.

With only a short time at their disposal, Armstrong and Aldrin had only a few things they could get done before they had to have the hatch closed. They raised an American Flag, deployed a solar wind collector, gathered forty-seven pounds of samples, and carried a laser reflector and the passive seismometer about twenty meters south of the LM for deployment. They hammered two, short core tubes into the soil, took about one hundred color photographs, and, finally, got themselves and the samples back into the spacecraft. Because of the restrictions imposed by the pressurized suits, by the shifted center of mass, by the weak gravitational field, and especially by the clumsy, pressurized gloves, the work was generally harder to do than it would have been in a shirtsleeve environment.

Compared with later missions, the suite of scientific gear that Armstrong and Aldrin deployed was quite modest and, as Jack Schmitt told the story during our review of this Apollo 11 summary, at least part of the reason was a concern over fuel margins.

"Probably it was spring of '68. The PSAC - the President's Scientific Advisory Committee which was chaired by Charlie Townes - asked NASA for a set of briefings that would detail how the first lunar landing mission would be conducted. And NASA had never done that because they were concentrating so hard on getting the spacecraft ready to fly. And it was a very good request; PSAC was right on the money. Asking questions like that is the way a science advisory committee can really contribute to the process, and the PSAC forced NASA to think things through. So what NASA did was assign two astronauts to each of three phases of the mission: launch to Lunar Orbit Insertion (LOI), LOI to TEI (TransEarth Insertion), and then the trip home. And Buzz Aldrin and I were assigned the middle part of that. He was to do spacecraft stuff in orbit and I was to put together what we were going to do once we were on the surface. At that time the only thing NASA really had ever done in any detail was the so-called design reference mission. In fact, NASA didn't do it; Grumman did it. And that was a mission with four 4-hour EVA's. And the only thing that had happened since then was NASA backed off and said 'Well, with the ALSEP (Apollo Lunar Science Experiment Package) on board and the geology experiment, we'll have two EVA's.'

"There was lots of discussion about it. I mean, at that same time, some people were saying 'Well, maybe we ought to just have one guy go out on an umbilical; it's too

dangerous.' Slayton wanted a buddy system -two guys going out with backpacks - and I was supporting him on that and I got into a lot of arguments. God, the kinds of things we went through to finally get there. And, at the same time, Buzz Aldrin was trying to get to be the first guy to go out. (Laughing) He had me working on some scheme to figure out how in the world we could justify having him and Armstrong switch places in the LM after landing. God! Anyway, in putting together the Lunar Surface EVA Operations Planning Book for the PSAC - which was the first time anybody tried to do a detailed timeline for two EVA's - it became increasingly obvious - when you put it in light of the problems the LM was having in terms of weight and everything - that the chances of 300 plus pounds of ALSEP flying were pretty small. So, in my draft charts before the final briefing, I included some issues that had to be addressed. And one of them was: do we need a contingency ALSEP? What were the two experiments that you'd like to have on the Moon if you never got another chance? And, very quickly, it was obvious what those were. One was the seismometer and one was the corner reflector. And so I had this on my draft charts.

"We did a dry run with the JSC management before giving it to PSAC. And, when that chart came up Bill (Wilmot) Hess just went ballistic! He wouldn't hear of not flying the ALSEP. I mean, the guy just lost it. And everybody was just sort of staring at him. He was Science Director and he just couldn't control himself. I don't think he's ever forgiven me for doing that. But the judgment of Bob Gilruth and George Low was 'It makes sense, so let's go to work.' Basically, we had six months - I think it was - to get it ready. It would be solar powered and lightweight. I don't remember how much it weighed. And Bill Hess was absolutely convinced - and was right - that, as soon as the contingency package existed, they'd take the ALSEP off of Apollo 11. Well, my position was that they were going to do that anyway and, if you didn't have something, you weren't going to get anything. God, we went around and around on that. But that's why Apollo 11 didn't have ALSEP but did have some science experiments."

Weight limitation were certainly one reason why Apollo 11 flew with only a few pieces of scientific gear. Another was the simple fact that, on this first landing, it was unlikely that NASA management would have approved an EVA long enough to allow the astronauts to deploy a complete ALSEP. On the Apollos 12 and 14, the ALSEP deployment typically took most of the first four-hour EVA and, as the first crew to do a lunar EVA, it seems unlikely that Armstrong and Aldrin would have been allow to stay out that long.

As Cernan suggests in his Apollo 17 commentary, there is always a best way to get a job done under lunar conditions; and, although Armstrong and Aldrin didn't have time to discover many of the tricks and didn't have the experiences of prior crews to guide them, the EVA went smoothly. That success can be ascribed readily to forethought, to careful

training, and to a measure of justified caution on this first lunar visit. The only significant problem that they encountered came when Aldrin tried to drive the core tubes into the soil. Despite hammering hard enough to actually dent an extension handle attached to the top of the tubes, on both attempts Aldrin only managed to drive the tubes about 8 to 9 inches into the ground. In hindsight, the cause of Buzz's troubles was the fact that, more than a few inches below the surface, lunar soil is almost perfectly compacted, a circumstance that had not been anticipated. The core tubes were of a fairly standard design which included an internal bevel to provide some compaction of the entering soil so that it wouldn't promptly fall out. Because the lunar soil was already very compact, it simply couldn't be forced into a standard tube and it was impossible for Buzz to drive one more than a few inches deep.

What was probably the least efficient work that either Armstrong or Aldrin did came during the final minutes when Armstrong used a piece of equipment called the Lunar Equipment Conveyor or LEC to get the rock box up to Aldrin in the cabin. Essentially, it was a clothesline. After Aldrin hooked the LEC to a pulley in the cabin, Armstrong hooked the rock box to the LEC, backed away from the LM to make the line taut, and then pulled hand-over-hand as the box bounced its way up to Aldrin. It was hard work. At the start of the EVA, Armstrong's heart rate had been about 120 beats per minute and it had declined more or less steadily toward a low of about 80 as he took pictures at the rim of the crater east of the spacecraft. With time running short, he began a hurried collection of rocks and soil and his heart rate climbed to the 120-140 beat range. And then, while he was using the LEC, his heart rate shot up to 160 beats per minute and Houston had to call for a short rest. Other Apollo Commanders didn't have to work quite so hard when they were using the LEC. The excitement of the moment and the rush of collecting the bulk sample surely were contributing factors in Armstrong's case. But the LEC was an inefficient tool and, beginning with Apollo 14, the astronauts started carrying at least some of their gear up to the cabin by hand. The 16 and 17 crews did away with the clothesline LEC entirely - having decided that it was more trouble than it was worth - and hand carried everything except a bag containing their camera. That bag they raised and lowered with a hook and lanyard, a humble rope that somehow managed to inherit the LEC's name.

Two hours and thirty one minutes after they first opened the hatch, Armstrong and Aldrin reported it closed again. There were still five hours to go before Houston said "Good Night" and there was still plenty to do. There were samples to stow, gear to be jettisoned, and a long list of housekeeping tasks to be taken care of before they could have a scheduled rest period.

They slept in their suits - or tried to - with Aldrin curled up on the floor and Armstrong propped up on the ascent

engine cover in the rear of the cabin. The rest period was, they said, "almost a complete loss." They were bothered by spacecraft noises and by sunlight leaking around the edges of the window shades and in through the sextant. They were cold and damp in the suits and, of course, they were really too excited to sleep. Not until Apollo 15 did anyone really get any sleep on the Moon. From Apollo 12 onward, the crews had a heater to help with the cabin temperature and hammocks they could lie in. However, it wasn't until Apollo 15 that the lunar stays were long enough - and the astronauts and mission planners had confidence enough - that the crews got out of their suits during the rest periods and, with the help of earplugs to cut down on the noise, really got some sleep. Aldrin may have gotten two hours of fitful sleep. Armstrong got none at all.

For seven hours Houston left them alone with their thoughts. Then it was time to wake up, have a quick breakfast, and get ready for the launch, the rendezvous with Collins, and the heroes' welcome awaiting them at home. If, from a practical point of view, Apollo 11 was a demonstration flight, a point of departure for the more sophisticated missions that would follow, it was still the one for the history books. The other crews would work in relative obscurity, stepping briefly into the spotlight but without leaving so lasting a public impression. There would never be anything quite like making that first footprint on another world but then, too, there was still a long way to go before humanity could claim to be more than temporary visitors to the Moon.

Apollo 12 - A Visit with the Snowman

For NASA, 1969 was a roller coaster year. The first half was full of feverish activity as thousands upon thousands of people did whatever was necessary to make sure that the first landing was achieved. But then, with the triumph still fresh in everyone's mind, it was time to look at what the future might hold in store. Unfortunately, it soon became evident that not only would the feverish pace of Apollo have to slow but also that the program might have to end.

For four years, the NASA budget had been shrinking from the peak it had reached in 1965. A decrease was, of course, inevitable because, during the peak years, NASA had to undertake a number of expensive projects simultaneously. There was the development of the Saturn V, the CSM, and the LM, and the construction of the launch pads and the Vehicle Assembly Building at the Cape and all of the new facilities at Manned Spaceflight Center in Houston. So it wasn't surprising that spending at the 1965 level couldn't be sustained. But there was an expectation that, once the landing was a reality, the budget would stabilize at a level that would let the lunar program continue. And there were even some who thought that a Mars program was in the cards. However, soon after the 1968 election, the incoming Nixon Administration had ordered a review of NASA's list of future programs; and the major implication of that review was that, while the nation had been committed to the Kennedy goal, it was the politics of space that had opened the public purse and not an overwhelming interest in the space program itself. Certainly, President Nixon was no great fan of the program and, now that the race with the Russians had been won, NASA's budget was headed for levels that would not only force long postponements of such cherished dreams as a space station, a lunar base, and missions to Mars, but also threatened the continuation of Apollo itself. In September 1969, the White House announced that lunar exploration would not continue beyond Apollo 20.

Although the Nixon decision was a blow to NASA, the consequences were not all bad. In light of shrinking budgets, NASA immediately announced that the remaining Apollo schedule would be stretched. Money could be saved by conducting launches only twice a year. Salaries and other personnel costs dominated the NASA budget and, by stretching the schedule, the agency would have to employ only enough people, particularly at the Cape, to prepare and perform one mission at a time. Stretchout also meant that planners, engineers, scientists, and astronauts had more time to assimilate experience and data between missions and, as well, it gave NASA a chance to complete hardware and procedures modification that would make the last few missions spectacularly productive. Of great importance were LM design changes which would allow an increase in landing weight from

eight tons to nine and that, in turn, meant that the LM's flown late in the series would be able to carry an electric-powered, wire-wheeled dune buggy called the Lunar Rover, and also greater stores of oxygen, cooling water, and electric power for longer visits. The combination of the Rover and an expanded-capacity backpack would let the crews stay on the Moon long enough to conduct three 7-hour EVA's and, during each of them, venture as far as ten kilometers from the LM.

Early in Apollo, NASA sketched out a sequence of missions which would lead to the first landing. "A" missions were unmanned tests of the launch vehicles and the Command Module; "B" missions were unmanned tests of the LM; "C" missions (Apollo 7) were manned, earth orbital tests of the Command Module; "D" missions (Apollo 9) were LM/CSM tests in earth orbit; "E" missions (none were flown) were tests in high earth orbit; "F" missions (Apollo 10) were lunar orbit tests; and the "G" mission was the landing. In 1968, NASA added three other mission types to the list: "H" missions (Apollo 12, 13, and 14) would be subsequent flights to other landing sites using the basic equipment; "I" missions (none flown) would be lunar orbit-only science flights; and "J" missions would be the longer visits that LM design changes would make possible. With Rovers at their disposal, each of the J-mission crews would be able to visit a variety of geologic features scattered around the local countryside, collect far greater quantities of rock and soil than walking astronauts could hope to carry, make use of an impressive number of tools carried on the Rover, and also give the research teams back on Earth a mobile experiment platform. In general, the J-missions promised a significant increase in productivity. However, before such impressive missions could be attempted, NASA had to demonstrate that crews could achieve pinpoint landings, work a full-day in the stiff suits and, if necessary, walk several kilometers back to the LM from a disabled Rover.

Pinpoint landings were essential for a number of reasons. First, geologically-interesting places were usually rugged and, quite naturally, tended to have few good landing spots close at hand. The chance of a successful mission into rough terrain would increase dramatically if targeting errors could be reduced down to the LM's maneuvering range of several hundred meters. Second, the site selection committees were eager to pick places rich in geologic variety. An accurate landing at a carefully pre-selected spot would allow the crews to visit a maximum number of features without spending excessive amounts of time driving from place to place. Third, pinpoint landings would allow the crews to train for specific EVA activities and, among other things, thoroughly familiarize themselves with landmarks and planned traverse routes. With crew time on the surface at a premium, there was much to be gained by minimizing the amount of improvisation caused by targeting errors. And finally, professional pride on the part of the flight crews and spacecraft designers demanded accuracy. The

Mercury and Gemini astronauts relished splashdowns within sight of the recovery ship and now, much to their delight, they were going fly a truly maneuverable spacecraft to specific spots on the Moon. The Moon might not have runways or landing pads, at least not during Apollo, but that didn't matter. The targets were well-defined. Relative accuracy and, therefore, bragging rights could be claimed.

For Apollo 12, the site selection committee picked an interesting spot on the Sea of Storms, about 1500 kilometers west of Tranquillity Base. Although, as Don Wilhelm's details in "To a Rocky Moon", the Apollo 12 site wasn't the first choice of the geologic community, it did have several things going for it. First, it was a reasonably level site. There were a number of large craters surrounding the target point, but otherwise the area presented no more in the way of hazards than those that Armstrong and Aldrin had faced. Second, the astronauts would be able to collect rocks and soil samples from another of the great lunar plains and, most interestingly to the geologists, from a place covered with eject from the young, prominent crater Copernicus which lies some three hundred kilometers to the north. And third, with an eye toward a dramatic demonstration of pinpoint targeting, if Apollo 12 Commander Pete Conrad and his shipmate Alan Bean landed close enough, they would be able to walk over to the Surveyor III spacecraft and even bring pieces of it back to Earth.

On April 19, 1967, the Surveyor landed on the inner slope of a fairly large crater, a fact which greatly reduced the immediate photographic return but which, ironically, made identification of the precise landing spot a relatively easy matter. From trajectory data, NASA knew where each of the Surveyors had landed to within a mile or two but, because each of the spacecraft was no bigger than a modest-sized lunar boulder, unambiguous identification in orbital photographs was all but impossible. However, details in the Surveyor photographs could be compared with details in the Lunar Orbiter pictures so that, in principle, the landing sites could be pinpointed. Ewen Whitaker, now retired from the University of Arizona's Lunar and Planetary laboratory, was a member of the Surveyor team and had the responsibility of identifying the landing sites. As the first pictures came in from Surveyor III, it was immediately apparent that the spacecraft had landed in a crater. It was a relatively featureless crater but there were a number of good-sized rocks scattered around, particularly to the north of the spacecraft. One pair of large rocks looked as though they were almost touching each other and it seemed to Whitaker that he might be able to find them when he started to examine the appropriate Orbiter pictures through the microscope. Within a couple of days, he was sure he had them; the rocks looked like mere pinpricks through the microscope, but there were other rocks visible as well and they made a pattern which matched up nicely with the Surveyor III pictures. Whitaker had found the crater.

A couple of years later, when the Apollo site selection committee was looking for a good place for the first precision landing, the Surveyor III site came easily to mind. Along with the other factors, the site offered NASA engineers a golden opportunity to examine spacecraft parts which had been exposed to lunar conditions for a relatively long period of time - thirty one months in this case - information which would someday be of use in designing space stations and lunar bases. If all went well, Conrad and Bean would be able to visit the Surveyor, photograph it, and then strip off a few components to bring back to Earth.

Surveyor Crater is a member of a distinctive cluster of craters. When viewed from the approach trajectory, the cluster looks not unlike a Snowman, with Surveyor Crater forming the fat torso. By using Lunar Orbiter photos and, as well, photos returned by the prior Apollo crews, NASA was able to construct a fairly realistic model of the landing site so that, during training in the LM simulators, the view out Conrad's window - actually a TV picture of the model - looked enough like the real thing that, at pitchover, Conrad would have a comfortable sense of *deja vu*.
Put a photo of the snowman here

On landing day, November 19, 1969, Pete Conrad and Al Bean were in fine spirits. At launch from Earth, they'd had a scare when lightning struck the ascending Saturn V and tripped virtually all the circuit breakers in the Command Module. It was a heart-stopping experience for people on the ground; but the crew stayed calm, the Saturn V kept them going toward orbit, and, in a matter of minutes, they had everything back on line. There was no permanent damage; and the flight to the Moon and the preparations for the descent were otherwise unremarkable. As pitchover approached, Conrad strained forward against his harness, trying to get a view of the horizon. He'd caught glimpses of the Moon's central highlands as he and Bean swooped down, feet first, toward the Sea of Storms, and as they got closer, he couldn't wait to find his target.

"I'm trying to cheat and look out there," he said. "I think I see my crater."

He wasn't absolutely sure but, seconds later, at pitchover, there was no doubt. "Hey, there it is! There it is! Son-of-a-gun! Right down the middle of the road!"

Bean glanced up and saw the Snowman, too. "Outstanding!", he said. The scene looked just like it had in the simulator. There was the Snowman,. Indeed, it seemed for a moment that Intrepid was going to land right in the center of Surveyor crater.

Conrad was delighted. "I can't believe it! Amazing! Fantastic!"

Bean fed him the numbers and, at four hundred feet altitude, Conrad took over manual control. He'd picked out a good spot west of the crater and short of the Snowman's Head beyond. He angled north to fly around Surveyor Crater and then south to avoid another, far shallower feature. There

were very few boulders in the area and, as they got lower, the LM exhaust began kicking up a lot of dust. During the last few moments, Conrad lost sight of the ground and had to rely on his simulator training to make a blind touchdown.

Although Conrad was sure of where he was going to land during the approach, once he was down he wasn't sure exactly where he was. He'd lost track of the landmarks while he concentrated on rocks that he could see through the dust so that he could see if he was moving left or right, forward or back. But he knew he was close, certainly within a couple hundred meters of the target.

During the first few hours after landing, while he and Bean had a quick meal and began preparations for the first of two 4-hour EVA's, Conrad spent more than a little time trying to figure out just where he'd landed. It was a bit of a puzzle. The landmarks which had been so obvious during the approach weren't at all obvious from the ground. Looking west out the window, he and Bean saw an undulating and otherwise featureless plain. Among other things, there was no obvious sign of the Snowman's Head. Head Crater is about two hundred meters in diameter and should have been right in front of them. However, as they became accustomed to the subtleties of the view, they began to realize that there was, in fact, a big crater practically staring them in the face. They hadn't recognized it because they were back a bit from the east rim and were looking directly away from the early morning sun. There was a shadow in the bottom of Head Crater, but it was hidden by the near rim. There was also a lack of color variation in the scene and that, too, made the crater hard to see. However, once they realized that there was a big crater in front of them, they quickly decided that it had to be the Snowman's Head. If so, then Surveyor Crater had to be right behind them. Conrad jammed himself forward against his window as tightly as he could, probably wishing he had a rear window or at least a rear-facing mirror, and tried to peer as far around the back as possible. He was rewarded with a glimpse of the telltale slope of another large crater.

Fittingly, it was Dick Gordon, traveling overhead in the Command Module Yankee Clipper, who nailed down the landing coordinates. As he made his second post-landing pass, he put his eye to the sextant in hopes of getting a glimpse of the LM, a feat that Collins had never managed. Of course, Gordon had a real advantage in that he knew where Intrepid was supposed to be. As he picked up the Snowman, it wasn't long until he spotted the LM's fifty-meter shadow.

"I have him," he said. "He's on the Surveyor Crater; he's about a fourth of a Surveyor Crater diameter to the northwest...I'll tell you, he's the only thing that casts a shadow down there."

In seconds, he was directly overhead. "The Intrepid is just on the left shoulder of the Snowman. He is looking at me. He is about a third of the way from the Surveyor Crater to the [Snowman's] Head."

Then he really got excited. "I see the Surveyor! I see the Surveyor! Hey! That's almost as good as being there."

Now there was no doubt. Not only had Gordon seen the LM but he'd seen the Surveyor itself. Conrad and Bean had landed right on target and, thanks to Ewen Whitaker, they'd even been sent to the right crater! This was going to be fun.

With the pinpoint landing accomplished and confirmed, the next task was to get the backpacks on, get outside to set up the science gear, and, if there was any time left before they had to get back in the LM for a rest period, take a short stroll around the area. Conrad and Bean were a pair of relaxed, happy astronauts. They wouldn't be mentioned in most history books but that didn't seem to matter. If anything, it took some of the pressure off. They laughed and joked, pleased with the situation and eager to get started. As Conrad told Houston, "Man, I can't wait to get outside."

Although they'd gotten a bit behind the planned timeline while trying to figure out where they'd landed, Conrad and Bean were models of efficiency once they got started donning the backpacks. With luck, the process could be completed in under two hours and that's just about how long it took. They made a few minor mistakes when, out of eagerness, they occasionally relied more on memory than on the detailed checklists. However, thanks to the checklists, they were able to get back on track after only a few minutes of wasted effort. Finally, about four-and-a-half hours after touchdown, they made one final check to be sure that they had good, airtight suits and then radioed Houston for permission to depressurize the cabin.

"Houston, are we Go for EVA?"

"Stand by, Intrepid. We'll be right with you," said CapCom Edward Gibson.

Conrad couldn't quite believe what he'd just heard.

"Stand by?! You guys ought to be spring-loaded!"

But, of course, Houston wasn't going to keep the explorers waiting long. Once all the status boards had been checked a final time, the Gibson radioed permission.

"Intrepid, You're Go for EVA."

Pete Conrad is not a tremendously tall person. The one-meter jump down from the bottom rung of the ladder had always seemed a bit intimidating, but now it gave him a chance to set the tone for the mission. The time for historic phrases had past; now it was time to have fun. "Whoopie!" he said as he made the plunge. "Man, that may have been a small one for Neil, but that's a long one for me."

Bean soon joined him on the surface and, once they'd both had a chance to get used to walking and a chance to savor the sight of the Surveyor sitting so close by, they got busy deploying the scientific gear. As on Apollo 11, there was a TV camera, a seismometer, and a laser reflector. And they also had a more-sophisticated solar-wind analyzer and a number of other physics packages that made up the ALSEP (Apollo Lunar Surface Experiments Package) that had gotten

bumped off Apollo 11. Most of the equipment, together with a central power station and transmitter, was stowed in two compact packages tucked away in the Descent Stage. Bean lifted them down with a pulley and attached them to the ends of a carrying bar - which would double as a radio antenna mast - in dumbbell fashion. The complete ALSEP weighed 250 pounds on Earth, but only about 40 pounds on the Moon, and Bean had no Particular trouble hauling the load to the deployment site about one hundred fifty meters west of the LM. The two experiment packages tended to bounce up and down as he walked and that made gripping the bar a little difficult; but, generally, he and Conrad had very few problems with this first major set of tasks.

fuel cask drawing

Apollo 12 marked the first lunar deployment of an electric generator powered by the decay of a tiny plutonium source. This thermal generator provided 75 watts of continuous power to the scientific equipment and, therefore, a continuous stream of data to the experimenters back on Earth. During the flight to the Moon, the source had been stored snugly inside a well-shielded cask designed to keep the radioactive fuel element intact in the event of an unplanned entry into Earth's atmosphere. Once they got to the Moon, Bean had the job of removing the plutonium source from the cask and inserting it into the generator but, much to his dismay, after he pulled it partway out, it stuck and refused to budge any farther. After a few minutes of fiddling with the long-handled removal tool, Bean got frustrated and suggested that they give the cask a couple of good whacks with the hammer. Conrad wasn't quite ready to be so unsubtle and wanted to try using the hammer as a prying tool. But, when that didn't work either, he, too, gave in to the inevitable and gave the cask a good, sharp rap. The fuel element slid out a fraction of an inch. He hit it again and harder. And again. And that did it.

The lesson? "Never come to the Moon without a hammer."

A second equipment problem involved the electric cables which connected the various units to the Central Station. Although the cables were fairly stiff, on Earth they tended to lie flat to the ground, held down by their own weight. However, on the Moon, the cables hardly seemed to notice the weak gravity and retained loops and bends they had acquired during storage inside the LM - loops that stood up from the ground rather like sections of a frozen garden hose. There were no disastrous tripping episodes during Apollo 12, but the need to dodge cables slowed the work.

Avoiding cables was a matter of watching one's feet or, from a more practical point of view, of watching the other guy's feet. The suits were bulky enough that, although the astronauts had to lean far forward to balance, they rarely saw their own feet and had a tough time keeping clear of obstacles. The suits also slowed the work in other ways. Because the inflated suit was stiff, it was difficult to flex the knees enough to kneel. The most practical way to grab or

manipulate objects close to the ground was to use long-handled tools. However, the tools themselves were sometimes awkward to use and, as Conrad commented, it all would have gone a lot quicker had they been able to reach down easily. It was only later, during the second EVA, that he and Bean discovered a couple of handy tricks.

Within three hours of leaving the LM, the astronauts had finished deploying the scientific equipment. They had gotten about a half an hour behind the nominal time line but were otherwise well pleased. They were both relaxed - with heart rates dipping down into the 80s - and Conrad would have whistled while he worked, had whistling been possible at 3.7 psi suit pressure. The only thing that had gone really wrong during the EVA was the loss of the TV camera. This was the first color TV camera to be landed on the Moon and, unfortunately, it quit working while Bean was moving it away from the LM. As was suspected at the time, he accidentally pointed it at a bright reflection off the LM and burned out the target in the vidicon imaging tube. As Bean said in technical debriefings with the engineers once he got home, the root cause was the fact that he hadn't been able to train with an actual flight camera. Development of the camera had lagged and NASA took delivery just a short while before the launch. In the interim, Bean had trained with a mockup and never paid attention to the camera's limitations. Fortunately, the loss of the TV wasn't critical from a technical point of view. Conrad and Bean both took plenty of photographs. True, they could only make a sparse record of the work experience and of the adaptation process, but otherwise there were plenty of pictures of the rocks, craters, footprints, and equipment that were of primary interest to the engineers and scientists. Nonetheless, things were going so well and the crew was obviously having such a good time - joking, laughing, humming, and singing - that the lack of a picture was a real frustration to those of us who had taken the Wednesday morning off from school or work to watch the coverage.

With the ALSEP deployment finished and with plenty of oxygen and cooling water in reserve, Houston gave Conrad and Bean a half-hour extension so that they could make their way to the boulder-strewn rim of nearby Middle Crescent Crater, a short, seventy-meter jaunt north and a little west from the ALSEP site. It had to be a quick trip because the flight controllers wanted them back at the LM in about twenty minutes, ready to start close-out. Still, this was the crew's first chance to put their geology training to use. mound photo

When Conrad first went out to the ALSEP site to scout out a deployment area while he waited for Bean, he had noticed a couple of meter-sized, conical mounds and was eager to take a look. Were these volcanic features? Or something else? On their way out to Middle Crescent, Conrad and Bean finally had a chance to take a close look and they quickly decided that the mounds were probably big clods of compacted

soil which had been thrown out by the Head Crater impact. They took pictures and collected a few samples and then moved on. Along the way, they found beads of glass lying out on the surface, and, at Middle Crescent Crater, hints of bedrock exposed in the inner walls. Twenty minutes didn't give them much time for careful consideration or comment; it was very much a matter of jog, stop, take a minute to marvel, take a few pictures, grab a sample, and jog again. But the hurried pace didn't really matter. If nothing else, the jaunt gave them some practice for the serious geologizing they would do during the second EVA. And, besides, it was all fun. Indeed, it took several reminders from Houston before they started back to the LM.

On the way back to the spacecraft, Conrad and Bean made good time, covering the two hundred meters in about five minutes. Despite a couple of stops to pick up irresistible rocks, they managed a net speed of about 2.5 kilometers per hour. On the second EVA, they planned to extend their range to about 400 meters and the short run proved that, should something need tending in the spacecraft, they'd have no trouble getting back in a hurry. Their heart rates had risen to only about 120 beats a minute and, although they were both a bit tired, they clearly had plenty of physical and mental reserves. They were happy and pleased with their performance.

After a four-hour, one-minute EVA, the crew of Intrepid repressurized the cabin and removed their helmets and gloves. They would have preferred to get out of the pressure suits for the night, especially since Conrad had inadvertently gotten some cooling water in one of his boots. However, as was demonstrated by later crews, doffing the suits would have taken nearly an hour and getting them on again the next morning another forty minutes or so. Their time on the Moon was limited and an hour and a half represented a sizable fraction of the total. More importantly, NASA and the crews were not yet ready to risk the chance of damaging zippers and other seals during doffing and donning. So they left the suits on, had a meal and a chat with Houston about second EVA, and then, about three and a half hours after closing the hatch, put covers on the windows and wished Houston "nighty-night." Purists might complain that the Sun wasn't about to go down. After all, local sunset was still a good ten days away. But the astronauts weren't purists. Their biological clocks said it was time for sleep; so it was "nighty-night" until the next day's wake-up call.

Conrad and Bean didn't sleep well. The hammocks and the heater made for an easier night than the Apollo 11 crew had, but nobody had been able to do anything about the excitement. Bean took a sleeping tablet but it didn't help much. In the morning, Conrad reported that they'd gotten about five hours of sleep but, in reality, they'd hardly slept at all. An hour ahead of the scheduled wake-up call, it was they who called Houston. They were eager to get outside again. After a quick meal, they got busy preparing themselves, their

suits, and the LM for the day's activities. Two and a half hours after calling Houston, they were out on the surface. EVA-2 traverse map

EVA 2 was to be a long, circular geology walk that would take them around the west side of Head Crater, and then southwest to a small, fresh impact feature called Sharp Crater. From there, they would walk east to a point on the southern rim of Surveyor Crater opposite the LM, and then make their way down to the Surveyor itself before climbing back up to the LM. In all, they planned to cover about 1300 meters, the equivalent of walking the first four or five holes of a public golf course.

During the entire second EVA, Pete Conrad was like a man possessed, constantly aware of the timeline and the list of tasks yet to be done, singleminded in his determination to complete everything on the checklists that they wore on their sleeves. He knew that they would have to keep moving. Not counting the time they took to load the backpacks with tools and sample bags before heading out, nor the time they spent packing up and dusting each other off before they climbed back in the LM, the traverse itself lasted about 2 hours and 45 minutes. Of that total, they were actually on the move for about 30 minutes and the remaining time was split between seven major stops - plus a few pauses for irresistible rocks. On average, they had about twenty minutes at each location. There were pictures to take, samples to collect, cores to drive into the ground, and even the occasional shallow trench to dig and, unfortunately, there never seemed to be enough time to suit Al Bean's sense of wonder. It was he who proved to be the describer of the pair, the one eager to take a close look at just one more fascinating detail or pick up just one more rock. As he said at the time, he could easily have spent the whole EVA at just one of the stations. But there wasn't time, especially not with Conrad - with occasional help from Houston - urging him on.

Conscious of the time line, they moved quickly from one site to the next and, once they arrived, were in constant motion as they turned to take photographic panoramas, manipulated tools and the sample bags, and did their best to grab rocks without having to bother with the tongs. With practice, they found that they could kneel, after a fashion, if they used the tool carrier or a shovel as a crutch, but getting up again took a fair amount of effort. Bean discovered a clever, unintended use for a sturdy sample bag tied to Conrad's backpack. Midway through the EVA, he realized that he could use it as a kind of toddler's harness or belaying rope to steady Conrad as he reached down for a rock. These and other little tricks that they learned along the way let them get the work done more efficiently. As a measure of that efficiency, during the first EVA they used about as much cooling water as had been predicted prior to the mission. During the second EVA, they used about 30 percent less than the predicted amount.

Although Conrad and Bean became more efficient as they went about their work, the one thing that they couldn't do anything about was the soreness that they began to feel in their forearms. Because the suits were pressurized, the glove fingers were necessarily stiff and hard to move. The engineers had made a good-faith attempt to minimize the problem by designing the gloves with the same shape as the relaxed human hand - that is, with the fingers curved slightly inward. At the very least, it was thought, the design would give the astronauts a chance to relax their fingers from time to time. However, with the fingers in the "relaxed" position, there was an opening of three to four inches between the tip of the thumb and the tip of the index finger. Consequently, if they wanted to grip anything smaller than the opening, they had to close their hands against the internal pressure in the suit. On this second EVA, with tools and other gear to carry, Conrad and Bean had their hands closed almost constantly. In relatively short order, the muscles in their forearms began to ache. They could and did rest their hands from time to time and eventually learned to pace themselves so as to minimize the ache. Still, it was a significant problem and, had their arms not begun to ache so badly, they would have had even greater gains in efficiency.

Both Conrad and Bean were fit and certainly were in no danger of wearing themselves out. They could stop, take a rest, and, if necessary, drop an item or two from the activity list. Throughout most of the traverse they both had heart rates in the range of about 110 to 130 beats a minute. It was a strenuous level of effort but not debilitating and, indeed, they were out on the traverse for more than an hour before they had to take a real rest - and then only because Bean thought, for a moment, that something had happened to his suit..

About midway through the EVA, after a two-hundred-meter, three minutes run eastward from Sharp Crater, Conrad had to called for a stop. Bean was ready for a rest, too, commenting that it was the first time during the mission that he'd really "worked up a heart rate". They had been moving quickly, at an average pace of about 4 kilometers per hour, enjoying the long, floating strides that lunar gravity made possible. At one point, Conrad said that he felt like a running giraffe filmed in slow-motion. But, with their heart rates reaching 160 beats per minute, they were getting winded and needed a moment's rest. During Apollo 17, on several occasions Jack Schmitt ran similar distances at 5 to 6 kph; but there was an important difference in that Schmitt didn't get nearly as winded. Indeed, on one memorable occasion, with his heart rate in the 120-130 beat range, Schmitt ran so comfortably that he sang in full voice. As it turns out, the big difference in performance was due to the fact that the Apollo 15, 16, and 17 crews wore suits with a redesigned waist joint that let them bend more easily. The design was changed so that they could sit on the Rover; but, as an added

benefit, it let them run with relative ease. With the stiffer suits, Conrad and Bean needed a brief stop for rest and some sampling. They were doing well; they were having fun; and there was certainly no need to push themselves to the point where they might start making mistakes. That was a sin that neither of them wanted to commit. They stopped, caught their breath, and then moved off again at a slower pace. They had learned an important lesson.

During the first part of the traverse, Conrad and Bean had gotten glimpses into the structure of the soil beneath their feet and the way that it had evolved. They had landed in the middle of the Ocean of Storms, an ancient mare or "sea" which had formed about four billion years ago when a basin - carved into the lunar surface at an earlier time by a very large impact - began to fill with basaltic lavas rising from the lunar interior. The lava flowed on and off for perhaps a few hundred million years, gradually creating a smooth, level plain. And then, slowly over the years, a steady rain of impacting objects had created a layer of soil - more properly, a layer of finely pulverized rock called the "regolith" - that was a few meters thick.

Throughout its history, the Moon has been bombarded by debris left over from the formation of the Solar System, a bombardment that continues even today, albeit at a much reduced rate from what it once was. There have been impactors of all sizes - dust motes, sand grains, pebbles, fist-sized rocks, boulders, and even the occasional projectile the size of a mountain. The large objects hit only rarely and made correspondingly large craters which, on average are well separated from one another. Small impactors hit more frequently because there are many more of them, and there isn't a square centimeter of the Moon that hasn't been blasted repeatedly by sand-grain-sized objects.

All of the impactors, large and small, hit with speeds of 20 kilometers per second or more and, in the beginning, they chipped and shattered the surface of the hardened lava sea. Collectively and gradually, they built a layer of rubble. Successive impacts churned the rubble layer down to a depth of about five meters, breaking up the rock and making smaller and smaller fragments. And, all the while, the smallest impactors - the dust motes and sand-grains - collectively sandblasted rocks exposed on the surface and ground them down to a powder that gives the lunar soil its characteristic, ash-grey color. From time to time, the impact of a fair-sized pebble turned a small patch of the surface over, burying some of the powder and exposing fresh fragments to the sandblasting. Gradually, over four billion years, most of the upper five meters was converted into a fine grained soil.

In recent times - say back over the last few hundred million years or so - most of the tiny impactors have struck the powdery soil itself. They dig tiny craters which give the surface a texture like that left on dusty ground by a light rain; and, in the small-scale violence of the impacts,

melt themselves and a few soil grains directly struck. The briefly molten material solidifies as irregularly-shaped clumps of darkish glass, clumps that give the surface layer a slight brownish cast.

For the most part, the appearance of lunar soil varies surprisingly little from place to place. There are few surfaces that aren't covered with fine soil; and, everywhere, the soil bears the imprints of craters of all sizes, most of them old and worn, with their circular outlines barely discernible beneath the overlapping effects of subsequent impacts. Here and there, there are fresher impacts and, at Apollo 12, there are none so fresh as Sharp Crater, a hole about 3 meters deep and 12 meters across which was dug out just a few million years ago by the impact of something about the size of a basketball. During the planning stages for Apollo 12, the crater's relative youth made it intrinsically interesting because, among other things, the crater and its ejecta would not have been disturbed very much by later events. The geologists wanted to know if there were indications that the Sharp impact had reached to the base of the soil layer. Seismological signals of such local phenomenon as astronaut footfalls, the impact of jettisoned backpacks, and the bounces of rocks thrown into craters would give indications of the depth of the soil at the ALSEP site; and the presence of rock fragments around young craters big enough to have reached bedrock could provide direct visual evidence. Significantly, the photographs taken by Conrad and Bean show relatively few rocks in the Sharp ejecta blanket, and there were certainly not enough rocks in the ejecta to elicit comment from either Bean or Conrad. At the place where Sharp formed, the regolith was probably deep enough - perhaps 6 to 8 meters - that only a few rocks were brought to the surface. Later in the EVA, they visited Block Crater and saw a lot of bedrock fragments there.

While Conrad and Bean were at Sharp, what did catch their attention was the bright, nearly white color of the fine ejecta and, as they approached the rim, the increasingly soft footing. Both the color and the footing were direct results of the violence of the impact. The impact broke the little clumps of dark glass, giving them the color and appearance of a shattered windshield; and it also tossed and churned the soil so that, when it fell, it took on the consistency of a freshly-poured pile of sand with grains balancing precariously on one another. Given enough time and exposure to the rain of small impactors, the Sharp ejecta will become darker and firmer, with each tiny impact creating a bit of dark glass and disturbing the balance of a few grains enough that they tumble into closer contact with their neighbors. That is, unless we decide to protect the area from further erosion by putting a large dome over the entire area as part of an Apollo 12 Landing Site Museum.

Surveyor Crater, itself, is old and very worn. As Conrad and Bean approached the subtle rim, they found that, like the ground near the LM, the soil was well compacted.

There were only a few rocks in evidence - all of them rather small and either tossed into the immediate area from some distance away or from Block Crater on the north wall of Surveyor.. Although the impact that made Surveyor Crater was certainly big enough to have reached bedrock, eons of erosion and filling had long since buried the evidence. On the inner slopes, the soil was just as dark as on the surrounding plain; and, based on their observations from the first EVA, the astronauts expected that the footing would remain good as they descended into the crater.

The Surveyor spacecraft sits about halfway down the eastern slope of the crater, having bounced and slid a short way as it landed. Just on the off-chance that the spacecraft was ready to slide a bit further, Conrad and Bean decided to walk down the southern slope to the Surveyor's level and then approach it by following a contour line. They had no intention of approaching it from below. As they made their way down the ten-degree slope, they found that the soil was only a little bit softer than on the rim; and, as they turned east, the only difficulty they had to report was that the slope made it harder for them to bounce from foot to foot. They simply couldn't move as fast as they could on level ground. Conrad even decided that the surface was firm enough that, had he known about it ahead of time, he might have been able to land Intrepid on the broad, flat bottom of the crater.

"It would have scared me to death," he said; but he thought he could have done it.

As the astronauts approached the Surveyor, they were surprised to find that the once white spacecraft had, apparently, turned light brown during its three years on the Moon. This was a real puzzle. The Sun was bright to be sure, but could the paint have changed color so quickly? Was Houston sure, they asked, that the spacecraft had, like the mock-up they'd used in training, been bright white when it left Earth? It took Houston a few minutes to find somebody willing to swear that the Surveyor had originally been lily-white, and by then Bean had noticed that even the camera mirrors appeared light brown. Could it really be a coating of dust? And why brown? All of the dirt in the area was distinctly grey. The only way to find out was to wipe the mirror - which came clean - and then wipe a patch of paint. Although some of the paint flaked off when Bean wiped it, it was soon obvious that, although Conrad had landed about 200 meters away, a little bit of the dust he'd kicked up with the LM engine had made it all the way over to the Surveyor. The astronauts walked around the spacecraft, trying to see if Sun angle made any difference in the apparent color. It didn't. In thin enough layers and with the right background, lunar soil looks brown.

For about forty minutes Conrad and Bean examined the robot spacecraft and the marks it had made when it landed. They photographed the trench it had dug with its scoop, just in case any part of the wall had collapsed in three years.

None had. Then they used a big bolt cutter to remove the TV camera, the scoop, and a couple of other parts to take back to Earth.

By the end of the stop, they had been out of the LM a bit over three hours and, in large measure because of Conrad's determination to "cover ground", they were only about ten minutes behind schedule. With only one station left, they were in great shape.

The last stop, at Block Crater, was rather brief. It was an important stop because the impacting object - again about basketball size - had hit on the inner slope of Surveyor Crater. As firm as the soil is on the inside of Surveyor Crater, it isn't as thick as it is out on the level plain, and the Block Crater impactor easily punched through to bedrock. There were rocks and boulders lying all over the place, some of them up to a meter across, and the astronauts had no trouble filling a bag with representative samples. Then it was back to Intrepid for close-out.

In two EVA's, Conrad and Al Bean spent 7 hours and 45 minutes outside the LM. Except for the loss of the TV right at the beginning, theirs was about as flawless a performance as anyone could have wanted. They accomplished virtually all of the mission objectives. They brought back to Earth a treasure of photographs, rocks, soil, and Surveyor parts; and they demonstrated both that the LM could be landed with precision and that a four-hour EVA was nowhere near the limiting workday for a well-trained astronaut. Once, during the second EVA, they pushed themselves a bit harder than the flight surgeon liked and were in need of a short rest. But they recovered quickly and proved that, at least in this terrain, with occasional rests they could walk a long way. It would have been nice to have a sip of water from time to time and bite to eat; and, certainly, they could have gotten a bit more done if they'd had a hand cart - or better yet - a Rover on which to load tools, containers, and other gear. But this was only the second landing mission and, just as Apollo 12 represented a decided leap in operational complexity over Apollo 11, further leaps were in store. Once the LM had been modified to carry the Rover and supplies for longer stays, productivity could increase even more. The limits were nowhere in sight.

And, finally, Apollo 12 was particularly noteworthy in that Pete Conrad and Al Bean simply had a lot of fun. In large measure, the contrast with Apollo 11 was a matter of personalities. Neil Armstrong's quiet reserve versus Pete Conrad's joyful mirth. But, then too, Armstrong and Aldrin had to work in an atmosphere of intense public scrutiny, constantly aware of the attentions of a global audience and of history. Unfortunately, the relative formality of Apollo 11 created a lasting impression of lunar exploration for a great many people. Pete Conrad and Al Bean had no such weighty matters to restrain them and they hummed and sang and laughed their way from station to station. It is regrettable

that the TV camera was damaged. The accident was understandable; but, no matter what the root cause, soon after the loss, the TV audience and the broadcast networks abandoned the mission. Shrinking audiences were probably inevitable after the drama of the first landing. The press of time forced the use of jargon and there were certainly long periods when the astronauts were doing little more than bagging yet another piece of rock. As entertainment, it could be pretty deadly at times. But, all in all, Apollo 12 was a lot of fun and a lot of it would have been well worth watching.

Apollos 13 and 14 - The Frustrations of Frau Mauro

The first two Apollo crews landed out on the smooth lunar mare, the lava seas that formed relatively late in the Moon's history. Both crews proved that, once the Commander took over control at an altitude of no more than 400 to 500 feet, he could move his landing spot by several hundred feet. After two landings out on the mare, NASA was ready for a visit to a site where landing accuracy promised insight into the history of the older parts of the Moon.

About half of the lunar Nearside - and virtually all of the Farside - is covered by heavily-cratered highlands, the light-colored regions which, as seen from Earth, contrast so strongly with the darker-colored mare. Because the mare rocks are relatively young and cover far less than half of the lunar surface, the scientific community needed highlands samples if they were going to understand lunar geology. To be sure, the Apollo 11 and 12 collections contained significant numbers of small rock fragments which differed markedly in composition from the bulk of the mare-derived materials; and there was every reason to believe that many of these "exotic" fragments represented ejecta from impacts in the distant highlands. However, while studies of these fragments produced plausible data on the general age and mineral content of highlands materials, there was no real substitute for taking a look at in-place samples of highlands bedrock.

Although NASA was not ready to commit a LM to a landing in really rugged terrain, the site selection committee had long been interested in a place called the Frau Mauro Hills, a small, relatively benign bit of highlands country sitting like a low island out in the middle of the Ocean of Storms. Of particular interest was a feature called Cone Crater, a comparatively fresh crater about 300 meters across. The Frau Mauro Hills are believed to be part of the extensive ejecta blanket laid down by the impact that formed the huge Imbrium Basin; and Cone Crater had been dug into a ridge of this material. Although the area is covered by materials derived from post-Imbrium events- such as ejecta from the large, young crater Copernicus some 500 kilometers to the north and, as well, materials dug out of the immediately surrounding mare by countless other impacts - Cone Crater was big enough that the astronauts would surely find Imbrium ejecta as they climbed toward the rim.

From an operational point of view, Frau Mauro offered some additional challenges and opportunities. Because the crew needed a relatively flat place on which to land, they would have to touch down more than a kilometer away from Cone and then walk to the rim. During the last half of the approach, the astronauts would have to climb a grade of about one in ten and the traverse promised to be a significant test of astronaut mobility. In terms of lunar surface activities, the Frau Mauro mission was far more ambitious than either of the other landings and, unfortunately, it took two tries to

complete. Jim Lovell, Jack Swigert, and Fred Haise - the crew of Apollo 13 - set out on the first mission to Frau Mauro; but a spacecraft accident forced them to abort the attempt before they ever got to the Moon. Indeed, they were lucky to get home at all.

For years, NASA had concentrated its energies on the obviously critical stages of missions: the launch from Earth, the departure from low-earth-orbit, lunar-orbit insertion, the landing sequence itself, lift-off, rendezvous, the departure from lunar orbit, and the fiery plunge through the Earth's atmosphere toward splashdown. Ironically, it was during one of the quiet times, during the long outward coast, that something went wrong.

Apollo 13 was launched about five months after Conrad, Gordon and Bean returned from the Moon. There had been only a few minor glitches in the early stage of the mission and, through the first two days and into the early part of the third, the flight seemed to be defying the worst fears of those prone to a habitual state of nervous anticipation with regard to the number 13. At the time of the accident, it was about nine in the evening in Houston - on the 13th of the month, of course - and, on board the spacecraft, the crew had just finished a routine mid-flight TV broadcast. Commander Jim Lovell and LM Pilot Fred Haise were in the process of completing a checkout of Aquarius, their lunar lander; and CSM Pilot Jack Swigert was preparing to make some star sightings with his sextant. At fifty-five hours, fifty-five minutes into the mission, all three astronauts heard and felt a "pretty large bang". It got their immediate attention and, during the next few minutes as they and the ground controllers made a rapid assessment of the health of the spacecraft, it became apparent that, for some reason, two of the three fuel cells in the Service Module had gone dead. No one knew quite what had happened, but there was no doubt that the crew was in serious trouble. If they were going to survive, they would need enough power, oxygen, and water for a four-day trip around the Moon and home to Earth; and, without a healthy Service Module, those three commodities were going to be in terribly short supply. Under normal circumstances, oxygen and hydrogen were combined in the fuel cells to produce electricity and water; and, with both oxygen tanks rapidly losing pressure, even the remaining fuel cell wouldn't last long. In addition to short supplies of these basic commodities, without power in the Command Module, they would have to rely on the LM Environmental Control System to remove excess carbon dioxide from the cabin. The LM system contained two lithium hydroxide canisters - a primary and a secondary - which, together, had been designed to handle the carbon dioxide output of two people for about 30 hours, rather than three people for at least four days. The LM did carry replacement canisters, but most of those were safely tucked away in the MESA, quite hopelessly out of reach. Quite simply, they didn't have enough LM lithium hydroxide canisters to handle the load. And, finally, the crew was

flying a trajectory toward the Moon that would not allow them to return to Earth without a major engine burn. The main engine, of course, was housed at the back of the Service Module and, with the power supply gone, the crew might as well have left the engine back at the Cape.

The people of Apollo took great pride in their resourcefulness and in their detailed understanding of the flight hardware. If there was a way to improvise and get the crew safely home, they intended to find it. And as they looked over the situation - flight crew and ground personnel alike - they realized that they had been very lucky. As desperate as the situation was, the accident had come early in the mission. They still had a healthy, fully-stocked lunar module. The margin of safety would be tight, but the LM had an engine to put the crew back on a homeward path, and it carried enough - not a lot, but enough - water, oxygen, and power for the four days. And there were plenty of lithium hydroxide canisters in the Command Module and, while they wouldn't fit directly into the LM ECS - being the wrong size and the wrong shape - surely a way could be found to put them to use.

Even in the earliest days of Apollo, during 1962 when NASA was still trying to decide on a basic mission mode, proponents of lunar-orbit rendezvous had argued that, in certain circumstances, the LM engines could be used as backups in case of a Service Engine failure. These "LM Lifeboat" scenarios were never studied in great detail, but enough people had given the general idea some thought - even to the extent of having run some flight control simulations - that, within an hour of the accident, flight engineers were busily calculating trajectories and burn durations, figuring out new navigation and flight control procedures, and refining estimates of just how long the critical supplies would hold out.

Oxygen turned out to be the least of the Apollo 13 worries. The LM carried generous stocks - including the backpack oxygen that Lovell and Haise were to have used for their first EVA at Frau Mauro. In order to conserve their own physical resources - and to minimize their carbon dioxide output - the crew would do their best to keep physical exertion to a minimum. Nonetheless, it was reassuring to know that they would only have to use about half of their oxygen stock in getting home. The power and water supplies were far more critical. A significant fraction of the electric energy stored in the LM batteries would have to be used during the engine burn and, if the astronauts were to survive the trip back to Earth, they would have to carefully conserve the remainder. All non-essential electronics would have to be turned off and that promised to make the trip home a damp and chilly one. Of even greater concern was the fact that, at first blush, there seemed to be no way to keep the Command Module batteries charged until they would be needed for re-entry. Under normal circumstances, the fuel cells in the Service Module were used to keep the CM batteries charged

and then, only in the last few hours of the mission, once the Service Module had finished its job and was jettisoned, were they brought on line. Unfortunately, the accident had killed the fuel cells and, unless a way could be found to use the LM batteries to maintain a charge, the crew would have no way to control their re-entry and would perish just as surely as if they had crashed into the Moon.

The problem in maintaining a charge on the Command Module batteries was only one electrical path between the LM and the Command Module and that was a sensor circuit which, as Fred Haise remembers it, allowed the crew to monitor power usage by the LM systems. Because the LM and the CSM had no physical or electrical connections during launch from earth, the monitoring circuit was established only after the crew had docked with the LM, removed the docking hardware from the connecting tunnel, and plugged in an umbilical cable. According to Jack Schmitt, "After the explosion on 13, somebody started working the schematics of the two spacecraft and figured out that they could configure switches and circuit breakers so that current from the LM batteries could be trickled over along this sensor circuit. And that's what they did for five days: trickle this current over to the Command Module batteries. Without it, they could never have re-entered (Earth's atmosphere)."

By turning off as much of the electronics as they could, they not only saved power for the critical needs of the LM engine and the CM batteries, but also cut down on the use of water. Even with a normal ration of about a liter of water a day, the crew would have drunk less than ten percent of the 150 liters of water onboard the LM; however, even in a powered-down mode, virtually all of the 150 liters was needed for the sublimators that kept critical equipment cool, so the astronauts cut their daily ration to about a fifth of a liter apiece, a small glass full. They would be plenty thirsty when they got home, but at least they'd have a chance. As it turned out, they did a stunning job of conservation and got back to Earth with twenty percent of the LM power left and ten percent of the water. Indeed, in hindsight they may have done too good a job of water conservation. Lovell lost fourteen pounds (and Haise and Swigert another seventeen pounds between them) and they were all "tired, hungry, wet, cold, [and] dehydrated" when they landed. Because of the dehydration and other factors, Haise developed a prostate infection, a fever of 103 degrees Fahrenheit, and was seriously ill for two or three weeks after getting home. But all of that was of secondary importance. They had made it back alive.

In large measure, the Apollo 13 crew survived their ordeal for the simple reason that, at the time of the accident, they had backup stores of critical commodities: extra power, water, and oxygen - and even an extra engine. Of course, had the accident happened while Lovell and Haise were on the lunar surface, or after they'd returned to orbit with rocks but no fuel nor anything else of immediate

survival value, then the outcome would have been tragically different. But that was the nature of the venture. Acceptance of the Kennedy challenge dictated the acceptance of calculated risks. True, NASA had worked hard to build redundancy into the spacecraft systems; and it is a bit ironic that, at one stage of the drama, the team had to work hard to get around the fact that they couldn't simply interchange the CSM and the LM lithium hydroxide canisters.

In both spacecraft, under normal circumstances, the cabin air was fed continuously through environmental control equipment where, among other things, lithium hydroxide reacted with the carbon dioxide and trapped it. A single canister began losing its efficiency after about 40 person-hours of use and then had to be replaced. Unfortunately - and quite literally - the square CSM canisters wouldn't fit into the round holes of the LM unit; and, unless a way could be found to use the square ones, the carbon dioxide content of the cabin air would rise to poisonous levels long before the crew could get home. The advertised 60-person-hour combined lifetime of two LM canisters was, of course, a very conservative figure and, in fact, by allowing the carbon dioxide levels to rise above normal limits, they were able to keep them on line for 107 person-hours, or nearly a day and a half. And they had one other primary canister - 40 person hours design lifetime, 80 person hours at the higher CO2 levels - that they were holding in reserve in case it took extra time to devise a way to use the CSM canisters.

There was, of course, a fix; and it came in the form of an ingenious combination of suit hoses, cardboard, plastic stowage bags, and CSM canisters - all held together with a liberal application of grey duct tape. As was usual whenever the Apollo team had to improvise, engineers and astronauts on the ground got busy devising ways around the problem and then checked out the new procedures. A day and a half after the Apollo 13 accident, the ground teams had designed and built a filtering device that worked to their satisfaction. They promptly radioed instructions to the crew, carefully leading them through about an hour's worth of steps. As Lovell wrote later: "the contraption wasn't very handsome, but it worked." And that was all that mattered.

include a drawing and photo of the canisters from the Apollo 13 mission report

With the solution of the carbon dioxide problem literally in hand, the crew of Apollo 13 looked to be in about as good a shape as could be expected under the circumstances. As long as the LM remained healthy, they had a good chance of getting home; and the odds certainly seemed pretty good. The design engineers had gone to great lengths to ensure LM reliability. Of course, the CSM, too, had been designed to be a reliable spacecraft; but two critical failures in one mission seemed a bit far fetched. In order to get home, the astronauts had to make two engine burns. The first came five hours after the accident and was designed to put them back on what was called a "free-return

trajectory", a trajectory that would take them home even without the second burn. They were still headed toward the Moon and wouldn't reach it for nearly another day; but, with the first burn successfully completed, when they swung around the backside, lunar gravity would send them homeward rather than out into the depths of space. The second burn was needed in order to get them home before the supplies ran out. On the new trajectory they wouldn't get back to Earth for over ninety hours and calculations indicated that a trip of that length was only marginal, especially with regard to cooling water. The key to success was to wait until after the Moon had swung them homeward and then give themselves a good, hard kick in the pants and cut about nine hours off the trip.

The first burn went smoothly and there was every reason to believe that the LM engine would function perfectly the second time as well. However, for this second burn, the crew had to take particular care to make sure that the engine was pointed in just the right direction and, because of the accident, they had to deal with some unusual navigation problems. Because they were traveling through vacuum, there was nothing to disperse the cloud of Service Module debris that enveloped the spacecraft. As they peered through the LM's one-power telescope trying to make star sightings, glints of sunlight reflecting off the debris made the job all but impossible. And to add to their difficulties, they were all exhausted and kept making uncharacteristic mistakes. But they kept at it and, with help from the ground, figured out how to use sightings of the Sun and the crescent Earth to verify their alignment and then did the job over and over to make sure that they had it right. When the time came, the burn was perfect.

It was two months before NASA was satisfied that the causes of the accident were understood. As Lovell later wrote, the accident did not have a single cause but, rather, was the result of an "accumulation of human errors and technical anomalies that doomed...[the mission]." The accident began, in fact, in 1965 when the design engineers decided to change the spacecraft power supplies from 28 to 65 volts. Normally, of course, such a change would cause a cascade of other changes as designers adapted their particular components to the new operating environment. However, the people building the innards of the Service Module oxygen tanks somehow never became consciously aware of the change. Each of the tanks contained a stirring fan, a heating element, and a temperature-sensitive switch designed to shut everything off if the element got hotter than about 25 degrees centigrade (80 F) and none of these components was ever redesigned to accommodate the higher voltage. NASA might have gotten away with the design flaw (as it had on Apollos 7 through 12) if one of the oxygen tanks destined to fly on Apollo 13 hadn't been damaged in 1968. This particular tank had originally been installed in the Apollo 10 CSM but, prior to that mission, was removed for

modification. At some point, the tank was dropped about 5 cm (two inches) and because of its very thin walls, suffered noticeable damage. Another tank was installed in Apollo 10 while the original was set aside for repair and eventual installation in the Apollo 13 spacecraft. Tests run on the tank after the repairs indicated proper functioning but, in the weeks preceding the Apollo 13 launch, ground crews experienced significant difficulties draining it. In hindsight, it was at this point that NASA should have taken a hard look at the health of the tank but instead, all of the cognizant individuals - the crew included - concluded that the problem was not serious. Replacement of the tank would have delayed the mission - by a month at least - and, at the time, it seemed acceptable to try emptying the tank by running the internal heater for several hours. No one imagined just how serious a problem the procedure would cause.

As we now know, the temperature-sensitive switch was not designed to operate at 65 volts. During normal operations, the heater was on for only brief periods and the switch never opened. However, during what proved to be a lengthy process of emptying the tank using the internal heater, the switch opened but, then, was immediately welded shut again by an electric arc driven by the high voltage. Indications that the switch had closed were missed. Subsequently, whenever the CSM was powered up, the heaters went into operation without the protection normally provided by the switch; and, at some point during pre-launch activities, the whole assembly reached a temperature of over 500 degrees Centigrade (1000 F). This was a high enough temperature to cause severe damage to the Teflon insulation protecting the fan-motor wiring and, as the Apollo 13 Review Board later concluded, "from that time on the oxygen tank was in a hazardous condition when filled with oxygen and electrically powered." The stage was set for the accident.

Despite all the rattling that must have gone on during the launch and subsequent engine firings, nothing untoward happened inside the tank until fifty-five hours, fifty-five minutes into the mission. At that moment, at a quiet time and, undoubtedly as a result of something so simple as the start up of the fan, the wires arced and the insulation caught fire. It was the 1967 Apollo launch-pad fire all over again, only this time it was a fire fed by a superabundance of pure oxygen, a fire that wouldn't quickly go out. The heat of the fire began boiling the liquid oxygen that mostly filled the tank and the pressure began to rise. Within a half minute, the pressure was too high for the tank's thin walls and they burst. The explosion wreaked havoc throughout the innards of the Service Module, rupturing the other oxygen tank and blowing out the side of the spacecraft.

From a purely engineering point of view, the Apollo 13 accident didn't reveal any fundamental flaws in the Apollo design concept. In any project of such size and complexity, unforeseen problems are to be expected and, what the accident

did was to underline the lessons of the Apollo fire: NASA needed to do a better job of identifying problems before they could happen. The agency needed to conduct another thorough review of designs and procedures, particularly with regard to components that came in contact with the oxygen supply and, in the future, to pay closer attention to design changes, manufacturing quality, and the implications of anomalous test data. But there was no need to go back to square one. From an engineering point of view, once the problem had been identified, the fixes were easily accomplished. True, the accident had cost NASA one of its now limited opportunities to complete a landing and had almost cost the lives of three astronauts; but when measured in terms of the engineering goals that had been set in the early sixties, NASA was still well ahead of the game.

The main trouble with such accidents is that they have the potential of causing real political mischief. Although the death warrant for Apollo had already been signed in January 1970 - with the assembly lines shutdown and one of the remaining missions cut from the schedule for lack of funds - it is not coincidental that two more missions were dropped in the interval following the accident. Congressional support for Apollo had been weak for years and now there was a new President who was less than an ardent fan; and, while prediction of the political impact of serious accidents is far from an exact science, any accident was bound to raise questions about the credibility of NASA and its programs. As both the Apollo fire and the Challenger accident of the Shuttle era indicate, serious accidents do not necessarily doom a program but, given the expense and high visibility of such enterprises, the political risks are considerable.

Apollo 14

When all was said and done, the Apollo 13 accident caused only about a four-month slip of the next mission. Apollo 14 was launched on January 31, 1971. Four days later, Commander Alan Shepard and Lunar Module Pilot Ed Mitchell landed at Frau Mauro. During the final approach, they recognized Cone Crater right at pitchover and, soon thereafter, picked up the familiar pattern of smaller craters near their aim-point another mile or so to the west. There wasn't, Shepard said later, any really flat ground close at hand; there were either craters or sloping ground wherever he looked; but he had no trouble finding a crater-free, LM-sized patch that was only 30 meters from his target.

The only problem with the landing spot was that it was on an eight degree slope; and, for 24 of the next 33 hours the astronauts had to contend with a tilting floor that threatened to dump Shepard over onto Mitchell's side of the spacecraft. In addition, the tilt contributed to a sleepless night between the two EVA's; but, otherwise, the LM attitude had no effect on the mission. No one had yet had a good

sleep on the Moon and Shepard and Mitchell were to be no exception. But they were down, virtually on target, and otherwise were in great shape.

Within about three hours of the landing - after reconfiguring the LM for takeoff and after taking time out to have lunch and to pass along some excellent descriptions of the view out the window, Shepard and Mitchell started to don their backpacks - getting ready, as Shepard said, "to go out and play in the snow." The mental picture came easily. Outside the window, the soft, rounded forms of the craters gave the look of snow-covered ground and, although the color wasn't quite right - it was "mouse-brown or mouse-gray" depending on where they looked in relation to the Sun - the black lunar sky made it easy to think of a snowy winter's night back home. And to top off the image, Shepard and Mitchell only had to look at each other, standing there in their cumbersome spacesuits, donning the thick gloves, eager to get outside. Play in the snow, indeed!

The first EVA was, by now, part of the routine. First, climb out and take a look around. Could they pick out the summit of Cone Crater? Yes; there it was, a low, conical hill off to the east, almost under the Sun, with boulders easily visible near the top. Then set up the TV camera (now equipped with a lens cap), then the portable high-gain antenna and the flag. Collect a contingency sample and take pictures, get the experiment package down off the LM (the fuel element slid easily out of its cask this time), and head off for the ALSEP site about 200 meters to the west-northwest.

During the first EVA, there were a couple of differences from Apollo 12. One was a handcart - called, in NASA-ese, the Modular Equipment Transporter or MET - for hauling some of the equipment - an addition to the mission made possible by the post-accident delay. The MET didn't provide the mobility of the Rover planned for the later missions, but it did give the astronauts the ability to carry far more samples, containers and tools than they could have carried in their hands and on their backpacks. And the other difference from Apollo 12 was a healthy TV camera. Shepard pointed it toward the ALSEP site before they left the LM so that those of us at home could watch them as they made the traverse - sometimes dropping out of view as they crossed low spots in the terrain. Throughout much of the ALSEP deployment they were both in full view of the camera.

The traverse took a bit longer than anticipated, in part because the rolling terrain forced Mitchell, who was carrying the ALSEP package, to take a couple of breathers. But basically, as Mitchell remarked during the traverse, the rolling terrain wasn't so much "difficult" as "unexpected"; they'd trained on a flatter surface, and the constant rolling forced a bit longer period of adaptation. Once they reached the ALSEP site, the stiff suits and gloves got in the way as usual, causing Mitchell to comment in a moment of mild exasperation that "it takes two of us to do what half of us

can (normally) do". Nonetheless, with the exception of some small seismic charges which wouldn't all fire, Shepard and Mitchell had no particular problems. By the time they were ready to head back to the LM, they had only lost only about a half an hour to the planned timeline.

Although Shepard and Mitchell could have used a good sleep before making the climb up to Cone Crater, both of them were too keyed up to make full use of the scheduled rest period. In the interest of getting in a full second EVA, they talked Houston into cutting the rest period by an hour and, naturally, spent a good deal of the time lying awake. Anticipation was a major contributor to their sleeplessness; but, as with Apollo 12, the mission simply wasn't going to be long enough for them to get out of the suits. Unpressurized, the suits were uncomfortable and irritating and, among other things, the neck rings made it difficult for the astronauts to find comfortable support for their heads. And as a final factor, once they were stretched out in the hammocks, the tilt of the spacecraft became more and more obvious. Rationally, they knew they were okay; but, at intervals through the night they awoke from a half sleep and, in the light lunar gravity, had the uncomfortable feeling that the LM was tipping over. Several times during the night, one or the other of them felt that they had to push aside the window covers and, just to be certain, take a look outside. In the morning, it was they who called Houston - a half hour before the agreed on wake-up time. They reported getting about four hours of sleep a piece, but that was certainly a generous estimate. The flight surgeons concluded that neither of them had slept much at all and, like the crew of Apollo 12, Shepard and Mitchell had to draw on mental and physical reserves to get them through the second day.

Because they had purposefully landed well beyond the foot of the Cone Crater ridge, the first part of the traverse was rather easy. The rolling terrain that surrounded the LM continued for a considerable distance to the east. On the first leg of the jaunt they moved off about 200 meters from the LM - about the length of a longish par-3 golf hole - and then stopped for about a half hour to collect samples, take pictures, and make a measurement of the lunar magnetic field with a portable magnetometer. Beyond Station A, they made a few other brief stops and, by the end of the first hour, had gotten about 650 meters from the spacecraft. It was here that it became apparent that they'd crossed onto Cone ejecta blanket. Although they noticed no obvious change in soil color or texture, they were climbing and were seeing more and more rocks on the surface, some big enough to be called boulders. The pace had been leisurely up to this point, a series of short walks and short stops. But now the real work was about to begin and they were running a bit short of time.

In comparison with some of the desperate, heroic treks of bygone eras - Shackleton's march across South Georgia Island with Worsley and Crean in 1916, for example - the

tale of Shepard and Mitchell's climb to Cone Crater falls far short of high adventure. If the LM had been parked at the bottom of the crater - with the crew running short of oxygen - it would have been a different matter. But then, no self-respecting Apollo astronaut would have gotten himself in such a situation if it could be avoided at all. NASA and the astronauts knew exactly what the operational limits were and weren't about to stretch those limits unnecessarily. Shepard and Mitchell were out to collect bedrock samples from the rim of Cone and, in the process, to see how difficult it was to climb the hill. From an operational point of view, it didn't matter a great deal if they didn't quite make it all the way to the rim. But there was pride at stake and, as long as they didn't spend too much time at it, reaching the rim was an important psychological goal. As they began to climb, they were only halfway to the rim and were about sixty meters below it; and they were also running about fifteen minutes behind the time line. Both they and Houston expected that they'd be given a thirty minute extension, but even that would give them only about half an hour to reach the rim. On level ground they would have been able to cover the 650 meters in no more than 15 minutes - less without the cart - but, here, their ability to climb was a real unknown. Consequently, they planned to spend as much of the time walking as they could, making only the briefest of stops to collect samples and take photos. As it turned out, they needed the whole half hour and a little more besides.

During the early stages of the climb, they made good time, Shepard usually in the lead pulling the cart, Mitchell trailing along trying to identify landmarks with the map. Mitchell did a fine job as an narrator, providing Houston with descriptions of such things as the color and texture of the surface and, from time to time, trying to make sure that he got a turn at cart pulling.

photo of Ed with the map

Before long, the grade was getting quite steep - about a ten-percent slope - and they were both breathing hard enough to hear back in Houston. The surface was soft and was littered with enough fist-sized rocks that, at one point when Mitchell was pulling, Shepard came up behind the cart, picked up the back end, and helped carry it along. It seemed to let them move faster. Shepard counted cadence: "Left. Right. Left. Right."

The march only lasted for a minute or so before Shepard had to call for a halt. His heart rate was getting up to 140 beats a minute and he needed a rest. As on Apollo 12, the stiff waist joint of the suits worn by the early crews was probably making itself felt. Shepard and Mitchell stopped for a couple of minutes at the first really good-sized boulder they'd come to - one about 12 feet long, four wide, and about four high. Sitting was out of the question; but they could at least stand at ease for a couple of minutes while they took a panoramic sequence of photos and some close-ups of the boulder.

By now they were climbing about one meter up for every five meters forward and they were only able to move for about a minute before they had to stop again. They rested, climbed a bit more, and then it was Houston's turn to call for a halt.

"Okay, Al and Ed," said Fred Haise, the CapCom. "They'd like you to take another stop here."

Shepard didn't argue. "Okay. We're really going up a pretty steep slope here.

"We kind of figured that," said Haise, "from listening to you."

Shepard took stock of the situation. They'd been out from the LM for about two hours and had perhaps another fifteen to twenty minutes before they would have to stop to take the bedrock samples and then head back to the LM. Although neither of them had much faith in their ability to judge distance, Shepard estimated that, at the present pace, it would be at least another half hour to the rim. It was time, he thought, to pick out some likely boulders - there were a few not far above them - and start sampling.

The two of them talked about it for awhile - Mitchell being particularly eager to press on - and then Haise broke in.

"Okay, Al and Ed. In view of your location and how long it's going to take to get to Cone, the word from the Backroom [the geology support staff] is they'd like you to consider where you are (to be) the edge of Cone Crater."

Mitchell wasn't ready to give in. "[I] think you're finks," he said.

Haise backed off just a little. "Okay. That decision, I guess, was based on Al's estimate of another, at least, 30 minutes and, of course, we cannot see that from here. It's kind of your judgment on that."

Houston's quick retreat gave Mitchell some encouragement. "Well, we're three quarters there," he told Haise. Then he turned his attention to Shepard. "Why don't we lose our bet, Al, and leave the MET and get on up there? We could make it a lot faster without it."

Shepard wouldn't hear of it. A dash to the rim, simply for the sake of it, wouldn't look good. And besides, they were both tired. "No. I think what we're looking at right here in this boulder field, Ed, is the stuff that's ejected from Cone."

Mitchell saw his opening. "But not the lowermost part, which is what we're interested in." If they pressed on toward the rim - he was reminding Shepard - they'd be more likely to get samples of the ejecta that had been dug out from the greatest depths. It didn't matter that the Backroom geologists would have been perfectly happy with slightly sub-optimum samples. They could continue the climb toward the rim in the interest of science, rather than astronaut pride.

Shepard decided to buy into the argument. "Okay, We'll press on a little farther, Houston. And keep your eye on the time."

A few minutes later, Haise reported that Deke Slayton, the former Mercury astronaut who had become head of the Astronaut Office, had volunteered to cover the bet if they decided to drop the MET. Mitchell backed off quickly.

"It's not that hard with the MET," he said. "We need those tools. No, the MET's not slowing us down, Houston. It's just a question of time. We'll get there."

Another few minutes later, they came to the top of a rise. It looked, Shepard said, like they'd reached maximum elevation. "It's leveled out a little bit. And it looks like we'll be approaching the rim here very shortly." But he couldn't be sure. Indeed, Mitchell suspected that they were south of where they needed to be; but the uneven ground made it hard to identify landmarks and he wasn't willing to press the issue. They couldn't be certain exactly where they were - not to within several tens of meters. Any of the little hills and ridges ahead of them - or off to either side - might be hiding the crater. They had to be fairly close, certainly within a hundred meters or less, but now it really was time to stop.

Haise passed on the Flight Director's decision. "Ed and Al, we've already eaten our thirty-minute extension and we're past that now. I think we'd better proceed with the sampling and continue with the EVA."

As it turned out, they were twenty or thirty meters south of the rim. Just a few more steps.

Like the other early landing crews, Shepard and Mitchell had spent most of their training time on flight operations and on basic EVA techniques. Indeed, for various reasons, the 14 crew may have been less well prepared, geologically, than any of the other crews. Nonetheless, they had been exposed to a certain amount of geology over the years and had been briefed about things to look for and, ultimately, did a conscientious job of collecting a representative set of samples - keeping their eyes open for anything out of the ordinary - and took the requisite documentation photos. After about a half hour of sampling and picture taking, they were ready to head back down the hill.

For a moment before they started, Shepard and Mitchell paused to get their bearings and to admire the view. Although they were looking down-Sun - that is, away from the Sun - they were high enough up that they could see shadows in the larger craters, shadows that gave the landscape a bit of texture. The landmarks that they'd used during the final landing approach were clearly visible around the LM; and out beyond it, the ALSEP package sparkled in the Sun like a "little jewel." All day they'd had trouble judging distance because there were no familiar objects to provide scale, no color differences to break up the scene, and no haze to help differentiate smaller, relatively nearby craters from larger ones in the distance. With experience, they might have used the presence or absence of boulders on crater rims as an indication of crater diameter and hence of distance. But to

their untrained eye, only the LM provided scale. It was about a mile away and looked it.

The trip back was quick and uneventful - a minute downhill for every two minutes up. As they descended, the shadows gradually disappeared and they had to keep close watch on the ground ahead of them. Once they got back on relatively level ground, small craters seemed to appear almost without warning, but at walking speed they had no trouble making their way. A few hundred meters from the LM they made another long science stop before they got busy with closet.

By this time, the combined effects of the sleepless night and the hard, and ultimately frustrating, climb were beginning to show. They were getting irritable and, during the final stages of the traverse, Houston heard a few "damns" and "hells" that indicated how tired Shepard and Mitchell were getting. The Apollo crews generally avoided profanity, at least when they were using open microphones. Consciously or subconsciously, they all chose words to suit their audience and it was only in stressful situations that any of them broke the unspoken agreement against cursing into a live microphone. Shepard and Mitchell were tired. They were feeling rushed and were a little worried that they wouldn't get everything done. Shepard may have been thinking that he wouldn't have time for the little surprise he'd planned; and, certainly, he and Mitchell were annoyed that they hadn't found the rim of Cone. In any case, as they were nearing the LM, Shepard let out a heartfelt "son-of-a bitch", and, in hindsight, it almost seems as though he was giving both of them permission to relax a bit.

Once back in the LM, having stowed their gear and the 45 kilograms of samples, the astronauts answered a few questions for the geologists and then took a few minutes to talk with Haise about the experience. Shepard started with some words of thanks for the people back home, words that hinted at the underlying frustration he was still feeling. The folks back in Houston, he said, had done "a good job of getting us sorted out...when we got behind the timeline; and we appreciated that help."

Haise was quick to offer re-assurance. "Well, we thank you again for doing a great job, Al and Ed. I think we have picked up everything we needed there."

"Gee, I sure hope so," said Mitchell. "It sure...(he paused to find the word)...sure was a panic from our point of view."

"Well," said Haise with a bit more re-assurance, "we kind of knew that before we got there."

"There were so many things we'd like to have done," continued Mitchell (inadvertently overlapping Haise because of the two-and-a-half-second communications lag), "so many things to do; so many interesting things to look at here - and we didn't even have a chance to scratch the surface. We hope we've brought back something that you can sort out as time goes on."

Then Haise tried to put things in perspective. Surely, he said, "it's a little better than the sandpile out behind the training building."

"Oh, man!" agreed Shepard.

"Don't you know it," said Mitchell.

"It really is," said Shepard. "It's fantastic up here."

The Apollo missions were so short - the first three in particular - that all the astronauts really had time to do was make an intelligent selection of samples that emphasized variety. And in the case of Apollo 14, the crew was particularly pressed for time. During their climb up to Cone there hadn't been time to do much more than grab samples. However, in the process, they demonstrated that it was possible to make long walking traverses over moderately difficult terrain. Perhaps if they had snaked their way up the hillside rather than making a frontal assault, the climb might not have been so arduous. But, in any event, Shepard and Mitchell had succeeded in climbing the hill and, although the Lunar Rover would provide a far more efficient way of doing geology, it was clear that, with some care taken in avoiding steep, uphill climbs, the later crews would be able to walk back to the LM from a Rover breakdown.

Apollo 14 was an important bit of preparation for the sophisticated Rover missions with which the Apollo series ended. It was a confidence builder. And it was also one for the record books. Al Shepard got a chance to take a few swings at a golf ball he'd brought along. The stiff suit forced him to swing one-handed and he fanned on the first two tries. But with the third he connected and the ball went "miles and miles and miles", he said. The truth wasn't quite so spectacular, but it was the first lunar golf shot.

The Apollo 17 Lunar Surface Journal, Part 9
Apollo 15: Lunar Rovers and the Cost of Drilling

Lunar Rovers

From a practical point of view, the first three Apollo missions were primarily engineering test flights. Exploration and science were of secondary importance and, indeed, the Lunar Modules which were flown on those missions simply couldn't carry much equipment. The LM had been designed as the sparest vehicle capable of completing a landing mission; and it had always been a struggle to find room in the weight budget for scientific equipment and exploration gear. Confidence in the spacecraft - coupled with incremental improvements in performance - permitted slight increases in the amount of useful cargo that could be landed on the Moon but, from a practical point of view, Apollo 14 was about the most sophisticated mission that could have been accomplished with the original Apollo hardware.

Of course, NASA and the space community as a whole had always wanted a good deal more from a mission than what a pair of walking astronauts could accomplish during a thirty-hour stay. As mentioned previously, in the early fifties rocketeer Werner Von Braun, astronomer Fred Whipple, and science writer Willy Ley published a series of articles in Collier's Magazine in which they described a hypothetical lunar landing mission on a far grander scale. They expected that a crew of fifty lunar explorers would journey to the Moon in three large landers assembled and fueled in earth orbit. Two of the landers would be able to make the round trip to the Moon and back and, on the outbound leg, would each carry a crew of twenty. The third lander would be the cargo ship, carrying a crew of ten and, in place of fuel for the trip home, about 300 tons of cargo. Von Braun and the others imagined that the expedition would stay on the Moon for six weeks, arriving just after local dawn, staying through that two-week day and the following night, and departing just before sunset on their second lunar day. Rather than live in ships, the explorers would, after unloading the cargo, disassemble the cargo hold and use the resulting half-cylinder sections as Quonset huts - one for living quarters and the other for labs. Of course, there was a great deal of material to be moved and Von Braun and the others provided the expedition with cranes - one on each ship - and with three ten-ton tractor-trailers. Once the base was established, the tractor-trailers could be put to use as exploration vehicles, first for trips in the immediate vicinity of the base and then, just before dawn on the second day, for a 300-kilometer cross-country trek to a large crater where, it was hoped, evidence would be found to prove once-and-for-all whether large lunar craters were formed by impacts or by volcanic action.

(In reality, high-quality photos taken with such instruments as the Palomar telescope on Earth and the Lunar

Orbiter spacecraft provided enough data that, for the majority of planetary scientists, the question had been answered - generally in favor of impact origins for the vast majority of features - long before Apollo 11. Readers interested in a more complete discussion would do well to consult Don Wilhelm's "To a Rocky Moon". However, as Jack Schmitt remarked during our review of this Apollo 15 summary, even for the majority who were convinced that almost all lunar craters were impact structures, "there were a few features we said might be volcanic caldera craters, primarily because they were even more strikingly polygonal than the impact craters. But even the large impact craters end up with polygonal outlines. It's determined by whatever fracture system you have and, in the case of Meteor Crater (Arizona), the fracture systems are northwest and northeast trending and you just get better excavation along those fractures and you end up with a square crater. On the Moon, it looks like it's a hexagonal fracture pattern that predominates and you end up with hexagons. There are some sharply polygonal craters. But, when you look at their rims in cross section, they're delta-shaped instead of ramp shaped. So I said that there's a good possibility that those are calderas rather than impact craters. We've never been to one so we don't know. I gave a paper on Copernicus once, and I think that abstract has more on that. But those are a minor percentage of the large craters.")

Von Braun's imagined lunar expedition was probably grander than anything that was really possible for a first mission. However, if global politics had not forced the early pace and sequence of space exploration and we had built up capabilities and facilities in Earth orbit before mounting the first lunar expeditions, perhaps we would have gone to the Moon with the intent of establishing a permanent base camp. Indeed, even within the constraints of Apollo, NASA would have liked nothing better than to design and build an unmanned, cargo-version of the LM to support long visits and, eventually, a modest lunar base; but, in the late 60s, with budgets shrinking and dreams being put on hold, all that was really possible was to upgrade the LM design so that crews could land in more heavily-laden versions which would let them stay a little longer and range farther afield.

Of course, NASA had no way of knowing until quite late in the game just how quickly the first landing would be achieved. Most of the people of Apollo had all they could handle in just getting the first generation hardware designed, built, and tested. Consequently, the agency didn't give serious thought to upgrades or to advanced missions until the first-generation designs were ready for test. Only in September 1967 was NASA ready to put some thought into an upgraded LM which would carry - as it turned out - nearly a ton of extra equipment and supplies. Because productivity could only be increased if the astronauts stayed longer on the Moon, supplies of food, water, oxygen, and power would take up much of the increased allotment. However, because

exploration and geologic survey work were expected to be the main focus of the three-day J missions, there were also discussions about taking along an electric-powered car. However, preliminary estimates suggested that there would only be room in the cargo budget for a Rover weighing about 225 kilograms; and it wasn't clear - at least during the Christmas season of 1967 when the first memos were being written - that a reliable, useful vehicle of so low a weight could be built.

According to historian Mitchell Sharpe, the notion of an wheeled, electric-powered lunar exploration vehicle made its first literary appearance virtually at the dawn of the Automotive Age. In 1901, almost as soon as it became plausible to think about driving on the Moon, a Polish writer by the name of Jerszy Zulawski described an early ancestor of the Lunar Rover. Like all those who would follow in his footsteps, Zulawski realized that combustion engines wouldn't be practical on the airless Moon and, rather, chose to power his vehicle with an electric motor. Like most later concepts of lunar rovers - including Von Braun's ten-ton tractor-trailer - Zulawski's was a big vehicle with an enclosed cabin. His, he said, could carry a crew of five and a year's worth of supplies.

For about a half century or so, lunar cars made episodic literary appearances and then, in the years following World War II, they received occasional attention from members of the spaceflight fraternity who were beginning to think seriously about what might be done on the Moon once von Braun's V-2 weapon grew into a real space launcher. Most importantly, people started to think about some of the engineering details - about vehicle weight, power supplies, and traction on various types of surfaces. Naturally, it took real money to move the vehicles out of the conceptual stage and it wasn't until the early, heady days of Apollo - when Congress gave NASA all but a blank check - that the first design contracts were let. There was no immediate need for a rover but, with an eye toward an eventual lunar base, it seemed prudent to make a small investment. The design process might take several years and, in the beginning, progress could be made by teams spending sums as small as a couple of hundred thousand dollars. (For comparison, the whole of Apollo cost about \$24,000,000,000 in the dollars of the time.) A number of contractors (Boeing, Grumman, Bendix, and others) even invested some of their own research money in the interest of having a competitive advantage when NASA decided that it really did want to fly a rover. The culmination of these early efforts was a concept called MOLAB (Mobile Laboratory): a two-man, three-ton, closed-cabin vehicle with a range of about 100 kilometers. In 1964, the Marshall Space Flight Center awarded design contracts to both Boeing and Bendix and, in 1966, both companies built 1/6th-weight prototypes which, early the following year, were put through field trials in the desert near Yuma, Arizona and scientific trials near Flagstaff. However, it was becoming

obvious that a lunar base was very far in the future and that there would be no need for so large a vehicle. After the trials, the MOLAB concept was mothballed but, not surprisingly, NASA turned first to Boeing and Bendix - with General Motors as an additional partner- when it came time to define a lightweight rover for the J missions.

Before proceeding with a discussion of the development of the Apollo Lunar Rover, Dave Scott - the Apollo 15 Commander - urged me to include a story that Jack Schmitt told me about lunar flyers.

"There was a major academic - as well as industrial - competition between the proponents of flyers and rovers. Elbert King at JSC was the in-house proponent of lunar flyers. Geochemists tended to like lunar flyers because they didn't worry too much about the geology that connects individual sample sites. And, those of us who are used to doing field work tended to like the rover because you were in closer contact with the ground, even though you couldn't go as far away from the landing site. Also, from an astronaut perspective, although some of the astronauts sort of liked the idea of having a flyer, I was concerned that you would have a very difficult time in training. We were right in the middle of trying to use the LLTV (Lunar Landing Test Vehicle) and having all sorts of trouble with that. (Three of four LLTV's crashed during training and testing before the end of Apollo). And, here was something smaller that you had to design a trainer for before you went to the Moon. It just didn't seem to make a lot of sense to me. And the issue was finally decided at a conference in Santa Barbara. I don't remember why we had the conference, but Max Faget was there, of all people. (Faget was an almost legendary engineer who headed Houston's Engineering and Development Directorate and who played a major role in the design of the Mercury and Gemini capsule and the Apollo Command Module). And Max finally said, 'You know, when you finally start to design this, people are going to come up with all sorts of good ideas about how to make it safer. And they'll be good ideas. And it'll grow (in weight) to the point that you can't use it.' And that statement, from Max Faget, killed the Flyer. You just never heard of it again. As soon as these proponents figured out Max Faget didn't want the flyer, they figured out there wasn't much point in proceeding any further."

The decision to proceed with a lightweight Rover wasn't made until May 23, 1969, the day that the crew of Apollo 10 left lunar orbit for the trip home. With the first landing now imminent, NASA had hopes of flying the first of the J-missions within a couple of years and, clearly, the Rover would have to be designed and built on a tight schedule. Preliminary design requests had been issued the previous November (1968) ; final design specifications were released on July 11; and, on October 28, a contract was awarded to Boeing. It was a cost-plus-fixed-fee contract initially valued at \$19 million and NASA wanted the first of the flight-ready Rovers delivered by April 1971. Seventeen

months wasn't much time and, as it turned out, meeting the deadline meant a lot of extra people working a lot of overtime. The total cost of the project eventually rose to nearly \$40 million. In a time of shrinking NASA budgets and some fairly widespread disillusionment with Apollo, the cost overrun generated far more press coverage than was warranted by the relatively small size of the Rover program. Some members of the public - not to mention a few Congressmen - didn't understand how three golf carts could cost 40 million dollars. The answer, of course, is that the major automobile manufacturers regularly spent far greater sums developing new model passenger cars and, if only three copies of a new car were ever built, they would be very pricey, too. When the time came, the Rovers performed beautifully and proved to be worth every dollar that NASA had spent.

The Boeing Lunar Rover was a far cry from the ten-ton, closed-cabin, seven-passenger tractor/trailer of the Collier's articles, but it was a nifty little machine nonetheless. Empty, it weighed in at a spare 209 kilograms (460 pounds) and could be folded up and stored (for the trip out from Earth) like an intricate toy. As Dave Scott points out, "the volume into which it could be folded was one of its most significant features," and that volume can be thought of as a sandwich 1 1/2 meters (5 feet) on a side and 1/2 meter (20 inches) thick. One it was deployed on the Moon, it was 3 meters long and 1 1/2 wide, with the tops of the twin seatbacks about 1 1/2 meters off the ground. When fully loaded with two astronauts and all their gear, it weighed a hefty 700 kilograms (1500 pounds). It rode on four wire-mesh wheels and, when fully loaded, had a ground clearance of about 35 centimeters (14 inches). It had four-wheel, all-electric drive with a 1/4-horsepower motor turning each of the wheels. Steering could be done with either the front pair of wheels, the back pair, or with both pairs; and, at low speed, the Rover could be turned on a radius equal to its own three-meter length. Between the seats and slightly forward of the astronauts, there was a small instrument panel containing displays of, among other things, the Rover's speed and also a range and bearing to the last place where the crew had initialized the navigation system - always a place within sight of the LM.

LRV cartoon here

For control, there was a simple T-shaped hand-controller located between the seats so that, if necessary, the Rover could be operated by either member of the crew. Naturally, none of the three J-mission Commanders ever relinquished control - nor did any of the LMP's breach etiquette by asking to drive. The Rover was capable of 10 to 12 kilometers per hour (6 to 8 miles per hour) on smooth, hard, level ground. By most terrestrial standards, of course, 12 kph is hardly a breath-taking speed; but, on the rough, heavily-cratered lunar surface, hazards could and did appear with exhilarating frequency. If nothing else, it was a very bouncy ride.

Although the Rover had been designed, primarily, to give the astronauts mobility and range, it also served as a scientific platform. Each of the Rovers carried a color-TV camera which could be operated remotely from Houston. Because of the high information content of the TV signal, broadcasts were only possible when Rover's high-gain antenna was pointed almost directly at Earth and, generally, the camera were only operated when the Rover was parked. Once a crew reached one of their work stations, they only needed a few seconds to point the antenna and then could go about their work while Ed Fendell ("Captain Video"), the camera operator on Earth, used zoom and pan features either to follow the astronauts as they worked or to supplement crew observations by using the TV to scan the countryside. And, finally, there was also plenty of room on the Rover for photographic cameras, film magazines, tools, sample bags, and, on Apollo 17, a small receiving station for one of the scientific experiments.

The honor of driving the first Rover on the Moon was supposed to have been John Young's; and, indeed, it was he and Apollo 16 crewmate Charlie Duke who participated in preliminary design discussions with engineers from Boeing and NASA's Marshall Spaceflight Center in January 1970. At the time, the Apollo 13 accident was still a few months in the future and NASA had, as yet, only formally announced the selection of one other crew: Shepard, Roosa, and Mitchell for Apollo 14. Nonetheless, Young and Duke, along with the Command Module Pilot Jack Swigert, were then serving as the Apollo 13 back-up crew and, in the normal scheme of crew rotation, were in line for Apollo 16. At the time, it was expected that their flight would be the first of the J missions.

Young and Duke liked what they heard and saw. Boeing had come up with a safe, simple design and the astronauts had only a few substantive suggestions. First, Boeing had given the Rover a pistol-grip control just like the ones the astronauts used to fly the LM and the Command Module. However, Young and Duke pointed out that, on the Rover, they would be wearing bulky gloves and wanted something that would be easier to hold. The pistol grip was replaced with a T-handle. Second, in the interest of providing navigation information so that the astronauts could figure out just where they were, Boeing was proposing a rather complex device which, like a missile guidance system, would provide the astronauts with map coordinates. Given plenty of time and money for development and testing, Boeing might well have produced such a device, but the astronauts were quick to point out that all they really needed was a readout of the direction and distance back to the LM. As it turned out, development of the navigation system still took a lot of time and was a major contributor to the cost overrun; but, eventually, it proved its worth. Not only could the astronauts get back to the LM "on instruments", but, much more importantly, during the traverses they could use the

navigation readouts to help them find particular geology stops.

Through the summer of 1970, Young and Duke and a few other astronauts participated in trials of various Rover prototypes. However, in September, budget cuts forced the cancellation of what was to have been a second handcart mission and the crew that was to have flown it - Dave Scott and Jim Irwin - inherited the first of the Rovers. In November, when Boeing delivered the first training version of the Rover, it was Scott who assumed the controls and, in the rough, volcanic country near Flagstaff, put it through its paces.

Dave Scott was a member of the third group of pilots selected to be astronauts. He was the first member of his group to reach space when he flew with Armstrong on Gemini 8; and was the first of the group to fly a second time when he flew as Command Module Pilot with McDivitt and Schweickart on Apollo 9. He then secured a firm place in line for a landing mission when, in April 1969, he was assigned as Commander of the Backup Crew for Apollo 12. By then, a pattern of crew assignments had clearly emerged. A backup crew could expect to skip two missions and then get the next prime-crew assignment; and there was every expectation that Scott and Irwin and their Command Module Pilot Al Worden would, in due course, be given Apollo 15. When the assignment was finally announced in March of 1970 - Scott says that they knew of the assignment well before it was announced - Scott and Irwin found themselves in the enviable position of having already gone through most flight training procedures for Apollo 12. For their own flight, they still spent plenty of the time in the LM simulators, but they were also able to devote nearly a third of their training efforts to geology and other lunar surface activities and, on launch day, were better prepared to do geology than any crew that yet visited the Moon. And, to top it off, they were headed for a geologist's paradise. Out for a Drive

From a geologic point of view, the Apollo 15 site was of enormous interest. It had a variety of features to be investigated - and it was also spectacularly beautiful. Scott and Irwin were scheduled to land on the fringe of Mare Imbrium (the Sea of Rains), in a small "bay" surrounded by tall mountains. If, during the Apollo 12 approach, Conrad and Bean thought they were skimming just over the mountain peaks, then this was the real thing. Indeed, in the seconds just before pitchover, as Scott flew the Lunar Module Falcon down through 9000 feet, the summit of 11,000-foot Mount Hadley Delta began to fill his window forward and left; and, on the other side of the spacecraft, Irwin could see the summit of Mount Hadley itself, a round-topped, 14,000-foot peak that dominates the local sky line. And, to add a final touch of grandeur to the scene, out the left window Scott could see a long, winding stretch of Hadley Rille, a mile-wide, V-shaped canyon, that seemed to snake toward him from the southeast.

Apollo 15 landing site photo

At pitchover, a scant three minutes before touchdown, Scott got a bit of a surprise. Like most places on the Moon, the Hadley landing area is littered with craters but, as it turned out, few are large enough or deep enough to have early morning shadows. There is nothing that jumps out at you like the Snowman or Cone Crater. Toward the south edge of the landing area, virtually at the foot of Hadley Delta, Scott could see a grouping called the South Cluster and, of course, the rille was out in front of him. But, out in the middle, a couple of kilometers NNW of where Scott wanted to set down, landmarks are few and far between. There are a few moderate-sized craters which, from the pre-flight analysis, looked as though they would have shadows in them at landing time; and Scott had spent time in the simulators learning to recognize them. However, as with the Apollo 14 site, the map and model makers had missed the subtle undulations that make this a rolling countryside and make the identification of small craters difficult at best. Part of the reason was that the Apollo 15 site is well north of the Moon's equator and the photo coverage didn't have the resolution that had been available for the earlier sites; and, the net effect was that, as Scott looked out the window, he couldn't find the patterns he had hoped to see.

Scott would have liked a clear target but, in truth, Apollo-12-style precision really didn't matter much for this landing site. Houston had been watching the tracking data closely and, just before pitchover when Scott was about 6 kilometers east of the target, Houston warned him that he was probably about a kilometer south of the planned track. A quick look at his position relative to the South Cluster and to the point on the rille where it makes a sharp bend at the foot of Hadley Delta gave Scott enough information to show him that Houston's call was a good one. So, he nudged Falcon's line-of-flight toward the north. Without clear local landmarks, he couldn't be certain of setting down right on target, but he'd be close enough that the difference wouldn't matter. He was about the right distance short of the rille (now trending northwest out in front of him); he was just about due north of South Cluster; and he was well out into the middle of the desired landing area. He was certainly within a few hundred meters of the target and, with the mobility that the Rover would give them, a miss of a few hundred meters would be a matter of only a few minutes' drive. The worst that could happen would be that they would spend a few extra minutes during their initial traverse getting their bearings.

In the hours after landing, prior crews had donned their backpacks and had gone outside to do an EVA. However, the timing of the launch and a desire not to thoroughly disrupt their sleep meant that, by the time they landed, Scott and Irwin had been awake for 11 hours and, if they had tried to get in a full 8-hour EVA, would have had to put in a 26-hour day before they got into their hammocks. Consequently,

they planned to spend the next several hours working inside the LM and then to have an eight-hour rest period before going out for the first time.

To fill out landing day, Scott and Irwin gave the scientists back in Houston a thorough description of the surrounding countryside. Rather than restrict themselves to the views out the forward-facing windows, they donned their helmets and gloves for what was billed as a "Stand-up EVA". (Scott now wishes that they had called it a "Site Survey".) Two hours after the landing they were ready. They bled all the air out of the cabin; and then Scott opened the overhead hatch. With that done and the docking hardware out of the way (a daunting task in the tight confines of the LM, Scott stood on the ascent engine cover with his head and arms outside the spacecraft, bracing himself in the opening as he took pictures with a 70-mm camera equipped with a long, 500-millimeter lens. By standing up in the hatch, Scott had a clear view all the way around the horizon.

The rolling nature of the terrain was, of course, even more evident than it had been during the approach and, as might be expected from the lack of deep, fresh craters in the area, in the near field Scott could see virtually no rocks bigger than a few inches across. "Trafficability," he said, looked "pretty good". They might be in for a bouncy Rover ride but, otherwise, it didn't look like they would have any trouble. In the far field, Scott had a clear view of the mountains and, as far as he could tell, the slopes were remarkably smooth. (Silver Spur photo) On Silver Spur, a feature that looked like a hogback ridge on the eastern flank of Hadley Delta, Scott saw lineations which he thought might indicate either structure or layering, but neither there nor elsewhere on the slopes could he see any large boulders. With no haze to obscure the view, his ability to pick out detail was limited only by his eyesight and, at the distance of Hadley Delta, he would have seen boulders bigger than a meter or so across. Off to the north at a similar distance, he could clearly see rocks blasted out of the bedrock at 800-meter-diameter Pluton Crater; but, on the mountains, the slopes were smooth. As Jim Irwin said later at the start of the first EVA, the Hadley site was a bit reminiscent of Sun Valley, the spectacular ski resort in the mountains of Idaho; and, everywhere Scott looked, there were the grey, rounded contours of the mountains and craters and - as it did for other crews - the mental leap from lunar dust to snow came easily.

SEVA photo of Hadley Delta and St George

After a half hour of verbal description and phototaking, Scott climbed down, reinstalled the docking hardware, closed the hatch, and then, along with Irwin, started doffing his suit. For the first time on an Apollo mission, the astronauts would sleep in their underwear, free for a few hours from the damp constriction of the pressure garment. They were the first of the LM crews to have the chance to get really comfortable in the LM hammocks.

During the hours when Scott and Irwin were actually asleep, they slept well that first night. Unfortunately, they didn't get quite as much sleep as they would have liked, but the shortfall was all in a good cause. They'd finished up the prior evening's tasks about an hour late; and then, in the morning, Houston had to wake them up an hour early to check out a small oxygen leak that was soon traced to an unclosed cap on the urine disposal line. It was a problem that was easily fixed and, as Scott told Houston, "the sleeping up here is really good; and if y'all ever see another little problem like that, why, we'd only be too happy to roll over and take care of it. I think, as a matter of fact, we'd even sleep better if we knew that you wouldn't mind waking us." Despite the late start and the early wake-up, they got about five hours of apiece and that was a lot more than any of the prior crews had been able to get.

Preparations for the first real EVA went quickly. Scott and Irwin discovered that they could chin themselves on some overhead guard rails and, while they were hanging, stick both feet into the suit. In one-sixth gravity, it was an almost effortless maneuver and, only four and a half hours after Houston wake-up, they were out on the lunar surface. The first order of business was to deploy the Rover. For this mission, rather than deploy the ALSEP experiments first, Scott and Irwin were going to take immediate advantage of the Rover and make a four-kilometer geology trip to the area where the rille abuts the foot of Hadley Delta. The advantages of the Rover didn't come free of cost, but the price certainly wasn't high in relation to the return. It only took them forty-five minutes to unstow and assemble the Rover and another hour to load it with tools and sample bags.

When he took the Rover out on a brief test drive, Scott was a bit disconcerted to discover that he didn't have front steering but, after a few minutes of fiddling with switches, decided to press on. From his pre-mission training, he knew that he could manage on rear steering alone and two hours after they started cabin depressurization, he and Irwin were rolling. The ride was about as bumpy as one might expect in a rough, roadless land. As Scott described it later in the mission, much of the terrain is so hummocky that, from the low spots, "you can hardly see over your eyebrows". Mostly, they drove along at ten kilometers per hour (10 "klicks"), going in and out of subdued craters, pitching up and down and rolling from side to side. At one point, Irwin joked that Scott's driving was making him seasick.

"What do you expect," said CapCom Joe Allen, "traveling on the mare!".

In reality, the rolling and pitching motions produced nothing like the thrills that they got when they occasionally crested a rise and came upon a crater fresh enough and big enough to give them a heart-stopping jolt. Often, Scott had no time at all to react and, when they hit, the Rover turned into a "bucking bronco" with all four wheels bouncing up off of the ground. Even if Scott did have a little warning, when

he tried to turn hard at any speed above about five clicks, the rear wheels tended break out and threatened to send the Rover into a flat spin. They were both very glad to be wearing seat belts.

The only real problem that Scott and Irwin had with the Rover concerned the seat belts. Prior to the mission, no one had fully considered that, in the light lunar gravity, the suits wouldn't compress very much when the astronauts sat down. Unfortunately, the belts couldn't be adjusted and the fit was very snug. Indeed, buckling up proved to be a significant chore, but was absolutely necessary. In order to complete all of their planned activities, they needed to make good time. Scott needed to stay as close to maximum speed as he could. He could minimize the unevenness of the ride by keeping his eyes on the road, by driving straight through the subtle craters, and by braking before he attempted any evasive turns; but there was still the occasional hard bump. Because of the weak lunar gravity, oscillations in the suspension system damped out more slowly than they would have on Earth and it was always a bouncy ride. It wasn't a fast drive, but it certainly was "sporty" and they were both glad to be wearing belts. Fortunately, there weren't many rocks big enough to bother the Rover nor, as Scott commented at one point, was there much chance of running into other traffic.

In principle, the problem of reaching a planned geology station was straightforward. There were plenty of landmarks on the horizon and, for the first EVA, the most useful of these was St. George Crater, a dramatic, two-kilometer wide scar which had been blasted into the flank of Hadley Delta just above and beyond their destination. The crater was visible throughout the drive and all that Scott really needed to do was aim his nose at it. However, he had a natural, pilot's interest in the performance of the navigation system and, on the outward drive, he and Irwin attempted to put it to use.

Because the navigation gave them a range and bearing to the LM, the first order of business in finding a specific spot on the map was to figure out just where they had landed. Any uncertainty in the LM location translated directly into an uncertain Rover location. Scott thought he knew where he'd landed but, as they drove along, Irwin wasn't having any luck matching craters they passed with ones on the photomaps. Of course, even if they had known exactly where they had landed, map reading was difficult because (1) there were few large and/or distinctive craters close at hand, (2) judging crater size was inherently difficult, and (3) the maps had been derived from photos of relatively poor resolution. So it was perhaps not surprising that Irwin was still figuratively scratching his head when, thirteen minutes and about a kilometer and a half into the drive, they came - quite unexpectedly - upon the rille. It was immediately obvious that they were well north of where they thought they had been. Looking down the trend of the rille toward the southeast they could see where it bends sharply to the west;

and, on the near rim, they could see their immediate target, the appropriately named Elbow Crater. Scott's first thought was that somehow they had been heading too much to the west; but, for now, the details didn't matter. As soon as they reached Elbow, the folks in the Backroom (as the Science Support Room was called) would be able to use the range and bearing at a known place to sort everything out. In the meantime, Scott and Irwin could see where they wanted to go and, so, turned south and drove along the edge of the rille. They reached Elbow Crater about ten minutes later.

During this first EVA, Scott and Irwin planned to spend a bit over an hour doing geology field work: fifteen minutes or so at Elbow and the rest up on the hillside near St. George. Although the scientific community had not yet developed a consistent description of lunar evolution, it was generally believed that the mountains at Hadley had been uplifted roughly four billion years ago as a result of the giant impact that formed the Imbrium Basin. During the first few minutes of that impact, great blocks of rock at what is now the edge of the basin were pushed up and out, forming the mountain cores which were then covered with Imbrium ejecta. Hadley cross section from the Sourcebook

(During our review of this Apollo 15 summary, I asked Jack Schmitt how much of the South Massif is rotated block and how much is ejecta covering? "Nobody knows. But probably not a lot, relative to the height of the mountain. For the big basins, what probably happens is that you get down to depths where lithostatic forces can compete with the force of the explosion and you get a lot of lateral motions and you get multi-ring collapse because of the waves that are set up. If there were a lot of ejecta covering the mountains, you wouldn't see the rings. On Orientale, which is our best example of a fresh, multi-ring basin, you still see...In fact, you see mare formed inside the rings. Certainly the tops of the mountains have a covering of ejecta. And, also, I think we know from (Apollo 17) Station 6, that some of the impact melt will be injected into the fractures that form under the crater.")

Over the first few hundred million years that followed the Imbrium impact, the basin filled with lava, apparently a thin sheet at a time. At any one place, a relatively long time may have passed between successive filling episodes; but, by three to three-and-a-half billion years ago, the lavas stopped welling up from the interior and the mare-forming epoch ended. After that, only the steady rain of impactors produced any change, creating a five-meter cover of regolith on top of the lava flows, and adding, as well, to the regolith that had been forming on the mountain slopes. The Apollo 11 and 12 sites had yielded representative samples of the basaltic lavas underlying the Sea of Tranquillity and the Ocean of Storms, respectively; and, at Elbow Crater, Scott and Irwin expected to find samples of Imbrium basalts. And then, up on the hillside at St. George, geologists hoped and expected to find samples of ancient lunar crust which,

rather than having been strongly shocked and altered like the Imbrium ejecta that Shepard and Mitchell sampled at Frau Mauro, had merely been displaced upward and outward from the center of Imbrium.

As Scott and Irwin got to work at Elbow, it soon became obvious just how productive the J-missions were going to be. At this, their first stop, they were over three kilometers from the LM and, yet, had plenty of cooling water, oxygen, and time for field work. They had plenty of tools, sample bags, core tubes, and film; and, most importantly, they were starting work feeling well rested. For ten minutes or so, they gathered rocks and soil, describing features that the TV couldn't capture and taking plenty of photographs. And then it was time to move on.

"I wish we could sit down and play with these rocks for a while," Scott said as they loped back to the Rover. "Look at those things!" Then, like Bean before him, he stopped to admire the glistening face of a particularly handsome rock. "They're shiny. Sparkly! Look at all these babies in here. Man!"

"Come on, Dave," said Irwin, playing Conrad's role of time manager. "There'll be lots of them. Let's get back [to the Rover]."

But Scott wasn't to be denied. "Can't resist it," he said, and it was only after he'd collected the rock that he was ready to "go find something neat in St. George". During training, Scott had become fascinated with geology and his enthusiasm was not to be denied.

A short distance beyond Elbow Crater, they began to climb up the flank of Hadley Delta. They weren't going to go all the way up to the rim of St. George. That would have required a significant cross-slope drive and, for the moment, all they needed was a point high enough that they could be sure of being up off the young, mare materials. As the Rover began to climb, their speed began to drop. Seven minutes from Elbow they found what they wanted: a meter-sized boulder sitting on the hillside about fifty meters above the valley floor.

What Scott and Irwin were looking for were coarse-grained crystalline rocks called anorthosites which had cooled slowly at depth not long after the Moon had formed. What they discovered was that the boulder was a close cousin to the rocks Shepard and Mitchell had brought back from Frau Mauro. It was a composite, heterogeneous rock called a breccia which had formed when a jumble of rock and soil fragments was fused together, probably by the Imbrium impact or by an even earlier, large impact. Because the first sizable rock they found on the mountain was a breccia, there was a good chance that breccias would be common and anorthosites, perhaps, would be rare. But only a complete set of samples would tell the tale of the mountain and, so, Scott and Irwin wielded rakes, scoops, cameras and sample bags, hammered a double section of core tube into the soil, and even turned the boulder over so that they could obtain

samples from beneath it, samples which might tell just how long the rock had been lying where they found it.
photo of the rille from St. George

The view from the slopes of Hadley Delta can only be described as spectacular. Thanks to the Rover-mounted TV camera, Scott and Irwin could share the view with watchers back on Earth. Off in the distance, Mount Hadley and the hills west of the rille gave the horizon a distinctive personality - missing at the earlier landing sites - and provided visual balance to the winding, sinuous rille which trends north away from the mountain. Because it was still early morning at Hadley, the eastern wall of the rille was in shadow. In contrast, the western wall and, in places, parts of the floor were fully lit. Because of the relatively low resolution of the TV camera, audience back on Earth couldn't see all of the detail that the astronauts could see; but, still, it was beautiful and, everywhere in the bottom of the rille, the floor was littered with boulders big enough to be seen by all.

By the time they were done, Scott and Irwin had spent fifty minutes at St. George. It was, by far, the longest and most productive geology stop that had yet been performed by an Apollo crew. Well-trained and well equipped, Scott and Irwin were able to make the most of the limited time and, as well, had the help of people back in Houston who could, for the first time, not only hear what they were saying but also see what they were doing. The geologists on Earth couldn't see minerals and textures in the rock but they could see how the work was going and, thereby, offer credible, real-time advice.

As they climbed back on the Rover, Scott and Irwin had three options for getting back to the LM. When they first reached the St. George station, CapCom Joe Allen had asked if they could see their outbound tracks, wondering if they'd be able to do the "Hansel and Gretel trick" and follow the tracks home. Scott laughed and reported that he'd already checked at Elbow and had no trouble seeing where the Rover had disturbed the otherwise pristine lunar surface. On this first visit to the site, with no other tracks to confuse the picture, there would be no doubt about finding the LM. And even without tracks, the surrounding mountains provided enough landmarks that they could have gotten close enough to the LM to see it. However, everyone was interested in putting the Rover navigation system to the ultimate test and, as Scott pulled away from the St. George station, he planned to drive as straight a line back to the LM as the craters and other obstacles would let him.

For the first part of the drive, Scott had to drive downhill. That meant that he had a clear view of the ground ahead of him and, therefore, a chance to comment on things a bit farther afield. In particular, he was eyeing the slope off to his left. When he and Irwin got their first look into the rille, it was quite obvious that the rille wall below Hadley Delta was covered with fine debris. There seemed to

be few, if any, boulders and Scott thought that it might be a place where someone could drive down into the rille - if not back out. From this closer vantage point on the hill side, Scott reported that the slope still seemed to be smooth and boulder-free, and he told Houston that "if anybody ever comes back, Joe, and wants to go down into the rille, have them come talk to us, because there's a good place to do it here." Perhaps he could have driven out of the canyon by making a series of switchbacks, but this wasn't the time to try. Indeed, it wasn't a minute later that he found out just how much there was to learn. On the way down from the St. George, as he crossed a slope only a little bit flatter than the one he'd just been eyeing, he got going a bit too fast, tried to avoid an obstacle, and "did a 180". Thinking back to Irwin's comment about Sun Valley, Scott decided that he'd just done the first lunar "christie" - and said so. It was a longish moment or two before he and Irwin stopped laughing and got going again.

If there was any residual doubt about the Rover navigation system it was answered just five minutes out of St. George when Irwin spotted a reflection off the LM. The spacecraft was dead ahead, a sharp little gleam on the horizon. It was a comforting sight out in the middle of the wilderness.

Scott and Irwin got back to the LM at about four hours and twenty minutes into the EVA and planned to spend the remainder of the EVA deploying the ALSEP experiments. In all, they planned to be out for a total of seven hours. However, for unknown reasons, Scott was using oxygen faster than had been expected and, once he was back at the LM, Houston suggested that he "do as little unnecessary moving around as possible". Scott was quick to point out that, for most of the remaining time, he was supposed to drill three deep holes into the lunar surface - two for a heat flow experiment and one for a deep core - and, as everyone knew from training, the drilling promised to be hard work. Indeed, it was probably the most demanding physical work that either of them expected to do. Houston would keep a close watch on his oxygen supply.

In most respects, Scott and Irwin had relatively little trouble with the ALSEP deployment and, with the exception of the drilling, they completed the work in about an hour and a half. If things had gone according to plan, Scott would have spent about a half an hour doing the drilling, emplacing the heat-flow thermometers, and disassembling the six deep core sections; but almost nothing about the drilling seemed to go right. On Apollo 16, Charlie Duke drilled his first heat-flow hole to the full 2.5 meter depth in one minute flat; and, on Apollo 17, Gene Cernan drilled his in a bit under three. However, both Duke and Cernan had the advantage of equipment which had been extensively modified as a result of what turned out to be a very frustrating experience for Scott.

At the start, the drilling went well enough but, after getting down 20 or 30 centimeters, Scott reported that the ground was getting 'stiffer" and that his rate of progress was slowing dramatically. After about five or six minutes of effort, he only had the drill stem about 170 centimeters into the ground and, as far as he could tell, it seemed as though he'd run into hard rock. Unbeknownst to Scott or anyone else, the problem wasn't hard rock but, rather, a fundamental flaw in the design of the drill-stem flutes. When the drill stem was turning and cutting, the flutes weren't carrying the cuttings to the surface but, rather, were getting clogged, thereby binding the stem tightly in the hole. When Scott said that he didn't think he would be able to get any deeper, Houston decided that this first heat-flow hole was deep enough and told him to emplace the probes before moving on to the second hole. In order to do that, Scott first had to detach the drill from the stem and, when he tried to turn the drill counter-clockwise to break the connection, the stem twisted freely in the hole. He then took hold of the stem with one hand and tried to turn the drill with the other, but it soon became obvious that the two were virtually frozen together. Scott struggled for a couple of minutes before Houston suggested that he get the "wrench" off the Rover and use it to get a better grip on the drill stem. It took a minute or so before Scott and Irwin figured out that "wrench" was the piece of equipment they knew as the "vise" intended for the separation of core sections. Much to everyone's delight, the vise did the trick. Scott offered heartfelt congratulations to the people in the Backroom, obviously glad to have finished this surprisingly difficult hole. The first hole should have taken no more than five minutes, but it consumed a quarter hour of precious time.

Any hopes that Scott may have had about the second hole were quickly dashed. As with the first hole, he managed to get the drill stem down about 170 centimeters but then no farther. With time running out, Houston told Scott that they wanted him to abandon the effort, at least for this EVA, so that he could help Irwin set up one last piece of ALSEP equipment and then head back to the LM for close-out. Tomorrow, after they had finished their second traverse and the drill experts had a chance to think things through, they could give it another try.

By the time they were ready to leave the ALSEP site, Scott and Irwin were about six hours into the EVA and, because of the status of Scott's oxygen supply, Houston wanted them back inside the LM in about thirty minutes more. Scott was eager to make the best use of that time as he could and suggested that they not bother with the seatbelts for the short drive back to the LM. He would drive slowly, he promised. Minutes were precious; and they would gain about three minutes by not fiddling with the belts and only lose one or so by driving at a slower speed. Back at the LM, Scott saved a little more time by not turning the TV on.

In all, these little economies probably saved about five minutes, which Scott then put to good use at the very end of the EVA. Once he'd finished all his planned close-out activities and had sent Irwin up the ladder, Scott asked Houston if there was anything else he might do. Rarely at a loss for suggestions, Houston was quick to ask that he erect the solar wind experiment. This was a job that Irwin was scheduled to do at the start of the second EVA and, indeed, when Scott reminded Allen that he hadn't handled the equipment since he and Irwin had finished their Apollo 12 backup training two years before, Houston backed off the suggestion. However, Scott was not about to waste precious EVA time by dawdling or by climbing the ladder early. So he asked Irwin, who was up in the LM getting sample bags out of the way, if he could look out the right-side window and talk him through the procedure. Why not get the equipment deployed now, he said, and give the experimenters lots of data?

"Okay," Irwin told him. "Just take it out about 50 feet."

"Okay. Right about here, huh?"

"Farther, if you want. Yeah. And just pull the tube out full. Careful when you get to the end, that little thing popped off the end."

"Okay"

"Just pull it on out."

"Okay."

"And [be] careful, when you rotate the screen, that you rotate in the right direction, so it doesn't pop off. Just extend the tube several sections."

Because of the thick gloves, Scott couldn't feel the sections lock, but he should see red marks come into view at the proper extension.

"Okay. Red. Red. Red. Red," he said. "Okay. That's easy enough."

Now he had to extend the actual collecting screen like a window blind.

"And make sure you get the bottom of the screen - not the wire - over the loop," Irwin told him.

"Okay I see that. The bottom of the screen is over the loop. It says 'Sun', Scott said, obviously pleased with himself. "I guess that means that's what you face the Sun, doesn't it?"

"Isn't that a neat experiment?", Irwin asked him.

"Yes, that's the kind of experiment I like. Okay, we're out here at good distance where it won't get any dust on it from the Rover. And I'll turn it into the Sun here; stick it in the ground."

After the drilling, it was nice to have a job so simple and satisfying. The lightweight pole, Scott told Houston, would make a "good core tube". It went into the ground easily. And with that he was done.

"Okay, Joe, solar wind is deployed." The five minutes were gone.

The day hadn't quite gone the way Scott would have preferred. There had been problems and he and Irwin had been forced to delete planned activities. What Scott really wanted to do was some geology and some driving, and the oxygen situation was getting in the way. Was there anything he could do about the oxygen use, he asked Houston? Was there a zipper that could use some extra lubrication, just in case there was a small leak? No, said Houston, it didn't look like a leak. It looked as though he was burning oxygen at higher than expected rates both while he was working and while he was driving.

"Okay," he said, "I'll breathe a little less tomorrow.

But there wasn't a need for anything so extreme, Joe Allen told him. He and Irwin had just set a bundle of new EVA records: six hours on the surface and a productive, two-hour, three-kilometer geology trip. If they managed another couple of EVA's like the first, then nobody was going to complain.

The Apollo 17 Lunar Surface Journal, Part 9b
 Apollo 15: The Genesis Rock

As Jim Irwin mentioned later in the mission, "the secret of living up here [in the LM] is getting out of these suits. It really makes a difference." After a full day's EVA, it was a great relief to be rid of the constant chaffing and rubbing, free to stretch arms and legs and flex fingers without constant backpressure from the suit, and free to let your underwear dry out. Like most things, freedom from the suit came at a price, and that price was the loss of elbow room. One-sixth g can be fun and restful but, except when they were in the hammocks, it was difficult to make much use of the low gravity within the confines of the LM. The cabin was a place to eat, a place to repair and prepare equipment with unencumbered fingers, and a place to sleep.

It was nice to be out of the suit; but, in the morning - rested and dry - they were eager to get going again. During training, Dave Scott had developed a real love for geology and the new day promised to be the sort he could really enjoy. As it turned out, it was one of the more memorable days of the whole Apollo program.

The need to finish the second heat-flow hole hadn't gone away, nor had the deep core; but, as had been discussed before Scott and Irwin bedded down, Houston was willing to defer those tasks to the end of the EVA. As planned, they would spend the first part of the day driving south again in the Rover for about four hours of exploration and sampling. Scott believed that he'd gone to the Moon primarily to take advantage of the Rover, and the less time the Rover spent parked at the LM or the ALSEP site, the better he liked it.

By the time Scott and Irwin were out on the surface and were ready to drive off, it may have seemed as though their luck had turned a bit. They had been forced to spend a little extra time prior depressurization cleaning up a few gallons of water that had spilled on the floor the previous night after a plastic part broke off their water gun; and they'd had to use tape to re-attach Irwin's backpack antenna which had broken off when he crawled back into the LM the previous night. But they'd been able to take care of both problems in short order and now, much to Scott's delight, they found that the formerly inoperative front steering was now working.

"You know what I bet you did last night, Joe?" said Scott to his CapCom. "You let some of those Marshall guys come up here and fix it, didn't you?" Perhaps, he suggested, Boeing had built a secret launcher so that engineers from Boeing and from Marshall could come up to the Moon "to fix their Rover".

Three and a half hours after wake-up and an hour after depressurization, they were rolling. It took Scott a little while to adapt to the new steering and indeed, after a few minutes, he decided to stop and switch to front-wheel

steering alone. The vehicle, he said, was much too responsive, especially when he was going downhill. However, he soon discovered that, with front-wheel steering, the rear wheels seemed to be drifting rather than centering properly. Four-wheel steering was better than two, it seemed, and it wasn't going to take long to adapt.

To start this second trip, Scott drove almost due south toward one of a handful of medium-sized, fresh craters on the lower slopes of Hadley Delta. With luck, they might find some of the unaltered samples of the ancient crust that had eluded them at St. George. The chances of finding fragments of bedrock depended, of course, on finding a crater both big enough that the impactor would have penetrated through the regolith and young enough that the fragments hadn't been re-buried by the same downhill movement of material that had smoothed the rille walls below St. George.

As they drove south, the mountain dominated the view. To Scott, it seemed "as big a mountain as I ever looked up." The lower slopes averaged about 8 to 10 degrees but, above them, the mountain sides steepened and rose nearly as far and nearly as fast as the slopes of Mt. Fuji in Japan. It was a rise of three-and-a-half kilometers in a horizontal distance of no more than seven, a slope of about 30 degrees. Because most of the mountain is so steep, any material dislodged by impacts will tend to tumble at least a short distance downhill and, as Scott and Irwin approached the place where the mountain and the mare meet, they noticed a clear change in the nature of the surface. About three hundred meters before they reached the base of the mountain, they noticed that the number of deep craters was dropping dramatically and that there seemed to be far fewer small rocks lying on the surface. Burial by talus that had tumbled down from the mountain - or by ejecta from impacts on the mountain slopes - seemed the most likely explanation.

Right at the base of the mountain, Scott and Irwin drove into a shallow east/west trough, a depression which can be interpreted in at least two different ways. According to one theory, during the mare-filling period the cooling lava shrank and pulled slightly away from the mountain. The resulting gap was then smoothed by impact erosion and partially filled by material tumbling down off of Hadley Delta. According to the second theory, the mountain has been subsiding ever since it was raised in the Imbrium impact and, therefore, the theory says, the depression marks the bounding fault, a moat that is partially filled in as it opens - again - by debris tumbling off the mountain.

Apollo 15 traverse map here

As they had from the LM, Scott and Irwin kept an eye out for fresh craters and boulders on the hillside but, even as they got closer and could pick out more detail, there was little more detail to see. Other than Spur Crater, a fresh, 40-meter feature where they planned to do most of their sampling, the only striking object that they saw while driving south from the LM was a large boulder a short way

upslope from Spur. Otherwise, the hillside had the appearance of a dry, sandy, well-used beach covered with soft hummocks and with poorly-defined, shallow craters.

The mission plan called for Scott and Irwin to climb the hillside a bit west of Spur and then turn to the east and make a three-kilometer drive roughly along a contour line. That would give them a chance to see what variety of samples were available before making a sampling stop at the far end of the traverse. They then planned to retrace their tracks, stopping once about halfway back to Spur and then, finally, at Spur itself. However, because the drilling wasn't done and because of Scott's oxygen use rate, time was at a premium and Houston asked them to think about the relative value of driving versus sampling. It wasn't very long before Scott and Irwin satisfied themselves that, except near the few fresh craters already marked on the map, any one part of the hillside was going to look pretty much like any other. They had been angling up slope - having passed Spur Crater on their right - and now were on about the same level as the boulder and about three hundred meters east of it. There didn't seem to be much point in driving farther east. It looked as though they could get representative samples here as well as anywhere else. So, they parked the Rover and got busy with what proved to be a long and very productive geology stop.

Working on the hillside took some practice. Without the suits, they might well have spent much of their time standing sideways to the slope, with the uphill leg bent a little to keep themselves upright. However, in the stiff suits it was difficult to stand sideways for very long and, most of the time, they had to stand facing into the mountain and leaning into it. As they soon discovered, work on the hillside was possible only because the soil was soft enough that their boots sank in a way, giving them extra purchase. In addition, they could sometimes use a small crater as a step or bench on which to stand. Indeed, they made life a good deal easier for themselves when, about twenty minutes into the stop, they moved downslope about 15 meters from the Rover - and about three meters vertically below it - to a flat-floored, 12-meter crater where they could work without fighting for balance.

After an hour's worth of basically pleasant, rewarding work, Scott and Irwin were ready to move on. They had collected a large number of samples, most of them reminiscent of the Frau Mauro breccias. They had dug a trench, and had taken panoramas and telephoto pictures of Mount Hadley and of the LM. Scott had even had the novel experience of getting a core from the rim of the 12-meter crater merely by pushing the tube with his hand into the soft, loose soil. The only really difficult part of the experience, they found, was climbing back up to the Rover. Scott, who has been described to me as a "moose", bulled his way up the slope while Irwin took his time. When Scott laughingly said that "I'd sure hate to have to climb up here [from the base of the hill],",

Irwin seconded the thought and suggested that they "work above the Rover from now on." Fortunately, once they were back on the Rover, both of them could relax for a few minutes before they had to climb off and work on the slope again.

As they approached the big boulder a few minutes later, Irwin decided that, here at least, it might not be such a good idea to park downhill of the work site. The rock was about a meter high, a meter wide, and about three meters long and, although it was partially buried and obviously had been sitting right where it was for millions of years, it was still easy to imagine the rock sliding down on them or the Rover. The rock was perched on a slope of about 15 degrees, the steepest they'd encountered, and prudence seemed in order. Scott parked about 15 meters west and slightly uphill from the boulder, but it wasn't long before the slope made them think again.

They both had difficulty getting out of the Rover and, once he was on his feet, Scott had trouble finding a good place to stand as he tried to point the high gain antenna at Earth. Houston began to wonder if, once they got down to the boulder, they could get back up to the Rover. CapCom Joe Allen urged caution.

"Hey, troops", he said, "I'm not sure you should go downslope very far, if at all, from the Rover."

"No," Scott told him, "it's not far."

The only way to find out if they could make it was to try, but Scott wanted Irwin to stay with the Rover while he scouted the slope.

Irwin offered encouragement. "I think we can sidestep back up," he said.

"It's not that hard," said Scott, still edging down toward the boulder.

Houston was usually cautious about offering advice to the crews but this was clearly an unusual circumstance and Allen firmly suggested that Scott try climbing back up before he got too far. Scott agreed that was a good idea. "Okay; I'm halfway, and I'll go back first. Why don't you just stay there, Jim?"

"Okay," said Irwin. "Come back up."

"The Rover makes [this slope] feel so easy [to climb]," said Scott.

"I know it," Irwin said. "[We] should have parked right beside it."

And that sounded like the best idea. Scott came back up to move the vehicle. Irwin decided that it would be easier for him to walk down to the new parking place rather than try to climb into his seat. Because of the stiffness of the suit, getting on board meant standing at the side of the Rover and jumping sideways into the seat and, on this slope, that wasn't going to be easy. Irwin had been watching Scott carefully and was confident that he could get downhill without trouble. Once Scott had gotten himself on the Rover, Irwin started down but, before he'd moved more than a few steps, Scott told him to stop. It was going to be easiest

for Scott to put the Rover in reverse gear and back up for a few feet before he turned downhill and he wanted Irwin to watch and wait until he had the Rover securely parked again.

Again, Allen urged caution. "Proceed very carefully now, please, " he said.

"Oh, we are", said Scott. "We're doing it really cool."

"Super cool," suggested Allen.

"Super cool," agreed Scott.

"How am I doing, Jim?", he asked as he backed.

"Doing okay. Want me to come over there and get on?"

"No, no. Stay there."

Slowly, Scott turned downslope, first headed west and then looping east below Irwin's position. He drove along the hillside a bit further until he was past the boulder, still above it slightly, and then turned down the hill again to complete an S-shaped path. He parked the Rover just a bit below the rock and to the east.

photo fo the 6a boulder

Scott still wasn't too sure that they'd be able to work around the boulder. The Rover was perched so precariously that the left-rear wheel was a good six inches off the ground and Scott decided that it wouldn't be prudent to leave the vehicle, just in case it decided to roll downhill on its own. He suggested that they abandon the effort.

No matter what they did next, Irwin had to pass the boulder on way down, so he stopped to take a picture. Then he noticed that the boulder seemed to be light-green in color and offered to come down and hold the Rover so that Scott could go up to take a look. A green rock was novel enough that Irwin wanted to make sure that the better geologist of the pair had a good look at it. Scott agreed instantly. Irwin climbed down and, once Scott was sure that Irwin was standing comfortably and had a firm hold on the Rover, he climbed up.

The boulder was green, all right, and a breccia as well. Scott grabbed a few fragments which, once they were examined back on Earth, proved to be full of iron-rich and magnesium-rich glass which produced the green tint. Scott also collected some of the surrounding soil which, as Irwin had noticed, also had a greenish cast. For about six minutes, Scott worked around the rock and then, gingerly, made his way back to the Rover. The slope made the work strenuous and, in hindsight, not much of scientific value would have been lost if they had abandoned the boulder. As it turned out, they found similar rocks once they got downhill at Spur. However, from an operational point of view, it was useful to know that, with some care taken in parking the Rover, it would be possible for crews to work on slopes at least as steep; and, indeed, the Apollo 17 crew spent most of their third EVA working on steeper slopes.

As he reparked the Rover, Scott had taken care to point it downhill, in hopes that it would make getting on easier. Irwin suggested that Scott get on first while he kept his grip on the Rover. Scott made it on the first try but

suggested that Irwin wait where he was until Scott had driven downhill a short ways to a small crater where he could get the Rover level enough that Irwin could jump on easily. Irwin even said that he'd be willing to walk the whole 300 meters down to Spur, but Scott vetoed the idea and, indeed, with the Rover level, Irwin had no trouble. For a second time, the crew of Apollo 15 proved the operational value of small craters.

Spur Crater is big enough that the north (downslope) rim provided a big, nearly-level parking pad and the work at this stop was relatively easy. It was also very rewarding.

One of the first things that Scott and Irwin noticed was that they were standing on more of the greenish soil. Irwin began to wonder if the greenish appearance might not be due to their dark visors. What if they got the rocks home and they weren't green after all? The ribbing would be merciless.

"I've got to admit it really looks green to me, too, Jim, but I can't believe it's green," said Scott.

"Oh, it's a good story," said Irwin, laughing.

"Something about green cheese? Who would ever believe it?".

Independently, Scott and Irwin decided to try the obvious experiment and raised their visors. As their eyes adjusted to the brighter light, the greenish tint faded a bit but, as Scott said, it was definitely "a different shade of gray." Two soil samples went into bags - samples that still had a greenish cast when they were examined after the mission - and then the astronauts turned their attention to other matters.

About fifteen minutes into the stop, as they were scanning the rim to make sure that they were getting a full suite of samples, Irwin spotted a four-inch rock that glinted in the Sun, sitting up by itself on a pedestal of breccia. It seemed to beckon, Irwin thought, and to say "come and sample me." As they looked more closely, there was no doubt about what they had found. Here was a crystalline rock made up almost entirely of the mineral plagioclase; and it was very different in character from the breccias and mare basalts that they had collected so far.

"I think we found what we came for," Irwin told Houston.

"I think we might have (found) ourselves something close to anorthosite," Scott said with some satisfaction, "because its crystalline, and...it's just almost all plag(ioclase). What a beaut."

Back on Earth, while Scott and Irwin were carefully bagging what came to be known as the Genesis Rock, commentators lost no time in trying to come to grips with the significance of the find. Once the great Moon Race had been won, America's interest in Apollo had declined fairly quickly and, by this time, all that was left in the public mind was a question of the Moon's early history. The Apollo 11 and 12 crews had brought back the mare samples with which geochemists dated the great lava floods that made the mare; and the 14 crew had brought back the breccia samples which

confirmed general impressions about the age and composition of the ejecta from the large basins like Imbrium. What remained to be found was a pristine fragment of the ancient crust and, in laymen's shorthand, this became the search for the "oldest rock." In some ways, the "oldest rock" took on characteristics of the Holy Grail and the Rosette Stone and its discovery was seen by many as the final Apollo task. There would be two more flights to fill in a bit of the detail; but, in the public mind, the quest was now over. Fortunately, NASA had no plans for Scott and Irwin to rush home if they did find an "oldest rock". One anorthositic rock from one site could not tell the whole story. As it turned out, even the Genesis Rock had been shocked at least twice in the four billion years or so since it slowly solidified deep within the lunar crust and, at the Apollo 17 landing site, Cernan and Schmitt found an even older fragment of the Moon. Still, the Genesis Rock was an important piece of the puzzle and Scott and Irwin were well pleased with themselves. They had spent time during training learning to "sort the unusual from the usual," as Dave Scott later said; and, in particular, had learned how to recognize anorthosite. They had been primed to look for it; and, after only three hours in the field, they found some.

During their stop at Spur, Scott and Irwin actually collected four pieces of anorthosite, with the Genesis Rock being the first and largest. Along with other tool, the astronauts had a large rake which looked and worked like a clam rake. Here at Spur, Irwin dragged it through the soil several times, trapping rock fragments of walnut size and bigger in the basket and letting the soil and smaller fragments flow out between the tines. In one two-foot-long swath, he got a remarkable total of 15 fragments - a real "jackpot" as Joe Allen called it - and his total collection proved to include not only three more pieces of anorthosite but also samples of breccia, some fragments of basalt which had probably been tossed up to Spur from the mare below, and also some "exotic" fragments thrown onto the site from even farther away.

The stop at Spur was one of the highlights of the entire Apollo program and, during the trip back to the LM, Scott and Irwin got a momentary fright when, during a hurried stop at the South Cluster, Scott noticed that Irwin didn't have a sample collection bag on his backpack. Convinced that Irwin's bag had dropped off somewhere back along the track, Scott quickly reassured himself that he'd been careful to put the collection bag with the "good rocks" under the Rover seat before they left Spur.

"Oh, well, win a few lose a few," he said.

There was certainly no time to go back and look for a dropped bag, even though the Rover tracks would show exactly where they had been. And, as it turned out, Scott was mistaken about the "lost" bag. As they were preparing to mount the Rover once more, Scott remembered that he hadn't

bothered to put a fresh bag on Irwin's back before they left Spur.

"Boy, you had me worried," said Irwin.

"I had me worried too. I knew [I hadn't lost] the one with the good rocks because I stuck that in the seat pan. But I thought I had put [a new] one on you, and now I remember I started to put it on you, and your harness looked loose, so I stuck it on the [back of the Rover] where it's got a lock. So we're okay."

And then Joe Allen offered a bit of apology. "And we knew all the time, Dave," he told them. "We should have told you. Wanted to keep you honest though."

The drive back to the LM was uneventful and, indeed, was a nice break in an otherwise busy and productive day. There were plenty of descriptions to pass along to Houston - descriptions of the samples, of their impressions of the sites, and of Mount Hadley out beyond the LM, but it was hardly physical work.

"Gee, it's nice to sit down, isn't it?," Scott prompted Irwin.

"Oh, it is."

"It's a good deal," Scott said, laughingly. "You hop off and work like mad for 10 minutes and hop back on, sit down, and take a break." It was a great way to do lunar geology, especially with more drilling awaiting them back at the LM.

From time to time during the drive, Scott and Irwin could see the LM out in front of them. From their station at Spur - about 60 meters above the spacecraft and, of course, nearly five kilometers to the south - they could see sunlight glinting off of it and were pleased to note that, with the nose of the Rover pointed at the LM, the bearing and heading indicators agreed precisely. Neither of them felt comfortable judging distance yet. Without familiar objects to help them - trees, telephone poles, houses, and the like - it was almost impossible to judge sizes and distances and, during the drive home, Scott threw in the towel. "I don't know how large 'large' is anymore," he said. But at least there wasn't any doubt about the Rover navigation system. At 2.4 kilometers out - according to the navigation system - they began to see details on the LM. Four hours after they set off for the mountain, they were back at "home, sweet home", 85 pounds of rocks and soil richer.

If the first part of the EVA made for the sort of geology-rich day that Dave Scott could really enjoy, the drilling promised to be his penance. And for Jim Irwin, the cost of the honor of having spotted the Genesis Rock was a set of soil mechanics experiments that he would perform while Scott did the drilling. Irwin almost wished that he could trade jobs; the instructions for the soil mechanics experiments filled five full pages on the cuff checklists. In comparison, the tasks for a geology stop usually only filled two pages.

As Scott told Allen: "Before we got out this morning, we figured you guys had a conspiracy against us, having Jim

doing...(the soil mechanics experiments) and me drilling at the same time."

The soil mechanics experiments were designed to give the engineers detailed information on the stability and load-bearing characteristics of the regolith, information that would be useful in planning for an eventual lunar base. The engineers had, of course, been able to deduce a good deal of such information from the depth of footprints and Rover tracks, the depth to which core tubes could be pushed and/or hammered, and the stability of the walls of trenches dug by the crews of Apollos 12 and 14. Here at the Apollo 15 site, Irwin would supplement those inferences with quantitative measurements made with an instrument which recorded the amount of force that he needed to exert to penetrate the soil with a thin, cone-tipped rod. As it turned out, the soil was about as hard and compact as any encountered by Apollo crews and that fact, in hindsight, suggests that Scott was not only fighting a poor drill stem design, but was also drilling into intrinsically stiff dirt.

Not surprisingly, NASA's experts had been thinking about the drilling problems ever since Scott abandoned the effort the night before and now suggested that he run the drill for a short while without pushing down on it. Then, if he noticed it starting to bind again, they wanted him to try raising the stem a little bit to clear the flutes. Unfortunately, even with Scott just holding the drill as lightly as he could, it bound up almost immediately and, as well, he found that it took a great deal of effort to pull the stem up even a short distance. With the power on, he said "it pulls me right on down with it." By straining for all he was worth, Scott managed to lift the assembly a few inches; that seemed to help for a few seconds, but then the drill bound up again, even tighter than before, like a "steel vise."

Scott's hands were beginning to give out and it wasn't long before Houston decided to call it quits again. Perhaps, they all thought, they'd made a little extra depth. However, when Scott tried to insert the heat flow probe, it wouldn't go deeper than about 100 centimeters. What had happened was that, when he lifted the stem part way out of the hole, the bottom section stayed bound in the hole and separated from the next one up. And when he started drilling again, the second section deflected to the side and became firmly wedged against the first section. In short, Houston's suggestion had only made matters worse. Fortunately, although the heat-flow experimenters had to take extraordinary care in interpreting the data from the second hole, they were eventually satisfied that they were getting good measurements. The results of the Apollo 15 heat-flow experiment were consistent with those made on Apollo 17.

After finishing the second heat-flow hole, Scott took a short break to help Irwin with a trenching experiment. While Irwin dug, Scott took pictures. Irwin got down to about a one-foot depth, but then had to stop because the soil was so compact that he was almost sure he'd reached bedrock. Scott

then helped Irwin seal a trench sample in a vacuum-tight can before getting back to what he facetiously called his favorite task. There was, after all, still the deep core to be obtained and Houston wasn't at all sure that the drill's power supply would last out the rest period between EVA's. It was now or never.

This time, mostly because of a good stem design, the drilling itself went fairly smoothly and Scott got the six sections of core tube in their full depth of 2.4 meters after only a few minutes of effort. However, although the core stems would turn in the hole when Scott pulsed the drill, once again, cuttings filled the flutes enough that he was unable to pull the core out of the ground. The hole had been drilled and, presumably, the core tube now held a detailed section of soil nearly half way down to the top of the lava below; but Scott was rapidly running out of oxygen and it was time to get back into the LM. The core tube would have to stay in the ground for a few more hours. Tomorrow, they would try to pull it out.

The Cost of Drilling

Because of the drilling problems and number of tasks new to this mission, by the end of the second EVA, Scott and Irwin were running an hour and forty minutes behind the mission timeline. When they climbed back into the LM at the end of the EVA, they had only twenty-two hours left before they were scheduled to go back to orbit; and, in that short period, they still had to complete their post-EVA tasks, get some sleep, conduct the third EVA, and then, four hours after climbing back in the LM for the last time, launch and rendezvous with Al Worden. They were short on time and, because Houston was insisting, sensibly, on both an on-time liftoff and a full night's rest, the third EVA had to be shortened. Nonessential activities - like a scheduled science debriefing - were dropped; but there wasn't much padding in the schedule. By morning, Scott and Irwin had only been able to catch up by about ten minutes and were looking at an EVA that would last "somewhere between four and five hours" rather than the nominal six. Allen tried to put things in perspective and noted the highest priority mission goals had already been achieved. With only slight exaggeration, he said that "we checked off the 100 percent science-completion square sometime during EVA-1 or maybe even shortly into EVA-2. From here on out, it's gravy all the way, and we're just going to play it cool, take it easy, and see some interesting geology. "It should be", he said, "a most enjoyable day."

Two and a half hours after wake up, Scott and Irwin had finished breakfast and, as they listened to Houston's plans for the day, were well into their preparations for the EVA. For the first three hours they would follow the flightplan and drive west to the rille for sampling and photography. But, then, they would have to turn for home without going to a cluster of craters called the North Complex where, from

slim evidence seem in orbital photography, the geologists hoped that evidence of post-mare volcanic activity might be found. Inevitable as it was, the deletion of the North Complex stop was something of a disappointment and Scott asked Houston to hold open the possibility of at least a quick foray. Joe Allen told him that the request had been noted. "We copy that, and it may well be that we can get up there. We'll just see how it goes."

Three hours after wake-up, Scott and Irwin were out on the surface. They made good time loading their backpacks and the Rover with tools and sample bags and, just forty-three minutes after depressurization, they were ready to leave the LM. However, before they could drive to the rille, there was the not so minor matter of retrieving the deep core and they could only hope that the bad luck they'd been having with the drilling had ended.

But it was not to be. The drill stem wouldn't budge - even with both of them lifting on the drill handles. At Houston's suggestion, they tried running the drill for a few seconds, but all it did, Scott said - laughing at the humor of the situation - was that it "sucked me right back down". There was power left in the battery pack after all and, Scott described the situation: "What happens, Joe, is that, when I turn the drill on, the drill drills - like all drills should."

What they needed was a jack of some sort, a way to gain some mechanical advantage, but that would have to wait for Apollo 16. For now, all they had was their own muscles and gradually, by getting elbows and then shoulders under the drill handles, they pried it up a few inches at a try. Time and time again they counted off, straining together on the count of three. Ten minutes into the effort there were some real signs of hope.

"Okay," said Scott, "it's coming. It's coming. Let me get underneath it here. 1, 2, 3."

"One more," said Irwin.

"1, 2, 3. Okay. I've got it. Okay. Let me have it now."

Scott pushed once more with his shoulder; and the core came out. Unbeknownst to anyone else, he badly sprained his shoulder in the effort. However, a shoulder would heal faster than a memory of a core tube left stuck in the lunar surface. They'd gotten the job done, and that was what mattered. Sore as he was, Scott would be able to get the rest of the day's work done without any problem. There certainly wasn't any point in calling the sprain to Houston's attention. Once he was back in the cabin he would take some aspirin to ease the pain but, for now, there was a final EVA to complete.

As he and Irwin struggled to remove the core, what Dave Scott wanted most for Houston to tell him was that the effort was worthwhile. It would be a while yet before he said anything, but his frustration showed up occasionally in his tone of voice. For one brief moment after they'd gotten the

core out, he was even a bit abrupt with Houston when Allen asked Irwin to go ahead and take some pictures of the trench. Somewhat pointedly and certainly uncharacteristically, he said, "Joe, just standby until we get this settled down; and then we'll come at you for what is our next task. You're going to have to just hold off on jumping ahead of us, because we always have to come back and ask you what you said anyway."

Allen, who surely ranks as the most diplomatic of all the people who served as EVA CapComs, backed off immediately. "Read you loud and clear," he said.

And there the matter might have ended, but for the fact that, despite having worked superbly as a stand in "wrench" at the end of EVA-1, the vise on the back of the Rover wouldn't work. The vise was designed specifically to grip a section of core so that it could be separated from the other sections. However, as Scott discovered, the vise would hardly grip at all. By grasping the core tube tightly in one hand, Scott managed to remove each of the top three sections but then couldn't separate the bottom three. As he worked, he realized that the vise was mounted on the Rover backwards, a remarkable discovery since the mounting hardware ensured that the vise could be put on only one way. As it turned out, the error originated in an engineering drawing which hadn't been caught because, during assembly of the training version of the Rover - either accidentally or for the obvious reason that the vise wouldn't work as drawn - the mounting hardware had been installed backward from the drawing. However, that information wasn't passed on to the people who assembled the flight Rover, nor was the drawing changed; and, consequently, Scott and Irwin found themselves with a tool that wouldn't work. Because the lower sections of the core tube had been turning in the ground longest, they were stuck together too tightly for Scott, even with Irwin's help, to separate by hand.

Finally, after Scott and Irwin had spent a half hour on the core, Houston advised them to lay the remaining sections on the ground and proceed with the traverse. Irwin noted that the remaining three-section piece was short enough that they might be able to take it into the LM as it was, although Scott wondered where it would fit in the Command Module. Houston had nothing, as yet, to say on the matter and, indeed, Scott finally decided that it was time to remark on the amount of time they spent on the core.

'Hey, Joe, you never did tell me that (core) was that important. Just tell me that it's important, and then I'll feel a lot better.'

"It's that important, Dave," Joe Allen said.

"Okay. Good. Because then I don't feel like I wasted so much time."

"No," said Allen. "Quite seriously, Dave and Jim, that's undoubtedly the deepest sample out of the Moon for perhaps as long as the Moon itself has been there."

After the mission, the Apollo 15 core tube was promptly x-rayed and Scott had the pleasure of showing the pictures at a press conference. During the drilling, he had penetrated over fifty distinct layers, an extraordinary record of the multiple events which created this particular column of soil. Studies of the deep cores obtained on Apollos 15, 16, and 17 provided details that were critical to an understanding of the processes that produce the soil layers. When combined with more qualitative observations about the depth of craters that bring blocks of bedrock to the surface, these details give some confidence in predictions of such things as the prevalence of rocks at depth, a matter of some importance to civil engineers designing buried or partially buried structures for a lunar base and to mining engineers interested in processing large quantities of regolith in order to extract such things as the hydrogen, carbon, and helium-3 implanted by the solar wind. From this point of view, the extra effort - that undoubtedly cost Scott and Irwin the chance to visit the North Complex - was worthwhile. And of course, as the first crew to attempt so ambitious a mission, it would have been extraordinary if Scott and Irwin had not run into difficulties at some point. Compared with the troubles that cost the Apollo 13 crew a landing, the loss of an hour's worth of time was a relatively minor matter. It would have been nice to get to the North Complex; but, then, none of the Apollo crews had time enough on the Moon to do all they could have done with the equipment at hand. A brief stay dictated compromise.

The series of minor troubles that had been plaguing Apollo 15 hadn't quite ended yet. With the core out of the ground, Scott's next task was to mount the Rover and, with Irwin standing by with a movie camera, put the Rover through its paces for the Boeing and Marshall engineers. Unfortunately, as Scott drove by for the first time, Irwin found that the movie camera wasn't working. On his own initiative, Scott decided that they would abandon the Grand Prix. The engineers would have to wait for Apollo 16 to get a movie and, for now, it was obvious that the Rover was working beautifully. Verbal descriptions of its performance would have to be enough.

Houston lost no time in supporting Scott's decision.

"That was a good try," Joe Allen said. "Let's press on to Station 9. Let's take a good, clean, comfortable look at that rille."

"Yeah, that's a good idea, Joe," said Scott, eager to be off. "Best idea you've had all morning."

An hour and a half into the EVA, they were finally on their way. Now that they knew almost exactly where they had landed, they knew that the drive to the rille would be a quick one: a trip of about two kilometers that would take ten to fifteen minutes, depending on the sort of terrain they encountered. During the Standup EVA, Scott had gotten a pretty good look at the countryside in all directions except the west. For the same reason that the Apollo 12 crew had

been slow to recognize that Head Crater sat just down-Sun of them, Scott hadn't been able to see much detail in the direction of the rille and, now that he was driving toward west, he and Irwin could only assume that they would find the same sort of terrain that they had found south of the LM. Consequently, their encounters with a series of three large depressions came as something of a surprise. On their own scale, the depressions were shallow - with inner slopes of only about three degrees or so. However, each of them was up to two hundred feet deep and that was enough to send Scott on a detour.

The surface, Scott said, "is smooth but rough. Smooth on a small scale" but rough enough on the large scale that "you really could get lost. Up and down."

"It's like driving over the big sand dunes in the desert," Irwin added. It wasn't at all like driving up to Hadley Delta, he said. There, "you could always look back and see the LM."

Along the section of the rille that Scott and Irwin were approaching, the western rim is about 30 meters lower than the eastern rim, and it was only at high points on the traverse that Scott and Irwin caught glimpses of the far wall. Ten minutes into the drive, at a point about half a kilometer short of the near rim, they got a momentary look at it. And then they saw it again when they got to a brief sampling stop at a small, fresh, soft-rimmed crater.

Over the last 200 to 300 meters of the approach to the rille, the surface slopes gently down toward a line of light-grey boulders that marked an apparent edge and, as Scott and Irwin approached, the number and size of rocks they saw sticking up through the soil increased steadily. Long before Apollo 15, a number of clues had suggested to geologists that Hadley Rille was a lava drainage channel - or drainage tunnel - left over from the time when the mare were being filled. Or, perhaps, the Rille had begun its life as a fault, or a series of faults, running roughly parallel to the western slopes of Hadley Delta which was then eroded - rather than filled - by the thin, liquid mare lavas. Whatever the rille's origin, once the flow of lava stopped, the steady rain of impactors gradually eroded roofs, rims and walls and slowly filled the bottom of the channel with debris, building up talus slopes, and moving the edges of the canyon outward. With luck the talus wouldn't be piled all the way to the rim and, from their perch on the edge, Scott and Irwin would be able to see, describe, and photograph layering in the far wall, layering produced by the sequence of mare-filling, lava flows. Limitations of time and equipment would prevent them from making the equivalent of a trip down the trails into the Grand Canyon for a close look at mare history; but at least, it was hoped, they would be able to see and photograph enough to give the geologists insight into the history of mare deposition.

Although pictures that Scott and Irwin took toward the south along the rille suggest that, along much of its length,

the talus slopes have built up nearly to the rims, when they looked across the canyon - a distance of no more than a kilometer - they could see obvious layering within the occasional outcrops that had been preserved. In the upper 60 meters of the far wall, they could pick out at least a dozen distinct layers; and, because of the winding nature of the rille, to the south they could see suggestions of similar layering in a section of the near wall.

500 mm looking south from station 9

500 mm of far rille wall, showing layering

[During a review of this Apollo 15 summary, I asked Jack Schmitt why there were outcrops visible. Was it that the rill wasn't old enough for the talus to have built up to the rim?

Jack told me, "Those rille walls are working away from the centerline due to impact. And, because they're steep walls, the debris has a statistical tendency to go down to the bottom, rather than lying on the walls. So they are going to maintain exposure, unless hit by an impact big enough to destroy the whole section of wall. The original configuration was probably a lava tube. Sometimes lava tubes are open and sometimes they're roofed over, depending on the dynamics of the individual flow episode. It's amazing how they tend to maintain themselves. There's probably melt erosion that helps to maintain them - and which coats over the walls and hides any layering in the surrounding rock. But, as soon as all the eruptions stop, impacts break through any roof that might have been present - which would be relatively thin - and start to erode the wall cover back. After that happens, you start to see the exposed layers."

I asked if the persistence of the vertical faces was evidence of hardness variations, like we see in New Mexico mesas. "That's why you see the layers. The interior of the flows are probably softer than the exteriors, because they haven't been quenched (by radiative cooling). The exteriors tend to be denser and harder, although that depends on how vesicular they were. So every flow is a different story. If you look at the Apollo 12 material that seems to have come from deep down in the flow - and actually some of the Apollo 11 rocks that I called gabbro to distinguish them by texture from basalt - when you get coarse crystals, they just tend to be more friable (breakable)."]

The visit to the rim of Hadley Rille not only provided glimpses into the structure of the bedrock underlying the landing site, but also a new perspective on the structure of the regolith. Although the thickness of the soil layer undoubtedly varies from place to place around the landing site, evidence from the seismic signals generated by the astronauts as they walked around the LM/ALSEP area and evidence from the depth of craters that brought up bedrock fragments suggests that the regolith is typically about five meters thick. However, as Scott and Irwin approached the rille, they had seen clear evidence of a thinning of the soil layer. The thinning was a simple consequence of the presence

of the canyon. Away from the rim, crater ejecta is scattered in all direction; the crater dug by one impact is gradually filled with ejecta from later impacts and, except for the effects of the occasional, larger impacts, the net result is that the average depth of the layer isn't influenced at all. However, near the rim, ejecta thrown toward the canyon tumbles onto the talus slope and isn't replaced by anything being thrown back out. Slowly, the canyon is filling and, the closer one gets to the rim, the thinner the soil layer. This thinning produces both a surface that slopes down toward the rille and an increase in the prevalence of rocks lying on the surface. Close to the edge, in a strip extending up to 25 meters back from it, there is hardly any soil at all and the surface is littered with boulders lying practically on bedrock. And it was bedrock that they were after.

Because the Rover had only 14 inches of clearance, Scott and Irwin parked on soil well back from the edge of the rille. Then, once they finished describing and photographing the far wall, they moved down to the boulders. Scott was quite confident that these were bedrock boulders; and Houston was so interested in them that they readily agreed to drop a more conventional mare sampling site scheduled for the trip back to the LM in favor of an extension here. Scott and Irwin took pictures, sampled boulders, raked the soil near the Rover for a collection of small rocks, bagged soil samples, and drove two short core tubes into the ground. In all, they collected over a hundred pieces of rock - all fragments of the bedrock basalt, excepting only six breccia fragments which were, themselves, made up mostly of bits of basalt.

The station was both productive and fun. Scott and Irwin had clear objectives for the site and, because of the value of the station, were given extra time so that they could work without undue haste. They didn't have any appreciable slopes to content with, so the work wasn't physically demanding. And, finally, the site offered enough interesting detail that they were able to put their geology training to very good use. It was a fitting climax to the mission and indeed, as they prepared to drive off, Scott neatly summed up his pleasure and his buoyant mood. "Man, am I going to miss 1/6th g. This is neat."

Time was running out. Fifty-five minutes after they stopped, Scott and Irwin were headed north, going to a spot another 200 meters along the rim so that Scott could take a second series of photographs for a stereo view of the far wall. It would be a very short stop - for photography only. Houston wanted them back at the LM in no more than 45 minutes. Lift-off was only five and a half hours away and there was a good deal still to be done. Scott understood the situation perfectly, but was still a bit disappointed. "Okay," he said. "Shoot! No time to go to the North Complex, huh?"

Allen recognized the question as rhetorical and maintained an appropriate silence while Scott and Irwin went

about the business at hand. Fourteen minutes after they stopped, they were moving again. They were still faced with the prospect of separating the bottom sections of core, but were determined that, somehow, they would get the entire core home. In the end, Houston decided that there would be room for the three connected section of core in the Command Module; and that is the way it was done.

In some ways, Apollo 15 was the last of the engineering flights. Armstrong and Aldrin proved that a landing could be made, and that a pair of astronauts could go out on the surface and do useful work. Conrad and Bean proved that the LM could be flown to a predetermined target, and that there was no real problem in working for several hours at a time. Shepard and Mitchell showed that, in the event of a Rover breakdown, a crew could walk back to the LM from a considerable distance. And it remained, then, for Scott and Irwin to put the Rover through it's paces and to demonstrate that the LM, the suits, the backpacks, and they, themselves, could handle a three-day visit to the lunar surface.

By the end of Apollo 15, it was clear that, after three very active days, Scott and Irwin had not exceeded any practical limits to the length of an Apollo mission. There had been a number of minor problems with the equipment and, as was further demonstrated on Apollo 16 and 17, an accumulation of small failures was inevitable. Perhaps they were approaching a limit. At the end of the first EVA, Scott forgot to stow the small antenna on the top of Irwin's backpack, and it broke off as he crawled through the hatch. They were able to tape it back on, but the accident illustrated what could and would happen over time. Dust was a continual problem and, despite their best effort to clean each other off at the end of the EVA's, the cabin got dirtier and dirtier. They put the suit legs in bags to help to control the dust and, each night, they cleaned and lubricated their zippers and neckrings and wristings. Nonetheless, the closures got balkier with each passing day. Outside, the dust got into all unsealed moving parts and, although the 15 crew didn't experience nearly as many dust-related Rover or tool problems as did the later crews, they accumulated scratches on their visors and, because the dust covered almost everything, had trouble reading gauges.

These small problems - and the inevitability that they accumulate - should serve as warnings for those planning more ambitious missions. However, in the context of Apollo, Scott and Irwin demonstrated that three days were manageable and that there was every reason to expect even greater success from the remaining missions. The drill stems could be redesigned, the vise could be mounted properly, and other lessons could and would be learned so that Apollo 16 and 17 would be even more productive.

Apollo 16 - Descartes Surprise

If political support for Apollo - and the funding that goes with political support - had continued at a high level into the 70's, by the time of Apollo 16 NASA might have been thinking seriously about establishing a permanent base camp on the Moon. Perhaps work would have been underway on an unmanned, cargo-only version of the LM. Such a vehicle would have been essential to the establishment of a camp and to astronaut visits longer than three or four days. NASA might not have been in a position to pick a site for a permanent base after only four landings and after only one three-day mission, and there still would have been a great deal of preliminary work to be done on Earth and on the Moon before anyone would have felt comfortable about starting construction. However, because Apollo 15 had gone so well, there would have been little hesitation about moving on to the next level of complexity. Although the second J-mission crew surely would have done some exploring and sample collection, they also might have been asked to test construction tools and procedures.

Of course, such a mission was never in the cards and, indeed, by the time of Apollo 16, NASA was already folding up its lunar tent. The Apollo assembly lines had been shut down and NASA had canceled three missions for which hardware had already been built. After Apollo 16 there would be only one more. Because Apollo was about to end, there was no new equipment to test, no new procedures to try. Nonetheless, with proven equipment and procedures at hand, the last two missions presented splendid opportunities to clear up some of the major uncertainties that remained in our understanding of the Moon as a planet.

If we had a picture of the Moon taken just before Imbrium and the other large mare began to fill, we would see huge basins excavated by enormous impacts and, everywhere else, the highlands terrain. When the mare lavas began to upwell and flow, they filled the basins and left the other seventy percent of the lunar surface uncovered. The Apollo 14 and 15 crews brought back samples of pre-mare materials, but neither crew visited a pure highlands site. As we have discussed, the 14 crew sampled a ridge of material ejected by the Imbrium impact, and the Apollo 15 crew explored some of the mountains that ring the Imbrium Basin itself. Because both sites are so closely associated with the Imbrium impact, there remained a distinct possibility that, in highlands areas far from the Imbrium rim, different geologic processes and materials might have been important. For example, some members of the geologic community thought that the central highlands looked like certain terrains on Earth built by volcanism and hoped that the Apollo 16 crew would find samples to prove the point.

(Readers interested in more details about such pre-mission hypotheses should consult Wilhelm's "To and Rocky

Moon", Heiken, Vaniman, and French's "Lunar Sourcebook", and Jack Schmitt's discussion that concludes this Apollo 16 summary.)

Apollo 16 was launched on April 16, 1972. The Commander, John Young, had flown twice on Gemini and had already been to lunar orbit as the Command Module Pilot on Apollo 10. Later, he would command the first Shuttle mission. The Lunar Module Pilot, Charlie Duke, had served with distinction as CapCom during the Apollo 11 landing. And, finally, the Command Module Pilot, Ken Mattingly, had been scheduled to fly on Apollo 13 but, because Duke had inadvertently exposed him to German measles, he was replaced at the last minute by his back-up, Jack Swigert. Like Young, Mattingly eventually flew as a Shuttle Commander.

Although Young and Duke flew a near perfect landing, setting down as close to their target as prudence and the rolling terrain permitted, they landed some six hours late. In orbit, after they powered up the lander and separated from the Command Module, Mattingly had been scheduled to perform an engine burn to put himself in a position that he could come to the rescue in the event of an aborted landing. However, during tests of the control systems for the Command Module's steerable rocket engine, a malfunction was detected in the backup system. Mission rules dictated that, at this point, the two spacecraft rendezvous in case it was decided that the crew would have to use the LM engines to get back to Earth. However, after six hours of tests and analysis, Houston decided that the engine problem could be worked around and that the landing could proceed.

At pitchover, Duke's first callout of a window angle showed Young that they were headed for a point about 600 meters north and 400 meters west of their target. Ten times, Young nudged the hand-controller to give the computer a new target. As with Apollo 15, the mobility of the Rover meant that he didn't need to land precisely on target; but the cost of this series of minor redesignations was very slight. Young's greatest concern was the fact that there were few shadows to show him where the level spots were in this rolling terrain; and it was only in the last few moments that he got some clues from the LM shadow. It was Duke who saw the shadow first as they came down through 250 feet. Seconds later, as they were coming through 200 feet, Young rotated (yawed) the LM to the right and could see the shadow out his own window and use it to estimate his altitude and the sizes of the craters ahead. Through a combination of skill and luck, he set down on a remarkably level spot. As he and Duke discovered once they got outside, had they landed "25 meters in any direction from the actual landing site, [the LM] would have been on a local slope of six to ten degrees." In particular, in the final seconds, Young had to hover so that he could fly forward and to the right, just beyond a small crater fifteen meters in diameter. Only Armstrong and Conrad landed more upright, and both had the advantage of young, lightly-cratered, mare sites.

Because of the delay in orbit, Young and Duke had already been awake for thirteen hours by the time they landed. If, as originally planned, they had tried to do a full EVA on that first day, they would have stretched the total to twenty-nine hours or so: four for EVA prep, eight for the EVA itself, and four more of post-EVA activities. But no one was interested in taking on the added risks that fatigue would have created as the day got longer and longer.

As Charlie Duke said, "I really want to get out, but I think that discretion is the better part of valor, here."

"Man, it's really tempting though," John Young added. "It really looks nice out there."

By getting out of the suits and donning them again in the morning, they would consume a couple of extra hours worth of oxygen, electric power, and cooling water; but, even having spent an extra five unplanned hours in lunar orbit, they still had at least a half-day reserve of water and considerably more of oxygen and power beyond what they would need for a full, three-day stay. Two hours after landing, Young and Duke were out of their suits and an hour later they were in their hammocks. Both of them slept soundly; indeed, they were the first crew to do so.

On this first night, Duke was awakened twice by warning lights triggered by a leaking regulator in the primary Reaction Control System. The problem had first occurred during LM checkout in orbit and, as with the CSM engine control problem, there had been some initial concern about aborting the landing. But, eventually, a way around the problem was found; and both times during the night - after getting over the shock of being so rudely awakened - Duke assured himself that there was no new problem to worry about, reset the alarm, and then went back to sleep. Living and working on the Moon hadn't yet become an everyday experience; but it was certainly becoming familiar enough that even first-timers could get some sleep.

The front half of the cabin, where the astronauts stood, was a space about six feet across, six high, and about three deep. The area aft of the crew stations was filled to hip height with the cover of the ascent engine. In preparation for sleep, Young and Duke had stacked their helmets and suits on the engine cover and then had strung a hammock - fore and aft at head height - for Young. Once he was bedded down, Duke then strung his own hammock close to the floor across the front of the spacecraft and climbed in. There wasn't much room to spare.

In the morning, once they'd gotten the hammocks stowed and had eaten, they then began the laborious process of getting ready to go out. They started with the Liquid Cooled Garment (LCG), a suit of underwear into which a network of thin plastic tubes had been woven. During the EVA's, cooled water would circulate through the tubes, carrying away excess body heat to sublimators in the backpacks. After donning their LCG's, they got into the pressure suits; and that was always a two-man operation. They started with Duke.

The light lunar gravity helped: "You should see me," Young said, "holding up this 50-pound pressure suit with one hand while Charlie is unzipping it with one hand. That's really neat." After getting the suit unzipped, Duke then chinned himself on an overhead guard rail and stuck both legs in while Young held the suit. Then Duke ducked to get his head into the neck ring and, finally put his arms into the sleeves. The suits were individually tailored for a tight fit and it all required a certain amount of contortion. In all, the process took about twenty minutes and, once Duke was suited, they hooked up the hoses which connected him with the LM supplies of oxygen and cooling water. For the time being, they didn't actually turn the water on, but did let oxygen flow into the suit and out the neck and wrist rings to provide some cooling. Then they repeated the process with Young.

For Apollo 16, there were a couple of unplanned steps in the EVA preparations. Because of the length of the EVA, each of the astronauts wore a drink bag inside his neck ring and had a tube he could suck on to get some refreshment. On Apollo 15, Jim Irwin's drink bag had never worked properly, causing him a severe case of dehydration. On Apollo 16, the bags leaked because of intermittent contact between the end of the tube and the microphones that each of them wore. In Charlie Duke's case, he'd been doused with four or five ounces of orange juice while he and Young were still in lunar orbit. Zero-gravity made sure that he got thoroughly soaked in the sticky stuff and, as he later told CapCom Tony England: "Tony, I wouldn't give you two cents for that orange juice as a hair tonic; it mats it down completely."

And, of course, the juice not only got into Duke's hair; it coated the inside of his helmet. Consequently, he had to wash out his helmet and dry it before he could apply a coating of anti-fogging agent; and then he had to blow some of the juice out of the microphone before it would work. Indeed, stray juice was also suspected as the cause of a sticky valve in the LM's Environmental Control System.

Young and Duke next had to put on their backpacks, the Portable Life Support Systems (PLSS's) which contained a lithium hydroxide canister to remove CO₂, supplies of oxygen and cooling water, and also the associated pumps and fans and the sublimator which actually got rid of the waste heat. Then came the helmets and gloves, a communications check, and, lastly, a check of the pressure integrity of the suits. In order to do the check, the astronauts first disconnected their LM oxygen hoses and connected the corresponding PLSS hoses. They then pressurized the suits so that they could check for leaks before depressurizing the cabin. They turned on the PLSS oxygen flow until the suits were 3.8 pounds-per-square-inch (psi) higher pressure than the cabin, and then turned off the PLSS oxygen and watched the suit pressure decay. During a minute of watching, they expected a drop of about 0.1 to 0.2 psi due to their own breathing and to the slow diffusion of oxygen into various nooks and crannies in

the suits. As usual, the pressure check showed that the suits were tight.

Prior to the pressure check, Young and Duke had been able to move a little, despite the small size of the cabin. In soft, unpressurized suits, they were clumsy but still could turn and bend and reach for checklists and pieces of gear with relative ease. Now, with the suits inflated and both of them wearing backpacks, the situation was dramatically different. In order to depressurize the cabin, Duke had to pull a number of circuit breakers on a panel at his right shoulder and change some valve settings on a panel behind him. The trouble was that, now, there was barely enough room for the two of them to stand, let alone turn. Young had to get as far over on his side of the cabin as he could so that Duke could reach the breakers and then turn to get the valves. Not until they were out on the surface would they have some freedom of movement again. Fortunately, they were pressurized for only a few minutes before it was time for Young to crawl, feet first, out the hatch.

Because of the experience of prior crews, Young and Duke were confident that they would adapt quickly to lunar conditions and, so, got to work immediately. They took a look around, checked the condition of the spacecraft, and marveled at the five-meter-deep crater Young had overflowed during the final seconds of the landing. The rear footpad was no more than three meters from the rim. Within ten minutes of Young's first step onto the Moon, they had the MESA (Modular Equipment Storage Assembly - their work table and equipment rack) adjusted to a comfortable height and were preparing to deploy the Rover.

Like the Apollo 15 crew, Young and Duke had been through training as a back-up crew for a landing mission (Apollo 13) and, so, for their own mission were able to spend about forty percent of their time training for the surface operations. Consequently, they completed deployment of the Rover and, later, deployment of the ALSEP experiments with only a few problems. In particular, the redesigned drill stems on the heat-flow experiment worked flawlessly and a jack-and-treadle greatly eased the job of extracting the deep core. It is noteworthy, as well, that Young used the Rover to mark a straight line of tire tracks for deployment of some geophone cables. A walking astronaut would have had some trouble keeping a straight line in the rolling terrain and, on Apollo 17, Gene Cernan would put his Rover to the same practical use.

It is perhaps unfortunate that the Apollo 16 ALSEP deployment is remembered primarily for a heat-flow cable that was torn loose. On every Apollo landing mission, crews complained about cables that were forever underfoot. The bulky suits and the chest-mounted PLSS controls made it almost impossible to see one's feet and, almost inevitably, cables refused to lie flat on the surface. Time and time again, astronauts got entangled. Sometimes they would feel the tug and stop. Sometimes the other member of the crew

would see them catch a cable and give warning. It was simply a matter of time before someone got a foot caught and, in the process, put enough stress on a cable to pull it loose. Such an accident finally happened on Apollo 16 and, because the cable broke at the connector to the heat-flow electronics package, there was no hope of a repair. If there was a lesson to be learned, at least in the Apollo context, it was the need for less fragile cable connections. There was one more mission to be flown; and the 17 crew, too, would have plenty of encounters with foot-grabbing cables.

Three and a half hours into the EVA, Young and Duke were finished with the ALSEP deployment and were ready to start on their first geology traverse. On this first trip out from the LM, they were to drive west from the spacecraft, directly away from the Sun, out to Flag Crater and then back. Inevitably, with the Sun low in the sky behind them, Young and Duke could see virtually no shadows out ahead and, consequently, they seemed to be driving into a featureless land. Young had to drive slowly in order to avoid the numerous rocks and small craters that covered the area. They were on the ejecta blanket of South Ray Crater, a huge feature about ten kilometers to the south, and the debris from that impact was very much in evidence. In addition, the low Sun added to the basic problem of estimating sizes and distances and, while Young and Duke had no trouble seeing South Ray off to the south, they had some difficulty identifying craters along their route. However, they were fairly confident that they knew where they had landed and, indeed, they reached the rim of Flag Crater with the Rover navigation system giving exactly the expected range and bearing.

If, like the other crews, Young and Duke found that visual navigation required a little experience, they certainly had no wasted moments once they were off the Rover and were ready to do some geology. Both Young and Duke had picked up a great deal of practical field experience during training; and, while Young was perfectly happy to let Duke do most of the talking, occasional remarks made it clear that, behind the Commander's "country-boy" facade, there was a shrewd and skilled observer. In all, they were away from the LM for about two hours and spent an hour and a half of that collecting samples and taking pictures at a two stops. Virtually all of the rocks proved to be highland breccias. There were no signs of the young volcanics that some geologists had hoped for.

For their second EVA, Young and Duke drove four kilometers south to a cluster of five craters - the Cinco Craters - on the slopes of Stone Mountain. They were to make three stops on the hillside and it was here that geologists had their fondest hopes of finding evidence of volcanism. There was none. It looked to Young and Duke as though many of the rocks they sampled on Stone Mountain had been sprayed onto the hillside by the huge South Ray impact. Nonetheless, the largest of the Cinco Craters had dug deep enough into the

soil layer to bring up pieces of the underlying rock and all of these proved to be breccias as well. The absence of volcanic samples was, of course, a considerable disappointment to some of the scientists. It was beginning to look as though the hills in the area were all composed of ejecta from ancient impacts. There was always the chance of a surprise on the final EVA; but, even if there were no volcanics, the breccias gave the scientific community some detailed information about how impacts, rather than volcanoes, had shaped the Central Highlands.

The lack of scientific surprises was also matched by the relative lack of operational surprises. From a pilot's point of view, a good mission was a mission without surprises, and as the day went on, Young and Duke proved once again the value of a well-trained crew. Their confidence in themselves and in their equipment showed up in the relative ease with which they worked on the hillside. They had learned from watching Scott and Irwin and, at one point when Young decided that he hadn't parked the Rover in quite the best position, rather than take time climbing aboard, he and Duke simply picked it up and moved it. They leaned on tools as they stood facing the slope, and sometimes even knelt as they picked up samples. They were confident in their ability to get up again. As they bounced around on the inner slopes of the Cinco Craters, sliding back a few inches on every hop, their heart rates rarely went much above ninety beats per minute; and, on average, they seemed to be having an easier time working on Stone Mountain than Scott and Irwin had on the slopes of Hadley Delta. Although physical differences between the two sites undoubtedly played a role, a major factor was surely the confidence that Young and Duke had gained from having watched the 15 crew go about their work at Hadley.

There were, of course, the inevitable glitches. The pitch indicator on the Rover fell off - so they made eyeball estimates. The harnesses that held the big sample collection bags on their backpacks wouldn't stay tight. Young's bag fell off during the outbound drive on EVA 3 - fortunately when it was empty - and, generally, they had to spend far more time than they would have liked tightening the harness straps. Similarly, the chest-mounted brackets that held packs of individual sample bags failed repeatedly and, eventually, they had to hand-carry a few bags at a time. The free-swinging rod on the gnomon - the shadow device that provided a scale and a local vertical in the pictures - broke off and they had to press their long-handled scoop into service as a replacement. At one point during EVA 2, Young caught his hammer on the right-rear fender, tearing part of the dust guard completely off. From then on, they drove in a rain of dust that was not only a nuisance but also contributed to a noticeable, and somewhat worrisome, heating of the Rover batteries. And, finally, on their way north from Stone Mountain, back toward the LM, they momentarily lost power to the rear wheels. At the next stop, Young tried

a number of switch settings and, in the process, disabled the navigation system. The problem wasn't noticed for awhile but, with Smoky Mountain marking the horizon to the north, they were able to steer with confidence back to the spacecraft which lay hidden by an intervening ridge.

The third EVA had to be cut a bit short because of the late landing. On this traverse, Young and Duke drove to North Ray Crater, a kilometer-sized feature that had been dug at least a couple of hundred meters into the lower slopes of Smoky Mountain. Although there had been no very high resolution photographs available before the mission, there were hints of big boulders on the rim of North Ray and, indeed, during the landing, Duke had snuck a peek up north and had assured himself that there were, indeed, some very promising rocks at the rim of the crater. What the geologists wanted were samples from a single, huge boulder if one could be found. What they hoped for was a rock big enough to show multiple igneous (volcanic) units. Specifically, they wanted - in the specific words and punctuation of the procedures volume - a "crystalline rock, larger than 5 meters (no breccias)."

Before they had gone more than a kilometer north of the LM, Young and Duke noticed that the frequency of rocks and small craters had dropped considerably. They were now off of the South Ray ejecta blanket and the driving got a lot easier. They were climbing steadily toward North Ray and, during most of the drive, the rim was hidden by intervening ridges. Time and time again it looked as though they would find the crater just over the next rise but the navigation system said that they still had a ways to go. So they pressed on and, eventually, found North Ray right where it was supposed to be. The navigation system was proving an invaluable aid.

From their perch on the slopes of Stone Mountain, Young and Duke had gotten a good look into South Ray Crater and, although most of the ejecta was a brilliant white color, here and there they could see streaks of dark material. At their various stops during the first two days, they had found white breccias with black inclusions and also black breccias with white inclusions. And, at North Ray, the pattern was even more striking. Near where they parked, there were large white boulders on the rim - again with dark inclusions - and, off to the north, a big black boulder that begged to be sampled. They examined the white rocks first and then, with only a limited amount of time left, finally had a chance to trot over to the black rock. There is a marvelous piece of film in the Apollo collection which shows people in the Backroom at Houston watching Young and Duke as they ran toward the boulder. These were the assembled scientists and astronauts - Jim Lovell, Jack Schmitt, Lee Silver, Bill Muehlberger and others - who provided advice and suggested priorities during the traverses. As Young and Duke ran, Ed Fendell - who operated the Rover TV camera remotely from Houston - steadily increased the zoom. Thanks to his

efforts, the astronauts seemed to stay about the same size on the TV screen, but the rock kept getting bigger and bigger. On they ran; and the smiles in the Backroom got broader and broader and the laughter got louder and louder. This was a big rock, as big as a house, and that was the name that stuck. Young and Duke spent a few minutes taking pictures, collecting samples, and marveling at the size of House Rock - Duke actually named it - and then they headed back to the Rover.

Because they were running short of time, Houston decided to omit a couple of other planned stops on the slopes of Smoky Mountain and have the astronauts head back toward the LM. On the way, they made a single stop, this one at another large, black boulder which had a south-facing overhang and a deep hollow underneath. The scientists wanted samples of soil protected from the solar wind and, as Duke reached into the hollow with his shovel, kneeling so that he could reach back in as far as possible, he noted that, if you reach under a rock, "in West Texas, you get a rattlesnake; here, you get permanently shadowed soil." Generally, the astronauts worked as a team when they were sampling; but here, as Duke worked around the rock, getting soil and chipping fragments off the boulder, Young was back of the Rover measuring the lunar magnetic field with a twin of the portable magnetometer carried by the Apollo 14 crew. Duke's solo sampling went fairly well, and the only problem he really had was in figuring out what to do with the individual sample bags once they were full. As Young had done at one point during the second EVA, Duke went back to the Rover, got an empty Sample Collection Bag, and set it down on the ground next to the boulder. The SCB's, as the acronym-addicted astronauts inevitably called them, were just barely suited to the job. They were 42 cm tall and, with only a 15 by 22 cm base, were a bit top heavy. Duke was working on fairly level ground and he found that, if he leaned sideways, he could place the bag upright on the ground and, later, to put samples in it. But, as Jack Schmitt was to learn on Apollo 17, SCB's were all too easy to knock over; and Duke wished out loud that he'd gone down to the local supermarket in Houston to get a shopping bag with a broad base and a couple of handles.

All too soon, it was time to load up the Rover and drive back to the LM. Although this final EVA had to be cut short, Young and Duke set several new records. In all, they collected 94 kilograms of samples, deployed over a half metric ton of equipment (the Rover included), and spent 20 hours and 12 minutes out on the surface. They didn't set a record for distance driven in a Rover. Scott and Irwin had managed to hold on to their pioneering record, at least for the moment, by nearly a kilometer. But there was no doubt that, although the reality of the Descartes landing site had proved a bit less dramatic than some had hoped before the mission, Young and Duke had accomplished about as much as was possible with the time and equipment available. On Apollo 17, Jack Schmitt's training as a professional geologist added

an extra capability in that he could recognize subtle relationships and detail and, therefore, that he and Cernan could be a bit more focused in their sampling. However, with time at a premium, none of the crews could make many stops or spend much time looking for the subtleties. Their primary task was to identify the main features of the site, sample the dominant rock types, and look for whatever variety might be present. In this type of work, a well-trained observer was as valuable as a professional and, as observers, the crew of Apollo 16 was unsurpassed.

At the time of the Kennedy decision, the Space Age was only four years old and the era of human space flight was only six weeks old. A few dozen small satellites had been put into low orbit around the Earth. A few of those had carried dogs or monkeys as stand-ins for future human space travelers. Seven spacecraft had been launched in the general direction of the Moon: two of them had flown by at respectable distances, a third had actually impacted the Nearside, and a fourth had swung around the Moon and transmitted back humanity's first, grainy views of the Farside. Yuri Gagarin had flown one orbit of Earth and Alan Shepard had taken a 15-minute sub-orbital ride in a Mercury capsule. And yet, only eight years later, Armstrong and Aldrin landed on the Moon and, during the three and a half years that followed, they and five other Apollo crews proved beyond a shadow of a doubt that, even within the limits imposed by short stays, by limited equipment budgets, and by the lunar environment itself, a great deal of useful work could be done. In many ways, the weak gravity field made work easier than it would have been on Earth, and only the need to wear the stiff, bulky pressure suits proved to be a significant impediment to productivity. It was clear that, with more time, better suits and equipment, and a spacious, indoor, shirtsleeve environment for making preparations and repairs, productivity could be increased significantly. By the time of Apollo 16, the limits of the program had been approached. The prior crews had tested equipment and procedures and, if the last two missions seemed a bit routine, it was only a mark of the maturity of the program. The Moon is an enormous planet; yet, in only six missions it was possible to put together a credible description of the main themes of lunar geologic history, sketch the distribution of potential resources, and gain some valuable experience in the conduct lunar operations.

The following is a brief discussion of the geology of the Apollo 16 site provided by Jack Schmitt during our review of the Apollo 16 summary.

"I think Apollo 16 was a major scientific surprise because we don't know how to interpret what we found. That's always a surprise to geologists, when they can't explain what they found. The pre-flight expectation - by some people - of finding volcanics relates back to the old issue of the Cayley formation, the light-colored plains. That still

hasn't been answered today. In the lunar geologic mapping program, before we had Lunar Orbiter or anything like that, the USGS geologists had identified these smooth plains - light-colored in the highlands - that seemed relatively young. I think the first name ever applied to them was Cayley. When I was flying over the Farside of the Moon (on Apollo 17), you could see these light-colored plains, without any significant features in them, in the bottoms of large craters. They're older than the mare because, everywhere I saw them, if you had a deep-enough, young crater that got down to where the mare had reached it's selenocentric level, you'd see mare in the bottom of those craters. My guess is that several different processes contributed to giving you about the same surficial features that were lumped together as the 'light-colored plains'. One was the debris flows that swept out from the really large impacts, the large basins. As it went out across the terrain, it was in the form of gasified, loose material and, when it settled, it just settled into these basins, leaving a relatively smooth surface. It was a process like an ash-flow or a landslide. Another thing that probably contributed to the formation of light-colored plains was: if you think about what would have been the logical course of eruptive events during mare formation, the major upwelling of mare basalt would have been preceded by a brief period of gas-charged debris eruption. When you begin to partially melt the differentiated, olivine/pyroxene-dominated portion of the lunar mantle, there's still going to be a little bit of volatile material left, even though most of that would have fractionated out. The trapped magma, as it crystallized around the olivine and pyroxene crystals, would have still contained some volatiles. And that's the low melting fraction. The first thing that's going to melt as that mantle got hot enough to melt at all - or evolve - would be this gaseous, early-melt material. And that would move up through a highly pulverized crust. Because, nothing had sealed the crust yet. the low-melting fraction would gather debris as it went; and it would be mostly highlands material that would erupt as debris flows and would probably settle into the same kind of areas. Now, if this had happened, you might expect to see relatively rimless eruptive centers in some of these basins and, indeed, you do - particular on the Farside. So I think several processes probably contributed to the light plains. And that's what we thought we were landing on at Descartes on Apollo 16. Others had taken it farther than I have here. They had said that the surface looked like they might have been the remains of rhyolitic ashflows and the like. I think the geologists got carried away. They were looking for something different and they over-sensitized the 16 crew to volcanics. And, indeed, there may be volcanics there. It's just they're hard to recognize because most of the material is debris taken up from the crust by whatever volcanic component was being evolved."

The Apollo 17 Lunar Surface Journal, Part 11
The End of the Beginning

Although curtain was coming down on Apollo, the final act was as spectacular one. The landing site, in a beautiful mountain-ringed valley on the edge of the Sea of Serenity, promised to be a geologist's paradise. In pre-mission photographs, boulders which had rolled down from the tops of the mountains could be seen on the lower slopes, just above the flat valley floor, and these promised indisputable samples of the mountain bedrock. There was a landslide that had flowed out into the valley off the side of one of the mountains, and there were small, dark craters that looked like they might be volcanic. And, finally, out in the middle of the valley floor, there were clusters of large craters that would yield samples of the valley fill.

And, to explore all of this, Deke Slayton had picked a two-man crew with, perhaps, the broadest range of capabilities of any of the Apollo crews. Commander Gene Cernan was a veteran of two prior missions - having flown with Tom Stafford on Gemini IX and with Stafford and John Young on Apollo 10. He was the only LM Commander to have flown a mission as Lunar Module Pilot and there were few in the astronaut corps who knew the spacecraft as thoroughly. And Lunar Module Pilot Jack Schmitt not only knew the LM but was also a professional geologist who, as we have seen throughout the previous chapters, was an active participant in the planning that had gone into the prior missions. If Taurus-Littrow was a geologist's paradise, then Jack Schmitt was the geologist.

The details of Apollo 17 comprise, of course, the core of this Journal. The following summary is provided as a preview and as a means of establishing the final context of the this mission in the Apollo series.

As on Apollo 16, Cernan and Schmitt began their work on the surface by deploying the Rover and then the ALSEP experiments. Many of the ALSEP experiments were unique to Apollo 17. Several were intended to give data on the geologic structure underlying the valley of Taurus Littrow. Holdover experiments from prior missions included a heat flow experiment (a last opportunity to confirm the Apollo 15 measurement), a cosmic ray detector similar to the one first flown on Apollo 16, and a deep core like the ones drilled on both Apollos 15 and 16. Other experiments flown on prior missions were missing - the solar wind collector, the corner-cube laser reflector, and the passive seismometer. The science advisory committees felt that sufficient data had been collected that these experiments could be dropped in favor of new ones. The new experiments included a second type of cosmic ray detector, an instrument for determining the composition of the extremely thin lunar atmosphere, a device for detecting meteorites and ejecta from local

impacts, and a long-period gravimeter intended as a gravity-wave detector.

Three of the new experiments figured prominently in the Apollo 17 geology traverses. One of these was an array of geophones designed to detect seismic waves generated by small explosive charges which Schmitt and Cernan later placed at predetermined spots as they drove around the valley doing geology. Detonation of the charges was commanded remotely from Earth after the crew was safely back in orbit. Analysis of the resulting data provided information about the subsurface structure of the valley.

The other two other pieces of new equipment were also designed to provide information about the subsurface structure: a portable "traverse" gravimeter (the TGE) and a surface electrical properties (SEP) experiment.

The traverse gravimeter was a simple experiment. The instrument, itself, was a battery-powered, stand-alone device packed into a closed, 6x6x12 inch box. At each of the geology stops, Cernan took the instrument off the Rover, set it on the ground, pushed a button to start the measurement and then left it alone while he took care of other chores. After about three minutes, the measurement was finished and, when he had a moment free from other tasks, Cernan pushed the "Read" button, read a string of numbers to Houston, and then put the gravimeter back on the Rover. Each of the measurements was a determination of the local pull of gravity; and variations in the measurements could be interpreted as variations in the density of the rocks below the surface. It was a simple, valuable experiment that took only a little time for a large return; and the only significant problem that Cernan had with the instrument was that of getting low enough to set it on the ground and punch the buttons. A taller instrument would have helped and, indeed, several measurements were taken with the gravimeter on the Rover. On such occasions, both astronauts had to make sure that neither of them touched the Rover before the measurement was done.

In principle, the SEP was also a simple experiment requiring little expenditure of crew time. At the end of the first EVA, Cernan used the Rover to draw a couple of perpendicular tracks upon which he and Schmitt then laid out antenna wires for the SEP's radio-frequency transmitter. There was a receiver/recorder mounted on the Rover and, while Cernan and Schmitt were out on their second and third geology traverses, the equipment on the Rover picked up signals from the transmitter. Those signals were influenced by variations in the electrical conductivity of the subsurface rocks between the Rover and the transmitter and, therefore, contained structural information. Unfortunately, at some point during the first EVA, the glue on a patch of Velcro holding down a dust cover on the SEP recorder failed. Cernan and Schmitt attempted to tape the cover shut but the tape didn't stick well to the dust-impregnated cloth and the instrument got fairly dirty. The SEP recorder was equipped

with a mirror-like radiator which was exposed to the black lunar sky during each of the rest periods and at each of the geology stops; and, had the mirror been clean and had the instrument not been quite so temperature sensitive, the radiator would have cooled the instrument enough to keep it running through all of the geology traverses. However, despite Cernan's best dusting efforts, the radiator was too dirty - and the receiver too temperature sensitive - to work properly. The instrument overheated and failed, returning relatively little useful information and taking up far too much crew time in the process.

The SEP problems emerged on Day 2, and were part of a series of minor frustrations in an otherwise very successful and productive mission. According to the mission operations plan, deployment of Rover and of the ALSEP was to have taken a total of four hours, leaving Cernan and Schmitt time for a 90-minute geology trip south from the LM to Emory Crater. However, through no fault of his own, Cernan had a great deal of trouble removing the deep core, despite the fact that he had a treadle and jack identical to the one Charlie Duke had used successfully on Apollo 16. The soil at Taurus-Littrow simply gripped the core very tightly and the effort of removing the core cost both time and oxygen. As a result of Cernan's troubles with the core - and to Jack Schmitt's considerable consternation - the first day's geology trip had to be shortened to an hour.

There were also problems with the gravity wave detector, a potential Nobel Prize experiment. Gravity waves were a predicted consequence of Einstein's theory of General Relativity and a confirmed discovery would have been a major achievement. In essence, the Apollo 17 experiment consisted of a delicate balance beam designed to respond if a passing gravity wave caused the Moon to oscillate. Seismically, the Moon is very quiet compared with the Earth. The moon does have quakes, but they are relatively infrequent and, a lunar gravity-wave detection coupled with a nearly simultaneous detection by instruments on Earth would have been a momentous event. During the trip out from Earth, the balance beam had been locked ("caged") and, once Schmitt deployed the instrument and had it more or less level, he uncaged the beam. Because it would have been impractical for Schmitt to level the instrument precisely, the experimenters then did some fine-tuning by adjusting the mass distribution on the balance beam. Or, at least, they tried. It soon became obvious that the beam couldn't be adjusted and, indeed, that it didn't seem to uncage at all. The experimenters were concerned that Schmitt hadn't deployed the detector properly and, in the end, he was asked to make repeated visits, finally hitting the instrument with a tool in an effort to get it unstuck. It was all in vain; subsequent investigation revealed that a design error, essentially an error in the assumed strength of lunar gravity, meant that the balance beam wasn't heavy enough to uncage.

On some of the prior missions, astronauts spent time in the LM cabin between EVA's making minor repairs to broken equipment. Conrad and Bean had fixed a broken scale and Scott and Irwin had taped a broken PLSS antenna. And, of course, the Apollo 13 crew had used tape, cardboard, and hoses so that Command Module lithium hydroxide canisters could be pressed into service in the battle against a carbon dioxide build-up. During the rest period after the first Apollo 17 EVA, Gene Cernan took up the art of fendermaking, using tape and spare maps to make a replacement for a fender lost early in the first EVA. What had happened was the, while Cernan was loading equipment on the Rover at the start of the EVA, he accidentally caught his hammer under the right-rear fender and tore it off. He taped the fender back on - albeit, with some difficulty because of the dust that coated everything and prevented a good bond. However, Despite Cernan's best efforts, during the drive back to the LM from the geology stop the tape failed and fender was lost. The Apollo 16 crew had lost a fender in much the same way and, in the interest of avoiding such problems as overheating batteries and sticking latches, Cernan was eager to fashion a replacement. While Cernan and Schmitt slept, members of the support team in Houston figured out how to make a replacement fender and how to attach it to the Rover and John Young got into a suit to try it out. In the morning, Young talked Cernan through the procedures; and the fix proved highly successful.

The first EVA had been a bit frustrating for Jack Schmitt. He wanted nothing more than to get out and do some geology; and, by the end of the first day, he was concerned that, if he and Cernan had to leave early for some reason, they would take home very little information about the geology of Taurus-Littrow. At the ALSEP site and, then, at their one geology stop, they had collected samples of coarse-grained basalt which, undoubtedly, represented the top layers of the bedrock that underlay the soil. However, they hadn't seen or collected any rocks that might be representative of the deeper bedrock or of the Massifs and, therefore, the site was not yet well characterized. Now, on the second day, they were going to be able to get to work and, indeed, the second and third EVA's proved to be exciting, productive, and full of fun.

To get things started, Cernan and Schmitt drove six kilometers west to a place called Hole-in-the-Wall at the base of the scarp. In the overhead pictures taken from the Apollo 15 Command Module, Hole-in-the-Wall looked like a place where it might be possible to climb the eighty meters to the top of the Scarp without straining the capabilities of the Rover. From the LM, Cernan and Schmitt could see a bit of Hole-in-the Wall on the horizon beyond the rim of Camelot, but it wasn't until they were actually fairly close that they had a good look at it. Hole-in-the-Wall was, as Cernan described it, a step leading up toward the south. The surface was smooth and, although they had to do a fair amount

of sidehill driving, the climb was effortless. Once up on top, they drove another kilometer to the foot of the South Massif and, there, spent an hour sampling boulders that had rolled down off the mountain. Although they spent most of their time working on a fairly steep slope and had to watch their footing, like the Apollo 16 crew they found the slope to be no more than an inconvenience. As they had during the ALSEP deployment and at the first day's geology stop, they moved with relative ease and, indeed, seemed to be making the maximum use of the limited flexibility that the suits afforded. They had no hesitation about leaning down on hands and toes to get a close look at a rock and, in appropriate circumstances, made good use of their tools as crutches.

This first stop proved a geologic bonanza and, consequently, Houston decided to lengthen the stay to the maximum allowed by the walkback constraints. With the Apollo 14 experience as a guide, NASA had made a conservative assumption that, in the event of a Rover breakdown, the astronauts would be able to maintain an average walking speed of 2.7 km/hour, about half the running speeds achieved by several of the astronauts over distances of a hundred meters or so. Making allowances for reserves - but no allowance for the backup capacity provided by the Oxygen Purge System (OPS) - the assumption of a 2.7 km/hr return speed meant that, at this farthest station, Cernan and Schmitt had to leave no later than about three and a half hours into the EVA. During our review of this usmmmary, Jack Schmitt said, "I remember arguing with them about how conservative the walkback assumptions were. Particularly where your landmarks are clear of you have Rover tracks to follow. You could almost certainly get into a fairly efficient motion that would have been better than 2.7 (kph). I can't document any estimates that we ever made, but we always thought that it was pretty conservative. On the other hand, the reason I didn't argue about it very much was that there was oing to be plenty of things to do. You didn't need to go very far (away from the LM) in order to reach all the interesting places that we wanted to get to in the time that we had available."

In all, Cernan and Schmitt spent sixty-four minutes at Station 2. It was one of the longest stops made during Apollo and, still, it was a frustratingly short time for so productive a stop. They sampled the two major rock types evident in the area and, although it is still an open question as to which of the rock types is more characteristic of the South Massif, there was no doubt that the Massif, like the mountains at Hadley, is made up of breccias. The samples the crew collected gave the geologists at home a great deal to think about.

On the next part of their journey, Cernan and Schmitt were going to retrace their tracks to the top of Hole-in-the-Wall and, on the way, planned to make a brief stop to collect some of the landslide material. For a normal Rover sampling stop, Schmitt picked out a likely place and, as Cernan rolled forward the last few feet, took a few "before"

pictures. Then, Schmitt used a long-handled tool called the LRV (Lunar Roving Vehicle) Sampler to collect a small rock and a bit of soil without either of the astronauts ever getting their seatbelts undone. Once the sample was collected, Cernan and Schmitt then took "after" pictures of the spot and drove on. Time was always at a premium; and, as Cernan and Schmitt were preparing to climb on the Rover at Station 2, there was a minor battle being fought between the geologists - who wanted the crew to spend time collecting rocks - and the geophysicists - who wanted them to spend time putting out seismic charges and making gravimeter measurements. As CapCom Robert Parker told the crew, the outcome of this particular skirmish was that "the gravimeter people have won today." The quick stop for an LRV sample was going to be replaced with a longer stop for a gravimeter measurement. The gravimeter stop would take longer because both astronauts would have to get off the Rover, and that time would have to be taken out of some later geology stop.

In reality, even more time was lost because the crew hadn't trained for a such a contingency and there was some initial confusion about whether or not both of them had to get off the Rover. Hoping to save time, Houston wanted the measurement made with the gravimeter sitting in its stowage slot on the back of the Rover but Cernan thought, at first, that he could sit quietly while Schmitt got off, started the measurement, and then collected a sample or two. However, the experimenters were concerned that the pumps and fans in Cernan's PLSS would perturb the measurement and it took an extra minute or two for everybody to decide that he had to get off.

Once Cernan was off and the Rover's suspension system had quieted down, Schmitt got the gravimeter started. Cernan had grabbed a camera equipped with a 500mm lens from under his seat and, while Schmitt used the LRV sampler to get some soil and rocks, Cernan took pictures of Massifs. The sampler consisted of what was called the Universal Handling Tool (UHT) and, attached to it, a stack of cup-shaped bags in a holder. The crew had used the UHT's to deploy the ALSEP. The tool was about a meter long. It had a pistol-grip handle and, at the other end, a socket-type fitting for the removal of ALSEP attachment bolts. At the business end, there was also a pair of retractable pins - worked with a trigger in the UHT handle - so that the tool could be locked into a suitably-equipped socket, such as one in the sampler head. The sampler made an excellent solo-sampling tool because Schmitt could collect a sample in the exposed, top cup of the stack and then remove that cup, seal it, and put it away before grabbing the next sample. The sampler eliminated the problem of manipulating a scoop and a bag at the same time, and the only real problem in using it was making sure that there was a pocket or a Sample Collection Bag (SCB) handy so that you could get rid of the sealed sample and free your hands. Here, Schmitt had to hold on to the sealed bags until

the gravimeter measurement was done and he could put them in an SCB that was hanging next to the Rover console.

Within a few minutes, the gravimeter measurement was finished and the astronauts were ready to mount the Rover. To do so, they stood at the side of the vehicle, next to their seats and facing forward. They gripped a handhold next to the console between the seats, jumped up and sideways, kicking their feet forward. With luck, they fell into a sitting position; but, here, Cernan missed his jump and fell to the ground. With the Rover handy, he had no trouble getting up and, in the process, noticed that he had uncovered a layer of very light-colored soil below about two inches of darker, brownish-grey surface soil. Most of the Apollo crews uncovered light layers from time to time and, in most instances, what they were probably seeing was highly-shattered - and, therefore, light-colored - ejecta from relatively recent impacts, with the top layer having been turned dark by the subsequent effects of countless small impacts which produce small globules of relatively dark glass. Here, however, the light material probably represented the unaltered landslide material and it only took Schmitt a moment to get a sample.

The next stop was planned for the rim of a small crater a few hundred meters north of Hole-in-the-Wall at the base of the Scarp. The astronauts had something of a wild ride coming down the slope and, once they were off, Cernan claimed a lunar speed record of "17 1/2 to 18 clicks (kilometers per hour)". While his claim can't be independently verified, there is no doubt that he was moving quickly and that he had managed to avoid a spinout in the process.

The next stop was at a place that came to be known as Ballet Crater and the stop was another source of long-lasting frustration for Schmitt. In the interest of making up for the extra time spent at Station 2 and at the Scarp gravimeter stop, this was to be an abbreviated station, one of perhaps twenty minutes rather than the planned forty-five. However, it soon turned into a comedy of errors and, in the end, they ended up spending about thirty-five minutes at Ballet.

The three things that the Backroom really wanted at this site were a double core tube which Cernan would drive into the ground, a gravimeter reading, and a pan. The core tube promised to keep Cernan busy for most of the twenty minutes - especially because the geologists in the Backroom wanted him to put the lower half in a sealed can. Basically, this was a one-man operation and, in the meantime, Schmitt could take the pan and do some solo-sampling. However, Schmitt's forearms were very sore and, as a consequence, he wasn't able to work with his normal efficiency. The source of his forearm soreness that, during the drive out to Station 2, the camera bracket on the front of his suit had started to work loose and, all through the drive, he had been forced to grip the camera so that he didn't lose it. Once they got to Station 2, he and Cernan managed to tighten the bracket, but the effort of keeping his hand closed against the pressure of

the suit meant that his hands and forearms sore and tired as he started to work at that stop. An hour later, the soreness and forearm fatigue had only become worse; and the drive to Ballet Crater hadn't been long enough to give Schmitt much relief.

Although the LRV sampler had it's advantages, Schmitt's tool of choice was a scoop with which he could be more selective in sampling and, as well, could be used to dig small trenches. However, solo-sampling with the scoop and the packet of flat bags attached to the camera bracket required some finesse and, with tired hands, Schmitt was short on finesse at Ballet Crater. The head of the scoop could be angled at 90 degrees to the handle but, once a rock had been captured, it was no easy matter to get a bag open and then get the head of the scoop high enough to dump the rock into the bag. Later in the mission, Schmitt worked out a technique of resting the scoop head on the ground and then walking his fingers down the shaft far enough that pouring was a relatively easy matter; but, here, solo-sampling proved to be much more of a chore than it had been for those astronauts who had longer arms and/or used tongs as their solo-sampling tool.

In order to close a sample bag, Schmitt had to get rid of the scoop for a moment but, with the head angled, it couldn't be stuck in the ground. Naturally, he rested it against his leg but, time after time, it fell to the ground. The job of grabbing it up was made a little easier by the raised rim of the crater because Schmitt could put his feet downslope. However, the slope also made balance a bit tricky and, not only did Schmitt drop his scoop, but also his packet of sample bags; and, in a final moment of frustration, he accidentally kicked over an SCB he had put down near him. At one point, he took a spectacular, spinning fall onto his hands and knees and, once he was up, had to take a couple of minutes to make sure that his camera hadn't been damaged. Fortunately, the camera and lens were okay and Cernan soon came over with a pair of tongs to help Schmitt collect the scattered gear. In a successful attempt to lighten the mood, Parker told Schmitt that "the switchboard (at Houston) has been lit up by calls from the Houston Ballet Foundation, requesting your services for next season," and in response, Schmitt did an impromptu audition, managing two big hops on his left leg, with his right leg flexed up and back about as far as was possible in the suit. Twenty years after the fact, Schmitt still feels the frustration of Ballet Crater; but, at the very least, the episode illustrates the problem of finding the right combination of tools and technique, particularly for unrehearsed activities. By the end of the mission, Schmitt had learned enough that solo sampling was no longer a particular problem.

Thirty-seven minutes after they stopped, Cernan and Schmitt were on their way again. The next target was a crater named Shorty and everyone had high hopes of finding something unusual. From orbit, Shorty looked to be a

different beast. It sits out at the tip of the landslide runout and is very much darker than the surrounding terrain. The most likely pre-mission hypothesis about Shorty was that it was an impact feature that had punched through the landslide material and excavated some of the darker material that covers most of the valley floor. However, there were some people who hoped that Shorty was actually a volcanic vent and that the dark material would prove to be glassy, pyroclastic material that had been spewed out in fire fountains. As it turned out, both camps were right. The dark material was pyroclastic, but it was the product of ancient - rather than modern - fire fountains and had been uncovered by the relatively recent Shorty impact.

As was typical of an Apollo 17 geology stop, once Cernan had the Rover parked, Schmitt hopped off and took a quick look around while Cernan took care of the dusting and the other house keeping. They were parked near a highly shattered boulder and Schmitt went over to take a look and then take a pan. Being a little gun-shy from his experience at Station 3, Schmitt wasn't about to start sampling until Cernan was ready to help him. Having looked at the boulder, he backed away to start the pan and immediately noticed that there was something very unusual about the soil that he'd stirred up with his feet.

"Oh, hey!", he said, obviously excited.

He paused for a fraction of a second. At the Scarp gravimeter stop he'd seen spots of color on the ground which, after a moment's consideration, proved to be spots of sunlight reflected off the gold foil on the front of the Rover.

"Where are the reflections? I've been fooled once."

And then he was sure. "There is orange soil!!"

The orange was all around him. He was very excited.

Cernan, who was still dusting, hadn't seen the orange soil yet and, at first, thought that perhaps Jack was letting his imagination run away from him. "Don't move it until I see it," he said.

"It's all over!! Orange"

"Don't move it until I see it," Cernan said again.

"I stirred it up with my feet," said Schmitt as he pondered the implications and started to think about a plan of attack.

By now, Cernan had turned around to look. "Hey, it is! I can see it from here."

"It's orange!", exclaimed Schmitt again.

Cernan wanted to be sure that he wasn't being fooled.

"Wait a minute. Let me put my visor up." But there was no doubt. "It's still orange!"

"It sure is! Crazy!"

"Orange!!"

"I've got to dig a trench, Houston," Schmitt said.

"Copy that. I guess we'd better work fast," said Parker, conscious that they would soon be up against the walkback constraints again.

"Hey," said Cernan, "he's not going out of his wits. It really is."

If the Ballet Crater stop was a comedy of errors, the Shorty stop was a demonstration of the efficiency that could be achieved by a talented, well-trained, highly-motivated crew. The patch of orange seemed to form a band that ran parallel to the rim of the crater and as Schmitt dug a trench across the band, it became evident that, under a thin layer of altered surface soil, the ground was a deep red at the center of the band, fading to orange toward the edge. By the time Schmitt had finished the trench, Cernan had finished dusting the TV camera - so that Houston could have a good look - and arrived with the gnomon and a supply of sample bags. The gnomon was a lovely little device consisting of a free-swinging staff mounted on a tripod base. The idea was to put the gnomon down on the ground next to a sample so that, in the pictures, the gnomon shadow provided information about orientation while the gnomon itself provided a vertical reference and a length scale. In addition, there was a color-and-grey scale on one of the legs to provide calibration for photoprocessing. Schmitt and Cernan didn't have to spend much time talking about what they were going to do. With the trench already dug, they took documentary photos; and, then, with that done, Schmitt used his scoop to get the first of several samples while Cernan got a bag open and ready. As soon as a sample was in the bag, Schmitt turned to present his SCB to Cernan who, once he'd sealed the sample bag, put it in Schmitt's SCB. Schmitt then turned to get the next sample while Cernan got another bag ready.

While the crew was getting trench samples, people in the Backroom in Houston were debating what they wanted next. On Earth, orange or rust-colored rocks and soil around volcanic vents are often the result of literal rusting of iron by volcanic water vapor. If this was the cause of the orange soil at Shorty then, small amounts of volcanic gasses might still be present and, at first, what the Backroom thought it wanted was a trench sample put in a vacuum tight can. However, by the time the crew was satisfied that the trench had been properly sampled and Cernan was on his way to the Rover to get the "short can", there was a change of heart in Houston. What they wanted was a double core which could later be sealed in one of the vacuum tight rock boxes.

"Did you want that in the orange," asked Schmitt?

Back in Houston, Parker heard a chorus shout "Yes" on the Control Room comm circuit and told the crew, "We can put cores in grey soil all the time."

Schmitt remembers thinking, at the time, that they might learn a bit more about the vertical distribution of the material by moving off the side to a thinner part of the deposit but, in hindsight, is very glad that they drove the core into the center of the orange band. When he and Cernan pulled the tube out again, the soil in the bottom wasn't red or orange, it was black. Back at the Rover, while Schmitt was getting a quick sample of the boulder, Cernan took the

two sections of core apart and found that the bottom of the upper section was a very dark grey as well. As it turned out, the dark color - and the orange as well - was, due to the presence of tiny spheres of volcanic glass, with the color differences having been produced by variations in rates at which the two types of glass cooled. Later, examination of soil samples and cores collected at other stops showed that both types of glass are widely distributed on the floor of Taurus Littrow and are the distinguishing component of the so-called dark mantle. Billions of years ago, when the valley was being filled with lava, fire fountains laid down deposits of pyroclastic glass which were then covered and protected by later lava flows. Subsequently, various impacts dug up glass along with fragments of basalt and, as the rock fragments were ground down into regolith, the glass was mixed in, giving the area its characteristically dark surface color. At Shorty, a layer of pyroclastic glass remained protected by overlying lava until the impact punched through about 19 million years ago. As mentioned previously, in a cratering event the ejecta is laid down as an overturned blanket; and the presence of the orange soil near the rim indicates either that it was dug up from nearly the deepest point of penetration or that it was injected into a rim fracture by the force of the impact.

Had there been time, Schmitt and Cernan easily could have spent several hours exploring the Shorty ejecta blanket and taking samples. Unfortunately, because of the extra time spent (very profitably) at Station 2 and (less profitably) at Station 3, they had only thirty-four minutes available at Shorty. They were still more than four kilometers from the LM and were right up against the walkback constraint. By the time they had the core back to the Rover, they only had thirteen minutes left. Working as quickly as they could, Schmitt finished preparing the core tubes for the trip home while Cernan ran over to the elevated southeast rim of the crater to take a color panorama. From his relatively lofty perch, Cernan had a good view of the rim beyond the Rover and it was only a moment or two before he spotted more of the orange soil. Beyond the boulder, he could see "a lot of orange stuff that goes down, radially, into the pit of the crater" and more patches of it around to the north side of the crater. Clearly, the impact had exposed a great deal of pyroclastic material but, not only was there no time to do more sampling, there wasn't even time for Cernan to give more than a quick verbal sketch of what he'd seen. After the mission there would be time to examine the pictures and to talk with the geologists and to figure out what it all meant. In the mean time, Parker wanted Cernan back at the Rover so that he and Schmitt could be on their way.

Because they could drive nearly three times as fast as the walkback speed assumed by the EVA planners, as Cernan and Schmitt drove toward the LM, it wasn't long before walkback was no longer a serious consideration. Part way back, they made a brief stop to deploy a seismic charge and take a quick

LRV sample and then made their way to the south rim of Camelot Crater, a large impact feature about a kilometer west of the LM.

During the first EVA, Schmitt had found coarse-grained basalts at the ALSEP site and, again, at Station 1. The longer a piece of lava takes to cool, the larger the grains in the resulting piece of basalt and it was a bit of a puzzle that they had found no pieces of fine-grained basalt which presumably would represent the uppermost layers of the lava flows. Camelot is a large crater, six hundred meters in diameter, that seemed young enough that the ejecta blanket would include a good selection of boulders dug up from as much as 150 meters below the valley floor. On the way out to Station 2, Cernan and Schmitt had driven by Camelot and had seen an extensive field of waist-high boulders on the southwest rim.

On close examination, the Camelot boulders showed many of the same characteristics that Schmitt had seen in the rocks at the ALSEP site and at Station 1. The boulders were made up of coarse-grained basalt and, in places, contained sheets of hollow, spherical cavities - called vesicles - left by a froth of gas bubbles that had formed in the cooling lavas. Now there was no doubt that they had identified the dominant form of the Taurus-Littrow basalts. There was still the question of why they weren't seeing any fine-grained versions, but that was a question to be answered through a detailed examination of the regolith samples back on Earth.

For about 20 minutes, Cernan and Schmitt worked in the cramped quarters of a boulder field, conscious of the potential for snagging their feet. They collected samples of the rock, samples of soil thrown up on the rocks by nearby impacts, and comparison samples of soil scooped up from between the rocks. They worked quickly and efficiently and, now pleased with themselves for a day's work very well done, skipped and sang as they made their way back to the Rover and, then, to the LM.

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The plans for Day 3 were at least as challenging as those for Day 2 and, as it turned out, the work was equally rewarding. From the LM, Cernan and Schmitt drove north about three kilometers to the base of the North Massif and, then, about 400 meters cross slope to the northeast to a big split boulder that had been seen in the Apollo 15 photographs.

Indeed, a number of boulders had been picked out in the pre-mission photos and the split boulder, in particular, seemed to have an associated trail. After landing, Schmitt had been able to pick out boulders and trails on the North Massif and now, as they got close to the mountain, it became evident that the trails, like those they'd seen the previous day at the South Massif, consisted of chains of crater-like depressions and linear gouges carved out by the boulders as they bounced, tumbled, and slid downhill. The split boulder lay just below a noticeable break in slope and, evidently, had hit with considerable force and had broken and then slide a short ways before coming to rest. In detail, it had broken into five pieces, with the largest of them being roughly six to ten meters on a side.

Although the mountain side is considerably steeper above the boulder, when Cernan parked the Rover, he and Schmitt found that their work was going to be very challenging. They had hardly noticed the slope driving up toward the boulder; but, once they climbed off the Rover, they had to lean forward into the hill to stay upright. At places around the boulder, they could stand in the furrow it had dug; but, for much of the hour that they spent at the station, they had to contend with the hill. It was a measure of the confidence that had been gained as a result of Apollo 15 and 16 - and the first two days of their own mission - that, while they laughed and joked about the slope, they showed no hesitation in getting the job done.

On the whole, the Station 6 boulder appeared to be a large piece of breccia like those they had seen at the South Massif, but there were some puzzling features that were only clarified toward the end of the hour. In places, Schmitt found vesicles that indicated that at least part of the rock had once been molten; and, eventually, he found a contact surface - a boundary between a blue-grey breccia and a tan-grey, vesicular breccia. Flattening of the vesicles in the tan-grey rock and evidence of melting in the blue-grey near the contact showed that the tan-grey breccia was very hot when it intruded into the blue-grey. Here was evidence that the Serenitatis impactor had struck deep layers of breccia formed in prior impacts and that, as the mountains were raised, streams of molten rock were injected into fractures. Both the flattened vesicles and caught-up bits of the blue-grey breccia in the tan-grey were indicative of a thick, viscous flow. Had Schmitt and Cernan been rushed at Station

6, they might have missed some of these vital clues and the geologists back home might not have been able to piece the story together from the samples. However, here the astronauts had enough time to make a fairly complete field study of the boulder and to make the critical observations. Gene's Station 6 pix of Tracy's Rock

After the mission, only Cernan had any regrets about their work at Station 6 and, at that, he was only sorry that he hadn't taken time to write his daughter's name on a dust-covered, uphill shelf on the boulder. He'd collected a sample of the dust and the spot can be seen in a famous picture he took of Schmitt next to the boulder with the valley visible beyond. Fortunately, Alan Bean was able to correct Cernan's error by painting the scene and adding Tracy's name. To those who know the story, the Station 6 boulder has become known as Tracy's Rock.

Before they could move on to the next stop, Cernan and Schmitt were faced with the tricky problem of getting back on the Rover. The vehicle was parked with Cernan's side uphill and it didn't look as though he would have any particular problem. But Schmitt had visions of not jumping high enough up into his seat, missing, and rolling downhill. As Scott and Irwin had done in a similar circumstance on Apollo 15, the 17 crew decided that the best plan was for Schmitt to walk down to a small crater where Cernan could get the Rover level enough for him to climb on board.

Station 6 was sufficiently productive that, in the interest of saving time, Houston wanted them to make the next stop only long enough for the crew to take a pan and collect a representative collection of small rock fragments. They were going to drive east along the mountain slope for a few hundred meters and there was no reason to believe that the rock types would change dramatically. Once they were stopped - on a shallower slope this time - Cernan took care of his dusting chores and, then, while Schmitt finished the sampling, examined a nearby, head-high boulder. It was another breccia; and this one, too, had been injected with molten rock. In this case, Cernan could see where small, individual fractures had been widened and filled with molten rock.

While Cernan examined the boulder, Schmitt proved that he had learned a great deal about solo sampling since Station 3. Once again, he had the scoop head at a right angle to the handle but now, once he had captured a few rock fragments, he rested the head on the ground, got a bag open, and then reached down as far as he could before grabbing and lifting the scoop. This way, he was holding the scoop close to the head and had no trouble pouring the sample into the bag. On occasion he tried to rest the scoop against his leg and it fell; but, now, he had no trouble retrieving it. The trick was to step on the head so that the handle rotated up high enough that he could grab it. As Cernan remarks in his commentary to the transcript, there is usually a simple, easy way to do everything.

Station 8, the next stop, was to be on the lower slopes of the Sculptured Hills, the exact place having been left to the discretion of the crew. No boulders had been spotted in the pre-mission photographs and the mission planners simply left it to the crew to find a place where, it was hoped, they could get samples to tell the geologists something about the Hills. Unfortunately, there were few boulders to be found and most of those proved to be pieces of the coarse-grained basalt which, evidently, had been thrown up onto the Hills from the valley floor. There was one intriguing rock uphill about 50 meters from the Rover and Schmitt, followed shortly by Cernan, made a trek up to see what it might be. It was a slow, hard climb and the boulder proved to be a shocked piece of old lunar crust which was coated with glass and, evidently, had been thrown onto the hillside from somewhere else. Samples of soil and rock fragments collected with the rake would have to tell the story of the Sculptured Hills and, indeed, post-mission analysis showed that there were close similarities with the North Massif.

If the climb up to the Station 8 boulder had been strenuous - and it is important to note that, as a result of the climb, neither of them experienced peak heart rates of more than 130 beats per minute - the trip back down to the Rover was nothing short of fun. At Station 6, after finishing his pan from above Tracy's Rock, Cernan had headed back toward the Rover using a high-speed skip. As he came up out of the boulder track, he got his weight too far over his right foot and took a spectacular fall. Because the soil was soft, because there were no exposed rocks, and because Cernan was moving downslope as he landed, the fall looked worse than it really was. In truth, he fell slowly enough that he had some control and landed on his hands and knees, even managing to avoid hitting his camera on the ground. Indeed, the fall was so benign that, twenty years after the fact, neither Schmitt nor Cernan could remember the incident. More immediately, at Station 8 the only adjustment that Cernan made as a result of the Station 6 fall was to change his downhill gait to a series of big, two-footed kangaroo hops. These gave him more stability but without any sacrifice of speed. It was fun and Schmitt gave hopping a try, too. As he made his way downhill, he started making skiing noises - Shhhh, Shhhh, Shhhh, Shhhh, Shhhh, Shhhh.

"Can't keep my edges," he said, trying to hop from side to side, pretending that he was skiing moguls. "Shhhoomp. Shhhoomp. Little hard to get good hip rotation."

As they left the Sculptured Hills, Cernan and Schmitt had only two planned stops remaining. The first of these was at a small crater named Van Serg which, in the pre-mission photos, bore some resemblance to Shorty. Indeed, all through the EVA, Schmitt - in particular - but sometimes Parker, too, had referred to Van Serg as "Shorty". No one was yet quite sure what the discovery of the orange soil really meant and there was hope of finding further clues at Van Serg. After

Van Serg, there was a final stop planned at a large Camelot-like crater named Sherlock but, even before Cernan and Schmitt had finished their EVA-3 preps, there was discussion about deleting that stop. The point of visiting Sherlock was to find evidence about the nature of the bedrock underlying the valley, and there was growing confidence that the question had been answered at the ALSEP site, at Station 1, and at Camelot. Consequently, Houston had been very comfortable about lengthening the stop at Station 6 and, now, had an option of having the crew spend additional time at Van Serg.

Unlike the frustrations of Ballet Crater and the excitement of Shorty, the mood of Van Serg was one of puzzlement. As Cernan and Schmitt approached the crater, they drove across a landscape littered with football-sized rocks and, the closer they got, the more Cernan had to maneuver. The Rover had a clearance of about 14 inches and, at low speed, it was certainly possible to run a wheel up and over taller rocks. But, here, there were so many rocks that Cernan had to turn frequently and he estimated his "wander factor" to be as high as fifty percent. That is, to go forward ten meters, he had to drive fifteen. The large number of rocks indicated that Van Serg was an impact structure. However, although the crater lies well out in the middle of the valley and should, like the larger craters around it, have dug up basalt, the rocks looked different from anything they had yet seen.

While Cernan dusted - and he had a great deal of dusting to do because the replacement fender had finally failed - Schmitt made his way up to the crater rim. The rocks looked highly shocked, he said, probably thinking about the boulder at Shorty. However, the more he looked at them, the more they looked like breccias. Many of the rocks seemed to contain light-colored fragments within a darker matrix and there was nothing that looked like the coarse-grained basalt. And, when the astronauts started to sample, they found that the rock was fragile and easily broken.

"I'm not sure I understand what's happened here, yet," Schmitt said. Van Serg "should have brought up (basalt) according to the theory, and it hasn't."

They never did find anything that was clearly basalt. As Schmitt complained, everything was covered with dust. In addition, there was no sign of any orange soil or anything else that even hinted at volcanism. It was a puzzle, and neither the crew nor Houston seemed to know what to do about it. Cernan and Schmitt collected samples, and then there didn't seem to be much else to do besides take a pair of pans and climb on the Rover for the trip to Sherlock. As they sampled, Schmitt wondered if, perhaps, Van Serg had hit a "window" in the basalt layers and had penetrated into an underlying layer of breccia; but there wasn't any way to answer the question by doing a few more minutes of field work. Houston wanted Cernan to take a few 500-mm pictures of

the North Massif while Schmitt finished sampling. Then it would be time to go.

By this time, Cernan and Schmitt had been out for nearly five hours. They had been working hard all day, scrambling around on the hillsides; and, at Van Serg, there had been nothing like the discovery of the orange soil to keep them going in the face of sore muscles. While Cernan took the 500s, Schmitt started a planned "radial" sample, a series of samples taken on a line extending out from the crater rim toward the Rover. The "radial" had been planned as a solo activity; and, therefore, Schmitt had the LRV sampler with him. It was attached to a device called a yo-yo which consisted of a small, spring-driven reel hooked to the suit, a two-meter-cable, and a clip to which the LRV sampler or one of the pairs of tongs could be attached. When not in use, the cable was wound on the reel and the tool was held tight against the suit. If Schmitt then wanted to use the sampler, he merely grabbed it and pulled to unwind the cable. When he was done, he let go of the sampler and let the spring rewind the cable and pull the tool out of the way. The trouble was that Schmitt also had his scoop with him and, as his troubles mounted, he wished that he'd had Cernan take the scoop back to the Rover. At first, the scoop was merely a nuisance because he could plant it in the ground, out of the way, while he used the sampler. However, all through the day, the latch which let him change the angle of the scoop head had been getting more and more difficult to use because of dust that was getting in the mechanism. And the latch wasn't the only thing that was getting fouled. There was dust in the locking collar with which the scoop was attached to the extension handle; and, as Schmitt grabbed the scoop to move to the next spot, the lock failed and the scoop head fell to the ground. Tired as he was, he managed to get down to retrieve it, using the extension handle as a crutch; but, as he tried to get up, he had trouble and had to run forward several steps to regain his balance. In hindsight, he believes that, had he not been so tired, he would have been a bit more cautious. He was working near the crater rim and was surrounded by rocks big enough to have caused a problem had he tripped.

Schmitt decided to go over to the Rover to get rid of the scoop; and his decision triggered one in Houston. The geologists decided that they weren't going to learn anything new by continuing the radial sample and Flight Director Gerry Griffin agreed. Parker told Schmitt to abort the radial and told Gene to finish up the 500s. Schmitt readily agreed that it was time to leave.

There was a bit of housekeeping to do - in particular, a gravimeter to be read - and, as they got back to the Rover, Gene suggested that they needed a sample of the soil. Because he had the scoop in hand - the head now re-attached - Schmitt started to take a quick sample and, almost immediately, found a layer of very white soil about 3 or 4 inches below the surface. Fascinated by his discovery, he

started to dig a trench, all traces of fatigue gone from his voice. Although Houston had been insisting that they leave Station 9 immediately, Cernan and Schmitt made a crew decision to stay for another few minutes so that they could get a trench finished, get some pictures taken, and get some samples bagged. They worked rapidly and efficiently. Houston did not interrupt.

While Cernan and Schmitt were digging, Griffin and others in Houston had an earnest discussion about an extension at Van Serg. The geologists were now a bit more enthusiastic, but Griffin was concerned about fatigue and, in particular, about the astronauts' hands. However, because Cernan and Schmitt seemed to have been revitalized by their discovery, Griffin decided to grant the extension and Parker informed the crew that the Backroom wanted a double core and some football-sized rocks.

Schmitt was skeptical about the feasibility of doing a double core. The ground was littered with rocks and there was every reason to believe that Cernan would run into more as he tried to hammer the core tube into the ground. If Schmitt had regained his enthusiasm about Van Serg, his fatigue hadn't completely disappeared and his tiredness was made evident when he started to argue with Houston about doing the core.

Not surprisingly, Cernan decided not to get involved and got busy assembling the double core tube. In hindsight, Schmitt says that he should have realized that Cernan wouldn't have much trouble. The rocks they'd tried to sample had broken easily and, as Cernan hammered on the core tube, it would meet occasional, momentary resistance and then would break through. Schmitt's difficulty in thinking this through was probably another symptom of the fatigue that had been masked by the discovery of the white soil.

Because Houston had decided to drop Station 10 completely, the Station 9 close-out was actually a fairly relaxed affair. The astronauts got the core sections separated and capped, changed film magazines, removed the data recorder from the SEP receiver, and deployed a seismic charge. There was even a moment or two for Houston to do some exploring independently of the crew. For a moment, it looked as though they had made a momentous discovery.

What happened was that Ed Fendell, who was operating the TV camera remotely from Houston, was doing a TV pan at the end of the Van Serg stop when someone in Houston noticed a patch of orange on the East Massif. Fendell zoomed in to take a closer look. Zooming didn't help; and Parker finally had to ask the crew "What's out there in the distance on a hillside in the field of view? The camera is pointing at it." And then, before Cernan or Schmitt even had a chance to figure out what he was talking about, Parker had the answer. "Oh, I'll bet it's the Italian flag, I'll bet. On the charge." What he realized was that Schmitt had put the seismic charge out about 10 meters east of the Rover. At the tip of the antenna, there was a small, bright, orange pennant

to serve as a warning flag and to make the charge more visible in color photos. When Fendell panned by the charge, he was looking at the mountains and the TV lens set at intermediate zoom. The pennant filled only a few picture elements and was badly out of focus, looking like a blurred patch of color on the hillside. Once Parker figured out what was going on, Fendell pulled back on the zoom and brought the pennant into focus. None of the people involved remembers why they called it the "Italian Flag", although Parker thinks it may have been a reference to the less than enthusiastic participation of Italian troops in World War II.

As they drove back toward the LM, Cernan and Schmitt soon started to see blocks of the coarse-grained basalt near the larger craters. From time to time during his running geologic commentary, Schmitt made stabs at an interpretation of what they had seen at Van Serg but none of them satisfied him. After the mission, it quickly became obvious that the Van Serg "breccias" were actually pieces of soil compacted during the impact - pieces of what is sometimes called "instant rock" or, more formally, "regolith breccia" - and, twenty years after the mission, Schmitt believes that the Van Serg impactor hit an unusually thick layer of regolith built up by the overlapping ejecta blankets of several large, nearby craters. Despite the size of the Van Serg crater, the impactor had simply not reached bedrock.

As we have discussed, none of the Apollo missions could be more than a quick scouting trip to a particular landing site. The Kennedy deadline forced NASA to build the simplest set of hardware capable of completing a landing mission and it is a credit to the design teams that, by the time of the J-missions, crews could spend three days on the Moon and had Rovers to extend their range. There was never any hope of doing more than scratching the lunar surface and producing an outline of lunar geologic history. By the end of Apollo 17, there were enough samples of the mare lavas and the highlands breccias that the geologists could be confident that they understood how the big basins like Serenitatis had been blasted out by impacts, how the mountains had been raised, and how the mare had been formed by flows of lava episodically welling up from the lunar interior. And there were intriguing details which, if not completely explained, seemed consistent with the general themes. If, for example, some geologists were disappointed that no evidence of recent volcanism had been found at any of the sites, the discovery of the orange and black soils at Shorty - combined with Schmitt's subsequent mapping from orbit of similar regions elsewhere around the borders of Serenitatis - made it easier for geologists to describe the mare filling phase of lunar evolution.

Our scientific understanding of the Moon will, of course, change and improve when we resume lunar operations sometime in the future. Gene Cernan liked to describe Apollo

17 as the "end of the beginning" and certainly, from a scientific perspective, Apollo was an outstanding start.

Beyond the science, and beyond the historic significance of the program, Apollo was also a chance to learn something about living and working on the Moon. As we move forward into a lunar base era and, in the long term, toward the creation of self-supporting lunar communities and industries, an examination of the Apollo experience will provide some practical lessons about getting work done under lunar conditions. Certainly, the crews demonstrated that, with some additional attention to suit design, future lunar workers will have no significant problems with mobility and dexterity. Not surprisingly, there were problems with equipment and procedures - many of them caused by the dusty environment - and, certainly, for longer term operations it will be essential to have the capability to clean, refurbish, and repair equipment on a regular basis.

By the end of the third Apollo 17 EVA, the lunar dust was causing a number of practical problems. As we have discussed, the locking collars on the extension handles and the pivot on the scoop head had become fouled with dust and were difficult to use. In addition, the replacement fender had failed and, as Cernan and Schmitt made their way back to the LM, they drove in a shower of their own dust. And then, once they stopped, Schmitt found that the gate latch on the back of the Rover - which, because of dust clogging had been giving them trouble since midway through EVA 2 - had failed, and the gate was flapping in the breeze. What is more, both extension handles and the attached scoop and rake had fallen off sometime since Van Serg. At the end of Apollo 16, Charlie Duke brought his scoop home and, although there are scratches on the scoop that were probably made as he used it to pick up rocks, a cursory examination of the latch mechanism did not indicate any substantial wear. It seems likely, then, that, had Cernan and Schmitt had the time and work space to take the tools and even the Rover indoors for cleaning and repair, they could have continued to get good use out of the equipment for far longer than three days.

However, three days and a cramped LM cabin was the most that any of the Apollo crews had available; and, under the circumstances, an amazing amount of good work was done. Because they were able to build on the experiences of prior crews, Cernan and Schmitt hold virtually all of the records for time spent on the surface, distances driven, numbers of samples collected, numbers of pictures taken, and so on. Building on the experiences of prior crews, they had confidence in their ability to get the work done. Like the prior crews, they quickly learned how to use the lunar environment to their advantage; and, although procedures and equipment will be developed that will make it possible to conduct lunar base operations even more effectively, there is much that can still be learned from the Apollo experience.

Postscript to the Apollo 17 Summary

During our review of the Apollo 17 summary, Jack Schmitt made a number of comments about mission planning and the philosophy behind the decisions that were made. In subsequent discussion, Gene Cernan responded to these comments and the following paragraphs are edited versions of the points that the astronauts wanted to make.

Jack began his comments by noting that he had argued for an extension to a 4-EVA mission by reducing the science payload. I asked him how much would have to have been removed. "As I recall, it wasn't a lot, because of the significant margins they already had in the mission planning. I think you also had to give up some of the margin. Early on, right in the beginning (of the Apollo 17 training and planning), I asked Gene if he had any problem with me discussing the possibility of a fourth EVA with some people. He didn't, so I did. But it was clear that Chris Kraft didn't have much interest in it. Deep down inside - and maybe not so deep - some people didn't want to fly 17, but they didn't know how they could get out of it. They said, 'Hey, we've gotten away with it this long, why don't we quit before we kill somebody.' Some people were talking that way right after Apollo 11."

Gene reacted to Jack's comments with the following: "Jack did a lot of lobbying, about two points. He wanted to land on the backside of the Moon, which I didn't think was going to happen. It's not a question of whether it could have been done; it was whether it was practical to do with the hardware we had. And the other thing was extending to four days and that's not something I really don't remember too much about. My gut feeling is that I was not too excited about spending an extra day without a good reason. In retrospect, had I known everything was going to go so well, I would have liked to have spent a week." Gene then switched to Kraft's reaction to Jack's proposal. "I dealt with Kraft off and on and I knew Kraft's feelings about our mission, all the way. He wanted us to get there and get home alive. I mean, as late as a couple of days or a week before the flight, he and I sat down and had a good talk about that. And his interest was for me not to take even the slightest additional chance, if I didn't have to. It was not mandatory that we land. It was mandatory that we get home alive. And Chris said that to me because, frankly, he knew I wasn't going to the Moon a second time without landing. I think he probably knew that Jack had worked up some ways for the AGS to help us if we lost part of our computer on the way down and need the AGS to finish our landing. But Kraft, all along, would have not wanted us to spend an extra day."

After our discussion of an extra EVA, I mentioned to Jack a question I had put to Pete Conrad - namely, why he and Al Bean hadn't gone more than 300 meters from the LM. I had expected him to make some comment about the suits or the PLSS's but, instead, he said that they wanted to be able to get back to the LM in a hurry in case something started to go wrong in the spacecraft and they needed to fix it or leave.

I also told Jack that I had mentioned Pete's answer to Armstrong and that Neil said he felt the same way.

Jack responded by saying, "On Apollo 11, nobody ever suggested that they go very far away from the LM. I don't remember that ever being a consideration. As 12, you know, was really programmed to be the back up to 11 and I think it was just general inertia that kept them from moving very far away on the second flight. but with 11 and 12 under your belt, and particularly with the way the LM performed for 13, people just said, 'Hey, it's alright. Houston can watch it. You guys don't need to worry about it.' And I didn't. Gene may have, but I didn't. I think that one thing that I had that the other guys never got was an extra level of confidence in Mission Control. Because I worked with those guys, right from the very beginning. I figured it was a good way to learn the systems. they had some little simulators they used. they knew the schematics. I just went to bed with those guys. And no other astronaut ever did that, at least while I was there. So I knew their capabilities were; and not only as individuals but also, from a systems point of view, I knew what they could watch. In my own mind, during all the simulations, I was competing with them. AS friends, but I was competing with them to try to see what the simulations people had done to us before they did. They almost always won, because they had better information. but it was still a competition. Nobody else did that. Some people look at me funny when I say that I didn't worry about the systems going bad. I just flew the mission and figured that it something was going to go wrong, we'd take care of it at the time. And I think I had that attitude because of that extra level of confidence that I had in the people who were watching the spacecraft. Now, I'll bet you that if the Apollo 12 landing had been off by a factor of two or three, they still would have gone to the Surveyor. Even at a thousand meters, I'll bet they would have gone. the pressure to do that would have been very high. I don't remember about the mission rule about how far they could go, but it wouldn't have been the first mission rule we waved, depending on circumstance."

I noted that Pete had been fairly firm in his statement about not going very far from the LM.

"Yeah, but that's because he landed near it. I'll bet he would have been just as firm about getting over to the Surveyor if he'd been 500 meters away and knew where it was."

In addition to having some doubt that Conrad would have "gone over the hill to get to the Surveyor", Gene said, "Jack worked very closely with those guys on simulations. He drank beer with them. He knew them. He trusted them. He liked them. And he depended upon them. Now, I liked them. I drank beer with them. I trusted them. They were your best friends on the ground. But they weren't with me on the Moon, and they weren't flying that spacecraft. And this goes back to the fact that Jack doesn't have a long history of flight experience. Jack has never been on his own out where his ass

was hanging in the sky. I think Jack flew because he had to fly, to become qualified to go to the Moon. And when that was done and he got out of the space program, he never touched the controls of an airplane again. Now, that's not a problem with me. Jack did a hell of a job and I want to go into that later. But for me, the bottom line was that Mission Control was not the final solution - we were. I don't care how many guys are on the ground. I don't care how many shifts they're working. I don't care how many simulations you've run with them, when you're out there, you're out there by yourself. Now Jack would say, 'Well, you're really not by yourself, you've got all those guys taking care of you.' They can watch you, but they can't do anything for you. And I think that's where the aviation philosophy comes in. When I'm out there on a dark night and a 500-foot overcast and I got to land on that god-damn carrier, those guys have got me on radar. They know who I am, they know where I am, they know how fast I am. And when I'm coming into that deck, they know whether I'm high or whether I'm low and whether my wheels are down, and whether my flaps are down. Everything there is to know about it. But none of them are flying the airplane. And none of them are going to hit the ramp. And none of them are going to fly into the water. I'm going to do that. And I liked the guys and I hit the beach with them. I drank beer with the Combat Information Control Officer and the LSO, the Landing Signal Officer. They were your best friends. Just like the guys in the MOCR. But the bottom line is that you're the one responsible, and you're the one accountable. And what your accountable for and responsible for is the success of the mission and your own ass. And I don't think Jack has that inbred philosophy and therefore - and this is not a bad rap, it's just the difference in our backgrounds - he used to depend on the guys in the MOCR. Anytime he was in a simulation or in the spacecraft, it was like they were sitting next to him. But they weren't. They were a quarter of a million miles away. And the interaction between me and them was just like flying in bad weather. I was flying with my son-in-law - and he flies - and he said "What if they told you to descend to an altitude and you had a problem with that or they told you to take a route and you didn't like it?" And I told him "If you remember nothing else when you're in an airplane, they're on the ground and you're up here. You're the commander, you are the decision maker in that airplane. Now, you can't violate rule; but if you don't want to accept something that they've told you to do, you just say, 'I'm sorry, I can't accept that' or, if you have an emergency and you need to say 'I can't descend to that altitude' or 'I can't take that heading'. You're the commander. They're just there to help you. And it's the same philosophy in a spacecraft. It doesn't change at all."

Sensing that Jack and Gene were, perhaps, talking about different aspects of the question, I said to Gene, "Let's go back a little bit to the LM. 11 and 12 versus later

missions. Neil and Pete both said that they were conscious of the LM being there. They wanted to be able to get back in in 10 minutes or 15 minutes if they needed to. But then, after 12 and the other flights, the community got enough confidence in the LM, that you, Gene Cernan, were willing to climb on the Rover and go to a place where you were an hour's drive away. So you have some greater confidence either in the spacecraft itself or in the ability of people to watch it from the ground."

Gene said, "I think that's a fair statement. We built on the accomplishments of the preceding missions. Now, it certainly is nice to know those guys are watching my helium pressure and my battery temps, or otherwise I'd have to carry a telemetry system on the Rover or on my back. So it was nice to know those guys were watching, and the fact that they could alert you to anything that might be wrong was very important. So I think the confidence grew in two areas. One, confidence grew in the LM itself; and not only in the fact that it worked but, also, that you could do things like shut down the inertial nav system. And we thought about that a lot before we decided you could do it. Because, once you shut it down, if you couldn't power it up again that was a big deal. But we got confidence that you could power it back up. It's like having a marginal battery in your car and you think you've driven it enough to charge it back up, but that first time you shut it down, you're just not sure it's going to start again. It's that kind of feeling and attitude. And we gained confidence, also, in the ground's ability. Working with Mission Control was so very positive. Could you have done the whole mission without those guys? Could we have gotten home without them? Yes, we could have, because we had to and we planned to be able to do that. Maybe not as precisely but we would have done it. (Going back to confidence in the LM) The LM's response to the thermal environment was always a big question. Well, we found out that there appeared to be no degradation on the shorter flights. And we found out that the ground could, indeed, from a quarter of a million miles, pretty accurately follow what the systems were doing while you were away. And, so, I think we built confidence, and that's why we were willing to go further away. But, you know, on Apollo 17, we were 6,7,8 kilometers away - and I don't care if we had the Rover to get back with or not. It all depended on how fast the problem would generate itself and how much confidence you had that you could get back in time. but, if something was going bad quickly, your chances of getting off the ground were not very good. You had to get back to the LM - walk or drive back - say you're 20 or 30 minutes away. You had to get in and, granted, you're going to bypass doing certain things if you've got a leaky helium pressure tank or you've got something else that's going bad pretty fast. Now, if you've got something that's degrading more slowly, something that might not be very good tomorrow, that's another story and you shorten the mission from three days to two days and you come

home. But, there's always the possibility of something that could really give you a problem - something not very subtle and it's pretty obvious - and, when you make a decision that you're going to go over the hill to grandma's house, and you look over your shoulder and you can't see the LM because it's over a hill or is too small to see, you've just made a decision that goes beyond confidence or not confidence in the LM. You've made a philosophical decision that you're going to take the chance, that the risk is worth it. You leave the LM in the best shape you can leave it in, you leave it as fail-safe as you can, and you leave it in the hands of the people who can't fly it for you or fix a problem, but who can watch it for you and say, 'we don't like what we see, why don't you guys get home.' Now, if you had an Apollo 13 kind of thing, you can forget it, because you're not going to get it home. And I knew that. Yes, we did what we did on 15, 16, and 17 because we had more confidence in the LM, more confidence in the response to the thermal environment, more confidence that the ground can stay on top of it. But we also said 'Why are we here? Let's go out and look around.'

"You know, it's kind of sad that in addition to all the other problems we'd have in going back to the Moon - like it's going to take twice as long as it did the first time (15 to 20 years versus 8) - I don't know that we have the mentality today to build upon what we did on Apollo. And it's sort of sad. Because if we went back again next week or next year or in another decade - which we probably won't, unfortunately, because it's going to be another generation - I don't know if we would have the mentality (I don't want to say "guts") to take the kind of risks we did when we did it the first time. Landing on the Moon was a risk. And I believe our inability to take risk today wouldn't allow us to do what we did when we did it. And that's a sad commentary; and I really feel strongly about that.

"Some people think that I'm crazy for having gone to the Moon twice. I mean, some of my peers think I was crazy. They think that going out there once was enough and wouldn't have gone a second time if they'd been given the chance. Some of them didn't even want to go once. Now, I'm not setting myself aside; I'm just saying that sometimes there are risks worth taking."

(Returning to the issue of confidence) "Jack says that he was always competing with the guys in the MOCR in simulations. Well, we all were. Simulations were war games for us. Figuratively, the simulations guys wanted to kill you. And that's where you built up your reputation as a pilot. And, if I ever had any supporters to get a crew or to get 17, it was probably because of some of my performances in those simulations. Not because I went to bed with the guys in the MOCR, but because they knew that I knew my business. They knew their business and I knew my business. When we had simulations, we were all working together, We were competing against the simulation guys, but the MOCR and the crews were always working together. Jack says "I didn't worry about the

systems going bad." Well, the ground could not do anything about the systems. And that's what I mean by Jack looks at the MOCR as being his co-pilot. The MOCR was not my co-pilot; it was ground control. They were there to help me. but I think that's the pilot mentality. On a dark, foggy night coming aboard a carrier, there isn't anybody in the world who's going to help you except you. I had a lot of confidence in the people who were watching. But they were limited; they were a quarter of a million miles away when it came to doing something about a problem. Not that the MOCR - and I was part of the MOCR - didn't bring the guys on Apollo 13 back. We devised flight plans and the dynamics and all kinds of things for them. But the guys who had to execute, the guys whose lives were on the line, were up in that spacecraft.

Now, Jack had a different attitude about all this, and that's just because of a difference in background. And it's not a knock at Jack. I mean, Jack can look at a mountain and see a lot of things that I can't because of his background and experience. He'll know whether to look at the left side of the mountain or the right side and I might walk right up the middle, without knowing what the hell I'm doing. I think that when Jack (and the other "scientist-astronauts) were selected for the program, Deke Slayton said 'If you're going to fly on my spacecraft, you're going to fly in my airplanes, too'. And there were some guys who looked at it as an opportunity and there were other guys who learned to fly airplanes because Deke said they had to do it. I think Jack looked at it as a square he had to fill to get to the Moon. Jack's objective was to get to the Moon, and I admire that, and he did well. He was a great Lunar Module Pilot, and Apollo 17 would have been done any better if I had flown with the best stick and rudder guy around. Jack flew airplanes because he had to fly, not because he wanted to fly - as evidenced by the fact that he hasn't flown since we came back. And, therefore, as part of his scenario, he looked for all the help he could get. And the MOCR certainly was help. Essential help. But they just weren't at the controls."

The Apollo 17 Lunar Surface Journal, Part 12
The Crew and the CapComs

Captain Eugene A. Cernan, the Apollo 17 Commander, was born in Chicago, Illinois on March 14, 1934. He received a B.S. degree in Electrical Engineering from Purdue University and an M.S. in Aeronautical Engineering from the US. Naval Postgraduate School. Cernan was selected as a member of the third group of pilot astronauts in October 1963. He and Gemini 6 veteran Thomas Stafford were assigned to the Gemini 9 backup crew but became the prime crew when Elliot See and Charles Bassett were killed in an aircraft accident in February 1966. Gemini 9 was launched on June 3, 1966. During their three-day flight, Stafford and Cernan performed three separate rendezvous with an unmanned target vehicle. Cernan also performed NASA's second spacewalk, spending two hours outside the spacecraft. As he discusses in his Apollo 17 commentary, the difficulties he experienced demonstrated the need for handholds, footholds, and a high-capacity spacesuit cooling system. After Gemini 9, Cernan served as backup pilot for Gemini 12; and, then, he and Stafford were joined by Gemini 3 and 10 veteran John Young as the backup crew for Apollo 7. In the normal course of crew rotation, they became the prime crew of Apollo 10, with Cernan assigned as Lunar Module Pilot (LMP). Apollo 10 was the final rehearsal for the historic first landing and was flown to check out all spacecraft systems and procedures. Stafford and Cernan flew the lunar module Snoopy on virtually the same trajectory that Armstrong and Aldrin took two months later. They flew down to 47,000 feet before discarding the LM Descent Stage and flying back out to a rendezvous with Young. Following Apollo 10, Cernan was assigned to the Apollo 14 backup crew as Commander, with Ron Evans as Command Module Pilot and Joe Engle as Lunar Module Pilot. By the time Apollo 14 was flown, Cernan had become the first and only Apollo astronaut to have trained as both an LMP and as a Commander. Following Apollo 17, Cernan helped in the planning for Apollo-Soyuz and acted for the program manager as the senior U.S. representative in discussions with the U.S.S.R. He resigned from the Navy and from NASA on July 1, 1976, and has kept very busy ever since as a consultant in the energy and aerospace businesses and as a television commentator.

Capt. Ronald E. Evans (USN) was born November 10, 1933 in St. Francis, Kansas. He was trained as an engineer at the University of Kansas and received a Master's Degree in Aeronautical Engineering from the U.S. Naval Postgraduate School in 1964. Evans was selected as a member of the fourth group of pilot-astronauts in April 1966. At the time of his selection, he was flying combat operations in the South China

Sea - from the aircraft carrier USS Ticonderoga - having previously served as a combat flight instructor. He served on the support crews for Apollo 7 and Apollo 11 before his assignment to the Apollo 14 backup crew and, then, Apollo 17. After his lunar flight, Evans served as backup Command Module Pilot for the 1975 Apollo-Soyuz joint flight and then transferred to the Shuttle program prior to his retirement from NASA in 1977. He died of a heart attack in 1990.

Dr. Harrison H. (Jack) Schmitt was born July 3, 1935 in Santa Rita, New Mexico, and grew up in the nearby town of Silver City. He received a B.S. from Caltech in 1957 and then spent a year studying geology at the University of Oslo in Norway. He received a Ph.D. in Geology from Harvard University in 1964. Before joining NASA as a member of the first group of scientist-astronauts in June 1965, he worked at the U.S. Geological Survey's Astrogeology Center at Flagstaff developing geological field techniques that would be used by the Apollo crews. Following his selection, Schmitt played a key role in training Apollo crews to be geologic observers when they were in lunar orbit and competent geologic field workers when they were on the lunar surface. After each of the landing missions, he participated in the examination and evaluation of the returned lunar samples and helped the crews with the scientific aspects of their mission reports. Because Schmitt was the only geologist in the astronaut corps and, as well, had spent considerable time becoming proficient in the CSM and LM systems, it came as no surprise when, in March 1970, he became the first of the scientist astronauts to receive a crew assignment. He joined Richard Gordon (Commander) and Vance Brand (Command Module Pilot) on the backup crew for Apollo 15 and was clearly in line to fly as Lunar Module Pilot on Apollo 18. After the cancellation of Apollo 18 in September 1970, many people expected that he would be assigned to fly on, Apollo 17, the last lunar mission. That assignment was announced in August 1971. After the completion of Apollo 17, Schmitt played an active role in documenting the Apollo geologic results and also took on the task of organizing NASA's Energy Program Office. In August 1975, Schmitt resigned from NASA to seek election as a United States Senator representing New Mexico. He served one term and, notably, was the ranking Republican member of the Science, Technology, and Space Subcommittee. He was defeated in a re-election bid in 1982 and, since then, has kept very busy as a consultant in business, geology, space, and public policy.

The LM CapComs

The following individuals either served as LM "Capsule Communicators" during Apollo 17 or spoke to the crew during the lunar surface operations. The term "CapCom" is a holdover from the early flights of astronauts in the "capsules" of the Mercury program.

Dr. Robert A. R. Parker was born in New York City on December 14, 1936. He was trained as an astronomer at Amherst College and at the California Institute of Technology where he received a Ph.D. in 1962. After graduation, he joined the Astronomy Department at the University of Wisconsin where, during the 1966-67 academic year, he supervised future Journal Editor Eric Jones, then a first-year graduate student. In August 1967, he was selected as a member of the second group of scientist-astronauts. He served as a CapCom for Apollo 15 and, then, for Apollo 17, as the Mission Scientist and EVA CapCom. Later, he was Program Scientist for the three Skylab missions flown in 1973. During the Shuttle era he flew on two Spacelab missions: STS-9 in November/December 1983 and the astronomy-oriented mission STS-35 in December 1990. Currently, he works at NASA Headquarters on the Space Station Program.

Col. C. Gordon Fullerton (USAF) was born October 11, 1936 in Rochester, New York; and, while a classmate of Jack Schmitt's at the California Institute of Technology, trained as an engineer. He received a M.S. in Mechanical Engineering in 1958. After graduation from the USAF Aerospace Research Pilot School at Edwards AFB in 1965, Fullerton was serving as a test pilot for the bomber operations division at Wright-Patterson AFB when he was selected into the U.S. Air Force's Manned Orbiting Laboratory (MOL) Program. When that program was canceled in 1969, Fullerton and others transferred to NASA. Fullerton was a member of the Apollo 14 and 17 support crews, serving as LM CapCom during the lunar landing and liftoff on Apollo 17. Subsequently, he joined the Shuttle program and was one of four astronauts who flew Approach and Landing Tests in 1977. In March 1982, he flew as Pilot on the third Shuttle mission (STS-3) and, with Commander Jack Lousma, performed the first - and, thus far, only - Shuttle landing at White Sands, New Mexico when poor weather had closed the dry-lake runways at Edwards. In July 1985, Fullerton commanded the 19th Shuttle flight, STS-51F. He currently supervises NASA's test flight operations at Edwards.

Dr. Joseph P. Allen was born June 27, 1937 in Crawfordsville, Indiana. He was trained in physics at DePauw University and, as a Ph.D candidate, at Yale. Allen was selected as a member of the second group of scientist-astronauts in August 1967. He served with distinction as the Mission Scientist and EVA CapCom on Apollo 15 and contributed a great deal of subtle humor to Apollo 17 as the "Goodnight" CapCom. He first flew in space in November, 1982 as a member of the fifth Shuttle crew (STS-5) along with fellow Apollo alumni Vance Brand, Bob Overmyer, and Bill Lenoir. He made his second flight, the 14th Shuttle mission, in November 1984. During this flight, he and Dale "Pinky" Gardner made a pair of spacewalks to retrieve two communications satellites which, the previous year, had failed to reach geostationary orbit.

Donald K. (Deke) Slayton was born March 1, 1924 in Sparta, Wisconsin. He began his flying career as an Army aviation cadet in 1943 and flew 63 combat missions as a B25 pilot in Europe and over Japan during World War II. After the war, he entered the University of Minnesota and received a B.S. in Aeronautical Engineering in 1949. He worked for the Boeing Company as an engineer for two years and then was recalled to active duty in the Minnesota Air National Guard in 1951. In 1955, he graduated from the USAF Test Pilot School at Edwards and served there until April 1959 when he was selected as one of the original Mercury astronauts. He was scheduled to fly the fourth of the Mercury missions but was removed from flight status because of a possible heart condition. In September, 1962, he became head of the Astronaut Office and, in that capacity, was responsible for making crew assignments - hence, the references to Slayton as "Boss" by the Apollo 17 crew. Slayton was restored to flight status in March 1972 and flew as Docking Module Pilot on Apollo-Soyuz in July 1975. In the Shuttle era, Slayton continued his role as manager of the flight test program and then resigned from NASA in February 1982 to become founder and President of Space Services, Inc. Deke Slayton died in 1994.

Col. Robert F. Overmyer (USMC) was born July 14, 1936 in Lorain, Ohio and trained in physics at Baldwin Wallace College and received a Master's Degree in Aeronautical Engineering from the U. S. Naval Postgraduate School in 1964. Overmyer was selected as an astronaut in the MOL Program in 1966 and, with many of the other MOL astronauts, joined NASA in 1969 when that program was canceled. Prior to his work as a member of the Apollo 17 Support Crew, he worked on the Skylab program. On Apollo 17, he served as launch CapCom and then as the prime Command Module CapCom. Later, he served as a member of the Apollo-Soyuz support crew and, during the mission, served as a NASA CapCom stationed in Moscow. Overmyer then joined the Shuttle program and first flew as Pilot on STS-5 in November 1982 with Commander Vance Brand. In April 1985, he commanded STS-51B, the 17th Shuttle mission.

Captain Thomas K. (Ken) Mattingly, II (USN) was born on March 17, 1936 in Chicago, Illinois. He was trained as an aeronautical engineer at Auburn University, receiving his Bachelor's Degree in 1958. At the time of his selection as a member of the fourth group of pilot astronauts, he was a student at the USAF Aerospace Research Pilot School at Edwards AFB. He served as a member of the support crews for Apollo 8 and 11 and played an important role in the development of the Apollo spacesuit and backpack. He was selected as Command Module Pilot (CMP) for Apollo 13 but was removed from the crew three days prior to launch because of possible exposure to German measles. The backup CMP, Jack Swigert, took his place and Mattingly subsequently flew as CMP on Apollo 16 with Young and Duke. From 1973 until 1978, Mattingly served as the head of the astronaut support team

for the Shuttle program and as the backup Commander for the second and third missions. In June 1982, Mattingly made his first Shuttle flight as Commander of the fourth mission (STS 4) and, then, in January 1985, commanded the 15th mission, STS-51C.

Captain John W. Young (USN) was born on September 24, 1930 in San Francisco, California. He was educated as an Aeronautical Engineer, receiving a bachelor's degree from Georgia Tech in 1952. After graduation, he joined the U. S. Navy and began flight training a year later. In 1959, he graduated from the U. S. Navy Test Pilot School. He was selected as a member of the second group of pilot-astronauts in 1962, and was the first of the group to be assigned a mission. He flew with Gus Grissom on Gemini 3 and later as Commander of Gemini 10 with Michael Collins. He then served as Command Module Pilot on the Apollo 10 lunar mission and backup Commander on Apollo 13 before landing on the Moon with Charlie Duke on Apollo 16. He and Duke also served as the backup LM crew for Apollo 17. In 1975, Young became the Chief of the Astronaut Office but remained active in development and testing of the Shuttle. He flew as Commander of the first Shuttle flight in April 1981 and flew his sixth space mission in November 1983 as Commander of STS-9. Young is still a member of the astronaut corps, although not on active flight status.

Brig-Gen. Charles M. Duke (USAF) was born in Charlotte, North Carolina on October 3, 1935. He graduated from the US. Naval Academy in 1957 and then joined the U.S. Air Force which had not yet graduated a class of young officers from its own Academy. After completion of flight training, he served as a fighter interceptor pilot in Germany, and, then, attended the Massachusetts Institute of Technology, receiving a Master's Degree in Aeronautics in 1964. The following year he graduated from the Air Force Aerospace Research Pilot School and was serving as an instructor when, in April 1966, he was one of 19 pilots selected in the fifth group of astronauts. He served as CapCom during the Apollo 11 landing and as Lunar Module Pilot with Young on the backup crews for Apollo 13 and 17 and on the Apollo 16 prime crew. Duke retired from the Astronaut Corps in 1975 and is active in private business and as a Christian lay witness.

Ed Fendell - the "fifth member of the J-mission crews who ran the TV camera remotely from Houston. (finish)

The Apollo Lunar Surface Journal, Part 13
The Valley of Taurus-Littrow

orbital pix of the landing site

The Apollo 17 landing site is in a spectacular valley called Taurus-Littrow on the southeastern edge of the Sea of Serenity (Mare Serenitatis). Sometime about 3.8 to 3.9 billion years ago, a mountain-sized asteroid or comet hit the Moon and blasted out a basin nearly seven hundred kilometers in diameter. Around the rim of Serenitatis, great blocks of rock were pushed out and up, forming a ring of mountains. In places, the blocks quickly fell again, and left radial valleys among the mountains. Taurus-Littrow is one such valley.

large scale photo of Serenitatis showing dark rim

About 100 to 200 million years or so after Serenitatis formed, lavas welled up from the lunar interior and began to fill the low places. Many of the flows first reached the surface at the weak, fractured margins of the basin; and, as Schmitt and Cernan discovered, at some stages the flows were accompanied by fire fountains that blanketed their surroundings with tiny glass beads. Some of the beads were orange in color, but most were very dark. Even from Earth, the borders of Serenitatis look dark and, prior to the mission, there were many who speculated that this was an indication of recent volcanic eruptions.

Good overhead showing main features of T-L

Taurus-Littrow is elongated on an axis that points northwest toward the heart of Serenitatis. At its inner, southeastern end, the valley butts up against a large, blocky mountain called the East Massif. Toward the south, a narrow outlet - partially blocked by a large crater - leads off to another valley. On the west side of this outlet, a second blocky mountain called the South Massif forms the southwestern wall of Taurus-Littrow. North of the East Massif, across an outlet into another small valley, the Sculptured Hills and farther to the west, the North Massif form the remaining walls of Taurus-Littrow. Between the North and South Massifs, the main exit from the valley leads out toward Serenitatis. This exit is about seven kilometers wide and is partially blocked by a kilometer-high hill called Family Mountain and, also, by a fault scarp that stretches between the North and South Massifs. In places, the scarp is 80 meters high.

The inherent geologic variety of Taurus-Littrow was a major reason for the selection of the site. From a landing point out in the middle of the valley, the crew could sample the dark soil, collect samples of the valley-filling lavas dug out by impacts, and sample pre-Serenitatis crustal material in both the North and South Massifs. Of particular interest were a number of large boulders seen in Apollo 15 orbital photographs of the lower slopes of the Massifs. Some of these boulders are sitting at the ends of tracks which show that they had rolled down from outcrops high on the

mountains. (photo of large-track boulder) Additional points of interest included a South Massif avalanche that drapes across the southern end of the scarp, and an intriguing crater called Shorty which sits like a dark blemish at the northern tip of the landslide outflow. Here, some of the geologists thought, might be a young volcanic vent. And finally, there were the Sculptured Hills which, from orbit, look as though they are not directly related to the Massifs and the Serenitatis impact but, rather, it was thought, might represent ejecta from the more recent Imbrium impact.

During the preceding missions, none of the crews that attempted pinpoint landings actually landed farther than about a half-kilometer from their target. Of course, as had happened in case of Apollo 11, larger errors were possible, particularly if the flight-path could not be updated during the powered descent; and NASA wanted to be sure that Cernan would be able to land even if Challenger were headed as much as four kilometers long or short of the target and as much as three kilometers to either side. Taurus-Littrow is not a large valley; and, indeed, the Apollo 17 crew was able to cover nearly half of it during their three geology trips. (drawing showing landing ellipse) Still, it is large enough to contain the landing ellipse and several more besides. The actual target point was on the valley's central axis, well away from the Massifs, and about six kilometers short of the scarp. This northwestward placement was chosen so that the crew would fly over the Sculptured Hills at substantial altitude as they entered the valley and, later, could drive to the foot of the South Massif without violating walkback constraints. In detail, the target area is a relatively smooth patch of ground in the midst of a cluster of large craters. The largest of these is Camelot Crater, about 600 meters across, and it promised good samples of the valley fill. Camelot is about a kilometer west of the target and provided Cernan with a visual fix at pitchover. Closer at hand, he had a trio of small craters called Punk, Rudolph, and Poppie to show him exactly where to land. He wanted to land midway between Poppie and Punk and just south of Rudolph.

photo detail of immediate landing area

Crater Names

Most of the craters and other features on the Moon which can be seen from Earth have had names for a long time. With the advent of Ranger and, in particular, Lunar Orbiter, lunar maps became more detailed and the list of named features grew but, as the time for the landing missions neared, there were still many unnamed features which were, nonetheless, going to be of importance to the crews. As Jack Schmitt indicates in his Apollo 17 commentary, he and others in the Astronaut Office started naming features in preparation for Apollo 8, the first lunar mission, because the crew was going to be using a variety of craters for landmark tracking and, as pilots, they knew that names would be much easier to remember and recognize than numbers. Later crews wanted names for

features that they would see at pitchover and might later visit or use for navigation on the ground.

Prior to Apollo, formal responsibility for naming features on the Moon (and other planets) rested with a committee of the International Astronomical Union. In the interest of cooperating with the international scientific community, for each mission NASA generally submitted a list of names for formal approval.- albeit, only after the mission was over. Generally, the only objections made by the IAU were to names with religious overtones and those honoring living persons, political figures, and philosophers.

The IAU was, of course, fighting a losing battle in that it was trying to impose order on what is an inherently disordered process. One need only look at a map of the United States and note the number of places called "Springfield" or "Bear Mountain" to understand the nature of the problem. Explorers put their own stamp on the places they visit; and pioneers then finish the job by putting names to every remaining hill and creek. Naming is usually very personal - the prerogative of the explorer or the first residents of an area. Some are prone to recycle familiar names and others love to flaunt convention. Order is rarely a consideration. Prior to the start of Apollo, of course, astronomers were the explorers and it was appropriate for them to put names to lunar maps. However, once Apollo was underway, the needs and wants of the Astronaut Office took precedence, at least with regard to the landing sites. Not surprisingly, the IAU was reluctant to recognize the changed circumstances. In an October 21, 1972 "Memorandum on Problems of Lunar Nomenclature", Donald Menzel, the Chairman of IAU Commission 17, complained that "no one (at NASA) has responded to my previous communications on the subject...I have brought the objections of the committee to certain practices adopted by various Apollo missions, in the question of lunar nomenclature, to the attention of NASA. Many of the names assigned by them to small features, for purposes of identification during the actual Apollo mission, were inappropriate according to our standards, or even duplicates of names already assigned. I have received a reply that these names are "unofficial," and therefore are not being submitted for approval. Unfortunately, this overlooks the fact that rock samples taken at various of these locations has (sic) the identifying names attached. Hence the names automatically get into the literature. Furthermore, some of the very large-scale maps used for the expedition have also been widely circulated. I have asked that the names for Apollo 17 be submitted to me for consideration and preliminary approval. Thus far, I have not had any satisfactory response and the mission is scheduled for December. I am writing a last minute request to NASA for the desired information. I have also had some telephone conversations with NASA individuals on this point, and have received the reassurance that they will follow the principles outlined."

As editor of this Journal, I believe strongly in the prerogative of explorers and the names discussed here are the ones used during the mission. Many of the choices are charmingly personal - Punk, Poppie, Van Serg, Camelot, and even a Bear Mountain.

[The following was a brief conversation Gene Cernan and I had on February 21, 1994 about the crater names.]

[Cernan - "Jack probably had more to do with naming the craters than anybody else, and he did a great job. I had no problem with any of them. All I said was, 'Hey, there's a few I want to name.' And I did name a few; and a couple of them I remember. One was what my daughter called my father, and that was Poppie. And it turns out that's what my granddaughter, Ashley, calls me. And so we have a Poppie Crater on the Moon. And we have a crater called Punk on the Moon, and that's what I called my daughter, her nickname. And that's what I call my granddaughter, as a nickname. And so those names are still appropriate."]

[Jones - "And the descent stage is sitting there, just a few tens of meters north of Poppie."]

[Cernan - "I wanted to name the one's I could see when I was landing. The only problem is that you spelled Poppie wrong. It's not 'Poppy'; it's 'Poppie'."]

[Jones - "Well, it's wrong in the whole Apollo 17 literature. We'll fix it."]

The following descriptions are based on material written by Jack Schmitt during preparations for Apollo 17. His words are indicated by quotation marks and, with his permission, have been lightly edited.

"The names chosen for crater designations (at Taurus-Littrow) generally attempt to honor men and women who have explored the far limits of human endeavor. These men and women are representatives of many, many others of their generations who were or are true humanists - no matter what enterprise may call upon them for excellence. Most of the crater designations reflect the bias of my own specific interests in literature, history of western man, geographical exploration and geology. Several other names were suggested by other individuals deeply involved in our mission. Their interest and contributions are much appreciated, with particular thanks due to Robert Parker, Eugene Cernan, James Head, Edward Wolfe, and Beth Williams."

map showing craters with names

Agassiz (crater) - "Luis Agassiz was one of several natural scientists who studied geological and biological samples and other information returned by early Army explorers of the American West (see Emory). This name also honors all the modern investigators upon whom falls the responsibility and opportunity of amortizing our scientific investment in space."

Agricola (crater) - "This was the Latin name of Greg Bauer (1494-1555), who wrote some of the first known treatises on mineralogy, geology, and mining. His most

famous work was on 16th Century mining and metallurgy. This book, *De Re Metallica*, was translated from Latin into English by Herbert Hoover and his wife. Hoover is also honored by this crater designation for his lifelong intellectual exploration of history and government and for his humanistic concern for all people following World War I and the Great Depression."

Bear Mountain - "Named because of its shape and because of its resemblance to a mountain of the same name near Silver City, New Mexico " Jack Schmitt grew up in Silver City.

Bowen (crater) - "Norman L. Bowen, geologist, performed experiments on the crystallization of silicate liquids that led the way to our present understanding of the origin and evolution of igneous rocks; an understanding which is now a critical element in our interpretations of lunar history." Bowen Crater is near geology Station 8 which Cernan and Schmitt visited on their third EVA.

Bronte (crater) - "Charlotte Bronte, novelist of the 19th Century, was representative not only of the literary innovations of her times, but also of the first golden age of women in literature."

Camelot (crater) - "The kingdom of the legendary Arthur, whether real or not, represents the seed of freedom, compassion, and achievement that exists in mankind. It is possible that our own movement into space was in part inspired by the influence of this Arthurian seed on John F. Kennedy. In this case and others, the imperfections of Camelot accent the greatness of its goals." The crew visited Camelot during the second EVA, and Schmitt's lusty rendition of the Lerner and Lowe song as they approached it is memorable.

Candide (crater) - "Named in honor of Voltaire, the 18th Century French novelist, who was instrumental in re-establishing humanism as a force in the politics of nations after centuries of repression. Although imperialism and new repression in the name of humanity followed, and is still with us, the re-establishment of humanism produced strong defenders of the individual."

Cochise (crater) - "Chief of the Chiricahua Apaches, Cochise, a humanist in his own right, is a representative of the first race of explorers of the Americas. The Indian people, although victims of the antipathy still felt between different races, nonetheless were among the foremost explorers of man's natural environmental and spiritual frontiers." Cernan and Schmitt made a brief stop at the rim of Cochise during the third EVA.

Durid (crater) - "Honoring the precursors of western man who, though dimly seen through the mists of Stonehenge, directed the eyes of an earlier race than ours toward the solar system and the stars."

Elves (crater cluster) - "A field of small craters honoring all those who prepare the crew and their spacecraft for the journey." The center of the Elves cluster is about a kilometer north and bit west of the crater Mackin.

Emory (crater) - "William H. Emory was one of the most capable members of the United States Army Corps of Topographical Engineers who, in the quarter century prior to the American Civil War, systematically explored the American West. This group of military officers and explorers had specialized training in the physical sciences and engineering, and held many close parallels to the Astronauts and Cosmonauts of today. Following in the footsteps of Lewis and Clark and the mountain men, they provided the basic information required to open up the West for travel and eventual settlement." The crew planned to stop at Emory during the first EVA but, because they ran short of time, made a geology stop near Steno, a crater much closer to the LM.

Explorer (crater) - "Named for the first United States earth satellite and for the series of unmanned spacecraft which have investigated the moon and other planets."

Family Mountain - "Named in honor of the families of the crew members and their associates. Their sacrifices go unrecorded but not unrecognized."

Faust (crater) - "Named for the traditional folk hero perhaps most fully developed by Goethe. The name honors both the authors of epic literature and also the unquenchable human thirst for knowledge and understanding of nature."

Frosty (crater) - "Named in honor of the Christmas season and today's children who will follow Apollo toward the far frontier of space." Apollo 17 was launched on December 7, 1972 and the crew returned to Earth twelve days later on the 19th. Frosty is one of the craters that Cernan named, all of them close to the planned landing spot.

Gatsby (crater) - "Honoring F. Scott Fitzgerald, one of the foremost novelists of his generation."

Hanover (crater) - "Honoring one of the many small mining towns of the United States which provided - and continues to provide - the material resources required by our nation in its search for the future." Hanover Crater is on the North Massif, just east of the Scarp.

Henry (crater) - "Named for Prince Henry the Navigator (1415-1460), supporter of early Portuguese explorations along the African Coast, though not an explorer himself. With his name, we also honor the managers and supporters of modern exploration." Cernan and Schmitt drove by Henry during the first stage of their EVA-3 traverse.

Henson (crater) - "Honoring Matthew Henson, who accompanied Robert E. Peary to the North Pole, and all members of ethnic or social minorities who reach for greatness as individuals beyond the confines of their minority status."

Hess (crater) - "Named for Harry Hess, chairman of the Space Science Board of the National Academy of Sciences during the formative years of Apollo. This outstanding scientist was instrumental in insuring that science contributed to and took advantage of the success of the Apollo program."

Holden (crater) - "J. D. Salinger's Holden Caulfield is representative of the characterizations of a post-World War II generation by which their creators forced an introspective look at ourselves and an understanding look at those around us. In varying degrees, these authors have influenced that generation's present search for a bridge between the past and the future."

Hole-in-the-Wall (point of ascent on the Lee Scarp used by the Apollo 17 crew) - "A common fictional geographical designation from western literature, used here to honor the authors whose work carried the excitement and challenge of the American West around the world."

Horatio (crater) - "Horatio Hornblower and his compatriots in the historical fiction of C. S. Forester provide the humanly personal insight into how ordinary, but then how extraordinary, heroes turn out to be. From the wooden ships and pathways of the sea of which Forester wrote, came many of the space-faring traditions that guide our course toward the stars." Horatio is just west of Camelot and crew drove past it on EVA-2.

Jefferson Scarp (North Massif segment of the Taurus-Littrow scarp) - "Thomas Jefferson was one of the leading political philosophers of history and a practical innovator during the early growth of our republic. His instigation of the Louisiana Purchase and the subsequent exploration of those territories provided the strength required to preserve the Republic."

Jones (crater) - "Named for John Paul Jones (1747-1792), Scottish-born naval hero of the American Revolution who established his adopted country as a seafaring nation which was, eventually, without peer."

Lara (crater) - "Named for Boris Pasternak's heroine from Dr. Zhivago and honoring all the inspiring women of history, known and unknown."

Lee Scarp (southern valley segment) - "Robert E. Lee was a man of immense ability and honor who, in his dedication to friends and tradition, found personal compromise with the future impossible. Such a national tragedy should represent a lesson we can safely learn only once."

Lincoln Scarp (northern valley segment) - "Abraham Lincoln's compassion, spirit, and intellect prevented the dissolution of a union; a dissolution after which the seed of freedom might have survived in the hearts of men but not in their societies."

Lewis and Clark (craters)- "William Clark and Meriwether Lewis began the American exploration of the western territories purchased from France by the young nation. Inspired by Thomas Jefferson, their explorations laid both the psychological groundwork for the future expansion of the United States in the West and the geographical basis for our growth and strength as a free nation."

Locke (crater)- "John Locke is representative of an age when interest grew in experimental science and observational philosophy as a substitute for the uncritical acceptance of

the science and philosophy of the past." Cernan and Schmitt drove past Locke and the nearby crater Henry at the start of the third EVA.

Mackin (crater) - "J. Hoover Mackin, geomorphologist, teacher, and gentleman was known for his ability to bridge the gap between quantitative and qualitative geologic studies. In later years, he was an irrepressible innovator and a supporter of lunar exploration."

Mariner (crater) - "In the tradition of Coleridge's Ancient Mariner, the modern day Mariner spacecraft are telling us of the unknown of the solar system and, in the telling, guide our way to understanding."

Mitchell (crater) - "Billy Mitchell, through his own sacrifice, showed us the practical and political reasons for being a truly air-faring nation. From the resulting foundation in aeronautics, we have moved into space, hopefully having learned his lessons well."

MOCR (crater) - "The Mission Operations Control Room is the area at the Manned Spacecraft Center in Houston, Texas, from which the Apollo missions are directed. The name honors all those people who provide the flesh and brains of every mission and who are truly the explorers of Apollo."

Nansen (crater) - "Named for Fridtjof Nansen (1861-1930), Norwegian Arctic explorer, statesman, and Nobel Peace Prize winner (1922). His studies of oceanography, meteorology, and nutrition underlay all future exploration work in the Arctic. Nansen represents the international character of all of mankind's exploration - past, present, and future." Nansen is a trough at the base of the South Massif and Station 2, the first major geology stop of EVA-2, was conducted there.

Nemo (crater) - "Although associated with Jules Verne, the patron novelist of lunar explorers, the term Nemo also recognizes the innovations in the novel and in personal philosophy produced by John Fowles and his contemporaries such as John Knowles, Jerzy Kosinski, and Ray Bradbury."

North and South Massifs - "Massif is a French term for a large mountain mass." These mountains frame the western end of Taurus-Littrow.

Poppie (crater) - 'Poppie' is the nickname given Gene Cernan's father, Andy, by Gene's daughter, Tracy. Throughout the Apollo literature - including Schmitt's original write-up of the crater names - the name is mis-spelled as Poppy.

Powell (crater) - "John Wesley Powell was one of history's outstanding explorers. One of the last true generalists in the explorations of the American West, he exemplifies the breadth of knowledge required in our explorations of all frontiers."

Punk (crater) - Gene Cernan's nickname for his daughter, Tracy.

Rogers (crater) - "Named for Will Rogers, American humorist, and Buck Rogers, early space hero, both of whom provided immeasurable inspiration to their own generations and to future generations."

Rondone (mountain) - "Rondone is a mountainous region of south central Norway and, as the legendary home of Pier Gynt, the name honors the drama of Ibsen, the music of Grieg, and all other innovators in their respective arts."

Rudolph (crater) - "Named for the Christmas season's famous recent addition and most inspiring hero." Like Frosty, Punk, and Poppie, Rudolph is near the actual landing site.

San Luis Rey (crater) - "Named in honor of the novel, The Bridge of San Luis Rey, by Thornton Wilder, which was a milestone in the growth of modern literature."

Sculptured Hills - "Domical hills surrounding the Littrow area that are so named because of their sculptured appearance."

Sherlock (crater) - "Sherlock Holmes, whose adventures were preserved for us by Dr. Watson, was not only the world's most famous and most brilliant detective, but was also one of the leading geological thinkers of his time. His knowledge of London soils and many other aspects of nature, combined with his use of deductive reasoning, serve as examples to all who aspire to understand the worlds around us."

Shakespeare (crater) - "Named for England's bard whose poetry and dramas are known not only for their beauty and their timelessness in the portrayal of the human condition, but also for their perfection of characterization."

Shorty (crater) - "Recognizing Richard Brautigan's collection of short stories, Trout Fishing in America, and other books which bring the literature of youth and life from the foundations of Salinger into the present." Cernan and Schmitt visited Shorty during EVA-2 and, on the southern rim, found a deposit of orange soil.

Smith (crater) - "Honoring William Smith (1769-1839) and other natural scientists of the 18th and 19th Centuries who established the fundamental axioms of geology from which we now build our theories on the evolution of the earth and, indeed, of all the planets."

Snoopy (crater) - "Named for the sometime-aviator dog in Charles Schulz' Peanuts comic strip and the 'longtime' supporter of quality and humor in space exploration." Following the 1967 Apollo fire that took the lives of astronauts Grissom, Chaffee, and White, Snoopy became the symbol of the reinvigorated Apollo quality assurance program. Schulz created a series of comic drawings of Snoopy as an astronaut which were put in appropriate places in the cuff checklists worn by most of the astronauts who walked on the Moon.

[Snoopy was also the name of the Apollo 10 LM and, during our February 21, 1994 meeting, Gene offered the following comments. "I probably had more to do with naming the Apollo 10 spacecraft than anybody, because I started it during a simulation. We didn't lie the call signs 'Gumdrop' and 'Spider' that they used on Apollo 9. So I told Tom Stafford, "Let's start calling John Young 'Charlie Brown'. (Charlie Brown - 'the rounded-headed kid' - is Snoopy's owner

in the comic strip.) And it was fun, because it wasn't just in simulators. We called him Charlie Brown in the office. And, if we were going to call him Charlie Brown, then our call sign had to be Snoopy. And, we realized that, by naming our spacecraft Charlie Brown and Snoopy, we could give the Snoopy Award a little more pizzazz, a little bit more exposure, and make it more meaningful. And after we did that, we had little Snoopy dolls that people would bring in a lay on top of our simulators."]

Spirit (crater) - "'The Spirit of St. Louis' honors not only the historic achievement of Charles Lindbergh, but also the search by Lindbergh and others for the reasons for uniqueness in the human spirit."

Sputnik (crater) - "Named for the USSR earth satellite series, the first spacecraft put in earth orbit by mankind."

Steno (crater) - "Honoring Nicholas Stenonis, a Danish natural scientist of the 17th Century, and all those known and unknown men and women who, with Steno, began to recognize the basic truths that underlie the physical sciences."

Cernan and Schmitt made their first geology stop near Steno Crater on EVA-1.

Stonewall (crater) - "Named for Stonewall Jackson, Lee's remarkable and dependable lieutenant, and honoring all those men who fought and died for these United States. This name also honors those historians who have recorded and interpreted the deeds of the past upon which we must build our plans for the future."

SWP (crater) - "Named for the Science Working Panel, the NASA advisory panel on the scientific aspects of the mission."

Tasaday (crater) - "Named for the 'Stone Age' tribe which was 'discovered' in the Philippines in 1971. Because of living in a dense rain forest, they are supposedly unaware of the moon's existence."

Tortilla Flats - "Tortilla Flats honors John Steinbeck and all writers who, in the 1930's and 40's, made us aware of the human side of the nation. With this legacy, today we attempt to equalize individual opportunity within the limits of human differences."

Trident (craters) - "An overlapping, triplet crater cluster shaped something like the three-pronged spear carried by the classical god of the sea, Neptune or Poseidon." Trident lies just south of the planned landing spot. Trident lie south of the landing site, beyond Poppie.

Van Serg (crater) - "Professor Hugh McKinstry, one of the leading exploration mining geologists of this century, wrote many educational satires under the pseudonym Nicholas Van Serg. The name honors him and all professors who, through dedication and ability, have infused the wisdom of the past into the understanding of the present."

Victory (crater) - "Specifically honoring Winston Churchill, a political giant in the continuing struggle to preserve the spark of individual freedom resting within the 'English-speaking peoples'."

Wagner (crater) - "Named for the great German composer whose works represent one on the high points in the development of Grand Opera; honoring Wagner as a representative of the composers whose works were a true flourishing of this art form in the middle to late 19th Century."

Walden (crater) - Honoring Henry David Thoreau and other poets such as Robert Frost who have shown us the profound personal insight that exists within the simple aspects of nature and of mankind if we only pause to observe and ponder."

Wessex Cleft (dividing the North Massif from the Sculptured Hills) - "Wessex, with its deep-rooted place in the far history of England and in the novels of Thomas Hardy, symbolizes the intangible strength that the land transmits to its people the world over. People have always been in transit from the land or to the land; now, space has offered the awesome possibility of final separation."

The Apollo 17 Lunar Surface Journal, Part 14
A Running Start - Apollo 17 up to Powered Descent Initiation

In a few pages, we will pick up the Apollo 17 mission at the time of Powered Decent Initiation (PDI), the beginning of the engine burn that took Cernan and Schmitt down to a landing at Taurus-Littrow. First, we will go back a few years to the point of definition of Apollo 17 and then, picking up at launch from Earth, summarize the mission up to PDI.

The mission that became Apollo 17 began life as Apollo 18. In the early years of the program, NASA had all that it could handle in getting the hardware designed and tested and it wasn't until late 1967 that NASA was in any position to sketch out a lunar program that included the possibility of missions past a first landing. In discussions with Congress, NASA Administrator James Webb indicated that the program would require 15 Saturn Vs and Command Modules and 14 LM's. This was enough hardware for the missions which were eventually designated Apollos 7 through 20. There was no way of knowing, of course, how much of the flight hardware would have to be used in test flights prior to the first landing and few would have predicted with confidence that the first landing would be accomplished as early as Apollo 11. The early success meant NASA had hardware for nine more landings and, on July 28, four days after the Apollo 11 splashdown in the Pacific, NASA announced a tentative schedule of flights up through Apollo 20. Apollo 12 was scheduled for November 1969; and, in general terms, Apollos 13, 14 and 15 were planned as missions using the same LM design flown on 11 and 12. Apollo 16, then planned for April 1971, would be the first of the missions to fly the advanced LM and the Lunar Rover. As mentioned previously, the latter type of mission was known as a J mission.

Crew Selection

A few weeks later, on August 8, 1969, NASA announced the crews for Apollo 13 and 14, the scheduled third and fourth landings. The backup crew for 14 included Gene Cernan as Commander, Ron Evans as Command Module Pilot, and Joe Engle as Lunar Module Pilot. In the normal scheme of crew rotation, Cernan, Evans, and Engle were expected to fly Apollo 17, then scheduled as the second of the J missions.

However, continued erosion of political support for Apollo forced NASA, on January 4, 1970, to announce the cancellation of Apollo 20 and, also, a stretchout of the schedule with Apollo 13 moved from March to April and Apollo 14 moved from July to an unspecified date in the fall. On March 26, NASA announced the selection of Scott, Worden, and Irwin as the Apollo 15 crew, with Dick Gordon serving as backup Commander, Vance Brand as backup Command Module Pilot, and Jack Schmitt as backup Lunar Module Pilot. No specific date was set for Apollo 15. NASA expected it to be flown about six months after the completion of Apollo 14.

In the absence of any further cutbacks, Gordon, Brand, and Schmitt would have been assigned to fly Apollo 18. At the time, Schmitt was the only geologist in the astronaut corps and it came as no surprise that he was the first of the scientist-astronauts to be assigned to a crew. As detailed by historian W. David Compton in his book, *Where No Man Has Gone Before*, the scientific community and some of the scientist-astronauts had long been lobbying for their assignment to crews and were upset that pilots with less seniority were getting seats while the scientists were relegated to support roles. Schmitt, in the meantime, devoted his efforts to learning the LM systems and other essentials of becoming a Lunar Module Pilot; and he also spent years making sure that the geology training for the pilots would actually be useful to them. There were strong arguments that, after only a few missions, Apollo was still very much an experimental program and, certainly, NASA was very aware that a failed or fatal mission could well be a political disaster. Thus, while it seems likely that lobbying by the scientific community contributed to Schmitt's assignment to the 15 backup crew, it is also likely that his own work as an astronaut was of far greater importance. Those who know Slayton well are adamant that Schmitt would not have flown had Slayton not believed that he was fully qualified to fly as an Lunar Module Pilot.

Unfortunately, in September 1970, Apollo 18 was relegated to the historical dustbin. A combination of the Apollo 13 accident in April and further budget tightening forced NASA to cancel Apollos 15 and 19. Apollo 15 was to have been the last of the non-Rover missions; and, when the remaining flights were renumbered, Scott, Worden, and Irwin inherited the first of the advanced LM's and the first of the Rovers from Young, Mattingly, and Duke who, as the Apollo 13 backup crew, expected to fly Apollo 16. With the renumbering, Apollo 17 would now be the last of the missions and, while Cernan, Evans, and Engle still had prospects of making that flight, it looked as though the 15 backup crew of Gordon, Brand, and Schmitt would be left out in the cold.

The scientific community was now faced with the possibility that none of the scientist-astronauts would get to the Moon and, as Compton discusses in his book, in the early months of 1971, they lobbied NASA hard. Ultimately, the decision was Slayton's and it is an open question whether the lobbying had any appreciable effect. Slayton certainly understood the logic of sending a geologist to the Moon and, with Schmitt as the geologist, the decision was probably not a difficult one. The announcement was made on August 13. Cernan, Evans, and Schmitt would fly on Apollo 17.

The following paragraphs have been derived from my February 21, 1994 conversation with Gene Cernan and deal with Gene's - and Jack's - road to Apollo 17. Readers should note that the Apollo 13/14 crews were announced in August 1969 and that the mission that would have been Apollo 20 wasn't canceled until January 1970. Further, the missions that

would have been Apollos 18 and 19 weren't canceled until the following September.

"In 1969, I was approached by Deke about assigning me as Lunar Module Pilot with John Young on the backup crew for Apollo 13. Deke never gave any guarantees that you were going to rotate and get any flight. He never said the backup crew of Apollo 13 was going to fly Apollo 16. But the bottom line is that I told Deke I'd rather wait for an opportunity to fly in the left seat and have my own crew - even though I knew that opportunity might not come - rather than commit myself and eliminate all other possibilities, except maybe a flight in Skylab, to fly Apollo from the left seat. I just wanted my own crew. Basically, Deke had said 'Well, you know the chances are you're going to fly on a lunar landing mission if your on the backup crew of Apollo 13. No guarantee. But the chances are you will.' And you know, flying with John would have been fine. But I just wanted to take my chances. So, in Deke's typical way, he said 'Fine. If that's what you want. But, you know, I'm not guaranteeing, number one, that I'll assign you the left seat on any mission and if I do assign you the left seat on a mission, there's no guarantee that your backup crew would rotate and, besides, the first mission you could possibly get as the backup crew in the left seat would be 14.' And then he said 'You know, if you get 14 (backup), there may or may not be a 17, because 20 is already canceled and people were talking about other missions being canceled. So you may be talking yourself out of walking on the Moon.' That's what he said, in so many words. And I said, 'I'll take my chances.'

"Charlie Duke (who flew with Young on Apollo 16) doesn't know what I just told you. But it's history, and it probably ought to be written down. And so I took my chances and reluctantly did not accept what was told me might be my only opportunity to walk on the Moon.

"Subsequent to that conversation with Deke, I was assigned to backup 14. And probably, at that point in time, backing up Al Shepard was the greatest challenge that any human being could ever ask for. Because Al Shepard was still a stranger to most people. But, once he and I had a couple of very candid, up-front discussions, we became very best friends. I think that what happened was that, as his backup, I had to tell him and then prove to him that I was his equal. And I think I did that. And he accepted me. He has mellowed a lot since he flew Apollo 14; and we've become very good friends with, I think, a great deal of mutual respect. But, prior to that, I didn't know Al Shepard very well at all, in spite of the fact that he was my boss.

"So, Deke threw me into the fire. He said (in effect), 'All right, you want a left seat backup? You got one!' In retrospect - and it was probably not too calculated on my part - it was the best pull-it-out-of-your-butt decision I made in my entire life. In turning down a chance to walk (on the Moon with Young) and then getting both the challenge and the opportunity of backing up Shepard, I put myself in the

very vulnerable position of maybe never flying on Apollo again, much less ever landing on the Moon. But, I told Al that our crew was going to do our best to get his crew to the Moon and back safely, and that we were going to be better prepared to fly he was. And, from that moment on, I gained his respect. And we had a ball. We enjoyed it.

"Now, how did the Apollo 17 crew finally get selected. Once we started backing up 14, it didn't take long to realize that the only thing that was obvious was that a geologist - and there was only one - was going to fly a mission to the Moon. And when 18 got canceled (in September 1970) it was like "Wow!" Jack was already on the back-up crew to 15 (that announcement had been made in March 1970). When 18 got canceled, we all know that there was a lot of political pressure to put Jack on a lunar mission. And there weren't any left except 17.

"Now, Deke was the kind of guy who could never have been pressured by anybody. Deke would have resigned. If the President of the United States have come to him and told him to fly somebody that Deke didn't think as qualified, he would have resigned. Deke would never, ever have put anybody on any mission who he didn't feel could god-damn do the job and do it well. Deke would not have put Jack - nor would Deke have put me - on that flight if he didn't think we could handle it. And, once he decided you can handle it, and once he put you on that flight, he would defend you to Kraft or anybody and stick by his guns. That's just the way Deke was. Deke was a no-bullshit guy. a let's-get-on-with-it guy. He was the Godfather. He was the true, inflappable guy, the one who'd listen to all the stuff about why you can or can't get something done and then say, "Let's get on with it." When I got selected for the space program, I got a call from Deke and he said "I've got a job for you down here, if you still want it." It's not like "Hey, Gene! Congratulations you've been selected!" And if I'd said "Deke, I've change my mind," he would have said "Okay. Listen, I'll look forward to seeing you again, some time." That's the kind of guy Slayton was. He never forced anyone to do any thing, and he never had anything forced upon him, other than his removal from flight status back in Mercury.

"So it became obvious that Jack was going to fly Apollo 17, and the thing we talked less and less about was what was going to happen to Joe Engle (who was then the Apollo 14 backup LMP). But the question was: who was going to fly as Commander? Deke never gave us any guarantees, never gave me a Guarantee One that I was going to rotate from 14 to 17. Not a one. And I knew what was going through Dick Gordon's mind at the time. All six of us - well, maybe Jack wasn't sure - but the rest of us were sure that Jack was going to fly on that mission. The question was whether Jack's going to take Joe Engle's place and we're going to rotate or whether they were going to take Jack's entire crew - the Apollo 15 backup crew - and put them on Apollo 17. Had Deke made that decision, he would have been well within his right

to make it. There was enough time, they were well trained, they were capable and they worked together well and, quite frankly, I don't know what tipped the scale one way or the other. All those little factors add up. How well you performed in simulations and all the other things.

"It was probably a pretty non-political decision, although, I think there were two camps. I think there were people who wanted to see Gordon and his crew fly, and I think there were people who probably wanted to see me fly, notwithstanding the fact that Ron Evans and I would fly without Joe Engle. Obviously, where I went, Ron Evans went. The question was on the table until October of 1971 when I got a call in Acapulco from Deke asking me how I'd like to fly Apollo 17 with Ron and Jack. I think Joe Engle knew the handwriting was on the wall. Because I wanted to keep my crew together, I had done some fighting for Joe to stay on the mission. And had a lot of sympathy and support from people. But only to the point where I was asked 'Are you telling me you will only fly with Joe? If you're telling me that, then it makes my decision a lot easier.' And I told Deke, 'No, I can't tell you that. I've fought too hard for the opportunity to have my own crew and to be in the left seat.' And it was not a question of Jack as an individual, it was just a case of wanting to keep your crew together, quite frankly. And I said 'No, I won't tell you that.'

"Now, I don't know how Deke came to the conclusion he came to. Maybe he took my background and experience - along with Ron's because Ron was a good pilot and had a good reputation with the simulation people and everybody else and studied geology hard - and put them up against Dick Gordon's and Vance Brand's capabilities and said "Notwithstanding the fact that we're going to break up the Dick Gordon crew, this is our best combination." I don't know how that decision was arrived at. I do know that there were people in Dick Gordon's camp and there were people in my camp. I say it probably wasn't a political decision, but I do have to believe that there were some strong supporters on both sides who made a difference. And if I had to pick two people who were on my side, I'd have to say that Stafford was one and Shepard was another. And I may never know. And if I had to pick, I'd said McDivitt was certainly in Gordon's corner, as was Conrad. And the reason Shepard would have been in my camp was because we did such a good job on 14. I mean, that was my key. I either flunked or passed the test on 14. And if I passed it, then I had to wait and see what was going to happen.

"There are always a lot of what-ifs that come up in talking about the Apollo crew selection. Had I chosen to fly the Apollo 13 backup crew and, eventually 16, who knows how it would have turned out on 17. Who would have backed up 14? And who would have flown 17? Just like the accident that killed Elliot See and Charlie Basset in St. Louis that put Tom Stafford and I onto Gemini 9, If that accident hadn't happened, Buzz wouldn't have flown in Gemini; but it did and

then, somehow, he found himself walking on the Moon. Who knows. He might have been a Command Module pilot. Or he might have flown an early Earth orbit Apollo mission and have gotten a lunar flight later on. Who knows.

"Anyway, I know that there were people who thought that Jack had a lot to prove. He got the Apollo 17 assignment because he was a geologist and there were some people saying he wasn't an aviator, that he shouldn't fly, that he couldn't handle it. So Jack probably had a little cross to bear in proving to those people that, not only could he handle the geology - which came natural - but also that he could handle the other requirements of being a Lunar Module Pilot.

"Some time ago I told you that Jack was an 'adequate' pilot, and I want to clarify that. Jack in a T-38 was an adequate pilot. He wasn't a great pilot, but he didn't have the experience to be a great pilot. And, quite frankly, I don't think he had the aptitude or the desire to be a great pilot. Jack flew airplanes in NASA because he had to fly. That was one of the squares to fill to get on the Moon. And that's not a knock. I flew with Jack in T-38's, and I think Jack was a safe and an adequate pilot. I don't think Jack thought he was the greatest pilot in the world. Most people who want to fly big-time or fly off aircraft carriers, if they're not a little arrogant and don't think they're the best pilot in the world, they should get in some other business. And, since we came back, Jack hasn't flown. To be a great pilot, you've got to think you can do it better than it had ever been done before. You know your limitations, but you have to be a little arrogant. I used to say, 'I dare the guidance system on the Apollo Saturn V to fail, because I can get us into orbit.' And if I didn't think I could get us into orbit, then I shouldn't have been there. And I knew I could land that lunar module closer than anybody else had done to their desired landing point. Whether I'm a few feet long or short, really didn't matter, but I had to go into that mission thinking that. It's the kind of arrogance - not egotism - that you have to have. And Jack didn't have that when it came to flying an airplane. Adequate is the word I used.

[In a prior conversation, Jack and I discussed his flying abilities. "I was a pretty good pilot, as long as I was doing it. As long as I was proficient and was getting lots of time. But if I stopped getting time, my skills degraded faster than somebody who trained as a teenager. And I've always interpreted that primarily as coming at it late and as having some neuro-pathways developed because of scientific training where you get to focus on things longer than you can focus on them when you're flying an airplane. As long as I was doing it routinely, more or less daily and getting good weather time, I was fine. I think I was as good as anybody. But if you put me into a situation where the skills of test piloting, fighter piloting, and formation flying are necessary, it was just outside my experience. Yeah, I would never stack myself up against those guys. But,

routine flying of a T-38 - and, by that, I mean emergency or otherwise - and helicopters, I had no qualms."]

Gene continues. "Now, when it came to flying the lunar module, 'adequate' does not describe Jack's ability to fly in the righthand seat of the lunar module. He was outstanding. He knew the systems. He knew the AGS computer. He knew the PGNS computer. He knew the dynamics. He knew what we were going to be looking at. Now, when I say 'fly', Jack didn't have much of a chance to land it (in the simulators) and Jack didn't have much of a chance to fly the rendezvous, but that wasn't his job. He trained hard. He studied hard; and he worked hard. Jack was not an 'adequate' lunar module pilot; he jumped in with both feet and was an outstanding lunar module 'pilot. Now, contrast that with Joe Engle. Joe was born with a stick and rudder in his hand. Joe Engle is probably the finest stick and rudder aviator that I've ever flown with in my entire life. He could make an airplane do things that I don't have guts enough to make it do. So Joe was an outstanding aviator. In contrast, Joe was only an adequate lunar module pilot.

[Jack continues. "When Deke Slayton said 'Are you ready to go?', I said 'Yes'. I do know that, if he talked to flight controllers, if he talked to the systems instructors, if he talked to the simulator instructors, he would have gotten - I think - a very positive evaluation about my ability to operate the lunar module. Because I think I worked at it harder than anybody except Fred Haise. Fred probably knew more about the lunar module - both sides - than anybody. The other side of the coin is that, if I had not demonstrated the capability to operate the lunar module from the right side, I wouldn't have gone. I'm absolutely confident that Slayton would never have allowed anyone to dictate to him putting somebody who couldn't fly the lunar module on the mission. And I can think of some people that he probably would have fallen on his sword to keep from flying. Just for that reason. Because he didn't think he could trust them with the spacecraft."]

Gene responds. "The bottom line was that you had Deke's endorsement, you didn't need anybody else's. Period. I think the simulator instructors, and the flight controllers, and all those guys had a direct influence and input into everybody being selected to fly. Because that was your on-going, dynamic test. And if they didn't think you were cutting the mustard, they could see it from there and lot easier than anyone else could. I'm sure that Deke used that input. Deke would have fought to his death against flying somebody if he thought wasn't qualified. So Jack can sit back and relax. When you have Deke's endorsement, you don't need anybody else's. Period.

"People ask 'How'd you ever get selected for the space program?' And, quite frankly, I don't have the vaguest idea. Every time I went to Houston (during the selection process) there were half as many guys as there were the time before; and all the guys that had broken world speed records and

altitude records weren't there. And there I was. I wasn't even qualified to be selected for the program. Didn't have enough jet hours. Didn't have all that test pilot time that those guys had. Yet, somehow, when all was said and done, there were fourteen of us and I was one. (Group 3 was Aldrin, Anders, Basset, Bean, Cernan, Chaffee, Collins, Cunningham, Eisele, Freeman, Gordon, Schweickart, Scott, Williams. Group 2 was Armstrong, Borman, Conrad, Lovell, McDivitt, See, Stafford, White, Young.) And as I look back, I don't know how all those other guys missed out. And when you get to crew selection, it's almost the same thing. It became a little bit more obvious towards the end of Apollo, perhaps. But you just did your best and let the chips fall where they may. And I did that all the way through backing up Apollo 14. I wanted a crew, but not so I could give orders. I just wanted the responsibility of my own squadron, which I never had in the Navy, and I wanted it on an Apollo mission. I don't know. Why do you want those things. Why did I go back to the Moon? If you risk your neck once, why do it the second time? Because I wanted to go back with my own crew. And it turned out to be the best Apollo crew there ever was, quite frankly. Building on other people's experience, we should have been better. But, had we had a chance to fly Apollo 11 or any of those other missions, we would have been just as good or better than anybody. There's no question in my mind.

Site Selection

Selection of a specific Apollo 17 landing site got under way in early November, 1971, shortly after the completion of Apollo 15. The effort was led by Noel Hinners, with guidance from Rocco Petrone, the Apollo Spacecraft Program Manager, and his successor, Astronaut Jim McDivitt. Schmitt and USGS geologists like Bill Muehlberger were also deeply involved. As with all of the Apollo missions, site selection was strongly influenced by operational considerations. The crews needed to land soon after local dawn in order to have good shadow definition of the terrain, and that dictated a short launch window that opened no more than once a month for each site. Further, because of the tilt of the Moon's orbit relative to the terrestrial equator, the tilt of the initial spacecraft orbit due to the latitude of the Florida launch site, and various constraints imposed by the possibility of an in-flight launch abort, the farther a potential landing site was from the lunar equator, the less likely it was that an acceptable trajectory existed for an arbitrary launch month. Beyond these constraints, the flight planners wanted a site far enough from the eastern limb that they would have at least 12 minutes of flying time - and preferably 15 minutes - between AOS (Acquisition of Signal) and the start of the final descent. The twelve-minute limit meant that acceptable sites could be no farther east than a lunar longitude of 34E and, as McDivitt made clear in a November 23, 1971 memo, only in the case of extraordinary scientific

merit should a site between 34E and 43E be considered. Irrespective of flight dynamics, it was essential that there be a fair amount of reasonably level ground within the landing ellipse and no large areas of unacceptable ground. And, finally, it helped if there was good, high resolution photographic coverage so that the selection committee and the EVA planners could be reasonably sure that a particular site offered a substantial scientific return.

In its effort to sort out lunar geologic history, the scientific community was interested in very old, crustal materials - such as the Imbrium ejecta breccias returned by the Apollo 14 crew from the Frau Mauro formation and by the Apollo 15 crew from Mt. Hadley Delta - and, also, materials that might be the product of recent volcanism. In general, it was felt that the lunar mare had been thoroughly sampled on Apollos 11, 12, and 15 and, certainly, there were now plenty of samples in hand from the Imbrium impact. During the Apollo 16 site selection process - which ultimately focused on the problem of young volcanics - considerable interest was expressed in such sites as (1) the mountains that lie between the Serenitatis and Crisium basins in northeast part of the Nearside; (2) the Crater Gassendi which, because of its great size, has a central mountain peak produced by rebound of the rocks pushed downward in the impact; (3) the Crater Alphonsus which was the target of the Ranger IX mission because its complex structure and lava fill; (4) the prominent, lava-flooded crater Tsiolkovsky on the Farside (a choice Schmitt vigorously tried to promote for Apollo 17); and (5) a variety of other sites such as the Crater Copernicus, the Davy Crater Chain, Crater Tycho, Crater Alphonsus, and Marius Hills (a potential volcanic site) which had all been of long-standing interest. As Schmitt discusses in his commentary, the added cost and risk of the otherwise-exciting Tsiolkovsky mission meant that the proposal never made any real headway and, as Hinnens details in the Apollo 17 Preliminary Science Report, scientific and operational considerations trimmed the list to two candidates: Alphonsus and Taurus-Littrow.

Apollo 15 was the key to the 17 site selection. The high resolution cameras carried in the 15 Command Module had produced very high quality images of the mountainous region along the ground track between Crisium and Serenitatis and it soon became apparent that Taurus-Littrow was a very interesting site. The mountains that frame the valley would provide an opportunity to sample ejecta from the Serenitatis and Crisium impacts and there was even the landslide that had put South Massif materials out on the valley floor within easy reach. Apollo 15 had carried x-ray and gamma ray spectrometers, and data from those instruments indicated that the Massif materials were different in composition from the mountains at Hadley. That result certainly justified the original interest in the general area. In addition, there was also evidence of young volcanics and, as described in a

February 16, 1972 site selection press release, the prospect had the geologists licking their lips.

"The targeted landing point itself will be on the other prime sampling objective (other than the mountains) which is the very dark, non-mare material filling the valleys between the mountains. On occasion, the dark material is found in small troughs on the mountain sides, indicating that it once thinly covered the mountains but has eroded off the steep slopes. This observation, plus the presence of volcanic-looking cinder cones, first reported by Apollo 15 Command Module Pilot Al Worden, indicates to lunar scientists that the dark material is an explosively-produced volcanic ash. The apparently low crater density in the area covered by the dark material also leads geologists to believe it to be among the youngest lunar volcanics. The explosive nature of the volcanism indicates a relatively high content of volatiles or gases, both of which have been exceedingly rare in all lunar samples seen thus far. If the Moon, as the preferred models indicate, had indeed cooled from the outside in, these youngest lunar volcanics should be derived from the greatest depths and may give the first good samples of the deep lunar interior."

As we have already seen in the summary of Apollo 17 surface operations, the original interpretation of the dark material was flawed, if only in the assumption that it had been produced by recent volcanism. Predominately, the valley fill is mare basalt and dark coloration is the product of ancient, rather than modern, volcanism. Nonetheless, in pre-flight analysis, the site looked to be very interesting and, as the mission proved, that interest was fully justified.

There was one final obstacle that had to be overcome before the selection of Taurus-Littrow could be made. Houston's Mission Planning and Analysis Division (MPAD) had estimated a landing ellipse that was three kilometers long and two kilometers wide and, therefore, too large to fit into the valley without including portions of the North Massif and/or some of the larger craters. After much debate between MPAD and Hinnert's site selection team at NASA Headquarters, techniques for the refinement of the LM guidance were agreed on that shrank the landing ellipse to a circle 1 kilometer in diameter. Taurus-Littrow would be the site of the last Apollo moon landing.

Assembly of the Apollo 17 flight hardware by the manufacturers had begun in February and March of 1971. The Lunar Module, which the crew later named Challenger, was shipped to the Cape on June 14, 1971 while the Command-and-Service Module, later named America, was shipped on March 24, 1972. In August 1972, the components of the Apollo 17 stack were fitted together and, then, were rolled out to the launch pad for three more months of checkout. As had been the case throughout Apollo, no significant problems were encountered and Apollo 17 remained on track for a December 6th launch.

Apollo 17 was the first-ever nighttime launch of an American space crew, a circumstance dictated by the extreme northeastern location of Taurus-Littrow and a desire to fly a heavily-laden LM. The launch was scheduled for 9:53 p.m. Eastern Standard Time, December 6, 1972; but, because of a malfunction of the automatic countdown sequencer, the launch computer stopped the count with only thirty seconds to go. While the problem was being fixed, the flight dynamics team redesigned the launch trajectory and the trans-lunar coast so that the crew would arrive in lunar orbit at the pre-planned time.

After a two hour and forty minute delay, the crew of Apollo 17 finally had a launch and were on their way. It was just after midnight, December 7. In later years, Navy veteran Gene Cernan was always mindful that this last Apollo lunar voyage started on an anniversary of Pearl Harbor Day.

The launch was flawless. During training, Cernan had spent time in the simulators so that, in the event of a guidance system failure, he would be able to reach orbit by flying the Saturn stack manually. During the actual launch, he checked to see whether or not he could see stars and the horizon but, because the cabin lighting was set high enough that they would not be blinded at the moment of ignition and, thereby, be unable to see the instruments, Cernan could see no stars. In the post-flight Pilot's Report, he stated "it is the Commander's judgment that the abort (to orbit) would only have been marginally successful because of the small amount of night adaptation the crew were able to acquire in-flight." He went on to conclude that, because it would take multiple failures to force a manual abort to orbit, it was more important to have adequate lighting in the cabin.

As usual, once the crew reached orbit, they and NASA took time to thoroughly check the health of the spacecraft before committing to the lunar journey. Twice the crew orbited Earth and, then, just before their third sunrise over the Atlantic, they reignited the S-IVB, the Saturn's third stage, for the 351-second burn that accelerated them to nearly escape speed. A half hour later, Evans separated the CSM from the spent S-IVB and turned around so that they could examine the LM and then dock with it. Schmitt reported that he could even see the Rover and that it seemed to be in good shape, still snugly stowed against Descent Stage.

The docking went smoothly, even though the crew was bothered by occasional soundings of the Master Alarm system. They suffered intermittent alarms throughout the first two days of the mission; but, because there were no accompanying warning lights, they concluded that the problem was probably due to an intermittent short in one of the instrument panels. It was a nuisance that could be ignored.

Almost immediately after docking with the LM, Cernan got down into the short tunnel leading toward the lander and removed the covering CSM hatch to check the latches holding the two spacecraft together. He found that three of the ten were not fully set but was able to close them manually. He

then got out of the tunnel and replaced the hatch. They were now ready to pull the LM out and away from the S-IVB. Cernan fired the explosive bolts that held the LM in place, and then Evans fired the CSM thrusters to pull themselves away. Schmitt ran the movie cameras to record these events and, eighteen minutes later, once they were safely out of the way, Houston fired up the S-IVB for one last time, putting it on a trajectory toward a planned lunar impact at a point picked to maximize the scientific return from the Apollo 12, 14, 15, and 16 seismometers. While they waited for the S-IVB burn, Cernan reported that, while he knew "we're not the first to discover this, but we'd like to confirm, from the crew of Apollo 17, that the world is round." In the two hours since the TLI burn, they had moved out far enough - about 15000 miles - that they could see the whole Earth. Because of the Moon's position in its orbit, they were south of the terrestrial equator, over the southern tip of Africa, and had no trouble seeing Antarctica. The Earth was nearly full and, at 30,000 miles, they took a stunning portrait of the planet. 17 portrait of Earth after TLI

Throughout the outbound journey, they had a good view back toward Earth. Schmitt, in particular, provided lengthy and detailed weather reports, complete with predictions. His first report, given while Cernan and Evans were getting out of their suits, went on for a full half hour and, as the Earth turned beneath them, he could update his predictions for various parts of the world. Later in the mission, CapCom Gordo Fullerton told him, "You're a regular human weather satellite."

Nine hours into the mission, they were ready to sleep. Cernan wore a headset in case Houston needed to talk; and he also wore biomedical sensors so that the flight surgeon could watch his heart rate and other vital signs. On this first night, none of them got more than about three hours of sound sleep but, for the next few days, the work load would be relatively light and there would be plenty of time to get adequate rest.

On the morning of this second day, Houston was ready to discuss a reset of the mission clocks so that when they got to lunar orbit at the pre-planned time, the clock time would agree with the times printed in the flight plan. In essence, they needed to add two hours and forty minutes to the actual elapsed time and Houston was looking for a spot in the flight plan where the reset could be done without significant disruption. Their first thought was to do the whole correction at 65 hours. However, the choice would shorten that work day from 16 hours to 13 1/3 hours and, after some thought, Houston decided that it would be best to modify the schedule in two stages and avoid any more disruption of the sleep/wake cycle than was already necessary. Between 46 and 65 hours after the actual launch, they would move all activities up one hour. That is, they would do the activities scheduled at 52 hours at 51 hours of elapsed time. Then, at 65 hours they would set the clocks forward to 67:40.

It was a bit confusing, even to the crew, but it avoided two clock changes and, because there were to be relatively few things going on between 46 and 65 hours, there would be only a few pencil changes in the flight plan.

About six hours after their first wake-up in space, Schmitt got down under one of the couches and, by holding onto one of the struts, was able to get some exercise by running in place on the bulkhead of what was called the Lower Equipment Bay. Before starting, his heart rate had been about 60 beats per minute and, much to the surgeon's pleasure, he was able to get his rate up to about 140. What is more, the engineers reported that he shook the spacecraft hard enough to stir the liquid oxygen in the Service Module tanks. Each of the tanks contained a fan and, when the fan wasn't running, heat losses at the walls created temperature gradients in the tank, a circumstance that the engineers wanted to avoid. By exercising, Schmitt had saved them the trouble of turning on the fan, thereby saving a little spacecraft power.

The second day was purposefully short. The landing was scheduled for about 2:30 p.m., Florida time, and the crew was then going to do a full EVA before getting to bed. They wanted to wake up on landing day at about 7:30 a.m., Florida time, and it had been decided that, after the disruption of their sleep cycle caused by the night launch, it would be best to get back to a morning wake-up as early in the flight as possible. After the launch, they hadn't gotten to sleep after the launch until it was about dawn at the Cape, and then their first wake up came at about 3:30 in the afternoon. However, by having only a ten-hour second day, they were asleep by 1:30 a.m. Florida time and could wake up at 9:30 a.m. with most of the adjustment already made and with three more sleep periods to go before landing day. With the help of a Seconal sleeping tablet, each of them got 7 1/2 hours of sound sleep on their second night in space and awoke feeling well rested and ready to go.

By now, they were a bit over half way to the Moon, about 125,000 miles out from Earth and the spacecraft was working beautifully. They had been consuming maneuvering fuel, water, oxygen, and electric power at very close to the predicted rates; and they were being conscientious about eating and drinking enough to keep the surgeon happy. After Schmitt reported on the weather for southern Africa and Argentina, Fullerton read a news summary that included items such as the ongoing negotiations in Paris between the United States and North Vietnam, the medical condition of former President Harry Truman, and the start of the Texas state high school football playoffs.

The first big event of the day was a mid-course trajectory correction which came about two hours after wake up, an exceedingly modest two-second burn of the Service Module Engine. Four hours later, they pressurized the LM, opened the connecting hatches, and, for the first time, powered up the LM systems for a 2 1/2 hour checkout. Once

they and Houston were satisfied that, with the exceptions of some minor problems with the comm system, the LM was in good shape, they powered down the spacecraft, crawled back into the CSM and closed the hatch. With all of the hardware - hatches and docking probes and the like - to be moved around, it was a time consuming process but, at this stage of the mission, there was plenty of time and there was no point in hurrying. After finishing with the LM, the astronauts ran a small, self-contained, heat-flow-and-convection experiment which proved to be so fascinating that Houston had to remind them to take care of some other items in the checklist. Schmitt thought that it was the best Saturday afternoon matinee he'd seen in a long time and wished that they'd had some popcorn. And then it was time for another weather report - this one from the Commander - another exercise session, an evening meal, and then another good night's sleep. Once again, each of them took a Seconal.

For this third rest period, Houston gave the crew of Apollo 17 a full eight hours and, for the first time in the mission, Fullerton had to wake the crew out of a sound sleep. As a wake-up call, he used the stirring strains of the Jayhawk Fight Song, in honor of Ron Evans' alma mater, the University of Kansas. It was going to be another quiet day and Schmitt thought their only problem was going to be keeping Evans from going back to sleep. After breakfast, the news from Earth, the weather report from space, and a little bit of housekeeping, Schmitt got back in the LM and powered it up for about a half hour so that Houston could take a look at the telemetry system. He made another brief check of the comm system and, as Houston had expected after thinking about things overnight, the previous day's problem were confirmed as being problems on the ground, rather than in the spacecraft. Cernan, who had been detained by an urgent call of nature, joined Schmitt for the last few minutes of the LM checkout. Then, once the LM checkout was completed, all three of them got into their suits, just to make sure they wouldn't have any trouble doing so once they got to lunar orbit. Cernan and Schmitt then got out of their suits and got out of the way while Evans, still suited, made sure that he could get the probe re-installed and the hatch closed as he would have to do prior to separation for the descent.

While they got ready for lunch, Cernan took a look back at Earth, conscious that this would be the last trip anyone would make out this far for some time to come. He told Houston "You can look right down at the Cape area - that's the Cape that we know, in Florida - and it's a little disheartening because the last time I was up here (on Apollo 10) looking back from this angle, they were moving another Saturn V for another Moon trip out on the pad already."

The preparations for lunch took a bit longer than usual and the reason was that Evans couldn't find his scissors. The food, much of it dehydrated, was sealed in tough plastic

bags. Each of them carried a pair of good quality surgical scissors so that they could cut the bags and get at the food. Without his scissors, Evans would get mighty hungry and his one hope, short of finding his own, was that Cernan or Schmitt would lend him a pair while they were down on the surface. After some joking about his predicament, they agreed to leave a pair behind.

After lunch, it was time to reset the clocks. Fullerton read them an explanation written for the press by the Public Affairs Office and, if possible, it was worse than what I wrote for this summary. Certainly Fullerton and the crew had a good chuckle over it. The important point was that, after lunch, they were 65 hours into the mission but had completed all the planned activities up to 67:40. Now, they could change the clocks and, from then on, behave as though they had launched on time.

The next item on the Apollo 17 agenda was an experiment called ALFMED or Apollo Light Flash Moving Emulsion Detector. On early missions, various astronauts had reported that, with their eyes closed, they sometimes saw brief streaks of light. The most reasonable explanation is that their retinas were being triggered by cosmic rays and, to test the hypothesis, Evans donned a helmet that covered his eyes and also contained slowly-moving plates of photographic film that would record any cosmic rays entering his head. He wore the detector for an hour and reported all of the flashes that he saw. These were later compared with the film record. As a control, Cernan wore a blindfold and also reported any light flashes he saw. It took Evans and Cernan about fifteen minutes to get sufficiently dark adapted that they began seeing flashes. Thereafter, they reported events about once every 2 1/2 minutes. The experiment was repeated on the trip back from the Moon, this time with all three of them wearing blindfolds. On that occasion, none of them reported any flashes. Readers may want to note, however, that the surgeon reported that the LMP seemed to be asleep during much of the homeward-bound experiment. ("My heart rate was very low anyway.")

On Day 5, the crew of Apollo 17 was to enter lunar orbit. The night before, CapCom Bob Overmyer told them that he wanted to give them fair warning "in case you all feel a bump there when you're about ready to go to sleep there. At 73:17:45 (hours after the planned launch time), you'll cross that magic line into the lunar sphere of influence." Ever since launch the Earth's gravitational pull had been slowing them down but, now that they were getting close to the Moon, they were speeding up again. Their slowest speed, relative to the Moon was 2354 feet per second and, thereafter, they "started hauling the mail".

Cernan was the first up on Day 5. Houston had decided to give them an extra half hour of rest, but the Commander was awake before they could send a wake-up call. On this night, he hadn't taken a Seconal and had still managed about 5 hours of good sleep. Schmitt had taken a tablet in order

to get to sleep and had slept soundly for over seven hours. Evans had also taken a Seconal but said that he thought he'd tossed and turned most of the night. However, the surgeon said that, although his periods of restlessness had been evident in the biomed data, none had been any longer than about ten minutes and it looked as though he'd gotten about 7 hours of good sleep.

As on Apollos 15 and 16, the Service Module contained a variety of scientific instruments designed to scan the lunar surface passing beneath the orbiting spacecraft. There were photographic cameras for high-resolution mapping; an infrared scanner to map variations of the surface temperature which would allow inferences about the variations of density and thermal conductivity of the surface layers; a radar designed so that it would not only measure variations in the height of the terrain passing beneath the CSM but also detect variations in the electrical properties and, hence, the structure to a depth of roughly a kilometer; and an instrument to detect emissions from the extremely tenuous lunar atmosphere. During launch from Earth and during the coast out to the Moon, the SIM (Scientific Instrument Module) Bay had been covered with a protective panel; but, now that the spacecraft was approaching lunar orbit, the experimenters were eager to get data and it was time to jettison the SIM Bay door. After breakfast, a urine dump, an update of data for an emergency abort procedure, the news, the weather, and a variety of other routine chores, the astronauts oriented the spacecraft so that, once they fired the explosive bolts to push the door away, it would move off far enough and in the right direction that, when they fired the Service Module engine to enter lunar orbit, they wouldn't run into it.

By later standards, the on-board Apollo computers were fairly primitive. The crew sometimes had to enter data (called Nouns) manually on a keyboard and then tell the computer what actions (called Verbs) to take. Memory was limited, although there was room for enough information that the computer could fly the nominal flight plan without minute by minute instructions from the crew. Houston could feed data for normal flight procedures directly into the computer when the crew set it up in Program 00 (called "pooh" for short) and put it in the Accept mode. For emergency purposes - say if they had to abort the mission and had lost communications with Earth - Houston occasional read up data "pads" which Schmitt then wrote into the appropriate blank spaces in the Flight Plan book. Because of the launch delay and the usual slight deviations of the trajectory from the planned path, Houston had a great deal of data to read up. Thanks to long hours of repeated practice, Schmitt and the ground team got the work done smoothly and without error. Slowly, Fullerton would read up a block of data and then Schmitt would read back what he had written before they moved on to the next block.

All through the journey out from Earth, the crew had gotten a good view Earth. As we have discussed, during the

early hours of the mission they had been treated to a nearly full Earth. By now, their trajectory had carried them to a point where the Earth was about two-thirds full. Most of the time, they had been flying the spacecraft with its long axis oriented perpendicular to the Sun, slowly rotating around that axis so that all parts of the spacecraft would be heated uniformly. This was called the Barbecue Mode. There were five windows: one over each of the seats that gave a view more or less perpendicular to the long axis, and two others that gave a view forward for use during rendezvous and docking. For about two-thirds of each spacecraft rotation they had a good view of Earth. During the other half of each rotation, they had, in principle, a view of the Moon. However, because they were going to be landing at an eastern site just after local dawn, the Sun had been behind the Moon throughout most the flight out from Earth. Therefore, the side of the Moon that they could see, the Nearside that always faces Earth, was in darkness and it wasn't until they got close that the perspective changed enough to see any of the sunlit portions. At a mission time of 86:46 - according to the reset clocks - Cernan reported their first view of the Moon.

"I've got the limb of the Moon...got it out the center hatch (the main hatch in the side of the vehicle, rather than the one leading to the LM) and we're just barely seeing the horizon of the Moon. But, boy, is it big."

It was, Evans said, just a tiny sliver of sunlit Moon, "a sliver of a sliver".

They were only about 5000 miles out and the Moon looked so big that Cernan had the impression that they were "coming right down on top of it". Half jokingly, he asked Fullerton if the tracking people were sure that they were going to miss the edge. Was the low point really going to be 73 miles as planned?

"Roger," said Fullerton. "That's about right. Don't worry, you'll miss it."

"I just wanted to hear you say it," Cernan replied, "because I'm going to hold you to it."

They had to shield their eyes to see the Moon because, at the moment, the Sun was sitting right on the lunar horizon. But it was worth the effort. Gene's pix of the crescent Moon

"Gordy, it's a sight to remember. Not just because of the uniqueness of the view, but because we've all got to ask ourselves if we really know where we are and what we're really looking at right this moment."

A few moments later, Cernan added "Gordy, it doesn't look like I'll have a chance to go to church today; but, under the circumstances, I guess it'll be okay. Next time you see the good father, you might have him put in a good word for us."

"Okay. I'll do that."

Although Cernan had been to the Moon before, on the Apollo 10 approach the western Nearside limb had been in

darkness and final hours hadn't been so visually dramatic. Cernan remembered that, on Apollo 10, he'd been impressed with how fast they seemed to be climbing away when they left lunar orbit for the trip home and, also, that he'd wondered what it would be like coming in that fast toward a surface he could see. Now he knew. Fortunately, there was plenty of work - and a great deal of pure professionalism - to protect him and the others from the full psychological impact of their seeming headlong rush.

"If you guys could get an idea down there," Cernan told Fullerton, "of the needle you're threading when you shoot for 50 miles at a quarter of a million miles, you'd be mighty proud of yourselves. I'll tell you, we are."

During our review of this summary, Jack Schmitt said that, "until I was going through my set of pictures, that I eventually gave to the University of New Mexico, and saw some pictures that Gene had taken, my memory was that we didn't see the Moon during the final approach. And I still don't have a personal recollection of looking at the illuminated edge of the Moon. Not a strong one, anyway. But I think that's because Gene was in the seat to do that. We were not in barbecue. We were in the attitude-hold mode. And he was in the position to see it and I wasn't. I may have glanced at it once. In fact, the more I talk about it, the more I think I remember him saying 'Come over and look at this'. But, for a long time, I didn't have any recollection of seeing any part of an illuminated Moon as we came in."

Gene replied, "Jack and Ron, never having had the opportunity to see what I saw on Apollo 10, can't appreciate the approach to the Moon that we had. I don't think anybody in any of the missions had this approach. I think everybody, starting with Apollo 8, went into darkness in the shadow of the Moon, and got on their back and, at a predetermined time, fired the CSM engine - in darkness and upside down and going backwards - and then, all of a sudden - maybe five minutes, maybe ten minutes later - we'd come out of darkness at fifty miles or thereabouts above the surface and it's 'WOW! Look at those craters. There it is. Man.' It's just like instant sunlight and we're THERE! I mean, it's like we've been flying in the darkness to rendezvous with this thing we can't see (the Moon - and we know we're close because we're in the shadow - and all of a sudden, WHAM, someone turns the lights on. And then the next major thing is to come around and see the Earthrise. Now, on Apollo 17 - and nobody told me it was going to happen - we went through the darkness and came out into sunlight before we got to the Moon. And we were coming in on this damn target and we were seeing, to start with, just a sliver, just a slice of the Moon. And then we started to see more of it as we snuck around behind it. and it's getting big so fast you can't believe it. And I'm telling you, you talk about rolling over on your back and making a dive bombing run at some point some 50 or 60 miles above the surface! That was the most spectacular entry into lunar orbit. And I don't think anyone appreciates it!

Except me! I don't think any of the other flights ever saw that. And I don't think Jack and Ron appreciated because I've got a feeling they thought it was supposed to be like that all the time."

Now they were only 2660 miles out and had been accelerated by lunar gravity to 5000 feet per second. Cernan had the monocular out and, when the Moon was in view, got a good look into some of the larger craters on the illuminated edge. But then it was time to change the spacecraft orientation so that the big Service Module Engine would be pointed in the right direction when they swept down to their low point over the Farside.

Half an hour before lunar gravity swept them around the west limb and out of radio contact with Earth, they had the linked CSM/LM re-oriented. Looking back past the LM, they could see the Earth. LOS (loss of signal) came at 88:43:21 and, eleven minutes later, the LOI (Lunar Orbit Insertion) burn to put them in a lunar orbit with a low point of 53 miles and a high point of 170 miles.

On their first pass over the landing site, the area was in darkness and, because they had just gone through the dawn terminator a few moments before and still had the Sun shining in the spacecraft windows, Earthlight was of no help. By the time they came around again, the Sun would be up at Taurus Littrow; but, first there was another burn to perform to put themselves in the proper orbit for the next day's descent. On this first pass over the Nearside and on the next as well, Houston took a careful look at the tracking data so that the burn parameters could be fine tuned.

While Houston was busy, the crew had an opportunity to admire the view and, throughout most of the Nearside pass, Schmitt gave a running commentary about the lunar surface below. Because they were near the high point of their initial orbit as they passed over the landing site, the Sun didn't go below their horizon for another ten minutes. But soon, thereafter, they began to pick out detail in the earthshine. Because the Earth was virtually overhead throughout most of the Nearside pass, there weren't any earthshine shadows to delineate the hills and holes until they had completed most of the Nearside pass. However, even without earthshine shadows, they could see differences in albedo, differences in the degree to which the surface materials reflected the earthshine. As an example, the bright rays emanating from the young crater Copernicus stood out quite well.

By the time the crew re-emerged from behind the Moon again, Houston had the new data ready. Cernan configured the computer so that it could accept the uplinked data while Schmitt copied additional information that Fullerton read up. There was a great deal to be copied and Schmitt and Fullerton didn't finish until just before the second pass over the landing site. Down below, the shadows were very long. The North Massif was almost completely shadowed by the Sculptured Hills and there was little that was visible out on the valley

floor. The only exception was the section of the Scarp near the crater Lara which, because of it is highly reflective and was sloped toward the Sun, stood out quite prominently.

For the rest of the orbit, the crew of Apollo 17 kept busy preparing for the burn that would put them in what was called the Descent orbit. On the early missions, the CSM flew a 60-mile-high circular orbit and LM fuel was used to take the lander down, first, into a 15 by 60 mile orbit and then to the surface. However, beginning with Apollo 14 and in preparation for landing the heavy J-mission LM's, the mission profile was changed so that, prior to separation, CSM fuel was used to put both spacecraft in the 15 by 60 mile orbit. Consequently, at the end of their second orbit, when they were once again down to about 53 miles above the lunar surface, the crew of Apollo 17 fired the Service engine and changed the orbit from 53 by 170 to 59 by 15, with the low point now just east of the landing site.

For the rest of the day, the crew did some more sightseeing and did some landmark tracking to help Houston fine tune the tracking data. They ran some of the instruments in the SIM Bay, took pictures out the window, ate some dinner and copied down some more data, including a few football scores. Evans had still not found his scissors and, by the end of the day, was talking about taking the spacecraft apart until they were found. Fortunately, Cernan and Schmitt agreed to leave him one of their pair so that he wouldn't go hungry and wouldn't have to destroy the Command Module. The crew said goodnight to Houston at a mission elapsed time of 95:47, not long after their fifth pass over the landing site. From fifteen kilometers, Cernan had seen quite a bit of detail in the area around his target point and said that "if we're anywhere near it (at pitchover), we'll recognize it, I think, without question."

Landing day was not only going to be a big day for the crew of Apollo 17, it was going to be a long day as well. If all went well and they got down on time and got the EVA started promptly, it was still going to be a 22 1/2 hour day from wake up to bedtime. Cernan and Schmitt had decided that there would be no point in a short landing day and a sleep period before going out. They were well rested and fit. And there was no doubt that the Moon would hold their interest.

The wake-up call for landing day was the John Denver/Steve Goodman song, The City of New Orleans, with its chorus of "Good morning, America, how are ya?" It was a happy song that had been suggested by people on the night shift in the press room - a song that matched the mood of the crew and, indeed, country-music-fan Schmitt requested a replay while he and the others finished waking up. Each of them had taken a Seconal; and Cernan and Schmitt, at least, had slept very soundly.

LOS at the end of the ninth orbit came only ten minutes after wake-up and, by the time Apollo 17 had re-appeared forty five minutes later, the astronauts were getting the

tunnel cleared and were getting into their suits. They'd had a very quick breakfast.

Check out of the LM went quickly and smoothly; and, not long after AOS (Acquisition of Signal) on the eleventh orbit, Evans was in his suit and was busily sealing up the tunnel in preparation for undocking. As one of the last items, all three of them donned their helmets and gloves and performed pressure checks. They would perform the maneuvers unpressurized for the simple reason that their dexterity was limited in an inflated suit. However, they wanted to make sure that, in an emergency, the suits would inflate and stay inflated as long as necessary.

As planned, the crew undocked the two spacecraft during the Farside pass at the beginning of the 12th orbit. For the next hour and a half, the two spacecraft flew close to one another so that the astronauts could make visual inspections and perform final checks of systems. Later in the orbit, just before LOS, Evans fired the Service Engine to boost himself back up into a 60-mile circular orbit so that, in the event of an aborted landing, he would be in an optimal position for a rendezvous. As seemed usual in Apollo, the crew had a little trouble getting contact with Earth through the LM's steerable, high-gain antenna but, otherwise, Challenger was ready for the landing.

Landing site photo from LM with CSM in view

At 110:57, Cernan and Schmitt pressurized the propellant tanks and, a few minutes later, made their last pass over Taurus-Littrow prior to the descent. Evans had not yet made his circularization burn and was ahead and slightly below them. It was a spectacular, oblique view of the valley. They were less than fifteen miles away, and the LM crew took a couple of color pictures. Cernan was particularly interested in the small group of craters that surrounded his target point, and he called out the names as he found them.

"Houston, I can see Poppy, right where we're going to set this baby down. As a matter of fact, I can see the triangle: Rudolph, Frosty, and Punk. Man, Gordo, this is absolutely spectacular."

At 111:57, Evans did his circularization burn and, five minutes later, the LM crew did a more modest burn to move the low point of their orbit down to 10 1/2 miles over a point east of the landing site. At AOS on the thirteenth orbit, Evans reappeared first and confirmed that the LM burn had gone well. And then, once Houston had a bit more tracking data with which to update the LM computer, everything was ready for the landing.

112:47:50 Schmitt: Okay. Coming up on 2 minutes (to Powered Descent Initiation (PDI); I'm changing over here.
 112:47:52 Cernan: Okay.

[They are making final preparations for the powered descent to the lunar surface.]

112:47:54 Schmitt: Master Arm, On. Two minutes (to go until ignition).
 112:47:58 Cernan: Okay, Houston. 2 minutes. Master Arm is On. I've got two good lights.
 112:48:00 Fullerton: Roger.

[By turning on the Master Arm switch, they are enabling activation of explosive devices with which they will open the fuel valves in the descent stage and others which would allow them to discard the Descent Stage in the event that they have to abort the landing. "Two good lights" refers to redundant pair of circuits.]

112:48:01 Schmitt: Mode Select is PGNS.

[The LM has two navigation systems: the Primary Guidance and Navigation System (PGNS), pronounced "pings", and the less capable Abort Guidance System (AGS), pronounced "ags" The AGS would only be used be used for guidance purposes in the event of a PGNS failure. In that case, mission rules call for an abort of the descent and a return to orbit. Under normal conditions, the AGS was used to double check the performance of the PGNS and, as Gene discusses below, it is an open question as to whether or not he would have aborted the landing in the final stages if the PGNS had failed and he was getting good AGS data.]

[Gene will next go down the list of critical events that will precede and immediately follow ignition. He and Jack have practiced this most critical phase of the mission many times; nonetheless, Gene is making absolutely sure that they both remember exactly who is going to handle each of the tasks. The terms are defined below as the events occur.]

112:48:03 Cernan: Okay. Once again, in average g, I'll get the Engine Arm (switch). You confirm the ullage, I'll get the Pro. I'll back up the ullage and get the Start.
 112:48:10 Schmitt: Roger. (Pause)
 112:48:20 Fullerton: Challenger, we're going to leave Batt(ery) 3, Off...
 112:48:22 Schmitt: (Garbled) Auto, Auto.
 112:48:22 Fullerton: ...until after ignition. We'll call you.

[Batteries number 3 and 4 in the descent stage are hooked up in parallel and should be showing the same voltage. However, during battery warmup in preparation for the descent, it was noticed that they had a voltage difference of

about 0.5 volts. Although there are no other indications of a problem, Houston wants to take battery 3 off line while they look at the performance of the electrical system. They will bring it back on line at 112:55:13.]

112:48:26 Schmitt: (To Fullerton) Roger. Yeah, I should have put that on like we talked about.

112:48:32 Cernan: (To Jack) Man, I'll tell you, we are getting close.

112:48:34 Schmitt: Looking out your window is really strange. (Laughing). From over here. (Long Pause)

112:48:56 Cernan: One minute, Houston, and we're standing by. We're Go for PDI.

112:48:59 Fullerton: Roger. You're looking good here. (Long Pause)

112:49:19 Schmitt: Okay, approaching 30 seconds. Blank DSKY.

112:49:22 Cernan: DSKY blank. (Pause) Average g.

[Cernan - "When you go into something as dynamic as an engine burn, you get major fluctuations in the accelerometers and, to navigate effectively, you have to average the accelerations over a finite period of time."]

112:49:30 Schmitt: Got two lights.

112:49:31 Cernan: Okay, Engine Arm is Descent. I think the tapemeter drove. I'm not sure. (Pause) Confirm the ullage.

[In other contexts, 'ullage' is the empty portion of a cask. Here, the word is used to describe a 7.5 second firing of the Reaction Control System (RCS) in order to settle fuel in the tanks prior to ignition.]

[Cernan - "At ignition, the tanks were about three quarters full of fuel and one quarter pressurized helium. The trouble was that, in zero gravity, you didn't know where the fuel was in the tank. Therefore, you had to apply a little acceleration and drive the heavy (that is, denser) fuel downward towards the outlet, towards the engine, so that, when you started the main engine you don't get a fistful of helium. Because we were flying with the landing gear and the main engine forward, to get proper ullage we had to fire the RCS jets briefly against that forward motion. We had the computer programmed to fire the thrusters for a few seconds prior to ignition; but, if Jack hadn't confirmed ullage, I would have used the hand-controller to give us manual ullage."]

112:49:38 Schmitt: Standing by for ullage. (Pause) Ten seconds. (Pause) Fuel ullage. We've got ullage.

112:49:39 Schmitt: Proceed on 99. It took. 2, 1, 0...

[P99 is the computer program which will perform engine ignition, with Gene doing a manual backup.]

[Schmitt - "Having gotten ullage, we pushed the computer's Proceed button which told it to continue with engine ignition."]

112:49:56 Schmitt: ...Ignition.

112:49:57 Cernan: Ignition, Houston. Attitude looks good. Engine Override is On, Master Arm is Off. We got a Descent Quantity Light On at ignition, just prior to ignition.

[The Descent Quantity Light is an indication of an inadequate fuel supply. In this case, it is a false warning. Gene discusses his reaction to the warning at 113:11:55, after the landing.]

112:50:04 Schmitt: DPC tank's good. RCS is good at 15 seconds.

112:50:10 Fullerton: Roger.

[We have been unable to translate "DPC" or find it in any list of Apollo acronyms. Undoubtedly, "DP" is "Descent Propulsion" and it is entirely possible that Jack got momentarily tongue tied as he checked the propellant tanks and meant to say DPS for Descent Propulsion System.]

[Schmitt - "Probably, I was doing a quick check to make sure the tank pressures were okay. Evidently, the Quantity Light was giving a false warning."]

112:50:11 Schmitt: RCS is golden. Should be stable throttle up. (Pause)

[For the first 26 seconds of the burn, the engine is fired at minimum thrust - about 10% of full thrust - so that the engine gimbal can be adjusted to put the thrust axis directly through the center of gravity.. At throttle up, the engine is switch to full thrust, where it will remain until the last couple of minutes of the descent.]

112:50:18 Schmitt: Stand by. There's...

112:50:20 Cernan: Throttle-up's on time, Houston.

112:50:20 Schmitt: ...throttle up.

112:50:21 Cernan: And the computer likes it.

112:50:23 Fullerton: Roger.

[Cernan - "Once you get into the computers, it's like riding a bicycle. Maybe you change to a different kind of bicycle, but it's still easy enough to learn. Long before we flew Apollo 17, I had gotten very comfortable with all of the computer systems. I had flown on Apollo 10 as Lunar Module Pilot and, on that mission, was responsible for a lot of things as far as computers were concerned, especially the AGS. Along with Tom Stafford, I also got to know the main computer to the point that I could sleep with it. After that flight I backed up Apollo 14. The morning of the Apollo 14

launch, I was ready to fly; and I knew those computers cold. And then came Apollo 17.

"The entry pad for the (PGNS) computer was between the two of us, by my right hand, just above the hatch. However, because of some experiences I had on Apollo 10 and so forth, I told Jack that, with very few exceptions, we weren't both going to be punching buttons on that main computer. On Apollo 10, Tom Stafford and I had had some trouble with the sort of situation where you think the computer's got one command and someone gives it another. Because of that, I told Jack that I was going to enter the commands and he was going to monitor me to make sure I did the right ones. He was going to run the AGS computer (with the DEDA, see below); but we weren't going to both be punching buttons."

[Gene uses the Display and Keyboard Assembly (DSKY) to enter data and commands into the PGNS. As he says, it is located at his right hand, over the hatch. Jack uses the Data Entry and Display Assembly (DEDA) to monitor the AGS and, later in the descent, to enter trajectory corrections.]

112:50:24 Cernan: (To Houston) Still got the Quantity Light on. (Pause) Okay, attitude looks good, Jack.

112:50:29 Schmitt: Okay. At 30 seconds (after ignition). Should have about 108 (degrees of pitch). (Pause)

[They are flying with their backs to the lunar surface and their feet pointing 18 degrees above the horizon. The LM pitch is zero when they are upright on the lunar surface.]

112:50:37 Cernan: (Marveling at the experience) Oh, boy!

112:50:39 Schmitt: AGS and PGNS are close.

[Schmitt - "The two, separate guidance systems had been initialized to the same data at some point prior to ignition. The AGS had some strapped-down gyros and wasn't as accurate as the PGNS; but, if the primary system failed, the AGS was certainly accurate enough to get us back to orbit. Here, I am checking to see that the two system are in satisfactory agreement. Sometime prior to the mission I had worked out a way to update the AGS's knowledge of altitude by inputting a value from the radar data as soon as that became available. We'll see that later. LMP's were always trying to get the AGS to the point that, if you had to, you could land with it."]

[Cernan - "We used to play around in the simulator to see if the AGS gave us enough information to land; and, quite honestly, if we were close I think we could have landed. There was a mission rule, as I remember, that we wouldn't land if we had a primary guidance failure. But one thing that people never paid much attention to is that, for most of the flight - and this is one very visible point - the ground has no control over what you're doing. They can send up information; but you're in command, you're flying the machine, and you're making the decisions. So who is to know

what decision would have been made if you were down around three or four hundred feet or six hundred feet or a thousand feet and you had a question about your primary navigation system but your abort navigation system looked good. The AGS didn't have the landing radar tied into it, but it was giving you descent information and you could use those pieces separately. And who knows whether you would have landed or not. We didn't want to go that far and not land because of a computer problem."]

112:50:43 Cernan: Okay, coming up on 1 minute.
 112:50:47 Schmitt: One minute. You ought to have 98 degrees of pitch. Okay, H-dot is high right now.

[H-dot is the descent rate, the time derivative of the altitude. They are descending faster than planned; hence, H-dot is high. The reason for this is that they are above the planned trajectory and the computer is bringing them down to it.]

112:50:57 Cernan: Mark it, 1 minute.
 112:50:58 Schmitt: Altitude's high.
 112:50:59 Fullerton: Challenger, Houston. I have a 169...
 112:51:02 Cernan: (Garbled under Fullerton) looks good, Houston.
 112:51:03 Fullerton: ...plus 03400, plus 3400 feet. Over.

[Fullerton is giving them a target update. According to tracking data, the LM is headed for a point 3400 feet short of the planned landing site. Because this is a substantial error, Gene will enter a correction into the computer so that it can modify the descent trajectory and put them on target. Jack will verify the entry.]

112:51:11 Cernan: (To Fullerton) You're looking at it.
 112:51:17 Schmitt: Okay; 3400. I confirm. (Pause)
 112:51:23 Fullerton: Challenger, you're Go for Enter.
 112:51:27 Cernan: Roger. Go for Enter.

[Cernan - "The ground couldn't fly the spacecraft or do anything with it, but they could read a lot of the data out. While I keyed the new data into the computer and Jack verified it on-board, they could also read it and verify it on the ground. Normally, they'd look at it and verify it before we'd go ahead and actually execute whatever command or whatever data they'd given us."]

112:51:29 Cernan: 1:30. We're Go coming through 57K.

[They are one minute and thirty seconds into the burn and are at an altitude of 57 thousand feet, or about 17 kilometers, above the lunar surface.]

112:51:31 Schmitt: Okay, the altitude's high and the H-dot is high. At least...That's right. (Pause) Okay, at one...(Correcting himself) At 2 minutes, you ought to have 89 on the ball.

[Cernan - "We had an inertial attitude gyro, like in an airplane, which we called the "eightball" or simply the "ball". It was essentially fixed in space and we would rotate the spacecraft around it. With the LM sitting on the lunar surface, the ball would have shown a pitch of zero degrees; and, while we were in the initial descent and lying on our backs with our feet forward, looking up at the sky and slowing down, it would show about 90 degrees or maybe even 108, depending on the trajectory. As we drifted in, we slowly pitched upright until, at 60 or 70 degrees pitch and 7000 feet altitude, we'd go through the big pitchover."]

112:51:43 Schmitt: We're still 30 feet per second high in H-dot. But we're about 8000 feet high...

112:51:48 Fullerton: Challenger, Houston,...

112:51:49 Schmitt: ...(make that) 7000 (in altitude).

112:51:51 Fullerton: ...we'd like you to cycle the PQGS switch Off and then back On.

[PQGS is the Propellant Quantity Gaging System. Cycling the switch will let them see if the quantity warning light is real.]

112:51:52 Cernan: Okay, Houston. Coming up on 2 minutes. (Pause as he listens to Fullerton) Okay. It (the switch)'s Off. And it's back On. Quantity Light is out.

112:52:06 Fullerton: Roger. That should be good now.

112:52:09 Cernan: And, Houston, we...(Hearing Fullerton) Okay. We have Engine Thrust and Commanded Thrust, full-scale high.

112:52:18 Fullerton: Roger.

112:52:19 Schmitt: Man, that looks good.

112:52:20 Cernan: Okay, babe, let's check them at 02:30.

112:52:22 Schmitt: RCS looks good.

112:52:27 Cernan: 02:30, I'm about 89 degrees...

112:52:28 Schmitt: Cabin looks great...

112:52:30 Cernan: ...coming through 51.5 thousand feet.

112:52:31 Schmitt: 89 is great. We're catching up on our altitude. We should start dropping H-dot here a little bit. AGS and PGNS are together. AGS has us a little bit out of plane. And we're north; (AGS) has us north of track.

[That is, the AGS is showing them north of the planned ground track. Jack will ask the question again in about 2 minutes.]

112:52:52 Fullerton: Challenger, Houston...

112:52:53 Cernan: Okay, Gordo; coming up on 3 minutes, we're Go and...
 112:52:54 Fullerton: ...you're Go at 3.
 112:52:55 Cernan: ...we're out of 49K. (Hearing Fullerton) Roger. Understand we're Go.
 112:53:03 Schmitt: Okay. At 3 minutes. 82's your ball number. We're still looking for (that is, coming down to) the right altitude. So H-dot is high.
 112:53:13 Cernan: Okay. (Pause) The day of reckoning comes at 4 minutes, Jack. (Pause) Got the weight building up, looking good. Attitudes are good.
 112:53:30 Schmitt: Okay, at 03:30, you ought to have 79...
 112:53:33 Cernan: Okay, it's right on.
 112:53:35 Schmitt: We're still a little high, about 2500 feet (high). H-dot is still high. (Long Pause)

[In the last two minutes, the altitude error has decreased from 7000 feet to 2500 feet and has closed, therefore, at a rate of 40 feet per second. At PDI, they were about 30 degrees of longitude east of what would have been the closest approach to the surface (perilune) of their pre-PDI orbit. Being east of the perilune, they were already descending toward the surface at a rate of about 67 fps - a rate which would have slowed in the absence of the burn - and they had planned to maintain that rate of 67 fps for the first seven minutes of the burn. Having started out above the planned trajectory, their total rate of descent has been a bit above 100 fps.]

112:53:50 Cernan: Okay. The tapemeter moves in spurts and jerks, both on altitude and altitude rate (in response to the first radar returns from the surface).
 112:53:56 Schmitt: Yeah.

[Schmitt - "There was a tapemeter display for showing the radar data - altitude and altitude rate (H-dot) - when that became available. Physically, it was a pair of tapes with numbers on them which moved up and down behind a needle."]

[Cernan - "We had so many rate needles that it's a little hard to remember; but we could change them to show a lot of things like attitude and altitude rates. I think we could change this particular tapemeter (which was next to the "8-ball" attitude indicator on Gene's side of the spacecraft) showed either the radar data or the computer's best guess about the altitude and altitude rate."]

112:53:58 Fullerton: Challenger, Houston. You're Go at 4 minutes.
 112:53:59 Schmitt: ED Batts are 37.2 (volts).

[These are batteries that supply electricity to the Explosive Devices which would separate the Ascent Stage from

the Descent Stage in the event of an aborted landing attempt. Jack will check the batteries periodically.]

112:54:02 Fullerton: Roger. ED Batts.
 112:54:04 Schmitt: ED Batts are 3...(Listening) Okay.
 112:54:07 Cernan: Okay, Gordo, yaw's coming at 340.
 112:54:11 Fullerton: Roger.

[See Gene's comment at 112:56:33. This yaw maneuver - a rotation around the thrust axis - is necessary to get proper high-gain antenna pointing for communications with Earth. Prior to ignition, they had the spacecraft yawed left by 70 degrees and are now reducing that to 20 degrees left. Once they get down to an altitude of 30,000 feet, they will go to a zero-yaw, windows-up attitude for the landing.]

112:54:15 Cernan: And the radar lights are out! Beautiful.

[The radar has acquired the lunar surface.]

112:54:19 Fullerton: Okay, sounds great. Both nav systems are Go, ...
 112:54:21 Cernan: You're looking at Delta-H.
 112:54:22 Fullerton: ...right on the line.
 112:54:26 Cernan: Okay. You're looking at Delta-H.

[Schmitt - "This was the difference between the radar altitude and the PGNS calculated altitude"]

112:54:28 Fullerton: And you're Go for a Verb 57.
 112:54:34 Cernan: Okay, Verb 57 is in.

[Schmitt - "Verb 57 allowed the radar data to be incorporated into the computer."]

112:54:38 Schmitt: Hey, Houston, is the AGS (indication that they are) out-of-plane correct?
 112:54:42 Fullerton: Stand by. (Pause)

[Cernan - "We had gone into lunar orbit in the CSM on a path that went from northeast to southwest across the front face of the Moon. That track took the Command Module over the landing site but wasn't exactly the right path for the final approach. So we flew the LM a little south out of the CSM orbital plane so that we could line up with our runway, so to speak, down the axis of the valley."]

112:54:47 Cernan: Okay, coming up on 5 minutes, Jack. Let's take a check at it. About 74 degrees (of pitch).
 112:54:51 Schmitt: That's good. 70 feet per second (descent rate); we're coming down. 36...You're still (garbled, either "two" or "three") thousand feet high;
 112:54:56 Fullerton: Challenger, you're Go at 5 minutes...

112:54:57 Cernan: Okay, Houston; we're now out of thirty...(Stops to listen)
 112:54:58 Fullerton: ...the AGS out of plane looks okay to us. (Pause)

[Fullerton will give them a fuller explanation of the out-of-plane indication at 187:40:10, just prior to launch.]

112:55:04 Cernan: Okay. Go at 5. We're out of 36.5 (thousand feet) now. We've got the Earth right out the front window. (Pause)

[Cernan - "We landed so far east and north that the Earth was in the southwestern sky above the mountains. Every other flight landed where the Earth was essentially overhead; so ours was unique in that, during our descent, we were looking right at the Earth as we were coming down in the valley. As those mountains rose above us, we were looking at the Earth - I mean - right smack in front of us! We didn't have to look up at it; it was right there. Can you imagine coming down, thirty-six thousand feet above the lunar surface and all of a sudden, almost nonchalantly, saying that you've got the Earth right out the front window? And all the other things going on at the same time?"]

112:55:13 Fullerton: Challenger, Houston. Battery 3, On, at your convenience.
 112:55:22 Schmitt: Battery 3 is On.

[They are about fifty miles from the landing site.]

112:55:25 Cernan: 05:30, Gordo. We're Go. We're out of 34K.
 112:55:28 Schmitt: 73 (degrees), 34 (thousand feet). We're right on altitude. The H-dot ought to start dropping off. Except that we want to keep it high.

[Their average descent rate during these 5.5 minutes has been 100 fps, with about 30 fps of the total due to the descent to the planned trajectory. Now, they are on the nominal flight path and Jack's "we want to keep it high" may be a reference either to the fact that the rate will start to increase again once they get down to about 32,000 feet or to the altitude/altitude rate chart he has been consulting. If this is a reference to the chart, he may be saying that they want to stay in the constant rate portion of the graph for a while longer.]

112:55:38 Cernan: (With a slight tone of authority, to Jack) You're allowed two quick looks out the window, one now and one when we pitchover.
 112:55:41 Schmitt: I can't see a thing except the Earth.
 112:55:43 Cernan: That's what I'm telling you to look at.
 112:55:45 Schmitt: (Laughs) Oh! There's the old Earth!

[Cernan - "Jack couldn't spend much time looking out the window. He went through the whole landing and hardly had a chance to see where we were going, because he was looking at fuel and oxidizer gages, looking at battery currents, updating the AGS computer, verifying my entries in the PGNS, and writing things down. So he was very busy inside the cockpit and probably stole a glance or two outside. I had to look outside. Actually, I had to look both places - inside and outside - but my primary focus was out the window and on all of the attitude and rate indicators that surrounded the window. My peripheral scan was forward, out the window, and to the instruments that surrounded it, and occasionally down to the computer when I had to execute a command with it. But poor Jack had to keep his head buried in the cockpit."]

112:55:48 Cernan: Okay, Houston, coming up on 6 minutes.
 112:55:51 Schmitt: (At) six minutes, you ought to have 72 on your ball.
 112:55:56 Fullerton: Challenger, you're Go at 6 (minutes).
 112:55:57 Cernan: 72 is Go.

[They are 40 miles east of the landing site.]

112:55:59 Schmitt: 31 (thousand feet). Altitude's great. H-dot's great. AGS and PGNS are very close, couple feet per second (descent rate) difference.
 112:56:07 Cernan: Okay. (Pause) Okay, Houston. As we went over the hump, DELTA-H just jumped.
 112:56:16 Fullerton: Roger.

[Cernan - "The PGNS was keeping track of our altitude relative to the landing site while the radar, of course, was getting raw data from the terrain below us. Knowing ahead of time that we were going to cross the mountains east of the landing site, we were looking for the altitude difference to change, and it was a comfortable feeling to see it happen."]

112:56:18 Cernan: And looks like it's back down.
 112:56:21 Fullerton: Roger. Sounds good.
 112:56:25 Schmitt: 6:30, Geno.
 112:56:26 Cernan: It looks good, babe.
 112:56:29 Schmitt: 72 (degrees). Altitude is right on. H-dot is very close.
 112:56:33 Cernan: Okay, 30K, Yaw to zero (that is, 'windows-up' for the landing.

[Cernan - "The pitch, roll, and yaw axes were different on the LM than they were on the Command Module; and we had re-defined them for pilot convenience. Pitch was rotation around the left/right axis; roll was rotation around the axis out the front window or the front hatch; and yaw was rotation around the thrust axis. When you were coming down in the

final approach and were pitched straight up, if you looked out the window at a particular point and yawed left, that point would move right in your window."]

112:56:36 Fullerton: Throttle down time (will be) 7 plus 26.

112:56:43 Schmitt: 7 plus 26.

[They have killed all but 1000 fps of their initial 5500 fps orbital velocity and will now descend at reduced thrust, initially 57 percent of full thrust.]

112:56:46 Cernan: Okay, we got everything? We're Yaw at zero. (Pause)

112:56:59 Schmitt: Okay. At 7 minutes, 67's your angle. 26...(Correcting himself) 27; that's great (garbled)...

112:56:59 Fullerton: Challenger, you're Go at 7.

112:57:00 Schmitt: ...H-dot's slightly high, but okay.

112:57:03 Cernan: Okay, Gordo. We're Go at 7, we're now out of 25,000 feet.

112:57:08 Schmitt: We're quite a bit out of the command module plane, but I guess we're on target.

112:57:14 Cernan: Okay, watch the throttle, now. Here it comes. (Pause)

112:57:21 LM Crew: Throttle down

112:57:22 Cernan: (It came at) at (7:)27; computer likes it.

112:57:25 Schmitt: Beautiful.

112:57:26 Fullerton: Roger.

112:57:29 Schmitt: Okay, 07:30, 63 (degrees).

112:57:31 Cernan: Okay, 1:45 to pitchover, Jack.

[That is, one minute forty-five seconds.]

112:57:33 Schmitt: Okay, 63's your angle

112:57:35 Cernan: About 56 now.

112:57:40 Schmitt: Okay, that's getting closer. (Pause)

112:57:42 Schmitt: H-dot and H are great. Standing by for the camera.

[This is the sequence camera, a sixteen-millimeter movie camera mounted in Jack's window which will take about one frame per second during the final approach. As of mid-1993, the film from this final descent was being shown over and over again as part of a LM cabin display at the National Air and Space Museum in Washington, D. C.]

112:57:50 Cernan: 19K, Houston. We're Go coming up on 8 (minutes).

[Ten miles out.]

112:57:55 Schmitt: Okay. The old camera's on, Gordy. Believe it or not.

112:57:58 Fullerton: How about that. You're Go at 8.
Monitor fuel, 2.

[Schmitt - "There were at least two fuel gages and, after watching their telemetry, the ground recommended which one we should use as a better indicator of fuel quantity."]

112:58:03 Schmitt: Fuel 2: (is reading) 27. That's good.

[Cernan - "We used a lot numbers and commands that didn't mean anything to most people. But, when you'd done the training and were using the numbers in context, you didn't need to put dimensions with them. All you said was 'Hey; Fuel 2, 27.' And, at the time, that meant something to us. You knew the systems and you knew what that 27 was supposed to mean and that it wasn't supposed to be 92 or 22. And you knew whether it was supposed to be gallons or pounds or whatever. You just talked in an abbreviated language because you were almost in a world of your own during that time, talking to each other with things happening in rapid sequence. Not a lot of people knew what you were talking about, except for the two of you and the people on the ground."]

112:58:09 Cernan: Come on, baby.

112:58:13 Schmitt: Okay, at 08:30, Geno.

112:58:17 Cernan: Okay, I got the South Massif.

[Gene's altitude is about 16,000 feet and the pitch angle is about 60 degrees. He is seeing the summit of the South Massif out the bottom of his window.]

112:58:19 Schmitt: Okay, update the AGS, Houston? Yes.

112:58:26 Fullerton: That's affirmative; update the AGS.
(Pause)

112:58:35 Cernan: Okay, Gordo, I've got Nansen; I've got Lara; and I've got the Scarp. (Five miles out.) Oh, man, we're level with the top of the Massifs, now.

112:58:45 Fullerton: Roger.

[They are five miles east of the landing site. Nansen is a large depression at the foot of the South Massif; the Scarp is a fault scarp that runs from Nansen northward across the entrance of the valley and up on to the North Massif; and Lara is a crater at the base of the Scarp about midway between the North and South Massifs. At this point, they are at about 12,500 feet altitude, about 5000 feet above the summit of the South Massif.]

[Cernan - "We landed in a valley that had mountains higher than the Grand Canyon is deep. Prior to pitching over, down in the bottom of the windows, the first thing I could pick out was the top of the mountains. And as we pitched up some more, I could begin to identify things in our valley. I had to lean as far forward as I could to look up over the top (of the window sill), but I could see them. And it seemed like we were down below the tops of those

mountains, down into the valley. It really did. Maybe we were still above the tops; but, as far as I was concerned, we were in that valley."]

112:58:47 Schmitt: Okay; (possibly reading the DSKY) 151, (possibly putting the numbers into the DEDA) 1510 entered.

[Schmitt - "This was a number going into the AGS to give it a new altitude reference; and it was taken off the computer which now had the radar update. When the ground agreed that the data was good, then I put it into the AGS for abort purposes. This was something I worked out with the AGS people; I was always trying to find a way to make the AGS better, and this was one of the things."]

112:58:52 Cernan: Okay, Jack,...

112:58:53 Fullerton: Challenger. You're Go at 9 (minutes).

112:58:55 Cernan: ...pitchover is at (nine minutes and) 24 (seconds into the burn); 24 on pitchover. Okay, Gordo, we're out of 11,000 at 9.

112:59:01 Schmitt: Okay, stand by for pitchover.

112:59:04 Cernan: Oh, are we coming in. Oh, baby.

112:59:11 Schmitt: Okay; through 9000.

112:59:12 Cernan: Stand by for pitchover, Jack.

112:59:14 Schmitt: 8000.

112:59:15 Cernan: I'll need the Pro(ceed).

112:59:16 Schmitt: I'll give it to you.

[Schmitt - "By hitting the Proceed button, the computer would start the next program in its repertoire. There was a whole series of programs called P64 and the like, this one being the program for events after pitchover."]

[Cernan - "Pitchover was very critical. I needed to look out the window to make sure the LM didn't pitch over too far; so this was one of the few instances in which we had planned for Jack to enter a command into the computer so that I didn't have to look down. Learning how to work together during the landing sequence was a critical part of our training. You get procedures, you get checklists, but two guys still have to learn how to work together and coordinate their resources effectively. This is a good example of that, and one that was much more critical than the lunar surface work."]

112:59:18 Cernan: Pitchover.

112:59:19 Schmitt: There it is! Proceeded.

[Cernan - "We still wanted to slow ourselves down by firing forward but now we also had to keep ourselves from falling in too fast toward the surface. I don't know how much we pitched over, maybe from about sixty degree to about twenty or thirty degrees (actually from 60 degrees to 20);

but, when we did, all of a sudden, bam, the lunar surface filled up almost the entire window."]

112:59:21 Cernan: And there it is, Houston. There's Camelot (Crater)! Wow! Right on target.

112:59:24 Schmitt: Wow! I see it.

112:59:25 Cernan: We got them all.

[Cernan - "Although there is nothing quite like the real thing, flying the Lunar Landing Training Vehicle (LLTV) had been a step toward realism from 'flying' the stationary simulators. In the LLTV you had your butt strapped to a machine that you had to land safely or you didn't make it. It still wasn't landing on the lunar surface, but it gave you a feel for what the actual landing would be like. Similarly, in simulator training we'd had a TV picture of a model of the landing site that was good enough that, when we pitched over during the actual landing, I felt like I'd seen the landing site before. I won't say that I totally felt like I'd been there before, but I felt like I'd seen that valley before, three dimensionally. So it was a very comfortable feeling to know we were right where we expected to be."]

[Camelot Crater has a diameter of about 600 meters and the planned landing point is about 600 meters east of its eastern rim. Camelot is also the westernmost of a group of large craters that are scattered around the center of the valley and is a very easily recognized landmark.]

112:59:26 Schmitt: 42 degrees, 37 degrees through 5500. 38 degrees...

[Cernan - "In addition to all the fancy gear, all the rate needles and everything, when it came right down to landing, we had etchings on the window in both pitch and yaw. And here, after pitchover, Jack is telling me where on the window the computer thinks we're going to land. The digital autopilot and the computer programs were designed to accept attitude impulses with my hand-controller. I could go 'blip' once and that would tell the computer that I wanted to change the target maybe a half degree or a degree in pitch. In effect, I was saying, 'Computer, I am now smarter than you. You think you know where the target is, but I'm looking at it out the window. I know where it is, and I'm going to tell you.' It was the same sort of thing in yaw, but you have to remember that yaw didn't directly change the flight direction because yaw is a rotation around the thrust axis. If I rolled to the left, I was going to put the engine to the right and drive myself to the left. If I pitch up, I'm going to put the engine more forward and I'm going to slow myself down and start to come down faster. But I could have yawed through 360 degrees and never effected my trajectory. So if I blipped the hand-controller in yaw, what it really said to the computer was that I wanted to land a little left and that it had to do a little roll to get over there."]

112:59:32 Fullerton: Challenger, you're Go for landing.
 112:59:34 Schmitt: ...5000 feet; 42 degrees through 4000; 47
 now; 47 degrees through 3500; 49 degrees. (Pause) 3000
 feet; 53 degrees.

[Cernan - "The fact that the target numbers are increasing doesn't necessarily mean that we were pitching up very much, only that we were getting closer to the target and, therefore, that it was getting higher in the window. I didn't respond to these because I was looking out the window and, if I needed to move, I just moved the hand-controller.]

112:59:54 Cernan: Okay, I've got Barjea; I've got Poppie; I've got the Triangle.

[The Triangle is trio of small, well-separated craters - Frosty, Rudolph, and Punk - west and north of the landing site. The Triangle is distinct from a merged-crater triad called Trident, south of the target point.]

[Cernan - "Poppie was my daughter Tracy's name for my father (Andrew 'Andy' Cernan). He never lived to see me land on the Moon and I named the crater for him. And Punk is what I used to call Tracy. I still do, even though she's twenty-six years old (January 1990)."]

[Readers will note that "Poppie" is mis-spelled as "Poppy" throuout the Apollo literature, including the maps that are reproduced in this Journal.]

112:59:59 Schmitt: At 2500 feet, 52 degrees. H-dot is good. At 2000, H-dot is good. Fuel is good. 1500 feet, 54 degrees, Gene. Approaching a thousand (1000). Approaching a thousand feet; 57 degrees. Okay, you're through a thousand, and I'm taking...Radar altitude and PGNS altitudes agree. You're through 800 feet. H-dot's a little high.
 00 31 Cernan: Okay; I don't need the (angle) numbers any more.

[Cernan - "The angles were useful from pitchover until we got down to a thousand or two thousand feet, and then you were flying by the seat of your pants to some degree. Besides, now I was looking at where we wanted to land, and was just putting it there. So I didn't need the degree numbers, just the altitude and descent rate."]

113:00:32 Schmitt: Okay, you're 31 feet per second, going down through 500. 25 feet per second through 400. That's a little high, Geno.

[Schmitt - "A lot high!"]

[The nominal descent rate at 500 feet is 17 fps.]

[Cernan - "I had it under control; I knew what the response was and how quickly we could slow down. It was comfortable and it saved fuel. In the Navy, we land aboard

carriers at 15 feet per second and I knew what that was; and I'd flown the LM simulator so many times that I knew what 15 feet per second at 100 feet was like and knew that I could slow it down to 5 feet per second awfully quickly."]

113:00:40 Cernan: Okay.

113:00:42 Schmitt: 300 feet, 15 feet per second. A little high. H-dot's a little high.

[The nominal descent rate at 300 feet is 9 fps.]

113:00:51 Cernan: Okay. I've got P66.

[Up to this point, Gene has been using the hand controller to tell the computer to move the designated landing point forward or back, left or right. In P66 he takes manual control of the spacecraft and uses the hand controller to change its attitude in pitch and roll. In short, he is now flying the LM with virtually no assistance from the computer.]

113:00:55 Schmitt: Okay; 9 feet per second down at 200. Going down at 5. Going down at 5. Going down at 10 (fps); cut the H-dot. The fuel's good. 110 feet. Stand by for some dust. Little forward, Gene.

[Here, Jack is confirming that Gene has a little forward velocity so that he'll land on ground he's just seen.]

[Cernan - "The tendency for most people flying the LM was to get a false impression of thinking that you were coming down straight. But, because of where the window was located, you would actually be drifting backwards. So I forced myself to land with about a foot or a foot-and-a-half forward velocity. And then, if I fell into the trap of feeling that I was going forward when I was really going vertical, it would be okay."]

113:01:14 Cernan: (Garbled under Jack)

113:01:15 Schmitt: Moving forward a little. 90 feet. Little forward velocity. 80 feet; going down at 3. Getting a little dust. We're at 60 feet; going down about 2. Very little dust. Very little dust, 40 feet, going down at 3.

[Gene wants about 5 feet per second down for the final phase; 2 feet per second would burn too much fuel and oxidizer. they will land with about 1225 pounds of fuel remaining, enough for about 117 seconds of hovering. For comparison, Neil Armstrong landed with only 50 seconds of fuel/oxidizer remaining, primarily because at pitchover he discovered he was coming down into West Crater and had to take over manual control quite early and fly beyond to a good landing spot. This was the only flight on which less than 100 seconds of fuel/oxidizer remained at touchdown.]

113:01:42 Cernan: Stand by for touchdown.
 113:01:43 Schmitt: Stand by. 25 feet, down at 2. Fuel's good. 20 feet. Going down at 2. 10 feet. 10 feet.
 113:01:58 Schmitt: Contact. (Pause)
 113:02:03 Schmitt: (Reading a checklist) Stop, push. Engine stop; Engine Arm; Proceed; Command Override, Off; Mode Control, Att(itude) Hold; PGNS, Auto.
 113:02:11 Cernan: Okay, Houston. The Challenger has landed!
 113:02:15 Fullerton: Roger, Challenger. That's super.
 113:02:17 Schmitt: Okay, Parker valves...

[Schmitt - "Parker valves controlled the RCS thrusters - the fuel and oxidizer - and there was always some concern that they might close at landing, just because of the little bit of shock. So the procedure was to go through and cycle (close and open) every one of them. There were, I don't know, sixteen of them on the wall in front of me and, while Gene was getting all excited, I was cycling switches."]

113:02:23 Cernan: (Responding to Fullerton) Boy, you bet it is, Gordo. (To Jack) Boy, when you said shut down, I shut down and we dropped, didn't we?
 113:02:28 Schmitt: Yes, sir! But we is here.
 113:02:30 Cernan: Man, is we here.

[Cernan - "In thinking about why we worked so well together, the most important point was that we had confidence in each other. Jack is a very astute and dedicated individual, very talented, and I felt very comfortable with him. He was not an aviator and he'll be the first to tell you that. But he took his responsibilities very seriously, learned quickly, and, in terms of technical understanding, was as good as anybody. He wasn't a passenger; he had learned how to be a good co-pilot. In much the same way, I wasn't a geologist, I wasn't a scientist; but I had learned to be a good observer. As soon as we hit the lunar surface, although I was still commander of the crew, Jack was the expert and I was his assistant. We had very different backgrounds. I was the professional aviator and Jack was the scientist; but we both knew enough about all aspects of the missions that we could be confident about working together.

"For the landing and lift-off phases, we were both dedicated to knowing all the intricacies of the spacecraft, all the details of the hardware and the software. Our responsibilities were different; but the fact that I knew all the systems on his side and he knew all the systems on my side was important. I'm the kind of guy who, although I knew I could depend on Jack, wanted to understand everything about the spacecraft. I was fortunate because I'd sat in the right (LMP) seat on Apollo 10, so I knew the AGS (Abort Guidance System). I knew what it could do and, when Jack would talk to me about the AGS or how we were going to use it, I understood because I had been there. And Jack took it upon

himself to be very familiar with the operation of the primary guidance computer (PGNS) and the other systems on my side of the spacecraft. But I know there were crews - and I won't name them - where one or the other of the guys was extremely weak in one or more of the systems. Crews where, if the guy in the right seat told the guy in the left seat something was right or wrong, the guy in the left seat just accepted it because he didn't know any different. And he didn't know enough to ask any questions. If the guy in the left seat is just going to depend on someone to throw him a number and not know what the number means or where it came from, and can't challenge it, can't know whether it's right or wrong, then he's not doing his job. With me, if it was ten degrees off, I would know it. And I'd say 'Jack, check your AGS; that's not right.' But if the guy in the left seat had no idea what the AGS was supposed to do, he might just blankly accept that number and go about his business and might or might not get in trouble as a result of it. Even a computer isn't right all the time, and certainly people are prone to mistakes; but if two guys both know a system you're least likely to make a mistake. Mutual respect and teamwork evolves from that.

"Landing on the Moon was a unique opportunity for us both; we didn't want to let it slip through our hands. We spent the time that it took: not just a few extra hours in the simulator, but all the time it took to really understand our spacecraft. Jack spent a lot of time with the people on the ground - more than I did. He got to know them and understand them. He'd go to them with questions like, 'How can you guys help me get my AGS smarter than it normally would be.' And, because he'd spent time working with them, they said 'Hey, we can work something. We'll put it into the checklist that we'll send you an update here and you do that there.' And those kind of things paid off in the form of a level of coordination and teamwork between us and the people the ground that was as good as on any mission.

"By the same token, I had a lot of personal pride that, if we had lost three quarters of our automatic systems, I still could have landed the vehicle safely. Same thing for leaving the lunar surface. True, you have to believe that you can do it; you would have no other choice. But I knew that if we lost all of our guidance computers, I could have flown that LM into lunar orbit for a rendezvous with Ron Evans. Manually. And by 'manually', I mean (visually guiding) with the stars, with the horizon of the Moon. I'd done it enough in the simulators that I knew what my remaining systems were going to tell me; and I had confidence that Jack was going to give me whatever information I need from him. You never know (if you're right about something like that), but I'm confident that we could have done it. And I felt the same way about the Saturn V launch from Earth. Ours was the first nighttime launch, and there were a lot of things we had to consider in terms of guidance control failures. The launches - both from the Earth and from the Moon - were the only truly automatic phases of the mission,

but we could take over and fly it manually to orbit. Aborting during Earth launch was the last thing I wanted to do, so I trained and planned. It was a lot more difficult at night than in the daytime because you didn't have horizons and things to look at; you had to look at the stars. We had several modes of failure that could have degraded systems. The worst would have been for all the guidance to fail so that you literally had to fly it by the stars. Now, I can never prove that I could have done it. But I did it a lot of times in simulators and really did - and still do - believe that I could have flown that Saturn V to orbit. It's one of those things were you say 'I hope it never happens; but I dare you. I'll show you. If you do fail, you just watch.' You had to have that attitude; and I think that attitude is reflected across the cockpit. You develop confidence in each other, and, from that, the teamwork evolves."]

[For the next several minutes, Gene and Jack will monitor the health of their spacecraft and prepare it for an immediate launch, should one prove necessary.]

113:02:31 Cernan: How does that look? That looks good.
 113:02:35 Schmitt: Pressures look great. Tank 2 is down just a little from before.
 113:02:39 Cernan: Okay, Engine Override is Off (garbled)...
 113:02:40 Schmitt: Manifold (pressure) is great. Manifold is right on. Go to Jets.
 113:02:44 Cernan: Okay. I am Jets.
 113:02:46 Schmitt: Okay. That side's complete.

[They have probably completed one side of a cue card.]

113:02:48 Cernan: Houston, you can tell America (that is, Ron Evans) that Challenger is at Taurus-Littrow.
 113:02:53 Fullerton: We'll do it.
 113:02:56 Evans: Hey, Challenger; this is America. I heard you all the way down. That's great!. Beautiful.
 113:03:00 Cernan: (To Evans) Ron, I had the meatball all the way.
 113:03:02 Evans: Beautiful!

[Cernan - "When you land on a carrier, you've got a mirror and you've got an orange light that reflects in the mirror. On the carrier you've got a row of green lights that also reflect in that mirror and if the meatball - the orange light - is below the green lights, then you are low, below the glide slope; and if the meatball's above the green lights, you are high. So what you do is fly your carrier approach so that the meatball is right in line with the green lights. So I was telling Ron that I had it 'locked' all the way in."]

113:03:02 Cernan: Jack, are we going to have some nice boulders in this area.

113:03:08 Schmitt: Okay. The old (16 mm sequence) camera's off,

113:03:10 Cernan: Okay.

113:03:13 Schmitt: Landing Radar (circuit) breaker, Open. Checking the water (tank). And, Gordy, ascent tank 1...We started out a little low (but) it's still...same place. That's water.

113:03:27 Fullerton: Roger, Jack

113:03:28 Schmitt: Batteries look good. (Pause) (Very excited) Oh, man!! Look at that rock out there! (Pause)

[Jack is probably looking at a 3-meter-high basalt bolder about 200 meters west of the spacecraft. It will come to be known as Geophone Rock and is just to the left of the LM shadow.]

113:03:40 Cernan: Absolutely incredible. Absolutely incredible.

113:03:45 Schmitt: I think I can see the rim of Camelot.

113:03:47 Fullerton: Roger.

113:03:48 Cernan: Epic moment of my life.

[During the landing, Gene's heart rate reached a peak of 128 beats per minute. The details are shown in an accompanying graph. For comparison, Neil Armstrong's peak rate was 150 - due mostly to the stress of having to avoid West Crater - while the rates for the other three Commanders for whom we have data were 110 for Alan Shepard (Apollo 14), 105 for John Young (Apollo 16), and 97 for Dave Scott (Apollo 15).]

113:03:49 Schmitt: Where'd you land? (Joking) You never let me look outside at all. Hey, you can see the boulder tracks (on the North Massif)!

[During the 3.9 billion of years since the Massifs were raised, boulders have been dislodged occasionally from outcroppings high on the mountains. As they tumble down toward the valley floor, the boulders carve grooves where they rolled or slid, and cut strings of craters where they bounced. The resulting tracks erode slowly because of countless small impacts and the downslope movement of soil.]

113:03:58 Cernan: Okay, Gordy. We're standing by for your Go. We look good. We're looking good onboard.

[In this case, "Go" is permission to stay.]

113:04:02 Fullerton: Okay. You're looking great here so far.

113:04:05 Schmitt: There are boulders all over those massifs.

113:04:09 Cernan: God, look at that propellant. We could have gone all around and looked around.

[As mentioned previously, at touchdown they had fuel enough left for about 177 seconds of hovering.]

113:04:12 Schmitt: We should have hovered around a little bit; gone and looked at the Scarp.

113:04:14 Cernan: No, thank you. (Jack laughs) I like it right where we are.

[Cernan - "From about a thousand feet down, the planned landing site looked good. So I was just concerned about spacecraft attitude and spacecraft motion during the final approach. I was not concerned about the terrain we were landing on. It was real nice to be down with lots of propellant left but, while it would have been fun to fly around the valley a little and then land, the important thing was to get the spacecraft down safely. It would have been like flying through a thunderstorm and making a safe landing, and having somebody say, 'Hey, we could have gotten more instrument time in that thunderstorm. And you say 'No, thank you.'"]

113:04:17 Cernan: Okay, Gordy. While you're waiting on that Go, I shot for a spot, around 2 o'clock from Poppie. There's a number of boulders out at 12 o'clock from Poppie, and I really think I'm probably not more than about 100 meters out in front of it, and slightly to the north. Actually, I may be a little bit closer to Trident than I expected Poppie to be. I think I've got Trident right out the left window. And our first cut at the mobility around here in the Rover (is that) it ought to be super.

[Here, Gene is using clock positions, centered on Poppie, with 12 o'clock being west. As Gene remarks at 113:05:13 and 114:30:17, he knew where he was relative to Poppie and other landmarks until he was down to an altitude of about 500 feet. At that point he had to concentrate on a level place to land and lost track of the landmarks. Because Evans took a high resolution photograph showing the LM on the surface (Pan Camera frame AS17-2309), we know that Gene landed about 100 meters north and perhaps 20 meters west of the center of Poppie. The planned landing point is about 230 meters west and about 60 meters south of the actual landing site and not far from Geophone Rock. The crater that Gene thinks is the westernmost part of Trident is actually Poppie.]

113:04:53 Fullerton: Okay. Sounds good. (Pause)

113:04:59 Cernan: But I tell you, the Massifs and Bear Mountain are two different products. (Pause)

113:05:08 Schmitt: Sure look it, don't they? (Pause) Of course, they're different slopes, too.

[Unlike either of the Massifs, Bear Mountain has a distinctly wrinkled, hummocky appearance. Jack is reminding Gene that the apparent difference may, in part, be due to lighting effects.]

113:05:13 Cernan: I think you're looking, probably...That may be Rudolph, right there, Jack, out your window.

[Again, Gene is mistaken. Rudolph is actually about 200 meters west and 150 meters north of the LM. The crater visible out Jack's window is unnamed.]

113:05:19 Cernan: I was looking more at those boulders and trying to stay in the spots in between them than I was...

113:05:23 Schmitt: Yeah, you did great, Gene.

113:05:25 Cernan: ...relationship to that crater.

113:05:26 Schmitt: Man, there was practically no dust, just a little bit of a film. You had the ground all the way to the ground.

113:05:31 Cernan: Yeah. I could call touchdown on the shadow. Look at that. (Pause) Really here. (Jack laughs)

[Once they start to deploy the ALSEP (Apollo Lunar Surface Experiment Package), Gene and Jack will have another discussion about the superb visibility they had during the final phase of the landing. The experiences of other crews are summarized at that point in the transcript commentary - 121:04:23.]

113:05:46 Cernan: Okay, Gordy. We're hanging in for your Go.

[Cernan - "The ground wasn't about to commit to a three-day stay when we'd only been there ten minutes. They wanted a chance to look at all the spacecraft systems. This initial post-landing phase was the critical one. Did you bust a tank? Was there any helium or fuel leaking? How was the battery power holding up? During these first few minutes, we were ready to launch immediately. They were taking a quick look and, if things looked okay, they would then let us go ahead and reconfigure the computers and the navigation system for a non-emergency liftoff. Then, after a half hour or so, if everything still looked okay, they would let us power down completely."]

113:05:48 Schmitt: (Relishing the thought of doing geology at this magnificent site) It better be a Go!

113:05:49 Cernan: Check everything again. Let's just double check.

113:05:52 Schmitt: Okay.

113:05:53 Schmitt: That hasn't changed.

113:05:54 Cernan: Okay, that's good.

113:05:55 Schmitt: The manifold (pressure) hasn't changed. The RCS hasn't changed. Ascent water hasn't changed. The batteries haven't changed.
 113:06:05 Cernan: Oh, my golly!
 113:06:07 Schmitt: Only we have changed.
 113:06:10 Cernan: You know, you can't see into Camelot, Jack; that rim is Camelot out in front of us.
 113:06:14 Schmitt: Yeah.
 113:06:15 Cernan: You (garbled under Fullerton)...
 113:06:16 Fullerton: Challenger, you'll be glad to hear you're Stay for T-1.
 113:06:21 Cernan: Gordy, you're a smooth talker, you know it? We are Stay for T-1. (Pause) (To Jack) Okay. You can forget all I told you about Verb 22 Noun 46.

[T-1 is a pre-programmed opportunity to launch and catch up with the CSM on this orbit. If, during these first minutes, Houston had decided that something was wrong with the spacecraft they would have told the crew to launch at T-1 or even sooner. With the Stay, they will now prepare for T-2, the next pre-programmed launch opportunity.]

113:06:31 Schmitt: (Either hearing some comm between Houston and Evans or joking that he's already forgotten Verb 22 Noun 46) What was that? (Jack laughs)
 113:06:37 Cernan: Okay. Let's find out where we are (in the checklist). Engine stop is reset.
 113:06:43 Schmitt: Okay, the AGS is ready for us if we need it.
 113:06:44 Cernan: Okay. I need a P12 time as soon as I get (P) 60...
 113:06:46 Schmitt: Okay. (Long Pause)
 113:07:02 Cernan: Okay, Gordy. You're looking at Noun 43. Copy that down, Jack, right here.
 113:07:09 Fullerton: Okay. We've got it.
 113:07:11 Cernan: 20:21 and 30:75, and I'm going to P12. (Pause) Okay. I need a P12 time from you. (Pause)
 113:07:28 Schmitt: Okay.
 113:07:29 Cernan: For T-2.
 113:07:31 Schmitt: For T-2, the time is 113...
 113:07:35 Cernan: Okay.
 113:07:36 Schmitt: 14.
 113:07:37 Cernan: 14.
 113:07:38 Schmitt: 2491.
 113:07:42 Cernan: 2491.
 113:07:43 Schmitt: Yes, sir. (Pause)

[Schmitt - "Here we were giving the computer information it would need for T-2. Just prior to descent, Houston had used their best information on the CSM orbit and had read us these times to copy onto a pad for use if we needed them. If we had to get off and get up into orbit at some time other than one of these pre-programmed times, we could have

launched into a low orbit so that we would have gradually caught up with him."]

113:07:46 Cernan: I can't feel any difference between 1/6g and anything else right now.

113:07:48 Schmitt: (Laughing) Well, you still got your restraints on.

[For the landing, they have been wearing restraining cables attached at the waist and to the floor on either side of them. The restraints keep them from being thrown around during the maneuvers.]

113:07:50 Cernan: Okay. 113:14:24.91. You happy with that?

113:07:53 Schmitt: That looks good, sir.

113:07:54 Cernan: Okay. (Pause) I got to change these numbers. (Pause) You didn't get an update on Noun 76, did you? (Pause) I don't think so.

113:08:09 Schmitt: No. No.

113:08:11 Cernan: Okay. No. (Pause) Okay; 5515. Hello, Gordy. How would you like me to handle R-3 of Noun 76?

[R-3 is computer register number three; Noun 76 is probably a data word.]

113:08:26 Fullerton: Stand by. I'll come back to you.

113:08:30 Cernan: Okay. (Pause) Oh, that radar performed super.

113:08:40 Schmitt: How was the view on the way down, Gene?

[Jack laughs because he had his head in the cabin throughout the landing.]

113:08:42 Cernan: You know, after we pitched over, I was just looking for a place to land, (so) I'm not sure. I just didn't want to hit one of those boulders out there which would have been as easy...And look at that. Look at right in front of us. I didn't want to land there either.

113:08:55 Schmitt: I see that one right in front of us.

113:08:56 Cernan: You see that? Now that's a hole.

113:08:57 Schmitt: Oh, the hole. I can't see the hole...

[Possibly a shallow, unnamed crater about 30 meters west and slightly south of the LM. From their position close to the surface, Gene and Jack can't see shadows cast by most rocks or crater rims in the direction opposite the Sun because the shadows are hidden by the objects casting them. This phenomenon, coupled with the general lack of color and contrast, makes it difficult to see much detail in the down-Sun direction. Because they've landed early in the local morning, down-Sun is currently almost due west, but will shift slightly north as the Sun rises about 12 degrees per day.]

113:08:58 Fullerton: Challenger, Houston. R-3, cross range, is okay as is.
 113:09:05 Cernan: Okay.
 113:09:09 Schmitt: Okay. We're coming up - -
 113:09:11 Cernan: We're in posture for a T-2, Gordy.
 113:09:15 Fullerton: Roger.
 113:09:18 Schmitt: Okay. I can see the Scarp. I can see Hanover. Good thing we didn't plan to go to Hanover.
 (Laughs) It's steep.

[Hanover is a sharp, fresh crater on the southwest flank of the North Massif, just east of the trace of the Scarp on the mountain side. Gene and Jack discuss it again during the EVA 2 drives to and from Nansen Crater at the foot of the South Massif. During early phases of mission planning, one of the traverses under discussion would have taken them along the flank of the North Massif to Hanover. Apollo 17 photo AS17-138-21118 is an excellent picture of Hanover, the Scarp, and the North Massif taken during the drive northward from Nansen at about 144:09.]

[Schmitt - "Hanover was simply too far away for us to have reached; and it had generally been decided that we weren't going to learn much about the Scarp in that area because of the North Massif debris that would have flowed onto it. What we really wanted was a place that would let us collect materials that would be different from what we had landed on, and that's why we went to Nansen."]

113:09:29 Cernan: Look at the boulder, halfway up the hill.
 113:09:31 Schmitt: Yeah.
 113:09:32 Cernan: Not halfway, just enough - -
 113:09:33 Schmitt: Yeah, the boulder tracks; they're beautiful.
 113:09:35 Cernan: It's sitting right there in the end of the track.
 113:09:37 Schmitt: There are tracks all over that hillside.
 113:09:39 Cernan: There's a boulder came right down to the surface there. See it?
 113:09:41 Schmitt: Yeah.

[Gene is pointing out a boulder that apparently has rolled all the way down to the valley floor.]

113:09:42 Cernan: That one (a boulder track) went right through that little crater...
 113:09:43 Schmitt: Yeah.
 113:09:44 Cernan: ...(and it's) sitting right there for us to sample. Look at it.
 113:09:47 Schmitt: Yes, sir.

[Cernan - "Although Jack's view was basically from a little south of west up to the north and mine was from a little north of west down to the south, I could get to the

left corner of my window and look out at least to the northwest and he could do the same to the southwest. And, although it was hard to do until we unstrapped, we could look out each other's windows, too."]

113:09:50 Cernan: I'll bet Bear Mountain and the Sculptured Hills are the same.

[The Sculptured Hills are behind them, out of sight, to the northeast. Gene is suggesting that they will also have a wrinkled, hummocky appearance, which they do in the early morning light.]

113:09:53 Schmitt: Yeah. Well, the slope's different. We'll have to look at it from outside. You may be right.

113:09:57 Cernan: Now I see why they call them "sculptured". My god, they're so hummocky that there's shadow all over them.

113:10:03 Schmitt: Yeah.

[They are passing time, waiting for T-2 and permission to get busy.]

113:10:05 Cernan: God, there are some holes and rocks around here. Who told me this was a flat landing site?

113:10:10 Schmitt: It is flat! For crying out loud. What do you want? An airtight guarantee?

113:10:14 Cernan: Let's see, we got about 2 degrees left (roll) and about 5 degrees pitchup.

113:10:19 Schmitt: We're about what? About 100 meters from Trident?

113:10:25 Cernan: Yeah, less than that. I think Trident's right here.

[Again, Gene is looking at Poppie. Jack's distance estimate is superb.]

113:10:27 Schmitt: Our shadow's about 100 feet (long), Geno, I think.

[That is, the LM shadow.]

113:10:30 Cernan: Yeah, we're only about...Yeah, less than 100 meters then.

113:10:34 Schmitt: It doesn't look that long, but it is...

113:10:36 Cernan: God, there are some holes I'm glad I didn't land in around here, I'll tell you. (Pause) Now, if you look at the (South) Massif, Jack. I don't know if you can see it over here. You see...They're almost like a series of linear boulder tracks, but they come crossways down the slope. So it looks like there may very definitely be some jointed...There's outcrop on top the Massif, too.

113:11:02 Schmitt: Oh, it sure looks like it: grey outcrop. It's a bluish grey compared to the brown- or tan-grey of the massif side.

113:11:13 Cernan: And a lot of that outcrop down on the bottom is boulder.

113:11:15 Schmitt: Yeah.

113:11:16 Cernan: Do you know what that reminds me of, way up on top...that outcrop? It reminds me of Sunset (Crater, a volcanic cinder cone near Flagstaff, Arizona) where you could just get a little piece of outcrop around the cone.

[Gene is probably referring to outcrops of basalt splatter on the Sunset cinder cone.]

113:11:23 Schmitt: That's right.

[Schmitt - "We had done one of our field tests near Sunset Crater, partly because it was volcanic terrain."]

[Cernan - "We didn't use a Rover at Sunset, but we had something that allowed us to be mobile. We did a 'typical' lunar traverse that sort of simulated, out in the field, the kind of traverse we would run through on the Moon. It was all pre-planned, of course; so we had an EVA 1, 2, and 3 where we were to do different things. At stop 1 on EVA 1 we were going to do this, take a sample of the soil, and then do that. Now, that doesn't mean that we were doing an exact replica of our traverse was on the Moon. We did some simulated traverses at the Cape, driving around in our suits to three or four little stations doing the mechanics of the stops, but not doing anything that could be called geology. Flagstaff put us in a far more realistic geologic environment; we could take samples and, even though the samples would be grossly different than we might find on the Moon, we'd run into things we hadn't expected to see and find extra tasks that needed to be done. The stations always took longer than what we'd planned and, in that respect, it was very good training."]

113:11:25 Cernan: Okay. Let's see what we're doing. We got 3 minutes for T-2. Let's take another check.

113:11:30 Schmitt: Okay. I just looked at them.

113:11:32 Cernan: Okay. Ascent (stage) looks good.

(Pause) Gordy, I noticed something ever since we've landed. The oxidizer quantity went from 7 or 8, and now it's down to 2, and the fuel has stayed constant.

113:11:49 Fullerton: Roger.

113:11:50 Cernan: And the Quantity Light came on somewhere, I believe, after we landed.

113:11:55 Schmitt: Yeah, it did. (Pause) I noticed the Quantity Light also. I was thinking "reg light", though, when I saw it.

[Cernan - "During the landing, there were a lot of things going on, but we knew right away that the quantity light was not something which was particularly urgent. We knew how much fuel we started with, we knew how much we'd been burning, and we knew the ground hadn't seen any changes.

Theoretically, by the numbers, we probably should have aborted. But you don't just do things; you don't overreact. It's a good example of what I meant when I was talking about Jack and I working well as a team, about understanding more than the superficial information, about understanding each other, and about understanding where the information was coming from. When Jack gave me numbers, I knew he was not just reading numbers. I knew that he knew where the numbers came from. And the same thing applies to the quantity indicator. I won't say that we ignored it, but there just wasn't anything else at that time to tell us it was important. We both noticed it, I called the ground's attention to it, and that was all."]

113:12:06 Cernan: Oh, man!

113:12:09 Fullerton: Challenger, we'll have a story on that (quantity light) for you later. We don't think we were really low level.

113:12:18 Cernan: Okay. It doesn't make any difference now, Gordy; except to talk about when we get home.

113:12:24 Fullerton: Roger.

[If there really had been a problem other than just an erroneous warning light, it was a problem in the descent stage and, therefore, is no longer of any practical concern to the rest of the mission.]

113:12:27 Cernan: And we're 2 minutes and counting to T-2.

113:12:30 Fullerton: Roger.

113:12:32 Schmitt: We better hurry if they're going to give us the Go. (Long Pause) How about some water?

113:13:02 Cernan: Yeah, you can zap me. (Pause)

[Cernan - "We could put the water gun through a little self-sealing hole in our helmets. It was like a little hatch at the cheek. You had to turn your head to get a drink; and I think Jack probably just took the water gun off the hook (behind him) and gave himself and then me a little squirt of water. This was the first chance we'd had to have anything to drink at all in the whole thing."]

113:13:10 Cernan: Oh, I tell you. That's something everyone's got to do once in their life.

[That is, land on the Moon.]

113:13:14 Schmitt: We're not going to have much time for T-2...

113:13:18 Fullerton: Challenger, Houston. You're Stay for T-2, and Go for the DPS Descent Propulsion System vent.

113:13:24 LM Crew: Okay.

[Schmitt - "What we were about to do here was depressurize the descent stage tanks by venting the helium.

You didn't want to actually empty the tanks and vent hydrazine and nitrous oxide onto the surface and contaminate the area. And you also didn't want the tanks to heat up and pressurize and possibly rupture during the three-day stay. So you depressurized them."]

113:13:25 Cernan: Okay. Understand. Stay for T-2, and Go for the DPS (pronounced "dips") vent. Let me get out of...Okay, we can't hack that. I'm going to get out of P12.
 113:13:34 Schmitt: Excuse me, Gene. (Pause)
 113:13:46 Cernan: Okay. You can unzip that water, if you'd like. And let's go off VOX. Let's go on PTT.

[Comm Break. VOX is the voice-actuated mode of communications. PTT or "Push-to-Talk" is the alternative. In the PTT mode, astronauts can only talk to Houston by manually activating the microphones that were part of the "Snoopy" helmets that they each wore.]

[Schmitt - "The key for your the microphone was a big blue knob on a cable at your side, so that if you leaned forward you might hit it and unintentionally let the ground listen in."]

[There is also a trigger-type key on the hand controllers.]

113:14:41 Schmitt: Okay. Regulator 1 is Closed, Houston; Oxidizer (and) Fuel Vents coming Open.
 113:14:43 Fullerton: Roger.
 113:14:44 Schmitt: Master Arm, On. Master Arm's coming On.
 113:14:49 Cernan: Okay, Gordo. I got two good lights.
 113:14:51 Fullerton: Roger.
 113:14:52 Schmitt: Descent Vent, Fire. (Pause)

[Schmitt - "The vents were opened with a little pyrotechnic device called the Apollo Standard Initiator."]

113:14:59 Cernan: Okay. Mark it. We did not hear anything on that one, Gordy.

[There was no audible bang when it fired.]

113:15:04 Fullerton: Roger. (Pause)
 113:15:11 Schmitt: Pressure's coming down, though. Pressure's coming down. (Pause)

[Gene's half of the following conversation is not audible; only Jack is on VOX, a conscious choice so that Houston can follow along. They are configuring the cabin for unsuited stay, and will take their helmets off fairly soon. Most terms in the following paragraphs will be defined during preparations for the EVA.]

113:15:20 Schmitt: (Reading from the checklist as they reconfigure the LM) Okay. Master Arm, Off. Okay. We'll

monitor oxidizer pressure until 20 to 40 (psi), and then Ox Vent, Closed; fuel pressure to less than 8 (psi). Fuel Vent. (Pause) Descent Quantity light - correcting himself) Reg light. Excuse me. (Pause) Okay. Mode Control, two to Att Hold. Well, we just keep going, I guess. (Pause) Yeah. Hey, we can press on. (Pause) Okay. (Pause) Okay. Now wait a minute. Here we go. Let's get that. Go up here first. (Pause) Because I haven't selected it. (Pause) 113:16:03 Schmitt: (Gene is now reading from the checklist as Jack sets controls on his side of the spacecraft) Okay. ECA Control is Closed. (Pause) (Battery) 3 is back on. Battery 5 is Off/Reset, and it's off the line. Battery 6, Off/Reset, and it's off the line. (Pause) Inverter number 2 breaker is In. Inverter 2. Let me check the voltage. Voltage is great. (Pause) Okay. Keep going. (Pause) Descent Engine Override's Open. (Pause) Ascent ECA Control's Open. (Pause) CWEA (Caution and Warning Electronics Assembly, pronounced "seewee") cycling, cycled; both lights are out. Okay. Cabin pressure is good. Okay. 113:17:04 Schmitt: And then, (Pressure Regulators) A and B going to Cabin. (Pause) A is to Cabin. B is to Cabin. Pull-Egress. (Pause) (Cabin Gas Return valve) Return is Egress. (Pause) (Cabin) Repress (valve) going to Auto. (Pause) Stand by for a noise. There you go. It's in Auto. Okay. Now it's your turn. Verify...(Pause) Wonder where it's going? (Laughs) Out, I guess. (Pause)

[Schmitt - "When you go to Repress, Auto, you get a little bit of gas flow across the valve; maybe we saw something that it ejected. Or maybe I was just wondering where the gas was going."]

[Details of the LM Environmental Control System (ECS) are discussed in the Introduction. For present purposes, we note that, during the descent, Gene and Jack wore their suits, gloves, and helmets - albeit with the suits unpressurized so that they didn't have to move their arms and fingers against the stiffness of any internal suit pressure. By setting the redundant oxygen demand regulators (A & B) to the Cabin position, they are telling the ECS to supply enough oxygen to maintain the cabin pressure at 4.8 psi. By setting the Suit Gas Diverter Valve to Egress, they are preventing any interchange of gas between the cabin and the suit circuit. However, in just a few seconds Gene and Jack will remove their helmets and gloves, resulting in gas flow through the neckrings and at the wrists. By setting the Cabin Repressurization Valve to Auto, they are preparing the ECS for an emergency cabin repressurization in the unlikely event that one should become necessary.]

113:17:51 Schmitt: Inverter 2 is selected. (Pause) Okay. And DECA Power, Open. (Pause) And guess what? Take your helmet and gloves off.

[Comm Break]

113:18:59 Cernan: Okay, Gordy. We're on page 1-1 (of the Lunar Surface Checklist). Helmets and gloves are off. Diverter Valves are IV (Intravehicular).

113:19:09 Fullerton: Okay. We're right with you.

(Pause)

113:19:16 Cernan: And you're looking at Noun 20. (Long Pause)

[Gene about to take star sightings to verify the alignment of the inertial guidance platform. The Alignment Optical Telescope is mounted on the wall between them, at about Gene's eye level. Noun 20 may be information about the current platform alignment.]

113:19:58 Schmitt: Window shades are going close. I'm using it instead of a light switch because I've got it covered up. (Long Pause)

[Jack is probably adjusting the window shade to let in a little light for his own activities while keeping the cabin dark enough for Gene to do the star sightings. Jack seems to be saying that he can't get to the light switch, probably because it is covered by his helmet and/or gloves.]

[Schmitt - "We couldn't see the stars out the window or when we were out on the surface. It took the collimation of the telescope to eliminate all of the reflected light reaching your eye from your surroundings. Even in the LM shadow, there were too many bright things in your field of view for the stars to be visible."]

[Cernan - "When you were in the lunar module, looking out the window, you certainly couldn't see stars. Using the telescope was sort of like being in a deep well; it cut out all the reflected light and let you see the stars. It was also generally true that, when you were on the surface in the LM's shadow, there were too many bright things in your field of view for the stars to be visible. But I remember that I wanted to see whether I could see stars, and there were times out on the surface when I found that, if you allowed yourself to just focus and maybe even just shielded your eyes to some degree, even outside the LM shadow you could see stars in the sky. And, quite frankly, under the right conditions here on Earth on a bright sunlit day, you can do the same thing. I could see stars through my helmet visor; not easily, but it can be done."]

113:20:22 Cernan: Gordy, you got Noun 20?

113:20:26 Fullerton: That's affirmative. We copy Noun 20.

113:20:30 Cernan: Okay. Jack's going to pick up the AGS - on the right side of that page - and I'll park the (rendezvous radar) antenna.

113:20:36 Fullerton: Roger.

[Schmitt - "We had the antenna in a ready condition during the descent landing and, here, we may be parking it in a configuration to minimize heating on critical elements."]

[A notation at the bottom on Surface Checklist page 1-1, left column, suggests that, here, they are parking the rendezvous radar in a position where it won't interfere with the star sightings. After they finish P57, near the top of the left column on Surface 1-3, they will re-park the radar, this time pointing up.]

[Comm Break]

113:23:01 Cernan: P20's in work. Correction, P57's in work. (Pause)

[P57 is the platform alignment program. It begins with a determination of the direction of the local gravity vector in relation to the spacecraft and then uses the data from Gene's star sightings.]

113:23:13 Fullerton: Challenger, Houston. Your DPS Oxidizer Pressure is 40 (psi) or less. You can close it.
 113:23:22 Cernan: Thank you, Gordy. (Pause) Gordy, while the P57 is doing its gravity work, let me say that the LNA (Lunar Navigation Aid) and the landing site, from a relief point of view, I think, are identical. I couldn't say enough for the LNA. I actually didn't look around nearly as much as I thought I would, or as I wanted to, because I had fixation on a reasonable spot to land. They're not all reasonable in that there's some very subtle, hummocky-like craters right in and around where we are. And there's not a lot of boulders laying on the surface, but there's a lot of what appear to be boulders that are covered up by some of the dark mantle. Numerous enough that you would not like to take a chance at putting a pad down on one of them or in one of those hummocky, subtle craters. As a result, I really didn't have a chance to look all around at where I wanted to except to put the bird down where I wanted it.
 113:24:36 Fullerton: Okay. We've got no complaint with that. (Pause)

[Schmitt - "The LNA was a model constructed by the Army Topographic Command for use in the simulator. It was made from data they extracted from Apollo 15 stereo photography. It was a fairly detailed model, mounted upside down on a ceiling. A TV camera "flew" to it as we "flew" the LM simulator and the picture was merged into our visual displays in our windows in the simulator. It was pretty good size; it covered the whole valley - past the Scarp, I know - and part way up the sides of the massifs."]

[Cernan - "The LNA simulations of the landing sites always tended to come fairly late in training, but I don't recall us having a great problem with it being extremely late. It may not have seemed adequate at the time, but it certainly was adequate."]

[The following paragraph has been edited for clarity.]

113:24:47 Cernan: I guess the thing that probably surprised me most about the site, as far as landing is concerned, is the fact that there were these buried, massive pieces of rock out here in the plains area, partially covered and filleted by the dark mantle. I hesitate to say they're outcrops but certainly they're buried massive pieces of rock (and we'll have to wait to find out) whether they're boulders or not. I expected to find a number of craters, but I guess I really didn't expect to find the rock types (that is, buried boulders) around. And we're talking about anywhere from 1 to 2 meters down to, oh, 2 or 3 feet, which, when they're sticking out and on the sides of some of these subtle craters, look pretty menacing. But that probably is the one thing that surprised me most.

113:25:44 Fullerton: Roger, Gene.

113:25:49 Cernan: The visibility prior to pitchover was such that I could see Nansen. I could see the Scarp. I could see Lara. I could not see Camelot until after pitchover. However, once I had pitchover, if I could have froze it right there like we do in the simulator occasionally, I could have picked out everything there was to see. Even at 6000 feet, the small triangle with Frosty and Rudolph and Punk were visible to me. I had Poppie from orbit, as a matter of fact, so it was easy to see. Barjea was a very sharp, round crater just as depicted on the LNA. The thing I really didn't get a good look at, because I didn't pay too much attention to it, was from Trident on to the south.

113:26:36 Fullerton: Roger.

113:26:37 Schmitt: Gordy, this is the LMP. Let me say that the inside of the spacecraft looked just like the simulator.

113:26:47 Fullerton: Very good, Jack. (Pause)

[Once again, Jack is lamenting that, rather than get a chance to look at the Moon during the descent, he'd had his eyes glued to the instruments.]

113:27:05 Cernan: Another interesting thing, Gordy. All the way through PDI prior to pitchover, Jack and I had the real America - or the other America - right smack out the front window all the way down, which was pretty spectacular.

[Cernan - 'Because we were landing early in the morning at a site so far east, we landed at a very early phase of the Moon and almost the entire Earth was sunlit. We took the picture of the fullest Earth that any crew saw because we left Earth almost at the New Moon. As we stayed there, the fraction of the Earth that was sunlit got less and less and it got to be a three-quarters Earth and then a Half Earth by the time we left lunar orbit to come home. On the surface, when we went to bed at night, we could see the American flag

out Jack's window and (out Gene's window) we could see the Earth sitting right on top of the South Massif. Because of where we landed, the Earth was fairly low in the sky and was always part of the scene. Looking at the Earth was something you could do casually, and you would do many times without even realizing it. That was the neat part about it being so low in the sky."]

[Schmitt - "Actually, what he could see was mostly the southern hemisphere because, when we landed, the Moon was below the plane of the Earth's equator. During the final phases of the landing, I had the center section of the LM blocking me. All I could look at was the North Massif. I took one look, but Gene had me so drilled on giving him those numbers I missed the whole landing."]

[Cernan - "I'm proud of that. That's professionalism. I don't think we have to take a back seat to anybody for any of the mission."]

[Readers will note that Jack saw Earth out his window at 112:55:41 which was about 5:45 into the burn. At that time, however, the LM was yawed left about 20 degrees for comm purposes. Less than a minute later, at 112:56:33, Gene went to a yaw of zero for the final approach and Earth rotated out of Jack's field of view."]

113:27:21 Fullerton: I bet it was. And you can consider yourself Stay for T-3.

113:27:28 Cernan: Thank you, sir. You're getting smoother (that is, becoming a smoother talker) all the time. If you're happy with Noun 22, I'll Pro(ceed).

113:27:39 Fullerton: Stand by one. (Pause) You're clear to Pro.

[Cernan - "You could align the inertial platform either with the stars or with gravity. Here, we were gravity aligning. I think Noun 22 showed you the new alignment angles (in yaw, pitch and roll, in tenths of a degree), and it gave you a chance to look at it and say 'Yes, I want it; I'll accept it,' or 'No, I'll keep my old alignment.' The fact that we were still aligning the platform means that we were still in a mode to leave the lunar surface on a contingent basis. We'd taken our helmets and gloves off, but still hadn't really powered down for a long lunar stay. In the worst case we could have lifted off without helmets and gloves; if you had to go, you went, as long as you had certain minimum things powered up in the lunar module. Now, eventually, we powered it all down - the computers, the platform - and, then we were really in a state of saying, 'We're comfortable here.'"]

[Comm Break]

113:28:41 Schmitt: Okay, Gordy. I had the angles matched on the steerable high-gain antenna and went to Slew, and it (the signal strength) held for a few seconds and then dropped off.

113:28:52 Fullerton: Okay. It looks pretty good (his tone of voice suggests "but not optimal"). You might try to peak it up just a little more.

[Fullerton is suggesting that Jack adjust the antenna pointing for a maximum signal strength from Earth.]

113:29:01 Schmitt: No, we're on an omni-(directional antenna) now.

113:29:06 Fullerton: Rog.

113:29:11 Schmitt: I'll try the steerable one more time here. (Pause)

113:29:21 Fullerton: Okay, you should be...

113:29:22 Schmitt: Okay. We're on the steerable, and I'm not going to touch it. (Pause) It's Steerable and it's Slew, and I got 3.8 (carrier signal strength).

113:29:40 Fullerton: Okay. That looks good to us, Jack. (Long Pause) Jack, we'd like you to verify the tape recorder, Off.

113:30:12 Schmitt: Yeah, that's verified, Gordy. (Long Pause)

[Cernan - "This was a non-voice recorder for LM engineering data. A lot of times, when you were out of line-of-sight communications, or you had to drop off a communication signal, the tape recorder would continue to record all the engineering data about all the systems that would normally have been transmitted back to Earth as telemetry. That way the ground eventually had a totally uninterrupted scan of information of how the systems had been operating. But, when we were on the lunar surface, they didn't need the tape recorder because we had good, real-time communications all the time.]

113:30:58 Cernan: Gordy, how does the fuel vent look to you?

113:31:04 Fullerton: Okay. Looks like 8 (psi) to us. You can go ahead and close it.

113:31:07 Cernan: Anyway, it...(Hearing Fullerton) Okay. I already did.

[Long Comm Break. Gene is now taking star sightings.]

113:38:28 Cernan: Gordy, I guess I'm puzzled on that one. I had the right star. (Pause) You see anything we did wrong?

113:38:41 Fullerton: Stand by. We're checking.

[Comm Break]

113:39:52 Fullerton: Gene, our only guess is that you might have loaded Noun 88 wrong. We'd like you to start over, and we'll watch you real close again.

113:40:05 Cernan: Gordy. Listen, I think we know what we did. We loaded Spiral for Cursor, and Cursor for Spiral. How would it be if we went through the P57 again and...(Pause) I guess we got to do it all over. Those old numbers are no good anymore.

113:40:25 Fullerton: Okay.

[Schmitt - "P57 was the star-sighting program and, in the telescope, you had a cross-hair which was the cursor and also an unwinding spiral overlaying it. And I guess that, at any particularly time, every star had a known set of inertial coordinates related to that cursor and spiral. As I remember, you loaded the coordinates of the star you were going to sight in the computer so that it could drive the telescope to the expected position; and, then, once you were sure that you had the right star, you zeroed-out the pointing and allowed the computer to take the refined information into account."]

113:40:28 Cernan: I'm sure that's what we did. We loaded Cursor for Spiral, and Spiral for Cursor.

113:40:36 Fullerton: Okay. And it's our fault, too. We should have watched that.

[Comm Break]

113:41:47 Fullerton: Jack, this is Houston. We do have the pre-PDI AGS cal numbers. You won't need to read them to us.

[That is, Jack can skip the readout called for in the checklist at the bottom, righthand column, of page 1-2.]

113:41:59 Schmitt: Okay.

113:42:03 Cernan: Gordy, you going to want a recycle on this gravity measurement? I doubt if it (the computer) will need it.

113:42:12 Fullerton: Stand by. (Pause) No; no recycle necessary this time through.

113:42:23 Cernan: Okay. (Pause)

[Cernan - "There was a program in the computer that literally could align the inertial platform to a local vertical defined by lunar gravity; or, of course, we could align it on the stars. But, generally, we would always tend to check the gravity alignment with stars, and then utilized both to align the platform."]

113:42:32 Schmitt: Gordy, ED Batts are (still) 37.2. (Long Pause)

113:42:49 Cernan: Gordy, let me comment about the handling of the bird. After you once fly it (the LM) around in orbit a little bit, you get accustomed to the thrusters, and it came back to me quite a bit from (Apollo) 10, anyway. And

you get a feel for acceleration and deceleration as well as the attitude-hold capability. And, really, the response, even with a heavy descent stage near the surface, is phenomenal. Responded exactly in the direction I wanted, held attitude very good. And, let me tell you, the LLTV (Lunar Landing Training Vehicle) played no small part in this landing as far as I'm concerned.

113:43:32 Fullerton: Roger, Gene. (Pause)

113:43:45 Cernan: Okay. Noun 22 again. I'll go ahead and torque them.

113:43:49 Fullerton: Okay. Go ahead.

[Long Comm Break]

[Schmitt - "As I recall, everybody was eventually supposed to go through LLTV training, but they were barely able to qualify all of the Commanders. All of us did get helicopter training as a precursor to the LLTV."]

[Cernan - "The reasoning behind giving only Commanders LLTV training, as best I can remember, was a combination of time, cost, and, quite frankly, safety. All the lunar module pilots wanted to fly the LLTV, strictly from a piloting point of view. When I was a lunar module pilot, I wanted to fly it. But, because we didn't have plans to land on Apollo 10, there wasn't any point in either Tom Stafford or I training in the LLTV; and, even for the actual landing missions, quite frankly, there was no need for LMP LLTV training. It would have been nice gravy to put on a chicken fried steak if the LMP's could have flown it as well as the Commanders; but, in reality, there was no need. There were two people to train for each flight anyway: the Commander and the Back-up Commander; and that pretty much took up all the time that was available. There were also some very real safety issues. We started out with four training vehicles, I believe, and we ended up with one. Joe Algranti (a NASA test pilot) ejected out of the first one. He was heading our aircraft operation before Neil ever flew the LLTV. And then two other people had to eject. So I was the last to fly the last one. It was a very unstable vehicle.

"The LLTV gave us training in the critical final phases of the descent, from 500 to 700 feet on down. It had a J85 jet engine which, basically, maintained a constant thrust - based upon the weight of the vehicle - and took away 5/6th of the weight. That put you in a simulated lunar 1/6 gravity environment. You had sets of RCS thrusters, just like the lunar module, to control attitude; but, in addition, you had two other, vertically-mounted, hydrogen-peroxide-fueled 'lift' rockets that were capable of handling the extra 1/6th of the weight above the 5/6th that the J85 removed. They let you control how fast you went up or went down. To fly a descent, you'd use the lift rockets to fly yourself up to about five hundred feet. Then you'd start a forward trajectory and pick a landing point a few thousand feet down a runway. The key was to practice, and to get familiar with the dynamics of a six-degree-of-freedom machine. The more

experience you got, the more you could displace yourself; or you'd give yourself errors; or, as you developed proficiency, instead of flying right straight down the runway, you could move over in the grass somewhere and put yourself in a position where errors were established before you started.

"The LLTV was inherently less stable than the LM itself; and we also had to contend with gusts of wind that could cause problems. But, LLTV training was very valuable because it really put your tail out on the line. It was not a simulator you could make a mistake in and then reset. If you made a mistake, you busted your ass, quite frankly. It also really brought home the uniqueness of the problems that you get with six degrees of freedom. By six degrees of freedom, I mean that not only could you roll, pitch, and yaw the vehicle and change your thrust direction because of the main engine, you could also use the RCS thrusters and move it laterally up, laterally down, laterally left, laterally right, laterally fore, or laterally aft. You had a combination of all those things to do when you landed a lunar module, and that is why the LLTV was so realistic. It was a great training device, one of kind and probably never will be seen or used again. The 'flying bridge'. The ugliest thing in the world; but it was an ingenious idea and an ingenious design, and I don't know how else you could have ever put yourself in a 1/6 gravity flying environment, with rocket engines, here on Earth, and still have six degrees of freedom. Helicopters are just vertical flying machines, and they were nothing like this at all."

[Gene has been making a new gravity measurement during the Comm Break.]

113:50:18 Cernan: Okay, Gordy. It's a little better.

113:50:22 Fullerton: Rog. Looks good.

113:50:28 Cernan: Okay, there's Noun 93. (Long Pause)

113:50:48 Fullerton: Okay. Torque it. (Long Pause)

[Cernan - "We aligned the LM inertial platform in orbit before we landed. Theoretically, it should have maintained its alignment, but a lot of things happened during landing which could have changed it. We fired engines; and all the little perturbations could have driven the alignment off just a little bit. So when I said, 'O.K., Gordy, it's a little better' I was referring to the angular difference between where the computer thought the inertial platform was aligned and where we now knew it was aligned based upon our gravity measurements and star sightings. There might have been only a few hundredths of a degree difference or something like that, and that looked a lot more realistic than it had when I got the cursor and spiral mixed up."]

[Gene is at the bottom, lefthand column, of Surface 1-2.]

113:51:32 Fullerton: Challenger, Houston. We're standing by for the (computer memory) dumps.

113:51:38 Cernan: Okay, Gordy. I'm ready to give the E-mem...(Hearing Fullerton) Coming at you. Mark it. It's on the way.

[Comm Break; they are now at the top of Surface 1-3.]

113:52:58 Cernan: Gordy, one other thing about the landing. I saw the (Contact) light, I think. And I heard Jack call it, the Contact light. I think I waited about a second and hit the Stop button. She shut down immediately. And, of course, you could feel the fall. I don't really feel we fell that much, but it was quite a change in acceleration at that point.

113:53:32 Fullerton: Roger, Gene.

[Cernan - "You hit the stop button when you're ten feet above the lunar surface, the length of the probes sticking down from each of the struts. You're coming down at two or three feet per second, and you've got noise, and the engine is effectively holding you up. True, you're in 1/6 gravity and you don't tend to fall very fast. But all of a sudden, one of the probes touches, you get the contact light, you shut that thing down and boom, your stomach goes up in your throat for a split-split second. You've shut down all your thrust - and it shuts down immediately - and you go 'burrup'. It was quite a change in acceleration. You wouldn't get that if you could fly all the way down to the surface smoothly and then shut down; but we weren't afforded that luxury for the Apollo landings because we wanted to shut the engine down before we actually touched down. There was always the potential problem of the descent engine digging into the soft sand if you landed at an angle or there was a mound below you. If you dug in the engine and it was running - with all the fire and brimstone coming out of it - it could have exploded on you because of back pressure. So you wanted to shut it down just a couple of feet into the air. You knew the drop was coming, but there was still a definite, abrupt physical sensation."]

113:53:36 Cernan: And I guess I had, from what I would guess, a foot or two per second forward speed on that one.

113:53:44 Fullerton: Okay. Sounds good.

[Cernan - "As for the forward velocity, which we talked about earlier, my plan was to have about a foot per second forward. Now, I suppose, accurately, I could have been looking at the gages at that time, it would have told me; but, probably, from 60 or so feet on down I hadn't planned to look at the gages because, once you get right down to that point, you use your eyeballs and you take what you get. If you're set up properly, you'll end up right. If you're not set up properly, you're going to end up improperly.

"There was a reason why I used the 'think' emphasis, 'I think I saw the contact light, and I think I waited about a

second and hit the stop button.' You're not a robot, but you are so familiar with what needs to happen, with what needs to be done, that you go ahead and do them on a reaction basis at the right times. You don't have to analyze them and think through each one of them. So when I reflected upon this, I said, 'I think I waited about a second and hit the stop button.' It might have been a half second, who knows what it might have been. As another example, on lift off from the lunar surface, the computer gives the ignition signal to the engine. However, whether it gets it or not, there's a backup because the command pilot hits manual ignition. Just as a backup. And one of the flight controllers told me I was like a tenth of a millisecond behind the computer. I was so close that they almost couldn't tell. They told me, 'We're not sure whether the computer hit it at T-Zero, or whether you hit it at T-Zero, because one was right on top of the other.' So you react to doing some of these things. After we lifted off, we don't want to overburn either; and if the computer didn't shut the thing off right when it should, you had to be right there when you wanted it shut off. Boom; you shut it off. Those were reactions you took almost involuntarily because you'd trained to do that. They weren't robotic responses because you thought through them before they happened; but then, when they happened, they made logical sense and, as soon as you got the contact lights, you started throwing switches."]

113:54:06 Cernan: And let me know when I can have the computer, please.

113:54:13 Fullerton: Okay. It's your computer.

[The computer has been in a dump mode, sending information to Houston. Here, Cernan wants to be told when the dump is finished so that he can use the computer again.]

113:54:15 Fullerton: And I'm standing by with parking angles when you're ready to load them.

113:54:20 Cernan: Okay. We'll be ready in a second. (Long Pause)

[These are parking angles for the Inertial Measurement Unit (IMU), the inertial platform.]

113:55:00 Schmitt: Go ahead with the angles.

113:55:02 Fullerton: Okay. These are the IMU parking angles. Plus 295.86. (Pause) I see you loading the radar. Do you just want to load these or write them down?

113:55:29 Schmitt: Go ahead. I'm writing.

113:55:31 Fullerton: Okay. Y will be plus all zeros. And plus 084.14. Over.

113:55:45 Schmitt: Okay. Noun 20 will be plus 295.86, plus all zeros, plus 084.14.

113:55:52 Fullerton: That's correct. (Long Pause)

113:56:16 Schmitt: Okay, Houston. I'm going to power down the AGS, if you're willing. (Pause)
 113:56:27 Fullerton: Not yet, Jack. We'd like you to read out 047 and 053 to us.
 113:56:36 Schmitt: Okay. You want the new ones. (Pause)
 113:56:46 Cernan: Okay, Gordy. If you're happy with Noun 22, I'll Enter them. (Pause)
 113:56:52 Fullerton: We're happy.
 113:56:56 Cernan: Okay. And it just dawned on me. I'm sorry about the zero on the Noun 69. (Jack laughs)
 113:57:04 Fullerton: That's okay. You're forgiven.
 113:57:09 Cernan: I appreciate that. (Long Pause)
 113:57:24 Fullerton: Okay, Jack. We got 047 and 053.
 113:57:31 Schmitt: Okay. Am I Go to pull the (AGS circuit) breaker? (No response; Long Pause)
 113:58:04 Cernan: Okay. Are you happy with Noun 20? (Pause)
 113:58:14 Fullerton: Okay. We're happy with Noun 20, and you're clear to power down the AGS.
 113:58:23 Schmitt: Okay.

[Cernan - "As I remember, we put Noun 20 in the computer, the computer did something with it, and then gave back a Noun 22. Then, if everybody was happy with the Noun 22, we'd go ahead, enter the Noun 20 into the working part of the computer, and power down the Abort Guidance System."]

[Comm Break]

113:59:37 Cernan: Gordy, the breakers are coming Open on 1-4 and 1-5.
 113:59:40 Fullerton: Roger.

[Comm Break. 1-4 and 1-5 are checklist pages showing the "powerdown configuration of the two circuit breaker panels.]

114:02:11 Cernan: Gordo, we're on 1-6.
 114:02:14 Fullerton: Okay. Thank you.

[Long Comm Break. They are now configuring spacecraft switches for the lunar stay. During this interval, there is a change-of-shift Briefing for the press and, on the Public Affairs version of the audio tape used to prepare this transcript, the tape ran only when there was a transmission to record - that is, it ran in a voice-activated mode. The original NASA transcript includes some times of utterances but it is impossible to interpolate the times of other utterances with out reference to the original, continuous tapes.]

114:11:31 Schmitt: Okay, Houston. We're at the bottom of (page) 1-8, and I'm standing by for your lift-off times.

[Checklist page 1-8 gives the configuration of the Environmental Control system (ECS).]

Fullerton: Okay, Jack. Lift-off time for rev 15 is 116:55:51; 16 is 118:54:28; 120:53:04; 122:51:40; 124:50:17; 126:48:53. Over.

Schmitt: Okay. Starting with rev 15, 116:55:51; 118:54:28; 120:53:04; 122:51:40; 124:50:17; 126:48:53.

Fullerton: That's a good readback.

[Comm Break. These are nominal liftoff times for upcoming orbits. Jack is entering the numbers in the on-board flight plan in case of a loss of communications. In an emergency, of course, they could lift off at almost any time; and, once on orbit, Evans could maneuver to pick them up. Next, Gene and Jack will reconfigure the cabin for their three-day stay on the Moon. The detail can be found on checklist page Surface 1-9.]

114:15:11 Cernan: Gordo, the PLSS is against the hatch, and we're installing the BRA.

114:15:15 Fullerton: Roger on that.

[Very Long Comm Break. The BRA is a restraining device, made of loose webbing, which they are installing across the front of the cabin. It contains two large pouches, one for each of the helmets. The name, of course, came from the resemblance of the BRA to a woman's brassiere. The PLSS (Portable Life Support System - the backpack) in question is Jack's, and has been strapped to the floor between them. Gene's is attached to the leftside bulkhead behind his left shoulder.]

Fullerton: Challenger, Houston. We've got three questions for you to help pin down your exact position, any time it's convenient. Maybe when you're taking the out-the-window pictures. Over.

Cernan: Okay, Gordo. I think we can give it to you. Why don't you wait? We're just getting the mag (film magazine) bag out and jett(ison) bags out from behind the engine cover here, to give you an idea where we are (in the checklists).

Fullerton: Okay. No hurry at all.

[They are near the bottom of the lefthand column of Surface 1-9.]

Cernan: (Answering Fullerton's earlier question) I had it (the landing position) pinned down for you until I got to about 500 feet, when I changed my mind.

Fullerton: Roger.

114:30:17 Cernan: Gordy, we're not going any further, and we'll answer your questions here when we get some time. My best guess is 150 meters from Poppie at 1 to 2 o'clock.

[Gene is giving a clock position relative to the crater, with 12 o'clock due west.]

Fullerton: Okay. We copy that.

Cernan: And I'll bet on that one. But we'll get with you in a minute.

Fullerton: Okay. 150 northwest of Poppie.

Cernan: Yeah. Mostly west, but slightly north.

Fullerton: Roger.

Cernan: I'll tell you, we're abeam, I think, just about abeam of Trident 1. I can see it out there, but I can't really define Trident 1 from Trident 2. And the thing that is a little different is that I appear to be closer to it than I normally would have expected to be.

Fullerton: Okay.

Cernan: That's probably as close as the Navy Captain can ever guess where he is anyway.

114:31:56 Fullerton: Rog. (Laughs)

[Long Comm Break. Again, Gene doesn't realize that he is actually about 100 meters north of Poppie and is mistaking it for the westernmost part of Trident. Had he landed at the target point, Trident 1 would have been about 400 meters to the south.]

114:38:37 Schmitt: Okay, Houston, we're just starting our eat period. Sorry to be a little behind. PRD (Personal Radiation dosimeter) readings are 17037 and LMP is 24117.

Fullerton: Okay, Jack. We got that. (Long Pause) Would you verify you're Biomed, Right?

Schmitt: Yeah, that's verified. How does it look?

Fullerton: Looks good.

[Houston can only read biomedical sensors one of the astronauts at a time, not both. Houston thinks they are recording Schmitt's vital signs and wants to make sure. "Right" refers to Jack's station on the right side of the spacecraft, facing forward; "left" would be Gene. They were supposed to start their meal break at about 114:12 and, therefore, are only about 20 minutes behind the timeline. Comm Break]

114:41:11 Cernan: Okay, Gordy. We're starting to cut into a little lunch here and, if you've got any questions, why don't you come up with them now?

[Cernan - "'Cutting into a little lunch' was a literal statement; we had to use scissors to cut open the plastic food bags."]

114:41:20 Fullerton: Okay. We're wondering if you can give us estimate of the angular position - clock position - of Rudolph. And can you line up Rudolph with a horizontal

feature out beyond it? (Pause) I should say "horizon feature" - out in the distance - not "horizontal".

Cernan: Okay. I thought Rudolph was right out there at 3 o'clock. Jack's looking at it and he said, yes, that is Rudolph right at 3 o'clock out his right-hand window.

Fullerton: Okay.

Cernan: I don't know if it'll mean anything to you, but (on) the shadow of the LM, the rendezvous radar antenna is pointing about one-third of the way down from the peak of Family. And that, I know, is pretty gross. And, Gordo, I must be right here abeam of Trident 1. The only reason I hesitate is that I'm so close; but it's probably, well I guess it's close to 100 meters - 80 meters anyway - to where the rim of Trident 1 falls off. And I am abeam of the center of Trident 1, and that's the only possible thing it could be. And that would put Poppie just about where I expected it to be.

Fullerton: Okay. (Pause) We just want to confirm. You're referring to Trident 1 as the easternmost part of Trident, is that right?

Cernan: No, sir, Gordo. It's always been the westernmost part of Trident. The (planned) landing site was on a line between Trident 1 and Rudolph and judging from what Jack's got out his right-hand window and what I got on my left-hand window we're right there, except possibly a skosh further south on that line.

Fullerton: Okay, understand.

Cernan: And the target point that was in the PGNS was right up where we all had expected it to be, about halfway between here and what we're calling the rim of Camelot. We can't see into Camelot; we can just see the rim of it. It's several, oh, at least 2 to 300 meters up there, I expect.

[The near rim of Camelot is about 800 meters due west of them.]

[Cernan - "This was typical of the problems you had judging size and distance on the lunar surface. Everything looked almost on order of magnitude (factor of ten) smaller than it really was. Certainly two to three times smaller and a lot closer than it really was. You had no telephone poles, no roads, no houses, no buildings to really judge distance by. Everything you looked at, you'd almost say, 'Well, it's just out there a few hundred feet', but it was probably a mile away. A boulder that looked like it was four or five feet tall might be a mile away and be 30 feet tall. You learned very quickly that you had no good way to judge of distance or size. Of course, after enough times of underestimating things you sort of recalibrated your system. You said, 'I know it looks like so and so, but it's probably so and so.' And even when we drove places, it didn't look like it was that far, but we kept driving, and driving, and driving before we got there. So, I'm not surprised that I was off by a factor of three here."]

Fullerton: Okay, what o'clock position is the west...(Correcting himself) the nearest part of the rim of Camelot? Or maybe, if it's better defined,...

Cernan: 12 o'clock.

Fullerton: ...define the south rim. Can you see the south rim of it?

Cernan: Yeah, Gordy, but it blends in so well; all we're seeing is an undulating high as the rim. And to the best of my knowledge, we've got the south rim at - or correction, the east rim - right at 12 o'clock.

Schmitt: Hey, Gordy, right at 12 o'clock, also, is a boulder that's at least 3 meters (high) and maybe 5, and I wouldn't be a bit surprised if you can find it (in the overhead photography). It's on a line between us and the intersection of the South Massif and the Family Mountain horizon. Just slightly left of that line or south of that line. And that boulder ought to show up on your best photography.

Fullerton: Okay, Jack. We'll take a look. One other question...

Schmitt: And that boulder's at least 200 meters away.

[This is Geophone Rock, and Jack has made an excellent estimate of it's size (3 meters) and distance. Like the LM, Geophone Rock is visible in one of the high resolution pictures taken by Ron Evans from orbit. It is one of the few rocks on the valley floor big enough to cast a shadow discernible in the photograph.]

[Schmitt - "I knew how long the LM shadow was at the time of touchdown, and I just adjusted my estimates accordingly. Nothing ever looked as long as it was. I think my own judgments would have been off by a third, maybe, if I hadn't applied known the shadow length. Everything looked smaller. Just as distances look shorter in clear air of the Western U.S. than they do in the East, the lack of haze and references on the Moon made estimates difficult."]

Fullerton: Okay. Can you see the west rim of Trident, and can you give us a clock position on the west rim of West Trident?

Cernan: Okay, Gordy. The west rim of Trident - which, by the way, is full of outcropping-looking boulders - is at 10 o'clock.

Fullerton: Okay, Gene...

Cernan: Okay, I can look back around the corner now (straining forward against the LM window so that he can look as far to the rear as he can) and I can see where the east - where Trident 1 rose up to its rim on the east side, and I would say we're abeam of a point one-third the way from east to west up the center of Trident; that is, we've covered one-third of Trident 1 and we're abeam of a point of a line that goes through the one-third point from east to west of Trident 1.

[Actually, they are just about on a north-south line through the center of Poppie.]

Fullerton: Okay, Gene; that's very clear. I think we've got you pretty well nailed down. And you're pretty close to the planned landing site.

Cernan: Yeah, I think it's very close to our planned landing site and I'm... (Chuckles) I'm anxious to see where Poppie is, because I think what I said earlier is true.

Fullerton: Okay. That's all the questions now. Enjoy your dinner.

[All of the Apollo crews, with the exception of Armstrong and Aldrin who had no specific target point, spent a significant amount of time after landing trying to figure out exactly where they were.]

[Cernan - "It absolutely amazes me that you can travel a quarter of a million miles and still worry about whether you're a hundred or two hundred feet short or long, or left or right of where you should have landed."]

[Long Comm Break]

114:50:24 Schmitt: Houston, I have calmed down, but be advised that our dinner is corn chowder.

[Jack says that a serving of corn chowder eaten during the trip out from Earth had given him a bad case of intestinal gas, much to the distress of Gene and Ron who, in the tiny Command Module, had no way of getting away from the resulting smell.]

114:50:34 Fullerton: Roger.

114:50:41 Cernan: He went to Captain's Mast for (flatulence from) eating that the other day.

[A Captain's Mast is a disciplinary hearing chaired by a naval unit's commanding officer.]

[Long Comm Break. At 114:56:45, Ron Evans passes over the landing site for the first time since touchdown and reports "Hey, I think I can see a light spot down there on the landing site where they might have blown off some of that halo stuff. It's between Sherlock and Camelot." A few moments later, he gives a coordinate of DN83.3 on map TL25-8, a position on the north rim of Poppie. A further conversation on this matter is reproduced just prior to 115:09:06.]

114:56:09 Schmitt: Gordy...Houston, 17. Houston, how do you read - (Correcting himself) "Challenger" - or whoever we are?

114:56:15 Fullerton: "Whoever you are", you're loud and clear.

114:56:20 Schmitt: I took the monocular and looked at some large boulders at our 12 o'clock position. They're probably

on the order of a half meter to 2 meters, buried but without strong filleting.

[On level ground, ejecta from small impacts in the surrounding regolith splash on the side of a rock and building up a skirt - called a fillet - around it's base. On a sloping surface there is also a contribution to filleting from downhill soil movement.]

114:56:30 Schmitt: And most of them that I could see had the same mottled light-grey and medium-grey texture, and it looked like there's a lineation in it. And whatever the mottling is, it's on a grain size or fragment size of a few centimeters, and it looks as if it's very uniform in that mottling; that is, there's one fragment size.

114:57:10 Fullerton: Okay.

[Schmitt - "I think that the mottling is due to an irregular, brown-glass patina that covers the rock surface. Each time a micrometeorite hits a rock, it splashes melt-glass onto the surrounding rock surface, building up the patina. However, each of the impacts also cleans off a small patch of the patina right at the impact point; and I suspect that that is what this mottled appearance is."]

114:57:13 Schmitt: There are a few (boulders) near one crater out at 12 o'clock (that are) dark-grey rock that may be glass coated. Matter of fact, one of them looks like it's right at the rim and might have been part of a projectile that made the crater.

114:57:34 Fullerton: Roger. (Long Pause)

[Schmitt - "This was probably a secondary crater, one made by a piece of ejecta from another impact. Clues that a crater is a secondary rather than a primary are an irregular crater shape and/or the presence of the boulder that made the crater. In this case, the glass on the boulder suggested that it had been thrown out of a high speed impact before it landed where we found it."]

114:57:47 Schmitt: The large boulder that I mentioned that's several meters in diameter...I'm not even sure it's a boulder. It does have a well-developed fillet. It's highly fractured. It looks like the fractures generally are north-south. At least we can't see end on into the fractures. And it's too far away to be sure, but it looks like it's mottled also, although there did appear in the monocular to be a more heterogeneous mottling. It might be a breccia.

[Geophone Rock is not a breccia and, on closer examination, Jack will describe it as a vesicular gabbro, a coarse-grained basalt containing small, spherical cavities (vesicles) left by bubbles of gas trapped in the rock as it cooled.]

114:58:27 Fullerton: Okay.

114:58:31 Schmitt: That boulder ought to be very close to the ALSEP site.

[Jack will need to pick an ALSEP site at least 300 feet (100 meters) west of the LM in order to minimize effects of the liftoff plume. When the time comes, he will put the ALSEP Central Station about 40 meters north of Geophone Rock.]

114:58:38 Fullerton: Roger. (Pause)

114:58:44 Cernan: (This paragraph has been edited for clarity) Gordo, in reference to these boulders, everywhere I can see out of my left window and out ahead of me - in referring to that boulder (Geophone Rock) Jack's talking about which is just a little bit on my side at 12 o'clock - it appears that the dark mantle has filleted and, for the most part, has covered part of or is up on top of some of the crevices and the crannies in the boulders themselves, with the exception of - well, I'll take that back - even the very small ones. I'd say (that) boulders of the size Jack's talking about - (boulders of a size) anywhere from 1 to 2 to 3 meters - that are visible through the surface, (cover) a very small percentage (of the surface), but when you look at them at our level, it looks like they are quite populous. I'd say there are maybe about 25 of them in view between myself and where the horizon falls off down away from us towards the South Massif (slightly south of west). The area back towards Station 1, at least the other side of Trident (off to the south and southeast), looks like it's more heavily strewn with some of these filleted and partially-mantled large fragments.

115:00:15 Fullerton: Roger, Gene.

[Schmitt - "In the pre-mission photographs, the area looked like it was covered with dark material. There also seemed to be fewer craters, most of them relatively subdued. So we were anticipating that there might be a mantling of dark, pyroclastic material. It turned out that there had been such deposits in the area, but that they were 3.5 billion years old and were mostly long-since buried. Some of the buried dark material had been mixed to the surface by impacting; and, so, the dark color is a marker for pyroclastic deposits, just not recent ones."]

115:00:20 Cernan: To say that there is a boulder, as such, actually sitting on the surface, I really can't find one, unless they're around some of these very small and possibly younger craters. But I think for the most part everything is somewhat mantled.

115:00:35 Fullerton: Okay. (Pause)

[Schmitt - "I think that the prevalence of buried boulders and the lack of any clearly sitting on the surface is part of a normal process. When it landed, a boulder would normally dig at least a little crater for itself; and as the fillet formed and the crater filled in, the boulder wouldn't look like it was sitting on the surface. Boulders actually sitting on the surface would have been rare."]

115:00:48 Schmitt: Gordy, I think maybe the predictions of a fairly thin regolith (the soil layer) were good. I have a crater at about, oh, 130 feet (from the LM). It looks like it's not more than a meter deep.

[Schmitt - "Normally I would have talked in meters but, for some reason, I knew the length of the LM shadow in feet. It was 110 feet long, I remember; and, apparently, the crater was down-Sun and next to the shadow."]

115:01:00 Schmitt: It's very fresh, has a bright halo around it, and it's very rocky in its interior and has some rocks that are at least 10 or 20 centimeters in diameter on the rim. It looks like it's penetrated into some much rockier substrate than what we're seeing on the surface. The surface itself looks like (it has), oh, probably 15 percent (coverage by) fragments greater than half a centimeter.

[Schmitt - "This was a bad interpretation on my part. These fragments were mostly regolith breccia (impact-compacted soil) like what we saw on EVA 3 at Van Serg Crater."]

115:01:56 Fullerton: Okay, Jack.

115:01:57 Schmitt: I don't see any general size sorting. I do have a crater out here that's maybe a meter in diameter - fairly fresh, although not bright halo(ed) - that has not penetrated to blocky material. And it looks like that the saturation crater size is very small in the area we can see; that is, there don't seem to be any old or very subdued craters. (Pause) Well, let me think about how to put that again. It's obviously saturated with craters a few centimeters in diameter, but when you get bigger than that, there seems to be more of a clear distribution rather than a saturation.

115:02:56 Fullerton: Okay.

[Because small craters are made much more frequently than large craters, a fresh surface will "saturate" first at the small end of the size range. That is, after a while there will be few spots not covered by centimeter-sized craters and, after a longer period of time, overlapping foot-sized craters will cover most of the surface.]

[Schmitt - "The saturation size should tell you something about the age of a surface. But you have to assume things like a time-invariant size distribution and that

nothing has been spread over the local surface to reset the clock. There are just too many variable to use the concept of saturation size at this scale. It's one thing to use it at an orbital scale (for craters of kilometer size and up); it's another thing to use it down here 'among the trees'."]

[For the next several minutes, Gene will describe the general view out his window. Corresponding photos, probably taken during one of the recent comm break, are AS17-147-22479 through 491. Readers unfamiliar with the dominant landmarks may find it useful to look at shadows cast by foreground rocks to get an idea of direction. It is early morning, and all the shadows are pointing west, toward 12 o'clock. As Gene mentioned, Family Mountain is due west of them. The South Massif is the very large, apparently flat-topped mountain next to the south, and Bear Mountain is south of them, over the RCS thruster that appears in the south-looking photos.]

115:03:02 Cernan: Gordy, let me give you a quick (description of the) "far horizon". At 12 o'clock, I've got Family Mountain. It and South Massif are a replica from their plane form from where I am, except that Family Mountain is much more symmetrical and rounds off to a very more definite peak. The South Massif, in turn, has got a high plateau, a high flat peak on top. My far horizon then, at 12 o'clock, from about 12 to 11:30 is dominated by Family Mountain. It's - well, I hate to use the word "anorthosite" without getting out of the spacecraft - but it sure is white. (Pause)

[The very light-colored highlands that cover most of the Moon's surface - in contrast to the darker mare or seas - are thought to be composed largely of anorthositic rocks which formed deep within the Moon, early in it's history. Apollo 15's Genesis Rock is a piece of virtually pristine anorthosite recovered on the lower slopes of Mount Hadley Delta.]

115:03:48 Cernan: It sure is white, but it's varied shades of white with sort of a tendency on its southern or southeastern slope to sort of be marble caked with a darker material much the same color as the mantle that we've landed on. Family Mountain disappears just about at the level of the rim of Camelot on my far horizon and just in front of it. That's at about 11 o'clock, just where the South Massif starts up very abruptly...Well, I'll try not to overestimate (the slope), but certainly 30 degrees, I'd say. Very abruptly to a very impressive altitude. I know I was at 13,000 (feet) when I said I was at their level, but it sure looked it from there. It plateaus off from about 10:30 to about 9:30, and then it starts sloping back down towards the east at about the same angle. Very symmetrical

.

[The actual slope of South Massif is about 26 degrees. The summit height is 2300 meters or 7500 feet.]

115:05:12 Cernan: There are several places where you can see what appear to be outcrops. I say "several" - about a dozen anyway - where you can see relatively large areas of outcrop on the South Massif. That outcrop is of a darker grey color than the white-grey of the Massif itself. The one most dominant outcrop is right at the change in slope to the west, where it goes upslope and then plateaus off, and there's a definite outcrop. And you can see several boulders on all levels of the Massif that have come apparently from outcrops and I feel certain we will be able to get to some of those that have come all the way down. South Massif, too, appears to be, in areas, marbly caked dirty, such as if it was sprinkled with a dirty or a darker covering, and that covering is more evident as it slopes back (down) here towards the east.

115:06:26 Cernan: As the far horizon now, I can see South Massif all the way to 9 o'clock, but then behind it, there's just a little breadloaf-type dome of a much darker, much-more-hummocky mound back there, relatively big. It's probably, from where I stand, at least 10 percent the size of the South Massif. Grey in texture (means "color"). There appear to be some lineations running...Well, as I'm looking at them, they're dipping down into the west at about 20 degrees, but that may be a Sun-angle problem. But they're definitely there.

115:07:15 Cernan: And then, contrasting that is Bear Mountain which is also much darker grey, much different than the Massif from where I stand, much more hummocky surface. It appears to be to me what I would expect Sculptured Hills to be like.

[The Sculptured Hills are out of sight, behind them to the east. The LM has only forward-facing windows.]

115:07:30 Cernan: One other thing about the South Massif is that - as I look at it at about 9:30 to 10:30 - there is a little knob of the South Massif that sort of flows towards the east or slightly towards the northeast. That's the one that tends to be a little bit more heavily covered with the darker, dusty material...

115:08:06 Fullerton: Challenger, Houston, over.

115:08:08 Cernan: There are...(Hearing Fullerton) Go ahead.

115:08:12 Fullerton: Okay. We're about 12 (to) 13 minutes behind the time line for starting cabin preps. And (the) Backroom is enjoying your descriptions, but we think we'd rather you press on with the preps and get ready to get out for a really good view. Over.

[The 'Backroom' is the Science Support Room.]

115:08:31 Cernan: Okay, Gordy. (Talking faster) We're doing this and eating too. We're trying to do them both at the same time, and we are pressing. Just want to say one other thing about the Massif. I can see a couple of places where very small craters have penetrated the Massif - craters maybe a meter or 2 in size, some (of them) 5 meters - and there's a lot of rock debris around them, which tends to (make me) believe that there is very little, if any, soft covering on that Massif. (Pause)

115:09:03 Fullerton: Roger.

[It is now Gene's turn to eat while Jack talks.]

[Cernan - "Obviously, Jack could draw a lot upon his geology background to be able to recognize and describe some of these features on the Moon. It was a tremendous advantage. But I also think that my training was certainly more than adequate for what I had to do. It was comprehensive and I spent a lot of time at it. In fact, I got some general geology training even before Apollo 10 and then specifically got involved for Apollo 14 and then again with Apollo 17. We spent a lot of time studying various aspects of geology, mostly by going out in the field but also - at least a little - by looking at photographs and samples from prior missions. I think Jack probably did more of that than anybody, primarily because of his interest but also because he was staying in the geology side of the business, analyzing the material coming back from each of the missions. I think it was recognized that we didn't have much time to be much else besides observers. If we had enough background and training to recognize that something was different and unusual, then we could photograph it and bring a sample back. That's about all you had time to do on the Moon anyway, no matter whether you were a fully trained geologist or not. Even if we had had more time for geology training, at some point you have to ask at what time do you stop becoming that much more qualified as a lunar geology observer.]

"One of the important parts of the training was getting to exposed to a lot of different things here on Earth so that, when you saw something on the Moon, you could say, 'Hey, this is similar to Sunset Crater at Flagstaff'; or 'This is similar to that impact crater I saw west of El Paso'; or 'This is similar in structure to the craters at the Nevada Test Site' or whatever. To me, the best way to be an observer is to have enough experience that you can describe whatever you're looking (at) in terms of something that people on the ground are familiar with. Of course, you can bring the pictures and samples back; but in real time, you can say, 'Hey, I'm standing in a crater and it looks just like Sunset Crater, or just like those craters we saw in Canada, or this rock is just like the pahoehoe we saw in Hawaii.' Then someone back on Earth who's seen the same things will know exactly what you're talking about. But, if you don't go to those places in training, if you don't have that exposure, it's hard to relate what a stream of pahoehoe

looks like. If you can say, "Gee, this is black just like that black car you're driving," then they know what color black it is. But if you say, 'Well, it's sort of a greyish silver black,' it could be anything.

"Geology was part of my job in this period of time in my life, but I'm sure that Jack will have a far deeper recollection of the lunar geology. That's his business; that's his profession. I've had a lot to say about the descent, because that's my profession. And I can sit all day and talk about what it felt like to be on the Moon, what it looked like, what it meant; but I probably won't recall a lot of the details of our lunar geologic traverses. Maybe I'll surprise myself. I don't know. As I've read some what I said about what things looked like out the window, I do recall some of it, and it does mean something to me. And I think that means I was pretty well trained to be a geologic observer. I think that was true in the case of most everybody who went; but I had the advantage of having a professional geologist with me."]

[At this point, Ron Evans is having a further conversation with Houston about his visual observations of the landing site at 114:56:45.]

[Capcom: America, while we're waiting for this lunar sounder to operate for 2 minutes, could you say again those map coordinates you gave us (for the light spot made by the descent plume). I dug out the map TL 25-8, and I got the 83.3, but what was the azimuth coordinate on that, Ron?]

[Evans: It was Dog November, and maybe just a little to the right (north) of Dog November.]

[Ron has the map oriented along his flight path, with west up and north to the right. The actual landing site is very close to DN.3, 83.3.]

[CapCom: Okay; Dog November. Thank you. And you think that's where they are, huh?]

[Evans: Yes.]

[CapCom: Okay.]

[Evans: Well, there's the...There's a real white spot down there, you know. And I didn't have...I only got a short...I only got a look at that thing for about 30 seconds before I had to do something else. But I'm recalling in my mind where the white spot is with respect to those...(Looking at the map) There's Camelot, and there's Sherlock. and, then from Camelot to Sherlock there were two other craters, and they were just a little bit closer to Camelot, but between those other two craters there.]

[CapCom: Good show. Roger.]

[It's a little hard to identify the two craters between Camelot and Sherlock - possibly Trident and the unnamed feature north of Poppie.]

[Evans: There's a white spot...Yes, there's a white spot on the...Like it might have been dust blowing or something, you know.]

[CapCom: Roger, That may be the rocket exhaust. It might be just a little off that light spot.]

[Evans: Yes.]

[Based on Gene's statements about the landing site, Houston is under the impression that the LM is a bit west of the white spot while Evans has the landing place identified to within 20 meters or so. It is a bit puzzling that Houston never tells the LM crew about this observation. Had Gene been told, he might have been able to sift his frame of reference and get oriented before starting the drive to Station 1. Evans will reconfirm this initial observation at 116:56. However, at 120:52 he will report that he cannot see the white spot any more. There's is, however, no doubt that he has seen the patch of ground scoured by the descent plume. Photo AS17-139-21203 will taken by Jack while he and Gene are working at Station 6 on the lower slopes of the North Massif. It will be taken through a 500-mm lens and shows the LM and the lighter color of the scoured area surrounding the spacecraft.]

[The photographs taken at about this point in the mission from Jack's window are AS17-147-22469 to 22478.]

115:09:06 Schmitt: Gordy, just a couple more words about the North Massif. It looks like (there is) a good distribution of boulder tracks. Many of the boulders are accessible. The tracks can be traced up at least to midslope. That's at my 3 o'clock position. And occasionally, at that midslope position, particularly northwest of Henson, you can see abundant boulders suggestive of outcrop. That's something that we had missed seeing on the premission photos. And it isn't as abundant as on the South Massif, but there are apparent ledge formers about midslope. (Pause)

[Henson is a 300 meter crater on the lower slopes of the North Massif at about Jack's 2 o'clock position. It is not to be confused with Hanover Crater which is farther west, but also on the lower slopes of the North Massif.]

[Schmitt - "Ledge formers are just outcrops that line up in an apparent ledge."]

115:10:08 LM Crew: (Occasionally keying their microphones by accident) Yeah, let's make (garbled) I don't know (garbled) a lot of (garbled). (Pause) (Garbled) it could be one.

(Pause) Give me that to throw away. (Pause)

115:11:03 Schmitt: Okay, Gordy. There's also a few very bright sparkles from the surface - not abundant, but a few.

[These were almost certainly glass beads.]

115:11:17 Schmitt: (Unintentional key) Well, let me...I need these.

[Comm Break]

115:13:52 Fullerton: Challenger, Houston. I'm going to hand you over to the good Dr. Parker here. Have a good trip outside there.

115:14:00 Cernan: Gordy, thank you. You do outstanding work and we sure do appreciate it, babe.

115:14:06 Fullerton: My pleasure.

[Cernan - "We had a nine-man crew. We had the Prime Crew (Cernan, Evans, Schmitt), the Backup Crew (Young, Roosa, and Duke), and then the three-man Support Crew (Overmyer, Parker, and Fullerton). And there was also a group of supporting engineers. Traditionally, the Support Crew became the principle CapComs because they usually knew more about what was going on during the flight than anybody. Maybe that changed here and there, but for the most part, we had Gordo (Fullerton), (Bob) Parker, Bob Overmyer, and also Joe Allen, who was one of our support scientists. They knew us; they knew how we talked; and they knew our mission. They worked with us in the simulations a good part of the time; and they worked with us virtually all the time once we started the full-scale mission simulations."]

[Comm Break. During this interval, the Public Affairs commentator gives the press an estimated landing site of DM.8 and 82.7, which is 100 meters west of Poppie, a location corresponding to Gene's erroneous estimate.]

115:17:12 Cernan: Bob, we'll give you a call in a minute. We just made a couple of suit adjustments.

115:17:16 Parker: Okay. Copy that.

[Gene and Jack donned their suits at about 107:40, prior to undocking, and then donned their helmets and gloves at about 10 minutes prior to PDI. After the landing and once they were sure that the LM was in good shape, they took the helmets off at about 113:18, about 16 minutes after touchdown. However, since they plan to make a full EVA during this first day on the Moon, they have left their suits on and, as they will tell Houston in a couple of minutes, they are now adjusting drink bags and food sticks inside their neckrings for use once they get outside. Comm Break.]

115:20:38 Parker: Apollo 17, Houston.

115:20:43 Cernan: Go ahead, Bob.

115:20:46 Parker: Okay, Challenger; we've just lost about 16 dB (decibels) on your high-gain signal strength there. We're wondering if you happened to hit the switch there, has it moved, or could you give us a check on it?

115:21:01 Cernan: We're nowhere near it. Stand by one. (Long Pause)

115:21:22 Parker: Okay. And, Challenger, that should be a Pitch of 21 and a Yaw of minus 45.

[Cernan - "The high gain (antenna) had a pitch axis and yaw axis. I don't think it had a roll axis. I don't think they were particularly related to the inertial axes of the spacecraft."]

[Gene's memory is correct. From the LM, Earth is at an elevation of 45 degrees and at a bearing 30 degrees south of west; therefore, these pitch and yaw numbers are not simply related to the direction of Earth in the local sky.]

115:21:31 Cernan: Plus 21 and minus 45; Rog. (Pause) Bob, (give us) about 2 minutes here.

115:21:38 Parker: Okay

[Long Comm Break. Based on Jack's mention of the Buddy SLSS (Secondary Life Support System), or BSLSS, at 115:27:18 and Parker's comment at 115:29:10, they are in the middle of the lefthand column of checklist page Surface 2-1. On this page they are stowing loose items, putting a 500mm lens on a Hasselblad camera, stowing film magazines and other gear in the Equipment Transfer Bag (ETB) which they will take outside with them, propping up a pair of cue cards for their pre- and post-EVA equipment procedures on the panel in front of them, turning on a heater for the urine disposal line - they will empty the urine collection bags in their suits when they get to the top of page Surface 2-5 - and attaching a lanyard (the LEC or Lunar Equipment Conveyor) to the ETB and clipping some pages containing emergency procedures to the instrument panel in front of them. These pages are 2-2 through 2-4.]

115:26:30 Schmitt: Bob, this is Jack. On that high gain, I'm up close to 3.9 (signal strength) now, which is better than when we landed. Do you want me to do anything to it?

115:26:41 Parker: Stand by on that. (Pause) Leave it alone. It seems to have gone away, Jack. It may have been a ground problem. (Pause) Did you guys adjust it, Jack?

115:27:03 Schmitt: Yeah, Bob. (Misunderstanding the question) We had to fix the drink bags and a couple other things.

115:27:08 Parker: No. Did you guys adjust the high-gain antenna?

115:27:14 Schmitt: No. I didn't touch it.

115:27:16 Parker: Okay. Copy that.

[For the next few seconds, Jack thinks he is in the Push-to-Talk mode of communication but actually has a live microphone. Parker will call his attention to the fact in about a half minute.]

115:27:18 Schmitt: Buddy SLSS's in there? No. That's over there.

[The Buddy SLSS is an apparatus which would allow the crew to share a PLSS in the event that the other one failed. It would only useful if the Rover were still working; walking

astronauts would not be able to move very far or very fast hooked together.]

115:27:28 Schmitt: Oh, did they?

115:27:30 Cernan: (Garbled) in there?

115:27:32 Schmitt: I thought it was over on your side.

(Pause) Okay? (Pause) Okay, that's over there. Bigger than it used to.

115:27:51 Parker: And, Challenger, we have you hot miked.

115:27:57 Schmitt: Well, because ...(Hearing Parker) Huh?

[Comm Break]

115:29:04 Parker: Challenger, Houston. Over.

115:29:08 Cernan: Go ahead, Bob.

115:29:10 Parker: Okay. When you guys get to the top of page 2-5...And I assume you're down still in the ETB, from what your comments were on the hot mike there. When you get to the top of page 2-5, we'd like you to put both Demand Reg's to Egress. Over.

[They are loading cameras, film, and other gear for the EVA into the ETB. By putting the oxygen demand regulators in the Egress position, they will cut off any addition of oxygen to the cabin except through the suit circuit. This is not a standard procedures at this point in the mission and Houston's request suggests they are checking some aspect of the ECS operation.]

115:29:26 Cernan: Okay, Bob. Will do. We'll give you a call as we go along.

115:29:29 Parker: Roger. Thank you.

[Comm Break]

115:30:55 Cernan: Hey, Bob, while I'm thinking of it, we're working with one pair of scissors down here. We're going to take them out with us in the ETB. You might make a point of reminding us to bring them back.

115:31:05 Parker: Okay. I copy that. Never did find Ron's, huh?

115:31:11 Cernan: No, sir, and I couldn't just leave him up there starving to death.

115:31:15 Parker: Roger on that.

[This suggests that they are in the middle of the righthand column of checklist page 2-1

[Schmitt - "Each of us had a pair of scissors which normally traveled with us, but Ron lost his on the trip out from Earth. We had a lot of fun kidding him on the way out and all the way back about losing his scissors in a spacecraft which was, after all, not very big. But the complication was that the whole timeline on the surface was geared to having two pairs of scissors. With two pairs, Gene

and I could leave one pair in the cabin and take the other pair outside - probably as a contingency tool - and not have to worry about taking it up and down (the ladder). However, because you needed the scissors to cut the plastic food bags, we finally condescended to leave one pair with Ron so that he could eat. And ultimately his scissors were found. I found them as we were preparing stowage for re-entry; but was able to signal to Gene that I'd found them without Ron knowing it. We continued to give him a pretty hard time and said that, in fact, we didn't think he'd lost them at all but he was trying to get away with these scissors as a memento of the flight and that ultimately the IRS (Internal Revenue Service) would be very interested in his activity. They were fancy, surgical scissors. At the splashdown party we had at the Flight Control Division - probably a month after the mission - we presented the scissors to Ron with great fanfare. We'd had to do an awful lot of preparation because, in order for the inventory of the spacecraft not to be confused, I had to let the crew assistance people in on the secret. I think what I did was put his scissors in my Personal Kit - my little bag of personal items. So there were two pairs of scissors in there. And that kit was supposed to come to us personally. That's probably what I did. I've forgotten exactly how we did the transfer without screwing up the inventory. It would have been a little hard to secretly carry the scissors up into the helicopter with us, because then, in the helicopter we changed out of our constant-wear garments into flight suits for our arrival on the carrier. So, I guess what I must have done is put the scissors in my flight bag."]

115:31:23 Cernan: By the way, how's he doing?

115:31:26 Parker: Stand by. (Pause)

[Parker consults with Bob Overmyer, the Command Module CapCom.]

115:31:40 Parker: Challenger, Houston. Your buddy is doing great,, and the sounder is also doing great, which is a surprise, I guess.

115:31:48 Cernan: I'm glad to hear that. (Pause) That was no surprise, Bob. We wouldn't have taken it if it wasn't going to work.

115:32:02 Parker: I thought about that after I said it.

[Comm Break]

115:33:09 Cernan: Bob, I just turned the Urine Line Heater, On.

115:33:12 Parker: Copy that. (Long Pause)

[Use of the heater keeps urine from freezing in the line before it reaches a sump in the descent stage. They have

finished loading the ETB and are in the middle of the righthand column of checklist page 2-1.]

115:33:25 Cernan: And the physical status of the crew is excellent, by the way.

115:33:29 Parker: Beautiful. The Surgeon's happy.

[Comm Break]

115:34:35 Cernan: Say, Bob, we're at the top of (checklist page) 2-5, and I forgot what it was you wanted me to do up there.

115:34:42 Parker: Okay. We'd like you to have Demand Reg's, both of them, go to Egress, please.

115:34:49 Cernan: Yes, sir. (Pause) Okay, they're Egress now.

115:34:52 Parker: Okay, thank you.

[Comm Break. The controls are on a panel behind Jack's station at about waist height.]

115:37:36 Cernan: Okay, Bob, we're in the middle of the first paragraph at 115:15 in the time line.

115:37:43 Parker: Okay; copy that.

[Long Comm Break. They are verifying closure of their suit zippers and are getting their EVA boots out of storage at the back of the cabin. They have finished emptying the urine bags.]

115:44:12 Cernan: CDR's OPS 5800 (pounds per square inch).

115:44:19 Parker: Okay; we copy 5800. (Long Pause)

[The Oxygen Purge System (OPS) is an emergency supply of oxygen, mounted on top of the PLSS. The OPS contains 5.7 pounds of oxygen stored at a pressure of 6950 psi, and is designed for use in the event of a partial failure of a suit seal, a suit puncture, or any one of several possible PLSS malfunctions. An actuator cable is mounted on the right side of the RCU and, by moving a lever on the cable, the astronaut can open his OPS shutoff valve, thereby releasing high pressure oxygen to a regulator which then introduces oxygen into the suit at 3.7 psi. In the event of either a slow leak or a failure of the PLSS regulator, the PLSS fan would continue to circulate oxygen and, although the crew would promptly return to the LM, there would be no great urgency. The OPS actually contains more oxygen than does the PLSS itself (1.8 pounds at 1400 psi for the PLSS), certainly enough for a few hours of operation. In the event of a fan failure, a loss of cooling, a build up of carbon dioxide, or - in the worst case - a complete PLSS failure, the astronaut could activate his OPS and open a purge valve installed on the lower right chest. The purge valve has two settings: a

low flow setting of 4 pounds per hour and a high flow of 8 pounds per hour.]

[Cernan - "The purge valve is nothing but a regulator, with two settings, in an open-loop system. You start with a supply (of oxygen) at one end and you regulate it out at the other end. It's just like a pressurized cabin in an airplane. In the case of an airplane, you pressurize the air from the engines, it goes into the cabin, and the pressure is controlled by an outflow regulator - which you could call it a purge valve. It will stay closed if you need to get the pressure up, or it will open to dump as much incoming air as it has to keep the pressure to a certain level."]

[In circumstances where the astronaut's own PLSS would still provided cooling or he and his crewmate were able to use the Buddy Secondary Life Support System (BSLSS) to share cooling water, he would use the low-flow setting and would have about one hour of oxygen available. The BSLSS consists of a set of hoses and connectors and is designed so that LCG cooling water can be shared while riding in the Rover. In the event that BSLSS can not be used, the purge valve would be put in the high-flow setting and the astronaut would have about 30 minutes of oxygen/cooling available.]

[Cernan - "At some point there had been a suggestion that we would have to stay close enough to the LM that we could get back in the case of a double failure of both the Rover and a suit. I didn't like that and, obviously, we (the Astronaut Corps) ended up winning the argument. There were lots of things you could do to share oxygen. Suppose that Jack's PLSS failed and he had to go on his OPS. The first thing I'm going to do is take my OPS off my suit and put it in his lap. Then I wouldn't have an emergency supply but he'd have two. I don't think that was ever written down anywhere, but if that had happened, he'd have had an hour of OPS oxygen and we would have been headed for home (the LM). That's the kind of thinking that went on. Now, particularly in the early Gemini days, we did stretch things and did some things that we would never do today. Do you think that we would go out today, in the Shuttle, in an EVA suit with a backpack with hot gas and you were so scared that the hot gas was going to burn a hole through your suit that you made the pants out of woven steel? But we did that in Gemini. Before we had more twenty minutes of EVA experience, we were going to send somebody out - namely, yours truly - with a hot-gas backpack. With fire coming out. We were burning hydrogen peroxide. We were going to put fire down our suits."]

115:44:45 Cernan: LMP's OPS is six thousand plus.

115:44:50 Parker: (Making a misidentification) Copy that, Jack.

115:44:57 Cernan: (Retaliating) Okay, Hank. (Long Pause)

[Gene recalls that Parker had a great deal of trouble telling the two of them apart during simulations. Hank Hartsfield was an Air Force pilot who, with six colleagues,

joined the Astronaut Corps when the Air Force's Manned Orbiting Laboratory program was cancelled in 1969. He first flew in space, as a Shuttle Pilot, in 1982.]

115:45:31 Schmitt: Okay. Both (OPS) regulators are reading slightly under 4.0 (pounds per square inch or psi).

115:45:35 Parker: Copy that, Challenger.

[Long Comm Break]

115:49:48 Cernan: Okay, Bob. The Urine Line Heater is Off and the Urine Line Breaker is Open, and we are down to applying antifog.

115:50:02 Parker: Okay. Copy that, Challenger.

[Long Comm Break. They are in the middle of the righthand column of page 2-5. An antifogging agent is wiped on the inside of the bubble helmets prior to each EVA. The helmet assembly consists of the clear, bubble helmet which is an integral part of the pressure suit, a visor assembly, and an outer, white-colored, thermal protection layer. Meanwhile, Houston is still fiddling with the estimated landing site coordinates. They are now giving DM.6, 82.1. People in the back room are still trying to make sense of the crew descriptions and now seem to be giving greatest weight to the supposed location relative to Rudolph and Trident 1.]

115:57:12 Cernan: Okay, Bob, the BRA is stowed.

115:57:16 Parker: Okay. Copy that, Challenger.

[Comm Break. Because they will soon don their helmets, they can now get the helmet storage bag out of the way.]

116:00:15 Cernan: Okay. We're starting PLSS donning on the LMP.

[That is, they are putting on Jack's backpack. They are at the top of checklist page 2-6.]

116:00:20 Parker: Roger. Copy that.

[Very Long Comm Break]

116:10:17 Cernan: Okay. The LMP has got the RCU connected to the PLSS.

116:10:25 Parker: (Making a misidentification) Copy that, Jack.

[Comm Break. They are near the top of the righthand column of checklist page 2-6. They have mounted a Remote Control Unit on Jack's suit chest and are making connections to the PLSS. The top surface of the RCU has an oxygen quantity gage, an oxygen fan switch, and a variety of warning flags. Communications switches are located on the bottom and

the switch which controls the flow of PLSS water through the Liquid-Cooled Garment is on the left side. Once outside the LM, Gene and Jack can mount their 70 mm cameras on brackets attached to the front of the RCU's.]

116:11:43 Cernan: Okay, Bob, I'm going to get on the (CDR's) PLSS, now.

116:11:48 Parker: Okay, Geno. Copy that.

[They will now repeat the PLSS donning procedures for Gene.]

[Cernan - "Getting the PLSS's on was very difficult. It was a two-man operation. The PLSS's were strapped to the side walls, at working height, and you had to back up against yours and the other guy would then unhook it from the wall and help you get it strapped to your back. The LM was so small that it was a very difficult operation, even in soft (unpressurized) suits."]

[Each of the PLSS's has a number of six-inch-long strips of Velcro on the back which, during the descent, helped hold Gene's on the wall at his right shoulder and Jack's on the floor by the hatch. The Velcro strips are plainly visible in the TV coverage of the EVA's.]

116:12:32 Cernan: (Unintentional key) Sublimator is (garbled).

[They are checking to make sure that Gene's PLSS sublimator exhaust is clear. The sublimator, which provides suit cooling, is described in more detail at 116:52. Very Long Comm Break]

116:22:17 Cernan: Okay, Bob. I've got my PLSS on. We're picking it up with verifying the powerdown configuration on the upper right-hand corner of the EVA prep checklist.

[Note that this is a separate checklist from the Lunar Surface Checklist which has been in use up to this point. Both contain the same EVA prep information but the EVA prep list is printed on stiff cards which are much easier to handle than the relatively bulky book which contains the full list of procedures to be followed while the crew is in the cabin. In the Surface Checklist, they are starting the section labeled "PLSS Comm Check" on Page 2-6. The Powerdown Circuit Breaker configurations are shown on pages 1-4 and 1-5 in the Surface Checklist.]

116:22:30 Parker: Roger. Copy that. (Long Pause)

116:23:00 Cernan: Circuit breakers are configured.

116:23:07 Parker: Houston copies.

[Comm Break. Once they have verified the circuit breakers, they start the comm check, beginning with Jack. We don't hear any of this activity until they get to the section

labeled "Audio (CDR)" at the bottom of the lefthand column of page 2-7.]

116:25:21 Cernan: (To Jack) Okay, I'm in VOX (voice activated comm). VOX Sensitivity is Max, A is T/R and B is Receive. Okay. You can open your breaker and connect to the PLSS comm. Houston, I guess you heard that.
 116:25:38 Parker: That's affirm. Loud and clear. (Pause)
 116:25:48 Cernan: (To Jack) Just Audio breaker. Your Audio breaker, that's all. Want some help with that? (Long Pause)

[Here, Jack gets off of LM comm and on to PLSS comm. They are at the top of the righthand column of page 2-7.]

116:26:08 Cernan: Yep. Do it while you're facing that way. Just hang them up. Best time to do it. All you've got (left to do) is water. (Pause) Okay, Bob. We're getting Jack up on PLSS comm, and we'll be picking it up on the comm check here on left-hand column of the bottom sheet (of the cue cards).
 116:26:35 Parker: Roger. We're following you. (Long Pause)

[The next item is closing Jack's audio circuit breaker.]

116:26:58 Cernan: (To Jack) Okay. You're on and locked. Okay, and you got the cover? Okay. Your Audio breaker, Closed. (Pause) Okay, on your PLSS PTT go Main; that's (to the) right. Okay. PLSS Mode A.
 116:27:16 Schmitt: A.
 116:27:17 Cernan: Okay; tone, On; Vent Flag, P.
 116:27:20 Schmitt: Got a weak tone and a Vent Flag, P.
 116:27:24 Cernan: Okay.

[The tone and flag indicate that Jack's suit isn't pressurized and also show that the sensors and indicators are working.]

116:27:23 Schmitt: Got a good tone right now.
 116:27:25 Cernan: Press Flag, 0; and 02...
 116:27:26 Schmitt: (Garbled) 0 and...
 116:27:28 Cernan: ...momentary.
 116:27:29 Schmitt: ...02 (Flag) still there.

[The oxygen warning flag indicates that there is no oxygen flow to the suit.]

116:27:31 Cernan: Okay, PLSS 02...
 116:27:32 Schmitt: It's gone.
 116:27:35 Cernan: What's your PLSS 02 pressure gage?
 116:27:37 Schmitt: The 02...
 116:27:39 Cernan: Give Houston a call and give it to them.
 116:27:40 Schmitt: I'm reading 100 percent, Houston.

116:27:43 Parker: Roger, Jack. And we're reading you slightly garbled but loud.
 116:27:50 Schmitt: Okay. Well, you're loud and clear, Bob.
 116:27:54 Cernan: Okay, Jack. You got that, and I'm reading you. How you reading me?
 116:27:57 Schmitt: You're loud and clear.
 116:27:59 Cernan: Okay. We will not unstow the (OPS) antenna. You are a skosh garbled, but very readable.
 (Pause) Okay. Stay where you are. I'm going to get mine.
 Okay. Audio breaker is...

[Comm Break. The checklist suggests raising Jack's PLSS antenna if comm is too garbled, but they decide that the comm is acceptable. Having made the audio check on Jack's PLSS comm, Gene now pulls his Audio circuit breaker, going off LM comm for a few minutes until he gets his own PLSS comm hooked up.]

116:29:35 LM Crew: (Garbled)
 116:29:37 Cernan: B. Okay. I got a tone.
 116:29:38 Schmitt: (Reading from the checklist) "Vent Flag, P."
 116:29:39 Cernan: I got a Vent Flag, P.
 116:29:41 Schmitt: "Pressure flag and 02 momentarily."
 116:29:43 Cernan: Pressure flag, and I still got an 02 Flag.
 116:29:46 Schmitt: Off with your tone.
 116:29:47 Cernan: Okay. The tone is gone. The 02 flag cleared.
 116:29:50 Schmitt: Okay. "PLSS 02 quantity."
 116:29:53 Cernan: Okay; and I'm reading 100 percent.
 116:29:57 Schmitt: Okay.

[They are now at the top of checklist page 2-8.]

116:29:59 Cernan: Okay. (Reading) "Note crewman in Mode B" - that's me - "cannot hear Houston." Houston, broadcasting in the blind; 100 percent (oxygen) on the CDR.
 116:30:06 Parker: Roger, CDR. Houston reads you loud and clear.
 116:30:13 Schmitt: (Still broken as heard in Houston) I read you loud and clear, Gene. How me?
 116:30:16 Cernan: I'm reading you loud and clear.
 116:30:17 Schmitt: Okay.
 116:30:18 Cernan: Give me a call again.
 116:30:19 Schmitt: Okay. How do you read, Gene? 1, 2, 3, 4, 5.
 116:30:22 Cernan: Give me again.
 116:30:23 Schmitt: 1, 2, 3, 4, 5.

[Because they don't yet have their helmets on, Gene can't be absolutely certain that he's hearing Jack through the comm system or directly.]

116:30:25 Cernan: I think so. I can't...Okay. I'm reading you. Okay. "PLSS. LMP (comm) go B."
 116:30:32 Schmitt: Going B. (Pause) Try that. B ...
 116:30:45 Cernan: Okay. How do you read me, Jack.
 116:30:47 Schmitt: (Comm much improved) You're loud and clear, and I got a tone.
 116:30:52 Cernan: Okay. Give me a short count once.
 116:30:54 Schmitt: Counting. 1, 2, 3, 4, 5.
 116:30:58 Cernan: You're great.
 116:31:00 Schmitt: Okay.
 116:31:01 Cernan: I had a tone, too. I still got a Pressure and a Vent Flag.
 116:31:03 Schmitt: And, Houston, how do you read the LMP?
 116:31:06 Parker: Roger, LMP. We read you loud and clear.
 116:31:10 Cernan: Okay, Bob. I'm reading you loud and clear, and he's not reading you in this mode. How me?
 116:31:14 Parker: I read you loud and clear also, Gene.
 116:31:19 Cernan: Very, very, good. We're both going AR, now. Let's go.
 116:31:23 Schmitt: Okay.
 116:31:24 Cernan: Ought to get a tone.
 116:31:26 Schmitt: I didn't, but my Vent Flag did clear.
 116:31:28 Cernan: There it is. Tone and a Vent Flag.
 116:31:31 Schmitt: There's my tone and Vent Flag.
 116:31:33 Cernan: Okay, Jack. The wheel is Houston and the blade is me. Hello, there; Houston. How are you reading CDR?

[Cernan - "There were two volume controls on the RCU and we obviously had Jack's switches set so that the wheel-like control controlled the volume on his comm circuit to Houston and the blade-like control controlled his circuit with me."]

116:31:41 Parker: Read CDR loud and clear. And, for your information, your TM (telemetry) on the PLSS's looks good.
 116:31:52 Schmitt: Okay.
 116:31:53 Cernan: (Garbled)...
 116:31:54 Schmitt: How do you read, Houston? This is the LMP.
 116:31:57 Parker: Houston reads LMP loud and clear now. You're much clearer than you were before, Jack.
 116:32:03 Schmitt: Very good.
 116:32:05 Cernan: Okay. Jack, we gave them our (oxygen) quantities already; so, Squelch, VHF B LMP, Full Decrease.
 116:32:11 Schmitt: Squelch B is to Full Decrease, huh?
 116:32:14 Cernan: That's affirm.
 116:32:16 Schmitt: Okay. It's Full Decrease.
 116:32:17 Cernan: Okay. On (circuit breaker panel) 16, leave that (Liquid Cooled Garment) Pump breaker Closed.
 116:32:19 Schmitt: Okay.

[Up to now, the circuit breaker for the LCG pump has been open. By closing it, they turn the pump on and get a flow of cool water next to their skins.]

116:32:20 Cernan: Oh, that's cold; but that's good. Okay.
 On (circuit breaker panel) 16, ECS, Cabin Repress, Closed.
 116:32:27 Schmitt: Okay. Is that a verify?
 116:32:29 Cernan: That's a verify.
 116:32:30 Schmitt: Okay. It's Closed.
 116:32:31 Cernan: Suit Fan Delta-P, Open.

[This circuit breaker controls a sensor which responds to a pressure difference (delta-P) across the suit circuit fans.]

116:32:33 Schmitt: Okay. Delta-P is Open.
 116:32:34 Cernan: And Suit Fan number 2 (circuit breaker), Open.
 116:32:36 Schmitt: 2's open.

[For redundancy, there are two fans in the suit circuit. Prior to this point, both circuit breakers had been closed and the fan selector switch had been set to fan number 1. Here, they are opening the circuit breaker for fan number 2 and then selecting for the disabled fan.]

116:32:38 Cernan: Okay. And I've got Suit Fan number 2. There's a Master Alarm. (Pause) Okay. And I heard it run down. Okay. I don't see a...No, there's not an ECS caution (light) until that thing runs down in about a minute or so. We'll watch for that.

[Cernan - "The 'fan' was a circulatory pump that moved oxygen through the suit hoses. What is happening here is that we are disconnecting ourselves from the spacecraft ECS (Environmental Control System). We've turned off the suit fans by pulling a circuit breaker because, without oxygen flowing in from the spacecraft, the fan wouldn't be pumping anything and might cavitate and burn out; plus, the fan would also use battery power and we wanted to conserve that. We had two indications that the fan was off. One was the simple fact that we could hear it, and the other was the Master Alarm which, of course, we expected. With us disconnected from the spacecraft, the sensing system thought that the fan had just failed and gave us the expected warning."]

[They are also waiting for a sensor to indicate that the water separator has run down. Next, Jack will change the settings of various ECS valves located on panels behind him.]

116:32:55 Cernan: Okay; Suit Gas Diverter, Pull-Egress.
 116:32:57 Schmitt: Okay. Diverter is Pull-Egress.

[Here, they are closing a valve which, in the Cabin setting, would allow oxygen to flow out of the suit circuit and into the cabin. It is a push-pull valve. With the valve pushed in, it is in the Cabin position. It is pulled out for Egress.]

116:33:01 Cernan: Cabin Gas Return, Egress.

116:33:03 Schmitt: Return is Egress

[Here, they are closing a valve which, in the Open or Auto positions, would let oxygen flow from the cabin back into the suit circuit.]

116:33:04 Cernan: Suit Circuit Relief, Auto.

116:33:07 Schmitt: Relief is Auto.

[In the Auto position, this valve will open if the pressure in the suit circuit exceeds 4.3 psi and will vent the excess oxygen to the cabin. They have reached the bottom of checklist page 2-8 and are about to connect their OPS's.]

116:33:11 Cernan: Okay. (Pause) OPS Connect. You ready?

116:33:17 Schmitt: Yep.

116:33:18 Cernan: Okay. Suit Isol(ation valve), Activate Override.

116:33:21 Schmitt: Okay. Override.

[The Suit Isolation Valve has been in the Suit Flow position so that oxygen could flow from the suit circuit into the suits. In the event of a suit circuit malfunction, a signal from a pressure sensor would release a spring-loaded activator which would return the valve to the Suit Disconnect position, thereby isolating the suit so that the astronauts could hook up to an OPS or a PLSS. Here, they are about to disconnect the LM O2 hoses and need to manually close the isolation valve by pushing the Actuator Override lever.]

116:33:22 Cernan: Okay. Disconnect your LM O2 hoses.

116:33:26 Schmitt: Okay. LM O2 hoses are disconnected.

116:33:28 Cernan: Okay. And they're stowed, right?

116:33:29 Schmitt: Right.

[Because the ECS is behind them and the hoses come from behind them, they will stow the hoses somewhere to the rear of the spacecraft.]

116:33:30 Cernan: Okay. Connect OPS O2 hose to PGA, blue to blue.

[The Pressure Garment Assembly (PGA) is the suit. They are mating the blue end of the hose to a blue connector in the suit torso.]

116:33:33 Schmitt: Okay. Where is it?

116:33:34 Cernan: Okay. It's sticking right...Turn around. No, that's not right.

116:33:37 Schmitt: No, that's the water.

116:33:39 Cernan: Could you turn towards me a little bit? Turn to the left. There you are, because I got to...Okay. Here it comes, right here. OPS hose under...No; right here.

[They are putting the OPS hose under Jack's arm.]

116:33:49 Schmitt: Here it is.

116:33:50 Cernan: Let me get it. I'll get it under your electrical cable. (Pause) Because you're going to want a purge valve in a minute.

[The purge valve is the "red apple" orifice used in the case of a PLSS failure to make a purposeful hole in the suit so that oxygen from the OPS would flow. The Red Apple is a bright red ball attached to the valve. It is easy to see and easy to grab and pull if the valve has to be opened.]

116:33:58 Cernan: Okay. That is locked and the lock-lock...Move your arm.

[Each of the hose connections has a ring lock and, in the ring, a "lock-lock" which ensures that the ring won't accidentally rotate open.]

116:34:02 Schmitt: This is up. Did you do that?

116:34:05 Cernan: I will in a second. (Pause) Move your arm. I can't see.

116:34:08 Schmitt: I'm trying to. (Pause)

116:34:19 Cernan: Okay. We're right here (on the checklist). Okay. And I'm going to "Connect OPS hose to PGA blue to blue, retrieve Purge valve." Let me give you a purge valve, and I'll pick that up, Jack. The cockpit's just as small as the mockup. (Handing Jack the purge valve to verify it's set properly) Okay. Here you are. You verify it's in Low (flow). (Confirming that he's read the checklist properly) Low.

116:34:37 Schmitt: Okay. It's in Low.

116:34:40 Cernan: Slip to the right just a skosh.

116:34:41 Schmitt: Yeah; slipped it to the right just a skosh.

116:34:44 Cernan: Oh, man, that's easy.

116:34:47 Schmitt: (Laughing) Whee. Okay. Pin's installed. (Pause)

[Jack has installed a one-inch-long latching pin in the purge valve.]

116:35:00 Cernan: And I might be an iceberg when I get out there, but it's going to feel good.

[Cernan - "Here, we were pre-cooling ourselves with spacecraft water before we disconnected. We didn't turn the sublimator on until we got the cabin depressurized and the hatch opened. The sublimator wouldn't work if it wasn't in a vacuum."]

[The sublimator will not work efficiently unless the cabin pressure is very low. On Apollo 12, moments after Pete

Conrad had gone down the ladder to the surface, Al Bean accidentally knocked the hatch shut while he was making a final check of cabin before going out himself. During the next few minutes, the sublimator put out enough water vapor that, despite outflow through the dump valve, there was enough of a pressure build up in the cabin to inhibit further operation of the sublimator. The pressure build up was very slight and Bean had no trouble re-opening the hatch.]

116:35:03 Schmitt: Okay. It's in.
 116:35:06 Cernan: Okay. (Verifying his own purge valve)
 My Purge valve's (set in the) Low (flow position), (It's) locked, and the pin's in. (Pause) Want some help with that? I want to take a look at it.
 116:35:18 Schmitt: There's the old Master Alarm.
 116:35:21 Cernan: Okay. That should be the Water Sep(arator).
 116:35:22 Schmitt: Yeah.

[The suit circuit contains a redundant pair of water separators, located downstream of the suit fans. The separators remove excess water from the oxygen stream. A caution light has just come on to indicate that the separators are no longer working. The response has come about three minutes after the fans were turned off. The nominal interval is about one minute.]

116:35:23 Cernan: It (the water separator light) is on.
 116:35:24 Schmitt: Yeah. It's barely on. You're going to have to push my lock-lock down.
 116:35:29 Cernan: I'll get it.
 116:35:30 Schmitt: I don't know why, but...
 116:35:31 Cernan: Why don't you check mine, too. Let's see it. I'm going to have to check you anyway.
 116:35:37 Schmitt: See if I can turn it this way.
 116:35:39 Cernan: Okay. (Long Pause) That's why; because it wasn't locked. Is that where you want it; facing down or in? You don't want it there, do you?
 116:36:08 Schmitt: No, I don't want it there. Must have had it in the wrong...(Garbled) (Pause)
 116:36:11 Cernan: Is that the way you want it?
 116:36:11 Schmitt: Yeah.
 116:36:12 Cernan: Okay. It's there.
 116:36:13 Schmitt: Good.
 116:36:14 Cernan: The lock-lock is down and it's verified Low (flow) and the pin still is in. Okay. Look at mine while you're there.
 116:36:25 Schmitt: Okay. It's facing in. Lock's in. Stand by; it's Low (flow). Pin's in; it's good.

[Now, they will connect Gene's OPS.]

116:36:32 Cernan: Okay. Let me get this thing right here. Reach that (OPS) hose for me under my arm. (Pause) Put it under the electrical cable.
 116:36:46 Schmitt: Okay.
 116:36:47 Cernan: I think that'll be better, isn't it?
 116:36:49 Schmitt: Yup. Okay. It's there and locked.
 116:36:54 Cernan: Verify lock-lock.
 116:36:56 Schmitt: It's locked.
 116:36:57 Cernan: Okay.
 116:36:58 Schmitt: And the (dust) cover is going on (over the connector).
 116:36:59 Cernan: Okay. (Pause) Look pretty good under that...
 116:37:04 Schmitt: Yeah, it does.
 116:37:05 Cernan: Yeah. That's fine.
 116:37:06 Schmitt: Good. Okay. You're covered.
 116:37:10 Cernan: Okay. I think we're getting to our favorite part here. (Laughs)

[Cernan - "We were getting ready to put the helmets on and pressurize the suits; and that was never a favorite part inside the Lunar Module because it was so hard to move around. With two guys in pressurized suits and both wearing PLSS's, it was almost impossible to move."]

116:37:14 Cernan: Okay. Purge valves are installed on both. PGA Diverter Valve; put it vertical.
 116:37:20 Schmitt: Okay. It's vertical.

[This diverter valve controls the distribution of oxygen into the suit. With the valve oriented vertically, all of the oxygen enters the suit at the neckring. With the valve oriented horizontally, some of the flow enters through the torso, in principle to help keep the suit dry. As far as I know, the cooling system worked so well that none of the astronauts ever put the diverter valve in the horizontal position while they were wearing the suits on the lunar surface. This suit flow diverter valve is not to be confused with the feedwater diverter valve on the PLSS, which is used to control the rate of cooling.]

116:37:22 Cernan: Okay; "Commander repeat (OPS connect)." That's done. Drink. Let's take a drink, and close the descent water.
 116:37:27 Schmitt: Okay.

["Commander repeat" means repeat OPS connection and purge valve installation procedures on Gene's suit. They've just finished doing all of that, so they now take a final drink from the descent-stage water supply before shutting it off.]

116:37:28 Cernan: My (garbled) is already prepared. And "drink and position mikes". (Pause)

116:37:41 Schmitt: Oh, those little jar covers are next.
(Pause) Okay. (Long Pause)

[We have been unable to translate "little jar covers".]

116:38:09 Cernan: Had enough water today (that) you could say you discovered me. I'm "water on the Moon". Okay.
Let's turn the descent water off, and let's stow this (water gun and hose).

[One of the important discoveries made from the Apollo samples was that the lunar rocks and soils are extraordinarily dry, lacking even water locked up in mineral structures that one almost always finds in Earth rocks. Because a local source of water would be very useful in the operation of a permanent lunar base, discovery of water of any kind would have been of great interest.]

116:38:19 Schmitt: Okay. (Descent) water's going Off.
Descent Water's Off.

[Jack is closing the valve on the Descent Stage water tank.]

116:38:22 Cernan: Okay. And it's...Man, is it...(Pause)
Okay. Position your mike.

116:38:34 Schmitt: Okay; mikes are good.

116:38:35 Cernan: Top of the page.

[They are starting the top righthand column on the cue card. In the Surface checklist, which contains the same information, they are starting the section labeled "Helmet/Glove donning at the bottom of the lefthand column of page 2-9.]

116:38:37 Cernan: Okay. Before we turn the (PLSS) fans on, let's make sure we've got...All I've got hooked here is the (LM) water. Those cables are all stowed. They're not in your way, are they?

116:38:45 Schmitt: No, not in my way.

116:38:47 Cernan: Pretty good. Let's...

116:38:49 Schmitt: (Garbled) though. Do you want to put this (garbled)?

116:38:53 Cernan: Yeah. (Pause) That's probably a little bit better.

116:38:58 Parker: 17, Houston. Over.

116:39:00 LM Crew: (Garbled)

116:39:03 Schmitt: Go ahead, Houston.

116:39:05 Parker: Roger. We're still seeing the commander's Suit Disconnect valve's in Connect. (Pause)

[Houston has noticed that the valve setting is incorrect. There is some telemetry from the ECS but very

little from the suits: water and oxygen quantities and water temperature, only.]

116:39:14 Schmitt: (Responding to Houston after changing Gene's Suit Isolation valve) How's that? (Pause)
 116:39:17 Parker: Yep, there it goes. We got it. Thank you.
 116:39:22 Cernan: Okay, Bob. (Pause) (To Jack) Okay. We got to get the PLSS fan on. Don't forget that's (operating on PLSS) battery power. (Reading) We can don our helmets, check our drink bags, don our LEVA's, protective visors, secure our tool harness. (Pause) Our O2 umbilicals are already stowed. CDR's under the handhold. Verify the following. Now, where we pick up our...(Pause)
 116:39:54 Schmitt: Have to put the helmets on, I think.

[Schmitt - "The helmet itself was a clear plastic bubble with a padded head rest inside at the back. The Lunar Extravehicular Visor Assembly (LEVA) was everything else that sat on top on the helmet. It contained the sun visors and also passive thermal protection."]

116:39:56 Cernan: Okay, yep. Then we pick up our gloves.
 116:39:58 Schmitt: I reckon.
 116:40:00 Cernan: Yep, there it is. Okay. Well, let's do one at a time here.
 116:40:05 Schmitt: That's mine.
 116:40:06 Cernan: That's yours. Okay. Do you want to turn your (PLSS) fan on for circulation (in the suit)?
 116:40:11 Schmitt: Well, I guess I better. Fan's on.
 116:40:13 Cernan: I'll pull this out just to get it out of your way.
 116:40:15 Schmitt: Okay. (Pause)
 116:40:24 Cernan: Okay. Okay. All your candy bars and lemonade, and all that jazz are all clear. Water, I should say. (Pause)

[Cernan - "We were going to be locked in the suit for maybe nine hours and we had a little water bag that we suspended from the inside rim of the suit. The bag hung on your chest and had a little one-way valve on the top of it so that you could turn your head and take a drink. It was like sucking on a nipple. And then we also had one of these high protein or high calorie sticks shaped like a ruler. It was a soft stick and you could chew it. We had it inside a little bag, and it was probably about eight inches long. It, too, was velcroed just inside the helmet ring and we could put our chin down and pull a little bit out with our teeth, take a bite, chew it for some energy. It was typical candy-tasting stuff. It was nice to be able to suck up a few ounces of water now and then and have something to chew on. That was it; I mean, we had no way of eating or drinking anything other than that. But having some water and a little candy was a real help; it really was. I remember that both the 15

and 16 crews had trouble with their drink systems. We didn't have any problems that I can remember; and I remember that, in training, it had to do a lot of times with the way you placed the bag. I don't think there were any great design changes; although, maybe, the one-way valve was worked over."]

[The in-suit drink bag was first used on Apollo 14. On Apollo 15, both Scott and Irwin had trouble getting theirs to work properly. Post-flight testing indicated that "the problem was associated with the positioning of the insuit drinking device within the suit.. After each EVA, the insuit drinking device was removed from the suit and all of the water consumed, thus verifying proper operation of the insuit drinking device valve. Ground tests using suited subjects and other equipment configurations indicated that the existing equipment provides the optimum configuration. The tests also showed that personal experience is essential to obtaining optimum individual positioning. Crew training is to include more crew experience in making the position adjustment required for the individual's needs."]

[After Apollo 16, the crew wrote that "on each occasion that the drink bag was installed in the suit, the crew encountered leakage due to interference between the drink bag nozzle and the left microphone boom. In the case of the Lunar Module Pilot, this interference resulted in an estimated 4 to 5 ounces of orange juice leaking on (the inside of) his helmet, his face, and the pressure suit neck ring. After the second EVA, the effect of leaking orange juice on the neck rings of both crewmen caused both pressure suit helmets to be practically impossible to remove. It was necessary to thoroughly clean the helmet neckring with water to remove the orange juice. The drink bags carried in the suit are a necessity to provide the crew with liquid while they are working 7 to 8 hours on the lunar surface, but the bags must not leak." The Apollo 16 mission report is otherwise silent on the matter of the drink bags and it seems likely that an effort was made prior to Apollo 17 to make sure that the crew understood exactly how to position the bags to avoid either the Apollo 15 or the Apollo 16 problems. The effort was successful, because neither Gene nor Jack had any troubles with their drink bags. Note that the Apollo 15 and 17 crews had water in their bags. Because of heart irregularities noted in both Scott and Irwin - although far more noticeably in Irwin - which were ultimately traced to a potassium deficiency, the Apollo 16 crew had potassium-laced orange drink in their drink bags. However, because of the problems they had with the sticky juice, Gene and Jack got their extra potassium in their meals and used only water in their drink bags.]

116:40:40 Cernan: Mmm. That sounded good.

[There is a solid, audible click as Jack's helmet locks into place.]

116:40:42 Cernan: Okay. Try it. Okay. It looks good here, Jack. (Pause) Okay. (Do you) want your LEVA?
 116:40:51 Schmitt: Guess so.
 116:40:56 Cernan: Okay. Enjoy it in there; you're going to be in there for a few hours.
 116:41:01 Schmitt: Can't think of any place I'd rather be right now.
 116:41:04 Cernan: Sounds like you're in there, too. Oh, too far back. Okay, that's better. (Pause) I'm freezing my "you-know-what" off.
 116:41:16 Schmitt: Me, too. (Both Laugh)

[They are still pre-cooling themselves with spacecraft water.]

116:41:19 Cernan: Okay. Does that look lined up to you?
 116:41:21 Schmitt: Looks pretty good.
 116:41:23 Cernan: Okay. Let me...
 116:41:24 Schmitt: Wait a minute. (Pause)
 116:41:30 Cernan: (Grunting) Let me get this down around. Okay. That's around behind you; thermally protected back there. That's below the OPS hose.

[Gene is adjusting the back flap of Jack's LEVA.]

116:41:43 Schmitt: Right now, I'm hoping to get out of this warm. (Laughs)
 116:41:47 Cernan: Okay. You're thermally...Let me double check that. The helmet is locked. Your visor is locked. It's one thing you don't want to lose among some others. (Pause) Okay. Okay, you want to give me a hand?
 116:42:11 Schmitt: Not particularly. (Laughs)
 116:42:15 Cernan: (Possibly referring to something that's blocking the neck ring) Oh, man. Where did that come from?
 116:42:20 Schmitt: Watch your nose, drink bag, candy bars, popcorn! (Pause) Click, click, click.
 116:42:33 Cernan: Squeeze hard back there.
 116:42:35 Schmitt: Want your fan (on)?
 116:42:36 Cernan: Yep.
 116:42:39 Schmitt: Looks good.
 116:42:40 Cernan: Okay. I can hear the fan running. Oh, man. Whew! (Long Pause) Looks good here.
 116:43:21 Schmitt: Yeah. That's all right.
 116:43:23 Cernan: There you go.
 116:43:25 Schmitt: It's new. Never been used before!
 116:43:27 Cernan: Make sure that (LEVA) flap in back goes below that OPS hose. (Pause)
 116:43:36 Schmitt: Want to put your protective visor down? (Pause)
 116:43:44 Cernan: Yeah, if you got that thing all...You got it all down?
 116:43:47 Schmitt: Yep.

116:43:49 Cernan: You happy with it (the LEVA flaps) back there?
 116:43:50 Schmitt: Yes, sir. You're nice and protected.
 116:43:52 Cernan: Okay.
 116:43:54 Schmitt: Good Velcro. Okay. You're all covered here.
 116:43:59 Cernan: Okay. Not my other one is it? No.
 116:44:01 Schmitt: No.
 116:44:02 Cernan: Okay. Ohhh! (Pause) I think we've got to get tool harnesses here. "Don LEVA's." Look at that scratch right in the middle of that thing. Okay. "Don LEVA's and lower protective visor."
 116:44:21 Schmitt: Okay.

[They are near the bottom of checklist page 2-9.]

116:44:22 Cernan: "Secure harness and self-doff straps."
 (Pause) Okay. Stay where you are. (Pause) Can't miss it.
 (Pause) Okay. "Stow the LM 02 (hoses). And comm (cable)."
 Okay. They're all stowed; everything except (LM) water (hoses), right?

[The self-doffing straps are secured to the side of the visor assembly and can be used to release the tool harness.]

116:45:12 Schmitt: Okay. Verify the following. "Check your helmet and visor."
 116:45:17 Cernan: Okay. You check me. I'll read them. "Helmet and visor, aligned and locked."
 116:45:22 Schmitt: Okay. That's locked.
 116:45:23 Cernan: Okay. 02 cover's all locked. There's a peek at them.
 116:45:28 Schmitt: That's locked.
 116:45:31 Cernan: "Purge valve"; everything down there.
 116:45:33 Schmitt: That's locked; that's locked.
 116:45:36 Cernan: "Comm carrier."
 116:45:37 Schmitt: Stand by. That's locked.
 116:45:39 Cernan: Okay. "Diverter Valve is vertical."
 116:45:41 Schmitt: Comm is that way. Diverter Valve is vertical.

[With the selector in the vertical position, Gene is getting all of his oxygen flow into his helmet. With the valve in the horizontal position, he would direct part of the air flow into the torso.]

116:45:43 Cernan: (Checking Jack's suit) Okay. One more time. Your helmet is locked; purge valve, locked. Yep. That (O2 connector)'s locked; that's locked; that's locked. And, let me see (the comm connector). Let me see! Yes sir, and that's locked. Don't let anything to chance (pause) today. And the Diverter Valve is vertical.
 116:46:25 Schmitt: Okay. Comm; you checked, too.
 116:46:29 Cernan: Yes, sir.

116:46:30 Schmitt: Okay. Verify your old white dots.
116:46:32 Cernan: Okay. Old white dots. My old white dots
(pause) look good to me.

[Cernan - "I think that, in order to make things easier and save time, all of the circuit breakers that had to be opened for an EVA were indicated with a white dot (on checklist pages 1-4 and 1-5). That way we could just go down the panel and shut off all of the things that we didn't want running while we were out on the surface. And all the switches that had to be changed had decals on them to show the proper EVA positions. It not only saved time, but it also cut down on mistakes; it was a lot riskier to read down a list of breakers that had to be pulled and switches that had to be thrown than to just take care of all the ones with white dots or decals. You'd done all the thinking ahead of time and, when it really counted, you almost didn't have to do any thinking."]

116:46:38 Schmitt: (Can you) move a little?
116:46:40 Cernan: Yeah, I'll move.
116:46:41 Schmitt: Okay.

[Jack needs to turn so that he can look at his circuit breaker panel. With both of them in suits and wearing PLSS's, there isn't much room to spare and Jack needs to have Gene change his position slightly so that he can turn.]

116:46:42 Cernan: Got it. (Pause) I'm going to miss Danny being out there to hand us those light PLSS's.
116:46:48 Schmitt: That's right. (Pause)

[This is a reference to training exercises. They had practiced donning full-sized PLSS's inside the LM and then trade those for smaller, lightweight units once they were outside. Danny Schaiewitz was the engineer who handed them in. He worked for the manufacturer, Hamilton-Standard. According to Ed Brisson, who headed up the Hamilton Standard operation at the Cape, Schaiewitz was well liked by the crews and socialized with many of them. Some of the other suit techs and engineers who were involved in Apollo 17 were Hamilton-Standard employees Jeff Robert, Ray Arnold, Gerry Goldstein, and NASA employees Al Rochford, Byron Smith, and Troy Stewart. The NASA engineers who made up the so-called Integration Team and made sure that the equipment and procedures used in training and in flight were all compatible included Dave Ballard (Team Leader), Terry Neal, Ray Malone, John Covington, Dan Bland, Ron Blevins, and Jim Ellis. This list was provided by Brisson and Rochford with additional information from Neal.]

116:46:55 Schmitt: You want it?
116:46:57 Cernan: Okay. I want the EVA decals, also, Jack.
116:46:59 Schmitt: Yup.

116:47:00 Cernan: White dots plus decals.
 116:47:02 Schmitt: Rog.
 116:47:04 Cernan: Okay, Bob, we're turning the page (that is, turning the cue card over).
 116:47:07 Parker: Roger. We're right with you. (Long Pause)

[In the Surface Checklist, they are in the middle of the righthand column of page 2-9.]

116:47:24 Schmitt: Okay. "Don EV gloves".
 116:47:25 Cernan: Okay; on...
 116:47:27 Schmitt: Is that it?
 116:47:29 Cernan: That's it. "Don EV gloves." Doing a little greasing in here.

[Gene used lubricants on both the wrist rings and on his hands to protect them from abrasion. Here, he is probably greasing one of his hands. Jack used nylon glove liners in an effort to protect his hands. Note that Gene and Jack have taken care of all of the circuit breakers and switches prior to donning the bulky gloves.]

116:47:36 Cernan: (Reading) And make sure your "wrist locks are locked. Glove straps adjusted and cover the wrist rings!" Golly. (Long Pause) I sure missed hearing it click, but they are locked. One of them is, anyway. (Pause) Okay, Jack. I verify...
 116:48:20 Schmitt: (Laughs)
 116:48:21 Cernan: What?
 116:48:26 Schmitt: Guess what?
 116:48:28 Cernan: They don't go on any easier in one-sixth g, do they?
 116:48:30 Schmitt: They break just as easily, too.

[One of the glove tie-straps may have broken. If so, it is a matter of no great importance.]

116:48:33 Cernan: Okay, I've got my one glove locked. One of the old dust covers.
 116:48:43 Schmitt: I never had that happen in training; you did.
 116:48:47 Cernan: It's locked. That's about as locked as it can go. Boy, I'd hate like the devil to have that (glove lock ring) pop open. Okay; that's very good. You want me to help you with one, or can you get it?
 116:49:04 Schmitt: Well, I don't know. I've only worked on one so far.
 116:49:08 Cernan: I've got a free hand before I grease it up.

[Cernan - "I'd gotten one of my gloves on at this point, so this was my last chance to help Jack with an ungloved hand."]

116:49:19 Schmitt: (Referring to the broken glove strap) I broke that one. (Pause)

116:49:25 Cernan: I'm telling you, from the looks of that soil out there, that drill may have a job ahead of it.

116:49:29 Schmitt: Yeah, I didn't have a chance to mention that. I don't think the regolith is very thick, and I think you've got rocks below it. (Pause)

[During this EVA, Gene will drill three 2.5-meter-deep holes, two for a heat-flow experiment and one for a deep core. If the soil layer had been thinner than 2.5 meters, Gene would have had a difficult drilling task ahead of him. However, as Gene's drilling and other bits of information will show, the soil is actually about 5 meters deep and he will have relatively little difficulty.]

116:49:37 Cernan: You got that?

116:49:38 Schmitt: Well, how does it look?

116:49:40 Cernan: Let me take a look. (Pause) No.

116:49:45 Schmitt: Didn't make it, huh?

116:49:47 Cernan: Yeah, well, let me...Hold your hand up here. Hold it up here.

[Gene is helping Jack don his glove.]

116:49:53 Cernan: Looks good on my side. How is your side?

116:49:55 Schmitt: Good over here.

116:50:56 Cernan: Okay. Let me pull this (wrist cover) down for you. (Pause) Okay?

116:50:08 Schmitt: Thank you.

116:50:12 Cernan: Get the old other hand. (Long Pause)

116:50:52 Schmitt: Okay. That's locked. (Pause)

116:51:03 Cernan: And my other glove is locked. (Pause) Now for the fun in back. (Laughing) Oh, me; oh, my. (Pause)

[Gene may be having trouble with one of his own glove straps.]

116:51:24 Schmitt: I think I got it! I think I got it. (Pause)

116:51:37 Cernan: Pull it and let go. Isn't that the word?

116:51:39 Schmitt: That's what they tell me. Want me to get it?

116:51:41 Cernan: I got mine...No, I got it. Verified your's locked?

116:51:44 Schmitt: Yes, sir.

116:51:45 Cernan: Okay. Both my gloves are verified locked. (Pause) How does that grab you?

116:51:54 Schmitt: Okay; feels good.

116:51:57 Cernan: Is your mirror on tight enough? Checklist on tight enough. (Pause) That's the best I can do; I guess.

[Here, Gene is referring both to a small mirror that Jack has strapped to his left wrist (along with a watch) and to the cuff checklist on this other arm. The mirror, which is used to see things on the front of the suit) is discussed in more detail at 163:19:53.]

116:52:19 Cernan: Okay.
 116:52:20 Schmitt: Now what?
 116:52:22 Cernan: Wrist rings are covered. "Note if PGA biting." No, mine's all right. Your's okay?
 116:52:26 Schmitt: No; it's fine.

[They are both now sealed inside their suits but have not yet pressurized their suits with PLSS oxygen. The PLSS fans are on and, as air moves through the backpacks and carbon dioxide is removed by the LiOH canisters, the suit pressure decreases and the suits can slowly collapse around them and "bite". The Apollo 12 crew experienced some discomfort at this stage and suggested that, if other crews had the same problem, they briefly turn the PLSS oxygen on to partially inflate the suits and alleviate the biting.]

116:52:27 Cernan: Okay. "LGC (Liquid Cooled Garment) cold as required." We been on cold all this time, right?
 116:52:30 Schmitt: Yes.

[Cernan - "During my Gemini Flight we had tried to use the flow of oxygen through the suit for cooling but decided that that wasn't adequate. So we developed the liquid-cooled garment. The way it worked was that the PLSS had two separate supplies of water. One was a closed-loop supply which was moved by a pump through the liquid-cooled garment. Then you had a sublimator which had another, physically-separate, open-loop supply of water. There was a cooling coil in the sublimator where the water in the closed loop could transfer heat to the open-loop supply and a diverter valve that determined how much of the suit water went through the coil. Because the open-loop supply was allowed to sublime into the vacuum, it cooled the coils and the closed-loop supply. You could divert around that sublimator if the suit was too cold or you could divert through it and get more cooling. Here, as we've already discussed, we had the sublimator turned off and were running cold LM water through the LCG, cooling down before we disconnected the LM water. We didn't turn the sublimators on until we got the hatch open."]

116:52:31 Cernan: Okay. Guess you can open that breaker, and I'll stop shivering. (Laughs)
 116:52:34 Schmitt: Okay.

[Jack is turning off the flow of LM water by pulling the LCG circuit breaker open.]

116:52:36 Cernan: And, we can disconnect the LM water hoses. Let's help each other with those, so we don't screw up the other hoses.

116:52:42 Schmitt: Okay; breaker's open.

116:52:43 Cernan: Okay.

116:52:44 Schmitt: Let me turn around this way.

116:52:45 Cernan: Okay. Go ahead and I'll... (Pause)

116:52:52 Schmitt: Okay. You want to get mine or you...

116:52:54 Cernan: No, I'll get yours.

116:52:55 Schmitt: Okay.

116:52:56 Cernan: Okay. First of all I'm going to take that (LM water hose) off. (Pause) (Connecting Jack's PLSS water hose) Okay. Now let me get your other one. There it is. Okay. We did this before. Stand right there. (Pause) It's locked, Jack.

116:53:27 Schmitt: Okay.

116:53:28 Cernan: It is locked. (I'll) get the (dust) cover on. (Pause) Okay. The cover is on. Okay. Yours off?

116:53:43 Schmitt: Get that in a second.

116:53:44 Cernan: Okay. Yours is just laying there, too.

116:53:49 Schmitt: Okay. Hang on.

116:53:50 Cernan: Okay. I'll push towards you. Make sure that thing falls in the hole, because yours didn't right away. (Pause) Did it fall in?

116:54:07 Schmitt: Yeah. Yeah, it's in the hole. Okay.

116:54:13 Cernan: Dust cover on?

116:54:15 Schmitt: Dust cover's on.

116:54:16 Cernan: And my PGA is going to start biting here if we don't get going. (Pause) Okay. "PLSS diverter..." I've got to turn my oxygen on a second, Jack.

116:54:29 Schmitt: Yeah, so do I. (Pause)

[They are adding a little oxygen from the PLSS tanks to slightly inflate the suits.]

116:54:32 Cernan: (Feeling the PLSS controls) That. That. There it is. Okay. It's on. (Pause)

116:54:44 Schmitt: A little hard to get it off, isn't it.

116:54:45 Cernan: Yeah. Okay. Mine is back off.

116:54:47 Schmitt: Yeah, mine is (too).

116:54:48 Cernan: Okay. "PLSS Diverter Valve, Min; verify."

116:54:56 Schmitt: Okay. Mine's Min.

[They are making sure they are in the minimum cooling setting.]

116:54:58 Cernan: Okay. "PLSS Pump, On." That's to the right.

[The pump moves the closed-loop supply of PLSS water through the Liquid-Cooled Garment.]

116:55:03 Cernan: "Pressure Reg's A and B, Egress."

[Cernan - "We were telling the spacecraft ECS system that we were going into an Egress mode and are about to depressurize the cabin on purpose.."]

116:55:06 Cernan: I think we're already at Egress.

[Houston had requested the changed setting at 115:29:10.]

116:55:07 Schmitt: Pump's on. We're in Egress.

116:55:10 Cernan: Okay, my pump's on. I can feel it running.

116:55:12 Schmitt: Keep talking.

[They are now finished with checklist page 2-9 and are about to start a suit pressure integrity check at the top of page 2-10.]

116:55:13 Cernan: Pressure integrity check. Okay. "PLSS 02, On." You ready for this?

[They will inflate the suits so that they can check for leaks while the cabin is still pressurized.]

116:55:19 Schmitt: I hope so.

116:55:20 Cernan: Okay. PLSS 02 On. Mine's on.

"Pres(sure) Flag and 02 Flag (will) clear, 3.1 to 3.4 (psi)."
(Pause) Okay. I'm coming up. I know that. (Looking at his watch) Gee, it's 10 minutes to 6 at home.

[That is, it's 6:10 PM Central Standard Time in Houston. Gene and Jack may be resetting their watches to 12 o'clock. The cuff checklist indicates planned EVA elapsed times at which various activities are to start and, by setting their watches, they will not have to depend on Houston to know what the elapsed time is. They will start the watches once they complete the pressure check and begin the final depressurization. There is no mention of watch resetting anywhere in the checklist, but there is an entry at final depressurization that reads "Start Wrist Watch :00." The figure ":00" is the EVA elapsed time of zero minutes. See Gene's comment at 118:29:57.]

116:55:46 Schmitt: Okay.

116:55:48 Cernan: Okay. I'm still coming up (in pressure).

116:55:50 Schmitt: Keep coming up. Just got mine on.

116:55:54 Cernan: Oh, okay. Well, I'm ahead of you then.

(Pause) Okay. The Press Flag will clear 3.7 - correction - 3.1 to 3.4 (psi).

116:56:06 Schmitt: What do you want me to do when I'm pressurized?

116:56:08 Cernan: Well, we want to make an integrity check.
 116:56:10 Schmitt: Yeah; but then what?
 116:56:11 Cernan: Can you reach those (LM) water hoses
 right there? By chance? Before you get too hard?

[The suits get relatively inflexible once they are
 inflated, making it even more difficult to turn or bend.]

116:56:21 Cernan: Stow them out of the way. Okay. When
 you get...When you get up...Okay. Press Flag cleared on the
 commander. (Pause) Okay. The 02 Flag did not clear. I'm
 at 3.8...Okay. 02 Flag cleared on the commander.
 116:56:48 Schmitt: Still got an 02 Flag on the LMP.
 116:56:50 Cernan: Okay, you're not up (to 3.1 to 3.4 psi)
 yet; I suppose.
 116:56:52 Schmitt: No.
 116:56:58 Cernan: Okay. I'm going to take my PLSS 02 Off
 for one (minute). Counting 1 minute; 57. Let me know when
 you're up, Jack, and I'll give you a minute hack.

[They will turn off the PLSS oxygen supply and spend a
 minute looking for indications of suit leaks.]

116:57:09 Schmitt: Okay. I'm clear.
 116:57:11 Cernan: Okay. You up?
 116:57:12 Schmitt: Yep.
 116:57:13 Cernan: You can turn your PLSS 02 off any time.
 Let me know when. Can you reach it? If you can't, I'll get
 it for you. (Pause)
 116:57:29 Schmitt: Why don't you get it.
 116:57:31 Cernan: Okay. (Pause) Okay; Mark it.
 116:57:35 Schmitt: Okay.
 116:57:37 Cernan: You're on the 30-second mark, and I'm on
 the minute mark.

[The second hand on Gene's watch was at 0 when he
 started his integrity check and at 30 seconds when Jack's
 started.]

116:57:39 Schmitt: Okay, and I'm at 3.8.
 116:57:42 Cernan: Okay. I'll give you a hack
 when...(Pause) Okay. I'm coming up on 45 seconds. (Pause)
 Okay. I'm one minute; I'm going back on. Okay, Houston.
 Commander went from 3.8 to about 3.67. I'll get yours on
 when you need it on, Jack.

[This slight decrease in suit pressure is normal and
 indicates good suit integrity. The decay is due partly to
 the fact that it takes the oxygen a while to fill all the
 nooks and crannies, and partly to breathe-down. Once they
 start a continuous flow of oxygen, the PLSS will maintain a
 pressure of about 3.8 psi.]

116:58:19 Parker: I copy that, Commander.

[They are still only 20 minutes behind schedule.]

116:58:26 Cernan: Okay. And we'll pick Jack up here in about 10 more seconds.
 116:58:29 Parker: Okay. (Pause)
 116:58:31 Cernan: Okay, Jack. I'm turning on. Did you mark it?
 116:58:35 Schmitt: Okay, Houston; 3.8 to 3.6. (Pause)
 116:58:45 Schmitt: Hello, Houston; you copy the LMP?
 116:58:47 Parker: Roger. Copy the LMP. Okay; and Challenger...
 116:58:51 Cernan: Okay. Standing by for your Go for depress.
 116:58:53 Parker: (Already prepared to give permission) You'll be glad to know you are Go for depress.
 116:58:57 Cernan: Thank you, Robert. I understand we are Go for depress.
 116:59:00 Parker : That's affirm.

[A little formality in the proceedings, The only one after the permission to stay for T-2.]

116:59:01 Cernan: Okay, Jack. Can you reach the front (dump) valve, or do you want me to (get the overhead dump valve)?
 116:59:06 Schmitt: Well, let me turn around here.
 116:59:08 Cernan: Okay, on (circuit breaker panel) 16...First, around on 16. Cabin Repress, Open.

[They are pulling a circuit breaker on panel 16 so that the LM's oxygen system won't try to repressurize the cabin when they open the dump valves in the forward and overhead hatches.]

116:59:16 Schmitt: Okay; 16...
 116:59:18 Cernan: Cabin Repress, Open.
 116:59:21 Schmitt: Circuit breaker is coming open.
 116:59:22 Cernan: Okay, and Cabin Repress valve, Closed on the panel.

[The repress valve is behind Jack's station on the right side of the cabin.]

116:59:25 Schmitt: Okay. The valve is closed.
 116:59:27 Cernan: Okay. If you can't reach it (the dump valve on the forward hatch), I guess I can.
 116:59:31 Schmitt: Okay. I just had a momentary tone.
 116:59:32 Cernan: So did I. I got it, too.
 116:59:33 Schmitt: Okay.
 116:59:34 Cernan: I think it was when you closed the Repress valve. (Pause) Can you reach it (the forward dump valve)? If not, I'll reach the overhead one.

116:59:42 Schmitt: I think you better reach the overhead one.

[Opening the dump valve in the forward hatch requires bending over slightly against suit pressure. Reaching the overhead valve requires raising an arm and can be a less difficult maneuver in the cramped confines of the LM, especially for a six-footer like Gene.]

116:59:45 Cernan: Okay. Slip over to your right. Some more. Let me turn here. (Pause) Wait a minute, I got to turn (to reach the overhead valve).

[Jack must be facing inboard. Gene wants him to lean toward the window so that Gene can reach behind him to get the overhead valve. In order to reach up with his right arm, Gene must also be facing inboard.]

117:00:05 Schmitt: Okay. How far down are we going to take it? 3.5 (psi), right?

117:00:08 Cernan: Yeah, wait a minute. I'm not there yet.

117:00:10 Schmitt: Well, I just want to make sure that I'm watching (the cabin pressure gage).

[While Jack watches the cabin pressure gage, Gene will open the overhead valve and let the pressure decrease from 5 psi to 3.5 psi. At that point, he will reclose the valve by putting it in the Auto position. In Auto, the dump valve will open only if the cabin pressure exceeds 5.4 psi. The suit pressure regulators will try to track the decreasing cabin pressure, and keep the difference at 3.9 psi. Because of a finite response time, the relative suit pressure will go up initially - to about 5.3 psi - and then decay. This is a last test of suit integrity prior to full cabin depressurization.]

117:00:14 Cernan: Okay; now. Okay, coming open. You ready? You reading the checklist?

117:00:19 Schmitt: Stand by Auto. (Cabin) Repress (valve) is Closed.

117:00:24 Cernan: Say when.

117:00:25 Schmitt: Okay.

117:00:27 Cernan: You ready?

117:00:28 Schmitt: Wait a minute, wait a minute, wait a minute.

117:00:29 Cernan: Okay.

117:00:30 Schmitt: Got the wrong place (in the checklist).

"Open, then Auto at 3.5." Okay; go ahead.

117:00:37 Cernan: Okay. Here it comes. I can see daylight through it.

[Cernan - "The valve, as I recall, was just a little circular disk that was held against a seal by the pressure in the cabin. It had a little lever and I could get enough

mechanical advantage to crack it a little bit and vent some of the air. I want to remember that we had some screw-type vents on the hatch of the Command Module; but I'm sure that this LM valve wasn't like that. Nothing in the LM was very fancy unless it absolutely had to be. Everything had to be as lightweight as possible, and that usually meant very unsophisticated designs."]

[The valve is a bit more complex than Gene remembers it but, still, is basically a simple device.]

117:00:40 Schmitt: Okay, it's coming down. Okay. That's four (psi). Stand by.
 117:00:53 Schmitt: Mark. 3.5.
 117:00:54 Cernan: Okay. It (the overhead valve)'s off.
 117:00:57 Schmitt: Okay. And your cuff gage should not be below 4.6, and mine's at...
 117:01:03 Cernan: Mine's at 5.0.
 117:01:04 Schmitt: 5.1. (Pause)
 117:01:10 Cernan: Okay?
 117:01:12 Schmitt: Okay. The suit circuit is locked up at 4.5.

[The Suit Circuit Relief Valve is in the Auto position and will open only if the suit circuit pressure is greater than about 4.3 psi. Note that the suits were disconnected from the suit circuit when Jack closed the Suit Isolation Valves at 116:33:21 and 116:39:14.]

117:01:15 Schmitt: We're at 3.5 (psi cabin pressure) and holding. And I'm decaying. I'm below 5.
 117:01:26 Cernan: So am I.

[Pressure regulators on the suits are gradually reducing the pressure difference to 3.8 psi.]

117:01:27 Schmitt: Verify that; okay.
 117:01:31 Cernan: Okay. I'll start my watch.
 117:01:35 Parker: Okay. We verify and we're counting.
 117:01:38 Schmitt: Watches started.
 117:01:41 Schmitt: Okay. "Overhead or Forward Dump Valve, Open".

[They will now reopen the dump valve and let the cabin pressure fall to zero. This is the start of the EVA.]

117:01:44 Cernan: Okay. Here it comes.
 117:01:46 Schmitt: And it's going down.
 117:01:47 Cernan: You going to want me to put this in Auto afterwards or not? So, I can turn around, Jack.
 117:01:57 Schmitt: Stand by.
 117:01:58 Cernan: (Garbled) Open...
 117:01:59 Schmitt: (Garbled)...
 117:02:01 Cernan: ...leave it Open.
 117:02:02 Schmitt: Leave it Open.

117:02:03 Cernan: No, we don't (put it in Auto), because then we don't want that hatch to get closed. (Pause)

[Cernan - "We wanted to leave the dump valves open because we were going to close the hatch for thermal reasons while we were outside. By leaving the dump valves open, we were making sure that, if any air bled into the cabin for any reason, then pressure couldn't build up inside the LM and make it tough to get that hatch open. Now, I also think that we did have an ability to open the dump valve (in the forward hatch) from the outside. I really believe we did, as I remember. But it was obviously still safer to leave the dump valves open."]

117:02:09 Cernan: I got to turn around here. Oh, boy!
(Long Pause)

117:02:33 Cernan: Boy, you sure get heavy (meaning "stiff") at 5 (psi), don't you?

[As the cabin pressure drops, the relative suit pressure increases for a while.]

117:02:36 Cernan: Okay. Where are we (in the checklist)?
(Pause)

117:02:44 Schmitt: We're right here, huh? (Pause)

[They are at the top of the righthand column on page 2-10, waiting for the cabin pressure to drop low enough - about 0.2 psi - that Gene can open the hatch.]

117:02:55 Cernan: What that was...(Pause)

117:03:02 Cernan: What's cabin (pressure), Jack? (No answer) Do you read, Jack?

117:03:11 Parker: Jack, this is Houston.

117:03:12 Cernan: Wait a minute.

117:03:13 Parker: CDR, we're not reading the LMP either.

117:03:16 Cernan: Now, how do you read, Jack?

117:03:20 Schmitt: Okay. You're loud and clear.

117:03:21 Cernan: Okay. (Pause)

117:03:23 Schmitt: We got a switch in the wrong place as usual, Bob.

117:03:27 Cernan: I just hit the Mode Select; that's all.

117:03:28 Parker: Okay. We copy.

117:03:30 Schmitt: Okay. "Partially open the forward hatch", when we can.

117:03:33 Cernan: Okay. Can you zap over to the left as much as you can?

117:03:37 Schmitt: To the right, you mean?

117:03:39 Cernan: Yeah. To the north.

[Jack must be facing forward now.]

117:03:40 Schmitt: To the north.

117:03:41 Cernan: The north.

117:03:42 Schmitt: The north. (Both laugh) Okay, it's about 0.2 (psi), Gene.

[Fully open, the overhead dump valve will reduce the cabin pressure from 5 psi to 0.08 psi in 180 seconds. The corresponding depressurization time for the forward valve is 310 seconds. Including the 17 seconds used to bleed the cabin to 3.5 psi, they are now 141 seconds into the depress.]

117:03:48 Cernan: Okay. Let me...

117:03:49 Schmitt: You going to be able to get to it?

117:03:50 Cernan: Yep. (Pause) You betcha. I've come this far. I'm not going to miss getting that hatch open. (Pause)

[Cernan - "The lunar module, in contrast to the command module, was nothing but a tin can that buckled when you pressurized it; a light-weight tin can just strong enough to hold the pressure we needed. When we depressurized the LM, all the skin surfaces relaxed; and when we got back in and pressurized, the hatch would bow out and you could sort of feel and see the panels bow out. The hatch was nothing but a flimsy little piece of metal with a seal on it. And it didn't have a big fancy lock. It just had a little lock like you might find on a barn door: a little lever that fit into a slot. You didn't really have to lock it, because the pressure held it closed."]

117:04:01 Schmitt: Hey, something just flew out (the hatch).

[Jack is probably looking out his window and has seen a bit of debris and/or ice expelled by the escaping air. They are about 153 seconds into the depress.]

117:04:03 Cernan: It's open now.

117:04:04 Schmitt: Gosh, look at those trajectories. (Laughs)

117:04:06 Cernan: Yeah. Put just enough air in here, we're...Okay; it's open, babe.

117:04:11 Schmitt: Okay.

[Gene has pulled the hatch open against about 0.2 psi of cabin pressure, and that is enough of a pressure difference to create a noticeable wind blowing out the hatch. The flow of air is visible because the moisture in it turns to ice crystals as it expands, and also because the wind picks up stray bits of paper and/or other debris.]

117:04:12 Cernan: It is open. (Pause)

117:04:18 Schmitt: Okay. "Final prep, PLSS (sublimator) primary H2O." I've got to figure out how to open that now.

117:04:25 Cernan: Okay. (Pause) When you're at 5 psi, it's (hard to reach the PLSS controls)...

117:04:40 Schmitt: We never did really train for this in the right way.

117:04:44 Cernan: Yeah, we did.

[Schmitt - "I know I had done this once in the KC-135 aircraft, but I don't remember whether or not that was an actual training exercise. We only got about 20 seconds at a time of 1/6-g in the airplane. And maybe we never even tried to open the PLSS (sublimator) water valve for lack of time. It was certainly harder on the Moon."]

[Cernan - "Another explanation is that we may not have trained with a 3.5 psi pressure difference. If not, then we wouldn't have had 5 psi suit pressures at this point in training."]

117:04:46 Schmitt: Okay. My water is Open.

117:04:48 Cernan: And my water is Open. (Pause; breathing heavily) Okay. Well, let's see; "Rest until cooling sufficient; 3.7 to 4.6 (psi)." I'm to 4.9; coming down.

117:05:11 Schmitt: Yeah, I am, too. Coming down.

[Cernan - "When you moved around, like we were here, inside the lunar module, and then when we were getting out and going down the ladder, it was work even in 1/6 gravity. We had heart rates going up at times, on the lunar surface, to 140 beats a minute. And I think probably through most of the EVA that I did breathe heavy because I've got a fairly good lung capacity - I've never smoked - and I tend to do that. Throughout many of these tapes on the lunar surface activity, you'll find me taking deep breaths and sounding like I'm "breathing heavily". But it really isn't labored breathing so much as me just taking fairly deep, open-mouthed breaths."]

117:05:12 Cernan: CWEA (Caution and Warning Electronics Assembly) status. Preamp's and ECS. Can you see that?

117:05:16 Schmitt: See a Preamp's, and I see ECS. Barely.

[Schmitt - "The ECS light came on in response to cabin depressurization. The fact that it came on confirmed that we were depressurizing; and showed that the warning system was working properly."]

117:05:17 Cernan: Okay. Water Sep Component Light, On.

117:05:22 Schmitt: Water...Excuse me, Water Sep.

[The water separator is a centrifugal device used to control humidity in the suit circuit.]

117:05:25 Cernan: Well, the next thing it says is that Gene gets out.

117:05:29 Schmitt: I don't see that.

117:05:32 Cernan: That's what it says on my (cuff) checklist. (Pause)

[They have completed all the steps on the EVA Prep cue card. Their EVA checklists are quite different, reflecting the division of tasks. Gene is on EVA-1 cuff checklist page CDR-6 and Jack is on LMP-6.]

117:05:38 Schmitt: Okay. Good heavens!
 117:05:40 Cernan: That means you got to get out of the way so I can open the hatch.
 117:05:44 Schmitt: Well, I'm going to have to turn around a little, I think, so I can help you.

[Jack will turn from facing forward to facing left so that he can reach over the open hatch (the top is waist high) and help push Gene down below the instrument panel.]

117:05:47 Cernan: Okay. (Pause) Boy, beware of that corner.
 117:05:53 Schmitt: This high pressure... (Laughs)
 117:05:55 Cernan: Yeah. I tell you at 4-1/2 (psi), you're really pretty heavy (means "stiff").
 117:05:58 Schmitt: What was that that came shooting up here? A piece of bread? (Laughs) Would you believe that?
 117:06:04 Cernan: Yeah, I'd believe it.
 117:06:07 Schmitt: Why is our hatch open? Somebody opened our hatch. Are you getting cooling?
 117:06:12 Cernan: I'm beginning to, I think. I still got a Water Flag. (But I'm) not hot.
 117:06:18 Schmitt: Stand by. Okay. (Long Pause) How does the water pressure look, Houston?

[The cooling system is not yet up to speed; hence the warning flag.]

117:06:46 Parker: Challenger, they're looking just a little bit low. We're still expecting them to build up. It's going to take a little while.

[In order to get out of the spacecraft, Gene has to face aft and get down on his knees, with his feet pointing out the hatch. He will then move his legs out, gradually lowering his torso toward the floor so that he can crawl out backwards. There isn't much room - fore and aft - and it takes patient effort to get out.]

117:06:53 Cernan: Okay. I'm getting down on my knees out here. How am I looking, Jack?
 117:06:57 Schmitt: You're just fine. I'm holding you away from the DEDA... (correcting himself) the DSKY.
 117:07:04 Cernan: Okay. I'm going to put this visor down now, I think. (Pause) How does that look to you?
 117:07:14 Schmitt: What?
 117:07:15 Cernan: How are my legs? Am I getting out?

117:07:17 Schmitt: Well, I don't know. I can't see your legs.

117:07:19 Cernan: Oh, okay. (Laughs)

117:07:22 Schmitt: I think you're getting out though, because there's not as much of you in here as there used to be. Oh, hey, Gene, when I get down there, I got to fix your tool harness (on the PLSS). Hold it.

117:07:32 Cernan: Okay. Can you reach it?

117:07:33 Schmitt: It's come off the bottom again.

117:07:36 Cernan: Can you reach it?

117:07:37 Schmitt: Well, I can't do it now, because it's come off from the bottom. I'll have to...

117:07:40 Cernan: Oh, the bottom of the PLSS, huh?

117:07:41 Schmitt: Yeah.

117:07:44 Cernan: Okay. Well, my legs are out. Keep that hatch open.

117:07:48 Schmitt: Can you squat down any further, because you're hooked on...(Pause) You're making it worse. Okay.

117:08:05 Cernan: How's that?

117:08:06 Schmitt: Okay. Now, be careful because you might hook it on something down there.

117:08:10 Cernan: Oh, the tool harness?

117:08:11 Schmitt: Yeah. The back. It's loose on your back; on the back of the PLSS.

117:08:15 Cernan: Oh, man, I don't like that. Okay. I'll watch it.

117:08:17 Schmitt: Well, I'll fix it when I get out there.

117:08:21 Cernan: (To himself) Okay. I'm still reading 4.0 (psi). Houston, the Commander is on the porch of Challenger.

117:08:30 Parker: Roger. We copy you, Commander, and your feedwater pressure is looking much better...

117:08:33 Cernan: How am I...(Stops to listen to Parker)

117:08:33 Parker: ...now, and you're probably getting cooling.

117:08:39 Cernan: Okay. Everything else look good to you?

117:08:42 Parker: That's affirmative.

[In reviewing tapes for all of the missions, it seemed as though the LMP's had an easier time getting in and out of the cabin; or, at least, didn't talk about their struggles as much.]

[Schmitt - "Most of the LMPs were smaller than the Commanders; that might have something to do with it. And you could open the door a bit more without someone standing behind it. And mostly, if somebody's there to help you, he's going to help you. And, if they're not there, you're not going to have all this conversation."]

[Cernan - "I think the main reason that the Commanders had a bit more trouble is that, with a fully-suited LMP standing over behind the partially open hatch, you couldn't get it open very far and you had to sort of get down on your knees and slip sideways. Then, once the Commander was out, the LMP could move over to the Commander's side of the LM,

open the hatch full bore, and use the whole cockpit for moving around and squatting down."]

[In a final review of the manuscript, Jack suggested another reason. The LMP always got out later than the Commander and, therefore, had a less rigid suit.]

117:08:46 Cernan: Okay, Jack. I'm going to get the MESA (Modular Equipment Stowage Assembly) ..

[Gene is reaching for the D-ring to release the MESA, a table-like structure containing tools, replacement batteries, food, etc. When Gene pulls the lanyard, the MESA will fold outward about 120 degrees from the northwest face of the LM. Later, Jack will pivot the MESA back up to a comfortable working height. By allowing the MESA to pivot beyond 90 degrees, the designers have made it possible for the crew to use the MESA even if there happens to be a small crater right where they need to stand.]

117:08:49 Schmitt: Okay. And I'll have an ETB ready for you.

[The Equipment Transfer Bag (ETB) is a soft-sided, padded bag about the size of a piece of luggage big enough to fit under an airline seat, being about 2 feet long and about one foot in each of the other dimensions. On Apollos 11 through 15, a TV camera had been mounted on the MESA so that the Commander's climb down the ladder could be watched. As on Apollo 16, the Apollo 17 camera is stowed away and there will be no TV coverage until Gene puts the camera on the Rover.]

117:08:51 Cernan: (Reaching for the D-ring) Oh, man; oh, man; oh, man.

117:08:58 Schmitt: Deploy, MESA!

117:09:00 Cernan: (Chuckling) Okay. Here it comes.

(Pause) There she goes, Babe.

117:09:08 Schmitt: Hey, hey!

[The MESA was located below Jack's station, to the right of the ladder from his perspective in the cabin. Obviously, he could watch the MESA deployment out his window.]

117:09:10 Cernan: There she is. All the way down; it looks like. Okay. I jettisoned...Oh, you want an ETB?

117:09:19 Schmitt: That's up to you.

117:09:21 Cernan: Yeah.

117:09:23 Schmitt: You're the commander.

117:09:24 Cernan: I got it! I got it. And, the (suit) pressure looks like it's started to stabilize at 3.8. I don't know whether I'm getting cooler or not, but I feel pretty good.

117:09:40 Parker: Okay. We copy that.

117:09:41 Schmitt: How about a jett(ison) bag, too?

117:09:43 Cernan: Okay. (Pause)

[This is a bag containing the day's accumulation of empty food bags and other trash. Later, Gene will get the jett bag out of the way by kicking it under the descent stage.]

117:10:00 Cernan: (Using the lanyard to lower the ETB to the ground) Oh, Jack, I could swing it over the - it won't be any problem - over the strut. Okay; and the jett bag is swinging free.

117:10:13 Schmitt: You mean the ETB.

117:10:14 Cernan: ETB. Oh, man. This looks like a Santa Claus bag.

117:10:18 Schmitt: It is (a Santa Claus bag).

[Gene is using a lanyard rather than the clothesline-like Lunar Equipment Conveyor (LEC) used on Apollos 11 through 15. Jack recalls that the LEC was "just another case of somebody looking for spiders under rocks", assuming that things were going to be harder to do than they actually were. Gene is using the lanyard to lower the ETB because it contains the cameras and, therefore, he doesn't want to risk dropping it.]

[Cernan - " I think that when I was backup for Apollo 14 we had some kind of conveyor belt that we would use ship things up and down. Quite frankly, as I recall, it was more trouble than it was worth and I don't believe we had it on 17. People sometimes would overreact and think up solutions to problems instead of sticking to the fundamentals that often worked better. If you wanted to take something up the ladder, you just carried it up, or put it over your shoulder. The things we had to haul in and haul out were not that heavy in 1/6th gravity. But here, obviously, we used a rope of some kind, probably with a hook on it, to lower the ETB straight down from the porch."]

[The Apollo 11 and 12 crews used the clothesline LEC to raise and lower all of the equipment they transferred between the cabin and the surface. On Apollo 14, Ed Mitchell carried some gear up the ladder without using the LEC. On Apollo 15, Dave Scott used the clothesline LEC for most transfers, although he, too, carried a few things up the ladder. It was the Apollo 16 crew that did away with the clothesline LEC and, like the 17 crew, they carried everything up and down except for the ETB, which they lowered with the lanyard LEC.]

117:10:22 Cernan: Oh, boy. There it goes. The Rover looks in good shape. ETB is down there. Okay. I've got all my visors down. Jack, I wouldn't lower your gold visor until after you get on the porch, because it's plenty dark out here.

[As on all Apollo missions, the LM was landed to the west, early in the local lunar morning. The ladder is on the

forward, west-pointing strut and, therefore, will be in the LM shadow throughout the mission. As Gene stands at the top of the ladder, the Rover is stowed to his right, in the southwest sector of the descent stage. The Rover is stowed in a folded configuration. There is a thermal covering over the Rover but Gene can see at least part of the vehicle.]

117:10:38 Schmitt: Okay.

117:10:39 Cernan: Okay...

117:10:40 Schmitt: (Going down the items on cuff checklist page LMP-6) Tape recorder...

117:10:42 Cernan: ...I'm on my way (down the ladder).

117:10:43 Schmitt: ...is off. Sensitivity, max and max.

[Jack is turning off the engineering-data tape recorder because the LM systems will be inactive during the EVA. Jack is also setting voice sensitivity controls on the comm system. On Apollo 11, Buzz Aldrin did not set his sensitivity quite to maximum and, as a result, his transmissions were broken throughout the EVA.]

117:10:55 Cernan: Okay, Houston. The Commander is about three quarters of the way down. (Pause)

[Cernan - " Getting down the ladder in the suit wasn't any particular problem. It would have been a lot easier without a suit; but, of course, we wouldn't have been going outside without them and they performed just tremendously, admirably. There had been a tremendous amount of technological development in the suit between my EVA on Gemini IX and Apollo 17. I mean, walking on the surface with the mobility of a Gemini EVA suit would have been damn near impossible. It was just an order of magnitude difference in technological development. Many people don't realize the importance and significance of the suit. It was everything. It was radio communications; it was cooling; it was breathing; it was pressurization; it was protection from the sun; it was protection from abrasiveness. It had to provide mobility, dexterity, safety, and reliability. It was a sophisticated spacecraft in its own right, one that has been, I think, overlooked in terms of its importance to the mission."]

117:11:09 Cernan: I'm on the footpad. And, Houston, as I step off at the surface at Taurus-Littrow, I'd like to dedicate the first step of Apollo 17 to all those who made it possible. (Pause)

117:11:30 Cernan: Jack, I'm out here. Oh, my golly!

Unbelievable! Unbelievable; but is it bright in the Sun.

(Pause) Okay! We landed in a very shallow depression.

That's why we've got a slight pitch-up angle. (It's a) very shallow, dinner-plate-like, dish crater just about the width of the struts (meaning the total span of the landing gear). How you doing, Jack?

117:12:12 Schmitt: Fine. Getting the circuit breakers verified.

117:12:19 Cernan: The LM looks beautiful. (Pause) Oh, do we have boulder tracks coming down (the side of North Massif). Let me see exactly where we are. I think I may be just in front of Punk.

117:12:43 Parker: Okay. We copy that, Gene, and are the boulder tracks...

117:12:46 Cernan: I'm beginning to...

117:12:46 Parker: ...to both the north and south?

117:12:53 Cernan: Okay. On the North Massif we've got very obvious boulder tracks. A couple of large boulders come within 20 or 30 feet of the (break in slope)...Looks like where we can get to them; there's a couple I know we can get to. Well, the Sun angle is such that, what I saw on the South Massif earlier, I can't see very well. But, I know there were boulder tracks over there. Bear Mountain...Boy, it's hard to look to the east (toward the Sculptured Hills). Bear Mountain and the Sculptured Hills have a very, very similar texture on the surface. The Sculptured Hills' (texture) is like the wrinkled skin of an old, old, 100-year-old man. (That) is probably the best way I could put it. Very, very hummocky, but smoothly pockmarked. I do not see any boulders up on the Sculptured Hills from here. But it's awful hard to look to the east and to the southeast.

117:13:04 Parker: Okay. We copy that, Gene. Have you got an LMP with you yet?

117:14:09 Cernan: Well, here come his feet. Jack, let me make sure...We didn't have an awful lot of dust on landing; but I can dig my foot in 8 or 10 inches, and I know we're at least that thick.

[That is, the regolith is at least 8 to 10 inches deep.]

117:14:20 Cernan: There's a small little 1-meter crater right in front of us with a whole mess of glass right in the middle. That's right in front of the MESA, as a matter of fact. Right where I want to park the Rover. Jack, you're looking good.

117:14:38 Parker: Beautiful, guys; beautiful.

117:14:42 Cernan: (Gene is walking around the LM to get his bearings) I'm going to take a quick look back. I think this is Poppie, and I can give you a real better idea where we are.

[There is a 20-meter-diameter, sharp-rimmed crater about 30 meters east of the LM. Gene may be thinking this is Poppie and is probably walking over to it at this point. At 117:45:45, Jack will take a color pan from behind the LM and a little north. Frame AS147-22511 shows the crater east of the LM and a set of footprints going out to it. Close examination of the foreground prints show that they are deepest on the west and that there is a fan of dust spray to the east of each print, both indicating that Gene was going

east. Out near the crater, there are also indications that Gene left the Crater in a southwesterly direction to go over to Poppie. This set of tracks continues in frames 22512 to 22514.]

117:14:48 Schmitt: Hatch is closed, barely.
117:14:51 Cernan: Hey, Jack, don't lock it.
117:14:53 Schmitt: I'm not going to lock it.
117:14:54 Cernan: We've got to go back there. You lose the key, and we're in trouble.

[By now, this was an old Apollo joke, having been used in some form by the 11, 12, 15, and 16 crews.]

117:15:01 Schmitt: Oh, I'm on the porch!
117:15:05 Cernan: Who said this place was smooth? Oh, boy! There's a lot of local depressions here I didn't figure existed.
117:15:17 Schmitt: Hey, who's been tracking up my lunar surface?
117:15:21 Cernan: Hey, Bob, I'm east of the LM now. I'm east of the LM, and the back strut of the LM is...Well, the LM straddles this crater I talked about, and that's where we get the pitch angle; the back strut is probably right down in the eastern one-third of that crater. Just a very subtle crater.
117:15:47 Schmitt: Hey, man; you had some forward velocity.
117:15:50 Cernan: That's what I wanted to have. (Pause)

[The footpad imprints indicate a little forward motion at touchdown.]

117:15:58 Cernan: Boy, I look at some of these rocks that are filleted here, Jack, and there sure are a lot of sparklies in them. Awful lot of sparklies.

[Cernan - "Fillets were not a surprise. We expected to see fillets on some sides of a boulder and not on others and saw fillets almost everywhere we went. On some of them, you could almost draw lines in the direction that the stuff had come from. We had a good background from training and knew where to look and how to interpret what we saw."]

117:16:08 Schmitt: You landed in a crater!

117:16:11 Cernan: That's a pretty good shot.

[Schmitt - "At some point, and maybe it's here, I stepped down off the ladder onto the sloping side of a boulder which had little balls of glass and debris that made it very slick. And I slipped and my left leg went out from under me. Fortunately, I was still hanging onto the ladder."]

117:16:15 Cernan: Okay. I'm going to get to work in a minute, just as soon as I take a look at Trident (actually Poppie).

117:16:18 Schmitt: Why don't you come over here and let me deploy your (PLSS) antenna.

117:16:22 Cernan: Okay. Just walk around for one second.

[Cernan - "You adapt very, very quickly. You very quickly realize, probably in the first couple of minutes, that you don't need to take baby steps or regular steps to get anywhere. Somehow your brain and your body coordinate your movements and, if you're going to go any distance - 10 or 12 or 15 feet or further away - you start skipping or hop-skipping to get where you're going. And it's not like you start running. It's just that you move with such ease. Later on, when you start moving at faster paces than we were doing here, if you decide to turn or change directions you have to think about your high center-of-mass and plan how you're going to handle that - or you're going to go tail-over-teakettle. But you adapt very readily, very quickly, physiologically and psychologically. You're conscious, as soon as you're on the surface, that you're in this 1/6 g environment and that you can move around so much more easily. I don't think we ever really said anything about it, but in five or ten minutes you knew in a general way what you could do and what you couldn't do in terms of the using 1/6 gravity to your advantage. Within the first few minutes, after we got the Rover down, we just picked it up - one of us on each end - and turned it around. The human being is a very unique, very adaptable creature."]

[Readers should note that Gene's trip to the small crater east of the LM and then to Poppie is roughly twice the length of the 60 meter trip Neil Armstrong made to an unnamed

crater east of the Apollo 11 LM. Neil's excursion was made near the end of his 2 1/2 hour EVA while, in contrast, Gene has only been on the surface for 5 minutes. This comparison illustrates the confidence that Gene and Jack had in their ability to adapt quickly, confidence that was based on the experiences of the prior crews. Gene's nonchalance about strolling off to look at craters is a foretaste of just how active he and Jack will be during their EVA's. Only the Apollo 16 crew was their equal in this regard.]

117:16:25 Schmitt: (Laughs) Hey, man, put your visor down.
 117:16:30 Cernan: And, I'll be over there, and you can fix my tool harness. I don't like that thing loose.
 117:16:35 Schmitt: I don't like it loose, either. What are you doing over there (by Poppie)? We're supposed to be working.
 117:16:39 Cernan: I was just going to give them a fix (meaning another estimate of where they landed). All these little craters, Jack, have got glass in the bottom of them. Here's another one.

[Gene remembers that they trained to recognize glass, an indication of very fresh impacts.]

117:16:46 Schmitt: (To Houston) There's very clear sweeping of the surface by the descent plume out, oh, about 10 meters. No, 15 meters. (Pause) (To Gene) Come over here, and I'll fix your antenna.
 117:17:10 Cernan: Okay. Hey, Bob, how big is Poppie supposed to be?
 117:17:14 Parker: Stand by. (Pause)

[Gene has probably started back to the LM. Frames AS17-147-22513 and 22514 show two sets of footprints. both were made by Gene - one on the way out, one on the way back.]

117:17:17 Parker: It looks on the map...
 117:17:19 Cernan: I didn't hear you. You cut out.
 117:17:21 Parker: Okay. It looks on the map like it's about 75 meters in diameter. Fairly subtle.
 117:17:28 Cernan: Okay. Okay, I tell you where I think I landed...Oh, about 100 meters from Poppie at 10 o'clock.

[Gene may be referring to an unnamed, 200-meter-diameter crater NNE of the LM. The near rim is about 150 meters from the LM. An alternative interpretation is that Gene is referring to the crater he just walked to, which is Poppie. This interpretation would seem to require that Gene has mis-spoken. They are about 100 meters NNW of the center of Poppie or, roughly, at 2 o'clock. I am inclined to believe that Gene has mis-spoken and has, for the moment, correctly identified Poppie. However, at no time during his three days on the Moon, will he be absolutely confident that the crater just to the south of the LM is Poppie.]

117:17:38 Schmitt: You think that's Poppie, huh?
117:17:40 Cernan: I think so. I think...
117:17:41 Schmitt: That's an awful big hole.
117:17:42 Cernan: (Letting himself be talked out of it)
Well, I know. I got to look around a little more. It sure
is not Trident. Bend over and I'll...
117:17:48 Schmitt: It might be part of Trident.
117:17:49 Cernan: ...get your antenna. Get your antenna.
Oh, a little more. (Pause) God, it's beautiful out here.
117:17:57 Schmitt: Well, hang on.
117:17:59 Cernan: Yep. (Pause)

[Jack probably has his knees bent but would not be kneeling.]

117:18:05 Schmitt: (To Parker) Okay. The immediate
surf(ace)...
117:18:06 Cernan: Not yet. Yeah, you talk to them. I
don't want you to stand up yet.
117:18:11 Schmitt: The surface is moderately cohesive, which
holds a pretty good footprint. Very fine grained. It looks
very much like previous soils (that is, soils at other Apollo
landing sites). (To Gene) You got her?
117:18:24 Cernan: Yeah.
117:18:26 Schmitt: You got a hole behind you now.
117:18:28 Cernan: Well, I'll stand in it, and you can get
at it better.

[Jack is now releasing Gene's antenna, held down by a
loop of Velcro on the top of the OPS to keep it out of the
way as they go through the hatch.]

117:18:31 Schmitt: Well, you got me right in (that is,
facing) the Sun. Can you come around this way? Ho-ho.
(Laughs) I'm going to have to get upstream of you.
117:18:43 Cernan: Look, you get up on the hill, and I'll
get in the hole.
117:18:45 Schmitt: Yeah. There you go. Whoa, whoa, whoa,
whoa.
117:18:48 Cernan: Don't move too fast. Boy, your feet look
like you just...
117:18:51 Schmitt: (Finishing the thought) Walked on the
Moon, huh? Well, I tell you Gene, I think the next
generation ought to accept this as a challenge. (Pause)
Let's see them leave footsteps like these someday. Got
another...Well, that'll be all right.
117:19:12 Cernan: Okay. What did you do with my tool
harness?
117:19:15 Schmitt: I'm going to work on it; that's what I'm
going to do. (Pause) Whoa; hold still.
117:19:21 Cernan: Okay. (Pause) Boy, I tell you, looking
to the east, you might just as well forget it. (Pause)

117:19:33 Schmitt: Well, let's see. How's this thing...I'm going to have to loosen it.

117:19:37 Cernan: Well, if you could just stretch it around.

117:19:38 Schmitt: I can't.

117:19:39 Cernan: You can't, huh?

117:19:40 Schmitt: But I will be in a minute.

117:19:42 Cernan: Don't loosen it to the point where you can't get it back on.

117:19:45 Schmitt: Won't. (Pause) Okay. You're almost reconfigured.

117:19:53 Cernan: Okay. (Pause)

117:19:59 Schmitt: Okay. (Pause) Somebody tied you on wrong, too. They've got the strap reversed for the Velcro. Okay, Gene. I think that'll hold.

117:20:15 Cernan: Okay, and I'm going to...

117:20:17 Schmitt: If it doesn't, I'll fix you again.

117:20:20 Cernan: Man, there's sparklies in the soil, Jack. You can just look at it. See them all over? Very fine grained. It's sparkly, that's all. Bob, I'm going to Min cooling...(correcting himself) or, intermediate cooling.

117:20:33 Parker: Okay. Copy that.

117:20:35 Schmitt: Boy, that sure...

117:20:36 Cernan: See the soil sparkle?

117:20:40 Schmitt: Yeah, I think that's little (pieces of) glass.

117:20:43 Cernan: Let's go back here and get to work, and I'll show you that crater that's got nothing but glass in the bottom.

117:20:47 Schmitt: That's a vesicular rock of some kind there, Geno. It almost looks like a Mono Craters (California) pumice, but don't quote me.

117:21:01 Cernan: Bob, I have to reiterate. Even the small, even the very small - the 1- and 2-inch, 3-inch - fragments that are laying around here - have been dusted and filleted...

117:21:12 Schmitt: Do-tu-doo!

117:21:13 Cernan: ...with the dark mantle.

117:21:16 Schmitt: And that sweeping by the descent stage goes all the way out there, Houston, to where we were; which was about 50 meters, I guess. Hey, man...(Jack stumbles) Whuh, whuh, whuh, whuh. Hey, these rocks, they almost have a very light pinkish hue to them, and they're not obviously breccia. Now, that's like a breccia there. But this is something else again.

117:21:50 Cernan: Yeah. I don't think there is any place you could land around here where you wouldn't have one foot(pad) in a crater.

117:21:54 Schmitt: Looks like a vesicular, very-light-colored porphyry of some kind; it's about 10 or 15 percent vesicles. I'm right in front (that is, west) of the LM. Quite a few of the rocks look of that type. Sort of a pinkish hue to them. The texture is coarse, but I'm not sure how crystalline they are, yet.

[A porphyry is a rock composed of two different sizes of crystals, usually large crystals imbedded in a matrix of small crystals. Vesicles are spherical imprints of gas bubbles trapped in a solidifying rock. The vesicle may be glass-lined if the rock cooled quickly, or lined with crystals if the cooling was gradual.]

117:22:24 Cernan: Okay; back to work. Jack, when you put up the ETB (on the MESA), check down there below it.

[Apparently, the scissors fell out of the ETB as Gene was lowering it. He may have seen them fall, or he may have noticed them on the ground when he got to the bottom of the ladder.]

117:22:31 Schmitt: Oh-ho-ho. (Laughs)

117:22:33 Cernan: Okay, let me take a look at the Rover.

117:22:35 Schmitt: Let's don't forget those (scissors).

117:22:37 Cernan: Yep.

117:22:39 Schmitt: That's my fault; I guess (for not packing the ETB carefully enough).

117:22:41 Cernan: Well...

117:22:42 Schmitt: Okay.

117:22:44 Cernan: Oh man, I tell you, we came down at just a little forward velocity. Look at that, right there. About a (one)-foot slip on the pad. I tell you, there's craters all over here. Okay, baby. I'd sure like to think that that (Rover) wheel is where it's supposed to be. It looks good to me. (Pause) Our next little vehicle to work. (Long Pause while Gene examines the Rover, using cuff checklist page CDR-7 as a guide) Okay. Bob, so far, the Rover looks pretty good.

117:23:39 Parker: Roger; sounds good, Geno.

117:23:44 Cernan: (To Parker) Hey, let me ask you. When I was behind the LM, I could look right into an area and see the bell of the ascent stage. I never realized that before, but I guess that's normal, huh?

117:23:55 Schmitt: Yeah; We saw it on the (launch) pad (at the Cape). Remember.

117:23:58 Cernan: Barely.

117:24:00 Schmitt: Remember when we went out there?

117:24:05 Cernan: The only reason I asked, Bob, I'm sure it's normal, and it doesn't look anything's missing, it's just right into the Sun.

117:24:13 Parker: Yeah, the consensus of opinion down here is that you can, also.

117:24:20 Cernan: Well, that's probably the best place in the world to get a consensus of opinion from. Okay, Jack, it's about work time. I've got this Rover about ready for your pull up there.

117:24:33 Schmitt: I got a little delayed here.

[Jack is raising the MESA to a comfortable working height and, after he finishes that, will open the thermal blankets that cover the stowed equipment and supplies. After that, he will climb up the ladder to release the Rover. He is completing the items on the top of cuff checklist page LMP-7.]

117:24:35 Cernan: Okay. (Pause) I'm sure glad those guys made us train so hard.

[As was the case with Apollo 16, TV coverage of the EVA won't begin until Gene mounts the TV camera on the front of the Rover. Commentary in the following section has been derived from a comparison of Apollo 17 dialog with the Rover Handbook, the checklists, and the video record of the Apollo 15 Rover deployment.]

[Cernan - "I've forgotten the details of how the Rover deployed, but it was a slick operation. It was all done manually but most of the steps just happened automatically as we pulled the tapes."]

117:24:49 Schmitt: Okay. The MESA's up. Let me know when you're ready to deploy.

117:24:55 Cernan: Okay. Babe, I am ready for you. Everything I can see looks pretty good. The walking hinges, you will be glad to know, are intact! They did not drop.

117:25:12 Parker: Roger! That's a first.

[The walking hinges are part of the Rover deployment hardware and support the LM-ward (forward) portion of the Rover center chassis section during the first part of the deployment.]

117:25:14 Schmitt: You want me to go up there and do that, huh?

117:25:16 Cernan: Yes, sir. The beginning.

117:25:21 Schmitt: You ready for me to deploy?

[Jack will climb to the top of the ladder to pull a D-ring lanyard release which will unlock the Rover from its stowage position. The Rover chassis consists of a long center section and shorter fore and aft sections containing, among other things, the wheel assemblies. The fore and aft sections are folded back onto what will be the upper surface of the center section and the wheels, in turn, are folded onto those fore and aft sections. The entire assembly is mounted on the southwest quadrant of the LM, with the wheels inward toward the spacecraft, the bottom surface of the center chassis facing outward, with the aft chassis up. When Jack pulls the D-ring, the top of the Rover assembly will swing out by about four degrees.]

117:25:23 Cernan: Okay. Let me just double-check. (Reading quickly from his checklist, page CDR-7) "Drape,

contingency, unstow aft deployment cable, verify walking hinge, forward and aft chassis parallel. They are.

[Gene has removed a thermal insulation blanket that loosely covered the Rover, unstowed the lefthand of two deployment tapes and draped it on the landing strut, removed a contingency tool from its storage position in the Rover compartment, readied the deployment cable, and checked that the Rover is properly seated in its deployment hinges. Once Jack releases the Rover and climbs down the ladder, Gene will begin pulling the righthand tape. This action will, in turn, slowly unwind a cable attached to the center chassis-section, allowing the Rover to continue it's outward and downward rotation around hinges attached to the fore end (stowed in the "down" position) of the center section. Jack, in the meanwhile, will keep the deployment cable taut, ready to apply force should the Rover hang up at any point during the deployment. After the Rover has rotated down by 15 degree, the fore end of the center chassis will encounter the walking hinges which stick out a short distance from the LM. This will shift the point of rotation outward and allow the Rover assembly to lift itself out of the storage compartment.]

117:25:31 Schmitt: MESA insulation is not coming off as easy as in training.

117:25:35 Cernan: Okay. Outrigger cables are taut. Looking good to me. Yeah, Jack. You can go on up. Go on up.

117:25:46 Schmitt: Okay.

117:25:47 Cernan: I'm ready for you. God, that LM is a pretty sight. Challenger, you're a beauty!

117:25:55 Schmitt: Well, let's see how good I am (at getting up the ladder).

117:25:57 Cernan: (Probably to himself) Don't drop that. Let me get that thing again. (Pause) Yes, sir. (Jack laughs as he jumps to the first rung) Yes, sir. You're pretty agile there, twinkletoes.

[Gene is commenting Jack's agility as he jumps up to the first rung of the ladder. This is the first time that either of them has tried it on the Moon.]

117:26:14 Schmitt: You bet your (pause, searching for a polite phrase) life I am.

117:26:17 Cernan: (Laughing) All I asked you to do was pull that handle up there. (Pause) Man, anything you grab, Jack...I just grabbed this lanyard that was in the dust (and it) is really black. (Laughs)

117:26:27 Schmitt: You ready?

117:26:29 Cernan: Go. She fell, Houston. She's open.

[The Rover has released and the top of the package has swung out.]

117:26:33 Schmitt: Okay. You've got parallel chassis; the wheels look good on this side.
 117:26:36 Cernan: Okay. They're good on this side. Get down and let's get it out. (Pause) I'll wait for you to get the deploy cable. I'll tell you, Jack, this place is not locally level.
 117:26:51 Schmitt: You're right.
 117:26:55 Cernan: Okay. There's not many places you could put the LM down and have it be zero, zero, zero (no pitch, no roll, no yaw). Okay. I'm ready if you are. (Pause)

[Because of the likelihood that at least one of the LM footpads would end up in a small crater, the Rover deployment hardware was designed to handle up to 14 degrees of either pitch or roll. Challenger is pitched up about 5.3 degrees and is rolled left about 2.6 degrees. John Young landed the Apollo 16 LM, Orion, with only 3 degrees of pitchup; but, on Apollo 15, Dave Scott landed Falcon with 9 degrees of pitchup and 6 degrees of left roll and, in the interest of caution, a trial deployment was run at the Marshall Spaceflight Center before the 15 crew began their first EVA. Both the test and the actual deployment were completed without difficulty.]

117:27:08 Schmitt: I don't know how much help I'm going to be.

[Jack will be on Gene's left as they face the Rover. Jack will back away from the LM, maintaining tension on the deployment cable while Gene backs away to the right of the Rover, pulling the righthand tape and lowering the aft section of the Rover. Jack is still on checklist page LMP-7. Gene is at the top on page CDR-8.]

117:27:10 Cernan: Well, I'm starting; you pull. It's coming. It's coming. It's coming, baby. How's your wheels on that side? Can you see them? Mine look good.
 117:27:21 Schmitt: Wheels? They looked good a minute ago. I got the Sun, so I can't tell much...
 117:27:26 Cernan: Okay. (Pause)

[Each of them is angling away from the Rover centerline at about ten degrees. Jack is not facing the Sun directly, but it is certainly in his field of view and is probably reflecting off of dust particles and scratches on his visor.]

117:27:36 Cernan: Eeee! The only way to do it.
 117:27:38 Schmitt: I'm putting all my weight. (Laughs)
 117:27:40 Cernan: Okay. Wait a minute. I'm coming down now. She's going to pop here.
 117:27:43 Schmitt: Okay.

[At 45 degrees of rotation, a number of things happen in quick sequence: the forward chassis section rotates 45 degrees off of the center chassis, the aft chassis flops down

and locks into place, parallel to the center chassis, and the rear wheels spring into position.]

117:27:44 Cernan: Wait a minute. Stand by.

117:27:46 Schmitt: I may pull a Jim Irwin here.

[At this point in the Apollo 15 deployment, Irwin stumbled and fell.]

117:27:47 Cernan: Wait a minute. Watch out. Here she goes!

117:27:49 Schmitt: Got her.

117:27:50 Cernan: Okay. Beautiful, Houston. The aft chassis's out.

117:27:53 Parker: Roger. Beautiful.

117:27:55 Schmitt: Beautiful. Whoa, whoa, wait, wait, wait, wait. Tried to get off the hinge there.

117:28:03 Cernan: Yeah, yeah. She's on, though. She's all in. She's in the walking hinges. I wish you could see it. Jack, those wheels did not lock all the way up though. We ought to pull them up before we...

117:28:14 Schmitt: (Garbled)

117:28:15 Cernan: Well, there it goes, by itself. Okay. Wait a minute. Wait a minute. Okay. Let me pull it until the outriggers cables get slack.

[Gene continues to pull the tape, lowering the aft wheels to the ground. At 73 degrees of center chassis rotation, the forward section, which is attached to the deployment hardware by a bracket called the "saddle" and, in turn, to a pair of telescoping tubes, starts unfolding again.]

117:28:27 Schmitt: Okay. Walk away from it; that's easier (than pulling the tape hand over hand).

117:28:35 Cernan: That tape up there on that reel...

117:28:37 Schmitt: Yeah, it's all...

117:28:38 Cernan: It's coming.

[Once the rear wheels are on the ground, Gene will continue to pull the tape. As the Rover moves out, away from the LM, the forward chassis will finish unfolding, and the forward wheels will lock into place.]

117:28:40 Schmitt: It's free reeling.

117:28:41 Cernan: Yeah. Let me...Let me...Don't pull it until I...Okay. Now I've got it. (Pause) Man, I'd fall into that crater (Poppie) if I went to the end of this line.

117:28:59 Schmitt: Houston, I do think we've got a different...

117:29:02 Cernan: Well, we're deploying it at an angle. Okay. The outrigger cables are free, Jack.

[The forward wheels have locked into place. The Rover is now hanging at about a 30 degree angle to the ground with the rear wheels on the surface and the nose of the vehicle still attached to the telescoping tubes and saddle. Gene will now take the deployment cable while Jack uses the lefthand tape to lower the front wheels to the ground.]

117:29:06 Schmitt: Okay. (To Parker) Got a different breed of rock up here. The stuff's sticking through this thin regolith...Or regolith, period. I don't know whether it's thin or thick yet. Oop, oop, oop bo-doop-boop. Okay. Mine's free.

117:29:22 Cernan: Let me get all this cable out of the way. Otherwise I'll...Got enough of this stuff. I don't like all that over there. (Garbled).

117:29:35 Schmitt: A geologist's paradise, if I ever saw one. Boy, you certainly are changing the color of that cable, sir.

117:29:44 Cernan: Man. Just tried a John Young trick.

[On Apollo 16, John Young tripped over an electrical cable at the ALSEP site, tearing it loose from the Central Station. Here, Gene hasn't tripped over anything vital, but because of the RCU and the general bulk of the suit, seeing one's feet isn't easy.]

117:29:48 Schmitt: Did it work?

117:29:50 Cernan: Yeah. (Jack laughs)

117:29:51 Schmitt: You're getting dirty.

117:29:52 Cernan: But, I'm still getting my balance. I didn't touch the ground. Just got to get some of this cable out of here.

117:30:02 Schmitt: I'm not sure my pockets are going to be accessible. (Pause)

[Each of them has a large pocket strapped to his right shin and another on his left thigh. Although the camera and the general bulk of the suit prevents them from seeing their own pockets, with practice they learn how to use them. Gene's pockets are clearly visible in AS17-134-20380, a tourist picture Jack will take at about 118:23.]

117:30:12 Cernan: Man, I'll tell you, I don't know how long this line to pull the Rover out is, but...(Pause) Well, I'll tell you, it sure is easy to get dusty, but that's nothing new to anybody. Okay, Babe, let me get...Whee!

117:30:31 Schmitt: I think it's safe to say this surface was not formed yesterday. There is a regolith; it looks classic. Seriate distribution of particles up to 3 or 4 centimeters, anyway. Then, you start to get maybe a selective distribution of large fragments.

[Schmitt - "In geology, 'seriate' is used to describe a population of objects in which successively smaller objects are more and more numerous."]

117:30:49 Schmitt: Got that cable?

117:30:51 Cernan: Yep.

117:30:52 Schmitt: Okay. I'm going to walk away with this one.

[On Apollo 15, Dave Scott stood next to the Rover and pulled the lefthand tape hand-over-hand. Jack will merely grasp the tape and back away from the LM. In a suit, using one's legs is a lot easier than using one's arms.]

117:30:54 Cernan: Okay; outrigger cable.

117:30:56 Schmitt: You ready?

117:30:57 Cernan: Okay. (Consulting his checklist, page CDR-8) "When forward wheels on surface"; okay. Let me pull (on the deployment cable to get things started). (Pause) Okay, Houston. She's continuing to come. (Pause)

117:31:14 Schmitt: (Backing away from the LM) Here's a couple of different-looking rocks. One's very white; one's quite dark. But we do have a general rock type, I think, in the area. (At least) of the big boulders.

[Schmitt - "A 'boulder' is anything about 20 cm or larger; loosely, anything you needed two hands for."]

117:31:24 Schmitt: Jesus, how much cable is there?

117:31:27 Cernan: There's a lot of it, Jack. Keep going. (Jack laughs) You're going to be a long way away. We're not there yet. Keep going. (Pause) Okay. We've got the front wheels on the surface, but keep going, I don't think you've got it up there.

117:31:48 Schmitt: I never thought I'd do geology this way.

[That is, pulling a deployment tape and describing rocks as he passes them.]

117:31:52 Cernan: Okay. I think you got it. Let me see.

117:31:58 Schmitt: Is it slack?

117:32:00 Cernan: I'll get up there and take a look.

(Pause) Okay. It's slack.

[The front wheels are on the ground and there is no tension on any of the cables.]

117:32:10 Schmitt: Longest cable in the world.

117:32:12 Cernan: It's slack.

117:32:14 Parker: Wait till you get to the ALSEP package.

[Each of a dozen or so ALSEP experiments has a cable connecting it to the Central Station.]

117:32:16 Cernan: Okay. By golly, those wheels did lock.
 117:32:19 Schmitt: (Laughing in response to Parker's ALSEP remark) I never knew that cable was that long, Bob. Oh, a glass-bottom crater with a little bench! Looks like one of the Flagstaff explosion craters except for the glass in it. Right out at 12 o'clock. That's the one I was talking about having a bright halo.

[Cernan - "Comparing things we were seeing on the Moon with things we had seen on Earth was the only way to go. The analogies may not have been perfect, but they gave people on the ground clear ideas of the important features of what we were looking at."]

117:32:40 Schmitt: I don't know whether it's easier to walk out there or to do what I did in training. That I said I wouldn't do on the Moon.

[Jack may be referring to the gait often referred to as the kangaroo-hop, which he had tried in training and decided wouldn't be efficient.]

117:32:52 Schmitt: (Referring to the cluster of deployment cables and tapes) Somebody's going to get tangled up with this thing.

117:32:55 Cernan: That's why I'd get it all under the LM somewhere. It took me 5 minutes to do and get it all out of the way. Okay, Bob, the front wheels locked in. I had to pull the rear wheels back to get them to lock in.

117:33:11 Parker: Okay. Copy that.

117:33:16 Cernan: At least no one let any air out of the tires.

[The Rover has wire wheels.]

117:33:19 Cernan: Man, I look like I've been on the surface for a week already. Holy smoley. Okay. (Reading) "Pull pins on deploy cable and fittings; move LRV from LM."

[There are fifteen pins attaching the deployment hardware to the Rover; all have to be pulled so that the hardware can be detached and discarded.]

117:33:29 Schmitt: Wait a minute. I haven't let my ...

117:33:30 Cernan: Okay.

117:33:32 Schmitt: ...other pins. It's going to take awhile. Think we can avoid that cable?

117:33:37 Cernan: Why don't you set it there, pull this pin, and then you can go back and get it; that is, it's better to use the Rover contingency tool, because...

117:33:42 Schmitt: Yeah, but that's off over there on the ground now, somewhere or another.

117:33:44 Cernan: Okay. Pull that pin. See if you can get that saddle loose.

[Once they detach the saddle, the Rover no longer will be connected to the LM.]

117:33:52 Schmitt: It's loose.
 117:33:53 Cernan: Ah, beautiful. Okay, we're going to have to move that line, Jack. You ready?
 117:33:57 Schmitt: I'll move it.
 117:33:58 Cernan: Okay. Let's find a...Back over here. See there?
 117:34:02 Schmitt: Yeah.

[Gene and Jack are picking up the Rover and positioning it so that the nose isn't right under the storage bay. They will move the Rover out a few feet and then align it roughly east-west.]

117:34:05 Cernan: Oh, man. (Pause) Face a little more east, so I don't have to run into the rim (of a crater on the initial test drive). Okay, how about here?
 117:34:18 Schmitt: You're the driver.
 117:34:19 Cernan: Okay; right there.
 117:34:20 Schmitt: You like it?
 117:34:21 Cernan: Like it.
 117:34:23 Schmitt: Okay. You got it.

[Gene and Jack will now configure the Rover, putting on the fenders, raising the seats, and so on. Jack turns to cuff checklist page LMP-8.]

117:34:24 Cernan: Now, Jack, you got some fenders and stuff for me...
 117:34:26 Schmitt: (Only semi-seriously) I was going to get my cable (out of the way under the LM). I thought you said I could work on the cable.
 117:34:28 Cernan: Ohh.
 117:34:30 Schmitt: You're putting me farther and farther behind.

[They are actually OK.]

117:34:32 Cernan: Oop.
 117:34:33 Schmitt: Don't forget your post.
 117:34:35 Cernan: Okay.

[Each of the Rover fenders is a two-part assembly. A portion extending from a point over the axle toward the center of the chassis is fixed in place, while a second portion is mounted on rails over the fixed piece. Gene and Jack will pull these extensions fore and aft (for the front and rear wheels, respectively), sliding them along the rails until they lock in place. Jack will extend the fenders on the left side of the Rover (from a passenger's point of view), and Gene will extend the rightside fenders. The

'geopost' is an anchor for the scientific equipment rack - the geopallet - which Jack will shortly mount behind the seats. The post is stowed flat on the rear chassis, top to the left; Gene will raise it and lock it into place behind Jack's seat on the right side.]

117:34:38 Schmitt: Okay. Pull pins. I can see a little yellow (garbled).

117:34:46 Cernan: Okay. The post is up.

117:34:50 Schmitt: Hinge pins.

[These are latching pins at the connections of the fore and aft chassis sections with the center section. These need to be pushed to lock. They may show yellow if not locked.]

117:34:51 Cernan: Okay. Yours is in, but mine is not.

117:34:54 Schmitt: Well, neither's my outboard one.

117:34:57 Cernan: My outboard is in, but my inboard is not.

117:35:04 Schmitt: And my outboard isn't.

117:35:06 Cernan: Well.

117:35:09 Schmitt: That's supposed to do it. But it didn't.

117:35:13 Cernan: Let me get the contingency tool and try to push those things closed.

117:35:16 Schmitt: Okay. Be careful. (Pause)

[The pins would difficult to reach by hand, and the contingency tool can be used to push them closed without bending over very far.]

117:35:27 Cernan: Here's a piece of glass I picked up. I'm going to set it right on the floor of the Rover. Jack, let me get that (contingency) tool. We got to get those pins in, I think. (Pause)

117:35:51 Cernan: Bob, you got any words on the yellow pins on the rear chassis?

117:35:55 Parker: Roger. The best way to put those in, if you've tried bouncing the chassis, would be to push them with the contingency tool. Which I think is what you're going to do.

117:36:06 Schmitt: That's affirm. Can you get that (tool), Geno? (Pause) Need some help?

[Gene is trying to pick the tool up off the ground and has fallen.]

117:36:23 Cernan: Nope. (Long Pause) Well, I found how to get up!

117:36:42 Schmitt: Did you fall down?

117:36:43 Cernan: (Breathing heavily) Well, this thing (the contingency tool) was in the mud down here. We'll find out in a minute.

[Cernan - "Even though the suit was stiff, and even though you weighed 300 Earth pounds with all that equipment,

in 1/6 gravity you weighed 50 pounds and could get up pretty easily. If you wanted to be cautious about getting up, and you had a rock or something like the Rover to give you leverage, you could literally get to your knees, get one leg out and, then push or pull yourself up with your hand. However, even though you could get up, you didn't want to fall, particularly a hard fall, because you were always aware that you could puncture your suit."]

[There will be several "falls" during the mission and, by the end of the third EVA, both astronauts will become fairly proficient at getting up, even without having a rock for leverage.]

117:36:52 Cernan: Okay, Jack. Got an "out" one here, huh?
 117:36:56 Schmitt: Yeah.
 117:36:57 Cernan: Let me try to push it in. (Pause) Okay. Yours is in.
 117:37:07 Schmitt: Good.
 117:37:12 Cernan: See if I can get mine in. (Pause)
 117:37:17 Schmitt: Want me to get it?
 117:37:18 Cernan: Well, yeah. Can you reach it from there? Just a nice firm (push)...I'll hold it (the tool) on it (the pin). Almost. A little more. Wait a minute. Let me get it. Let me get it right. (Pause) Okay; push. It's in. It's in.
 117:37:35 Schmitt: Very good. Why don't you put that (tool) between the seats?
 117:37:39 Cernan: Okay. Bob, they're in.
 117:37:40 Parker: Copy that.
 117:37:44 Cernan: Okay. Now where was I (in the checklist? I got my fender, got the post, got to get the seat. (Probably leaning over to get the seat) Ahhh.

[The seats and seat backs are made of loose weave of wide strips of nylon, rather like a light-weight lawn chair. At this point, the seats are still folded flat onto the chassis, held down with Velcro, and have to be raised. Gene is at the bottom of CDR-8.]

117:37:54 Schmitt: Ready?
 117:37:56 Cernan: I'm going to take it a little slower here in a minute.
 117:37:58 Schmitt: Yeah.
 117:38:01 Cernan: Just a little bit slower in a minute.
 117:38:04 Schmitt: The blush is off the rose. Okay, your front pin is in. And both of mine are in.
 117:38:12 Cernan: Okay. I'll look at them. (Pause)
 117:38:25 Schmitt: Not quite as easy as in the training building.
 117:38:28 Cernan: Well, it's a case of knowing how to play in 1/6 g, is what it amounts to. Okay. (Pause) Okay. I'm ready on the...
 117:38:40 Schmitt: You locked? Yeah. It's locked.

117:38:43 Cernan: Let me get the seat down. Okay. I got the console.
 117:38:47 Schmitt: Okay; and I got the handle.
 117:38:50 Cernan: Okay; mine's pulled.
 117:38:51 Schmitt: Mine's pulled.
 117:38:52 Cernan: Come on down, baby. There it comes. Stiff, but come on.
 117:38:56 Schmitt: There it is.

[The control console had been stowed perpendicular to the center chassis, pointing in toward the LM between the folded fore and aft sections. Gene has just rotated the console down to put it in good viewing position in front of the seats. The T-handles which Gene and Jack are positioning are inboard handholds which had been stowed in a "down" position alongside the console support. Gene is now on CDR-9.]

117:38:57 Cernan: Okay; make sure your T-(handle) locks.
 117:38:58 Schmitt: I'm not...You're not all the way down yet, Gene.
 117:39:00 Cernan: Yeah. I'm locked.
 117:39:01 Schmitt: There you go.
 117:39:03 Cernan: Okay.
 117:39:04 Schmitt: Okay. I'm locked and secured. Okay.
 (Pause)
 117:39:18 Cernan: Oh! Jack, I put a little piece of glass I picked up right by the Rover, here.
 117:39:22 Schmitt: Yeah. Okay.
 117:39:23 Cernan: Just a little piece. I'm going to leave it right behind your footstool. It just sparkled at me. I had to pick it up. See that?

[Somewhere in here, Gene and Jack raise their footrests at the front of the center chassis.]

117:39:28 Schmitt: Okay, that's yours: your sample for the day.
 117:39:33 Cernan: I doubt that. Man, I tell you, zero g is a piece of cake if you - (correcting himself) or 1/6 g - if you'd play it right.

[Cernan - "Working in one-sixth g outside a spacecraft was head and shoulders over working outside in zero gravity, as I did on my Gemini IX flight. It's true that, in zero gravity you can float around and move around easily; but it gives you so many other problems. One-sixth g is just enough gravity to give you a 'down', but it's not so much gravity that it gives you the problems working in a heavy pressure suit that you'd have on Earth. It's just enough gravity to give you a reference and it's not enough to hurt you. Much better than zero gravity. I'm a one-sixth g supporter any day in the week. And, even in the spacecraft, when we were out of the suits, eating and working and talking, one-sixth

gravity - by far - was much better than zero gravity. You could drink water out of a cup; and, if you set something down, it stayed down."]

117:39:45 Schmitt: Okay, Gene, you've got fenders; (verifying the front hinge pins) your pin was good. I checked that. I could see mine, too. Mine are okay, and you'll have to check your outside ones.

117:39:57 Cernan: Okay. My two pins are good here.

117:39:58 Schmitt: Yeah. And mine are good.

117:40:00 Cernan: This one isn't quite flush. Almost. It's good.

117:40:02 Schmitt: I'm going to pull your flags. Oops, I bent that one. And your attitude indicator is free.

[A roll and pitch indicator is mounted on the left side of the console. It had been locked in position with long pins. There is also a Caution & Warning Flag on the top of the console which Jack has just unpinned.]

117:40:17 Cernan: Man, look at that stuff go, will you? Went over that...(Stops to listen to Parker)

[Jack has just discarded the locking pins. Because of the lack of an atmosphere and the low gravity, a flick of the wrist will send even flimsy objects flying long distance on seemingly flat trajectories; and, as the object flies away, there is none of the fluttering and rapid deceleration that air resistance can cause on Earth.]

117:40:18 Parker: And, Jack, this is Houston. Looks like your water temperature's getting pretty high. You might want to go to intermediate cooling or slow down or something. Looks like you're getting a little warm. (Pause)

117:40:38 Cernan: You hear them, Jack?

117:40:39 Schmitt: Yeah. I got it. Thank you, Bob.

[Because sublimation necessarily results in a loss of water from the open-loop supply, it is best to run the PLSS at minimum cooling as much as possible. When the astronauts are working hard, they sometimes have to run the cooling system at the intermediate setting for several minutes at a time. Maximum cooling tends to be very cold; it isn't used very often and then only for a few seconds.]

117:40:42 Cernan: Okay, Jack, get that (Rover deployment) cable, because I tripped over it coming back.

117:40:45 Schmitt: Yeah. I'll get it.

117:40:47 Cernan: Okay. Let's see. (Reading, starting at the bottom of CDR-8) Verify hinge pins and seal. Erect seat; seatbelt. Armrest is lowered. Pull T-handle. Console's lowered. Tripod apex (part of the deployment hardware) is gone both sides. (Contingency) tool behind footrest; that's done. Front hinge pins are in. Erect footrest. Extend

front fenders; they're down. (Pause) Verify batt(ery) covers are closed. They are closed. And let's keep them clean. Man, do these gloves fit good!

[The batteries and an assortment of Rover electronics are mounted on the front chassis section, forward of the footrests. Gene is in the middle of CDR-9.]

117:41:21 Parker: Okay; and 17, you're right on schedule.
 117:41:23 Cernan: Okay. (Pause) Thank you, Bob. (Pause)
 Did you tell Captain America (Ron Evans) we're on the surface?
 117:41:40 Parker: Roger. We broke the news to him a while ago.
 117:41:47 Cernan: Okay; next spacecraft (that is, the LRV) to power-up is going to commence right now. (Pause)
 117:42:03 Schmitt: Okay. That takes care of that little job.

[Jack has probably gotten the deployment cable out of the way.]

117:42:10 Schmitt: How's my cooling look now, Bob? Oops.
 117:42:13 Parker: Rog. It's come down quite a bit. You were eighty-six (degrees F), and now it's down to seven five. Looks much better. We didn't want you to sweat.
 117:42:20 Schmitt: Well, I'm just a hot geologist; that's all.
 117:42:24 Parker: Or something. (Long Pause)
 117:42:43 Schmitt: Somebody (that is, Jack himself) kicked dirt all over the MESA.
 117:42:47 Cernan: Let's see if there is any life in this here baby. (Burps; Long Pause) Okay. Getting up and on.

[Gene is mounting the Rover, climbing into the lefthand seat. He will fasten his seatbelt, turn on the Rover power, and take a test drive.]

117:43:13 Schmitt: Give me a yell when you start to go, and I'll try to be sure to be there with the camera.
 117:43:16 Cernan: Okay. (Pause)

[Jack will take color pictures of the test drive.]

117:43:24 Schmitt: Big bag is deployed.
 117:43:29 Parker: Copy that. (Pause)

[Picking up an item at the top of LMP-7 that he skipped in order to help Gene with the Rover, Jack has hung the big bag from the front edge of the MESA. The big bag is a long version of the Sample Collection Bags (SCB's) they will wear during the geology traverses. The big bag will stay on the MESA until the start of the third EVA when Gene and Jack will install it on the Rover gate so that they can put big rocks

in it. At the end of the EVA, they will carry it up to the cabin with about 100 pounds of large samples in it. The best picture of the big bag is AS17-143-21924, taken by Jack at the end of the EVA-3 traverse at about 169:12:28.]

[Gene's breathing can be heard as he climbs on the Rover and attaches his seat belt. His breathing can be heard primarily because he is leaning forward to get the belt. Getting on the Rover is a relatively simple matter of standing along side and jumping up and inward, aiming for the seat. A slight jump and a pull on the handhold does the trick.]

117:43:44 Cernan: Well, the seat belt fits perfect.

117:43:49 Schmitt: Shoot. I thought I was going to get to drive.

[Schmitt - "Although we did a little training with me sitting in Gene's Rover seat, there was never any anticipation that Gene would decide that he didn't want to drive."]

117:43:52 Cernan: Man, I got so much dust over my visor already, I got to wipe it off. Get that lens brush; I want you to dust me off a little later, Jack.

117:44:04 Schmitt: The lens brush!?

[Jack finds the suggestion incredulous; the lens brush much too small for the job, being about an inch long and perhaps a half an inch wide. The bristles are very fine, perhaps camel hair.]

117:44:05 Cernan: Well, I've got to dust my visor off with something.

117:44:08 Parker: Roger. Don't use your glove or the dust brush.

[The dust brush, to be used for sweeping dust off the battery covers and other large surfaces, is the size of a large house-paint brush, perhaps six inches across. The bristles, like Gene's dust impregnated gloves, would scratch the visor.]

117:44:09 Cernan: Okay; when I was bringing that...(Responding to Parker) No, we'll use the lens brush, Bob.

117:44:15 Parker: Roger.

[Cernan - "The dust was very difficult to work in and was a big hindrance. It obscured your vision if you let it get on your visor. It was almost like a dew or mist because it clung to everything. It got on every movable surface, it got in the suits, and when we got out of our suits in the spacecraft in between EVA's, it got in the pores of our skin and got under our fingernails. And it didn't just get on the

outside parts of our nails and get them dirty but, literally, it got down between the skin and the nail. It took three months for lunar dust to grow out from under my nails. It infiltrates.

"I describe lunar dust as being like very, very fine graphite. But graphite is a lubricating material; this is not. This is just the opposite; it's very abrasive. And it has a smell very few people, if any, have smelled on the Earth. It smells something like spent gunpowder; like you've just fired a shotgun or something and you can smell that powder. The dust made lunar operations half again more difficult than it would have been without the dust. It took time to dust ourselves off, to clean the equipment. I knocked a fender off and quickly found out that you can't operate in a rover vehicle without a fender because you throw dust all over."]

[Schmitt - "I don't remember the dust creating an obscuration problem, except that, when you looked back into the Sun, the Sun would sparkle over it like a dirty windshield."]

117:44:17 Cernan: (Probably facing southeast) Okay. Let's try to see if I can read in this Sun.

[Gene is reading power-up instructions written on a decal affixed to the console.]

117:44:21 Cernan: (Talking to himself) Check hand controller. Let's wipe it out a couple of times to make sure we got all the steering. She's wiped out.

[Schmitt - "'Wiping out' the controller is a hand motion a bit like wiping a table. It's an old pilot's term for what you do to the stick in an airplane to check that all your ailerons are working, and Gene was just transferring that expression to the Rover, checking all of the controller positions."]

117:45:00 Cernan: She goes forward and she goes reverse. She's back in forward; and she's wiped out, and she's in park. Reverse is down. Okay. (Pause) Here we go. Stand by for life. It ought to be on this one. There's life in this here baby. Beautiful.

117:45:10 Schmitt: I don't know who's responsible for packing this ETB, but I think it was me. You didn't by any chance pick up those scissors, did you?

117:45:19 Cernan: No, sir.

117:45:20 Schmitt: They're going to be hard to find, but I think we can do it.

[Schmitt - "The whole exercise had been put together on the assumption that we would have two pairs of scissors; but, because Ron had lost his and we had left him one of our pairs, we had to keep track of the one pair we had left.

And, of course, they'd fallen out of the ETB as it was being lowered out of the LM. We took them out onto the surface just as a contingency tool, but we had to have them when we went back in the LM because otherwise we would have had a tough time opening the food containers."]

117:45:25 Cernan: Well, they were right down there (on the ground below the porch), unless you picked them up. That's exactly where the Rover tool was, too, and I picked it up, so they're probably there. I didn't see them though. Okay.

117:45:40 Schmitt: Okay. I got my camera.

117:45:42 Cernan: All the breakers closed except NAV.

117:45:47 Schmitt: The old 4 o'clock pan!

[Jack is going northeast of the LM - to the 4 o'clock position - to take a panoramic sequence of photographs. This is the only time during the mission that Jack has color film in his camera. He is now on cuff checklist page LMP-9. Gene is leaving the circuit breaker for the navigation electronics open and will not initialize the Rover navigation system until he is about to leave the ALSEP site at 121:41:37.]

117:45:50 Cernan: Okay, Houston. Amp-hours. I'm reading 115. Amps are 0. Volts are 82 and 82. Batteries are (pause to read the temperature gages) 95 and 110. Forward Motors are off-scale low, off-scale low; and Rears are off-scale low, off-scale low. (Long Pause) Houston, you with us?

117:46:28 Parker: Roger. We copy that.

117:46:32 Cernan: Okay. (Pause) (Talking to himself as he reads the decal and sets the circuit breakers) Drive Enable, Forward is going Prime 1. Take it nice and easy. Rear going Prime 2. And that is Both; I know that. That's Secondary. Okay; Steering, go Forward to A...Boy, it's hard to see in that Sun...and Rear to D. Rear to D. Drive Power Forward going to A. Now, I didn't feel any Earth-shaking rumbles like I do in the trainer, but let's see what happens.

(Pause) Okay, Jack. I'm going to find out in a minute.

117:47:33 Schmitt: Okay.

[The one-g training Rover used on Earth was a far more substantial vehicle.]

117:47:34 Cernan: Okay. Here we go. Okay. The runt...the fright...the front wheels turn. I can't see the rear ones.

117:47:43 Schmitt: (Finishing the pan) I'll verify them in a minute.

117:47:50 Cernan: Okay. I can't see the rear ones, but I know the front ones turn. And it does move. Hallelujah. Hallelujah, Houston! Challenger's baby is on the roll.

117:48:04 Parker: Roger. Copy that. Sounds great.

[Cernan - "While I don't remember the details, if the Rover hadn't worked, we were going to try and cover some of

the same ground; but we wouldn't have gone nearly as far or have accomplished nearly as much as we did."]

[Schmitt - "It was my position that the probability of the Rover failing was small, so why waste our time in training or planning on walking traverses that you could put together fairly easily in real time. You knew basically where you wanted to go and you just would have to see how well you were doing and how much energy it was going to take. We couldn't have taken all of the equipment, but we had the bags for samples. I'm not sure we could have mounted SCB's on both sides of the PLSS's - might only have had one apiece - but we could have put quite a bit of equipment in one SCB and samples in the other. It would have been awkward, but there would be no question that we would have gotten something done. The real question is how far we could have gone. And I suspect that on the first EVA we wouldn't have gone very far until we were use to it. But it is still my contention that, if you got up to speed striding, you could have gone as far as you did with the Rover. It just would have taken more energy and your walkback constraints would have changed. I'm sure the Flight Control people would have been very conservative with walkback, at least with the first two EVA's; we might have gotten the envelope opened up a little bit for the third. I doubt if they would have let us go to Nansen, because that was right at the edge of the Rover walkback envelope; but we probably could have gotten up the hillside to Station 6, simply by going sidehill rather than directly uphill like the Apollo 14 guys did. But I just couldn't imagine very many reasonable failures that would keep you from having the Rover. You had front and rear wheel drive so you could go either way; and you could lift it out of any hole it got into."]

117:48:08 Cernan: And judging from the way it's handling, I think the rear wheels are steering too.

117:48:19 Parker: That's a first.

[On both of the other Rover missions, the rear steering was inoperative at power-up. For unknown reasons, those Rovers later regained rear steering - at the start of EVA 2 in the case of Apollo 15 and after Rover preps in the case of Apollo 16. Because the Rovers all had front steering as well, the losses were not of any particular concern.]

117:48:23 Cernan: What do you see, Jack?

117:48:26 Schmitt: Well, you're (at the) wrong angle. Yeah, they're turning!

[Gene is driving around the back (east side) of the LM, more or less toward Jack who is still northeast of the spacecraft. Jack's photos of the test drive are AS17-147-22521 thru 22527.]

117:48:28 Cernan: How does that grab you?

117:48:30 Schmitt: They're turning.
 117:48:32 Parker: How about that.
 117:48:36 Schmitt: Come towards me, baby! Looks like it's moving.
 117:48:40 Cernan: Oh, boy. (To the Rover) Keep moving.
 (Pause)

[Gene's tone of voice suggested that, just for a second, he thought something was wrong with the Rover.]

117:48:51 Schmitt: Don't run over me.
 117:48:53 Cernan: Don't worry.
 117:48:57 Schmitt: Man, if they don't like this...
 117:48:59 Cernan: How's that?
 117:49:00 Schmitt: Let me move back. Okay?

[Jack is trying to take a picture of Gene on the Rover with the Earth in the background. Earth is about 30 degrees south of west and at an elevation of 45 degrees.]

117:49:06 Cernan: How's the time line, Bob?
 117:49:11 Parker: As far as I can tell, you guys are right on within a minute or two.
 117:49:17 Schmitt: The Earth's just a little high for me, Geno.
 117:49:19 Cernan: Okay.
 117:49:21 Schmitt: I'm not sure I can get it without getting way away.
 117:49:23 Cernan: Okay. Don't worry.

[That is, Jack doesn't think he'll be able to get both Gene and the Earth in the camera's field of view without getting a long way away from the Rover. However, because the 70-mm camera's field of view is only about 40 degrees, even at a great distance Jack wouldn't be able to get both Gene and the Earth in a horizontal shot. The key to success, as they will discover during the flag deployment, is to get close, hold the camera at knee height, and shoot up at an angle.]

117:49:26 Schmitt: Somebody said it (Earth) was going to be just behind the South Massif. (Laughs)

[From the LM, Earth is at virtually the same azimuth as the 2300-m South Massif summit; however, the summit elevation is only about 11 degrees.]

117:49:29 Cernan: Okay. I'm going to take a little spin around here, and I'll meet you at the front end (of the LM).
 117:49:32 Schmitt: Okay.
 117:49:36 Cernan: Boy, there's a lot of static, though, every time I start driving. (Long Pause)
 117:50:09 Cernan: I know what that was over there, I think. Let me see. Whee!

[Gene is still trying to figure out exactly where he landed, and may be driving east to take a close look at craters he thinks might be Poppie and Barjea.]

117:50:16 Schmitt: Okay, Houston. The basic material around the LM is just what I said: a fine-grained, medium-gray regolith-appearing material that has the standard seriate population. (Long Pause)

117:50:50 Schmitt: The craters, though, (that are) bigger than about a meter in diameter seem to get to (that is, excavate) rock fragments (pause) which I haven't yet learned how to pick up.

[Schmitt - "At this point, I was talking out loud, just getting a feel for what things looked like, transitioning from the theory and the experience of others to personal experience. We expected that craters bigger than some size would penetrate through the soil and bring up bedrock fragments; but I hadn't yet learned to distinguish between regolith breccia (soil compacted and partially fused in an impact, also known as 'instant rock') and actual basaltic rock fragments that would have come off the bedrock. The language I used often wasn't very precise at any point in the mission, but at this point I was just feeling my way about how I was going to talk about these things."]

117:51:05 Cernan: Okay, Jack. I'm going to give them our position here. I think I know exactly where we are now.

117:51:12 Schmitt: (To himself) Well, once you get them dirty, just like the boys say, it's hard to tell what they are.

[That is, it's difficult to classify dust-covered rocks.]

117:51:20 Cernan: Okay, Houston. I'm parked right next to Barjea. And we (that is, the LM) are, from Barjea, (at) 12 o'clock...Jack, how far...Oh, you can't see. You're looking at the Sun. I guess about 150 meters due west of Barjea. And that's why we looked so close to Trident. I'm coming right up on Poppie. No question about where I am now. I've got Trident, and when I get up there...We are abeam of Trident 1, just where I said we were. I'm right at Poppie. We're about, oh, 100 meters just about due west of Poppie, which is almost in line with Barjea, of course; but basically (the LM is) on the (north-south) line, I think, between Rudolph and Trident 1. And, as I look at it in cross section, about 100 meters north of Trident 1.

117:52:34 Schmitt: That's the landing point! (Pause)

[Gene may have driven out to an unnamed crater about 200 meters east of the LM but well short of Mariner and San Luis Rey.]

[Schmitt - "I wasn't going to worry about where we were exactly. We were close to the planned landing site and we certainly weren't going to have any trouble finding Camelot or any of the other places. (Changing topics) Somewhere, and possibly in here where Gene was describing the landing site, the cuff on my urine collection device was too tight. I needed to urinate but couldn't unless I really forced it. And that was very uncomfortable. Once we got back in after the EVA, I took the rest of the cuffs and stretched them over the hand-controllers in the LM."]

117:52:45 Schmitt: Sure get dirty fast.

117:52:47 Cernan: Jack, that is Trident right here that we walked over to.

[There is a very shallow depression ENE of Poppie which may be contributing to Gene's confusion.]

117:52:52 Schmitt: (Laughing, having fallen while trying to pick up a rock) I just got my first initiation to getting very dirty.

117:52:56 Cernan: You sure did. (Laughs)

117:52:59 Schmitt: Where are you? Are you ready to go?

117:53:02 Cernan: I'm coming right around the front now. Houston, did you get that position?

117:53:05 Parker: Roger. We copied that, Geno.

117:53:08 Cernan: And Bob, I'm...I'm...I'm very firm of that now. I'm almost positive, unless I'm awfully mistaken about Trident. I don't see how I could be from here.

117:53:22 Schmitt: At the sacrifice of my cleanliness, Houston, the basic light-colored rock type in the area looks very much like the cristobalite gabbros of the...I didn't see cristobalite, but it looks like the gabbros in the mare basalt suite. The coarse-grained clinopyroxene plagioclase rocks.

117:53:48 Parker: Okay. We have that.

[Schmitt - "I spent a lot of time in the Receiving Lab looking at samples from the other missions, and had in my own mind a grain-size classification and a variety of other classifications that I'd be using throughout all of this. I shouldn't really have used the term 'gabbro', but it had stuck in my mind as a way to distinguish a coarser-grained version of basalt. That is, if I could see distinct, clear crystals and make a guess at what they were, I think I consistently called it a 'gabbro'. However, by definition, basalt is fine-grained; gabbro has the same chemical composition but is coarse grained, although more coarse grained than anything we saw in on the valley floor. So I probably confused a lot of people on the ground. But this was coarser-grained than a lot of things that I had seen in hand specimens from other missions. This had grains up to a millimeter or so across, where as many of the samples (from

other missions) were so fine grained that they were even glassy."]

117:53:50 Cernan: Jack, I'm going to park...How about along side (the MESA)?...Am I gonna screw up that little crater with glass in it if I park there?

117:54:03 Schmitt: Well, we will eventually.

117:54:04 Cernan: Well, there's that one anyway. Let me park right here.

117:54:07 Schmitt: I'm sure we'll find some more.

117:54:10 Cernan: Yep. (Pause) (Looking at the dirt on Jack's suit) Where you been? (Laughs)

117:54:14 Schmitt: I fell down!

117:54:16 Cernan: Okay, that's about close enough. Isn't it?

117:54:19 Schmitt: Yeah.

117:54:20 Cernan: Okay, she (the brake) is locked. Here, let me get the 15-volt supply.

117:54:22 Schmitt: I think this camera is probably a little dirty on the lens.

117:54:27 Cernan: Okay, Houston. We're parked.

117:54:30 Schmitt: (Having taken the camera off) No. The lens is okay.

117:54:32 Cernan: When you uncover one of those lens brushes, I want to use it on my visor. Oh boy. (Sounding a little frustrated) It just takes a little getting used to the 1/6 g, Jack.

[Cernan - "Here, I was obviously getting out of the Rover. And it just took a little while to find out how to do it. With the gravity too low to really pull you down to the ground when you got out, you literally had to push yourself up and out. You quickly learned how to do things the easy way, because there is an easy way in 1/6 gravity."]

117:54:45 Schmitt: I want to put this camera over here right now, because it's pretty dirty to put back in that bag.

[The checklist calls for Jack to put his camera in the ETB; however, he is probably setting it on the MESA.]

117:54:51 Cernan: (To himself) Okay, get to work.

117:54:54 Parker: Roger. We copy that guys. You're about 7 minutes behind right now.

117:54:58 Cernan: (Reading checklist page CDR-10) "LRV front configure." Whoops. Hold it.

[Cernan - "After we had unstowed the Rover from the LM and had assembled it, then we had to load it. We had to load the front end with all of its electronics, communications gear, and television, and the back end with all of our tools, all our collection bags, all our sample bags, everything else was all loaded on back there. The only big exception was the ALSEP equipment which Jack carried out to the site."]

117:55:03 Schmitt: (Responding to Parker's comment about being 7 minutes down) What!? Okay, we'll catch up. (Pause) I haven't quite learned how to pick up rocks in my hands yet, Bob, or I would of had you a sample. That's why I fell down. (Singing) "My day will come." Oh! Oh! It's an old blue traverse gravimeter!

[Cernan - "This is a very characteristic expression of Jack's, always acting surprised when he finds 'the old brown whatchamacallit'."]

[As per checklist page LMP-9, Jack has gone to the northeast LM quadrant to remove the geopallet. Among other things, the geopallet contains a portable gravimeter which will be used at all of the geology stops. The gravity data will give information about the deep geologic density of the valley. Like everything else, the geopallet is stowed behind some thermal insulation. As Jack removed the insulation, the gravimeter and the other gear was exposed. The gravimeter is stowed on the right rear surface of the pallet. AS17-142-21730 is a photo of Gene operating the gravimeter at Station 8 during EVA-3.]

117:55:33 Cernan: Okay. On the plains of Taurus-Littrow. What a valley. I'd like to cut through here, with a T-38 sometime.

[The T-38 is a supersonic aircraft and Gene is imagining roaring up the valley at about 500 knots.]

117:55:44 Schmitt: That'll be the day.

[Jack says that, here, his intent was to mimic John Wayne.]

117:55:46 Cernan: Yeah, it will.

[There being no air on the Moon in which to fly a T-38.]

117:55:49 Schmitt: Whoa there.

117:55:50 Cernan: You never know.

117:55:51 Schmitt: Friend of mine...

117:55:52 Cernan: (Scanning checklist page CDR-10)

"Install LCRU, lock posts"; I'll get that. Okay. That's the next big hooker, the LCRU.

[Cernan - "The LCRU (Lunar Communications Relay Unit) was a couple of big electronics boxes to handle the radio and TV. The whole thing was about 18 inches wide, about 6 inches high, and maybe 12 inches deep; it had dust cover flaps and, when we weren't driving, we could open the flaps and expose a radiator so that the LCRU could cool. We put it on the front of the Rover and, once we got that thing set up, we didn't even have to relay through the LM."]

[Schmitt - "Either the batteries or the LCRU cooled by using a wax reservoir. Probably the batteries now that I think about it. The idea was that the wax (3.5 pounds) would melt while you were using the battery and generating heat; and then, between EVA's, it would radiate and cool and the wax would harden again. The LCRU had mirror radiators."]

117:56:03 Schmitt: Okay, geopallet's off the LM.

117:56:06 Parker: Copy that.

[The geopallet consists of a two-part assembly: (1) the pallet which attaches to the rear chassis and the geopost; and (2) the gate which, as you face the Rover from the rear, can be swung open from left to right. The pallet contains a sampling scoop, a gnomon, a hammer, two sets of tongs, two extension handles, an LRV (Lunar Roving Vehicle) sampler, the Traverse Gravimeter, and six Sample Collection bags (SCB's). The tools will be illustrated and described at appropriate places in the text. Jack will attach some of the tools to brackets on the outside of the gate for easy access.]

[Schmitt - "Eventually, that gate latch got dust in it and wouldn't work. On our last traverse, when we got to the LM, the gate was flapping in the breeze."]

117:56:09 Cernan: You know, you just got to take it easy until you learn to work in 1/6g.

117:56:12 Schmitt: Well, I haven't learned to pick up rocks, which is a very embarrassing thing for a geologist.

117:56:18 Cernan: Yeah, I look like an elephant stumbling around here. (Pause) (Talking to himself) Careful with the LCRU. One dust cover came off. Careful with this baby (because of the relatively fragile electronics). (Pause) That's the real one (rather than a training version). (To Jack, who is mounting the geopallet on the back of the Rover) Boy, you sure move that Rover around when you do that. (Pause)

117:56:56 Schmitt: Hey! The geopallet is locked on.

117:57:01 Parker: Copy that. (Long Pause)

[The pallet has a long, open-topped, vertical sleeve or socket attached to the right front. Jack positioned the pallet over the post so that, as he lowered the pallet, the post slid into sleeve. He then swung the pallet across the aft chassis until a locking device engaged. Now, he is removing and discarding the handrails he used to grip the geopallet while he carried it.]

117:57:25 Schmitt: I'm getting pretty good at throwing things. Already. (Pause)

117:57:56 Cernan: Man, that thing (a connector on the Television Control Unit or TCU) won't want to go on. That's because it's not in there. Put it in right, and it goes on. Okay, the power cable's on the TCU, Bob.

117:58:08 Parker: Got that. (Pause)

[The LCRU has two open sockets which fit onto a pair of short posts on the front edge of the forward chassis. Gene has fitted the LCRU onto the posts and then pushed down a simple lock on each post. He is now mounting the TCU in a "locking collar" on the front of the righthand battery and is making an electrical connection to the LCRU.]

117:58:21 Schmitt: TGE (Traverse Gravimeter Experiment) is On. (Reading the display) 22...Oh, you just want the last ones. Okay, 07.

117:58:31 Parker: Okay. Copy that.

[Jack is powering up the TGE. Measurements can be made when the instrument is on the Rover or with it removed from its mounting bracket and set on the ground. Here, Jack is reading out numbers on the display. The display consists of three 3-digit numbers.]

117:58:32 Schmitt: 07. (Pause as he turns to checklist page LMP-10) God, (laughing hard) the dirtiest checklist in the world!

117:58:43 Cernan: Doesn't take long, does it? (Jack laughs) Doesn't take long. (Pause) Manischewitz, look at that go! Did you see that?

[Gene may have discarded some of the TCU packing or, perhaps, a dust or thermal cover. As he discusses at 118:39:52, statements like his "Manischewitz, look at that go! Did you see that?" were later taken out of context by a writer of UFO books to "prove" that aliens had paid them a call.]

117:59:04 Schmitt: I wish you'd be more careful.

117:59:05 Cernan: What?

[Schmitt - "Throwing things was fun; but you also had to watch out you didn't hit somebody."]

117:59:07 Schmitt: (Laughing) No, no, no! Not the television camera! (Pause)

[Schmitt - "We were trying to upset the ground, Ed Fendell in particular, and make them think Gene was about to throw the TV camera. Ed was the person who remotely operated the TV camera from Houston."]

117:59:18 Cernan: Okay.

117:59:19 Schmitt: It's warm out here, you know? I'm certainly glad I got cooling.

117:59:23 Cernan: Okay, the TCU is locked in.

117:59:25 Schmitt: Houston, I've seen an awful lot of rocks, as I work here. They look just like those pyroxene gabbros that I mentioned. The pyroxene's iridescent in the bright

Sun. The grain size is about, oh, between...Maybe the mean is 2 millimeters with max maybe up at 3 or 4. And it looks like predominantly a pyroxene plagioclase rock...(correcting himself) clinopyroxene, but I haven't looked at it real closely. (Pause)

118:00:16 Cernan: Okay, Jack. I'll set the rake on the...

118:00:19 Schmitt: Beautiful.

118:00:20 Cernan: ...on the seat.

[Gene is in the middle of CDR-10 and has removed the rake from the MESA and is putting it on his Rover seat. In a few minutes, Jack will attach the rake to one of the extension handles and fit it in a mounting bracket on the rear of the gate. For now, Gene is getting the rake out of the way so that he can unstow the low-gain antenna described below.]

118:00:22 Cernan: I just haven't learned...I'm getting more finesse now. I think you can overwork yourself, instead of making use of the 1/6 gravity.

118:00:32 Schmitt: Yeah.

118:00:33 Cernan: It's going to take a whole EVA to get familiar.

118:00:36 Schmitt: Well, I hope it doesn't. (Pause) I find I'm using my arms almost as much as I ever did. I remember the last time I was on the Moon: about 2 hours ago. (Pause) (To himself) Okay, guess what? That old hammer goes to the gate top. (Pause) The blue-handled hammer. What more could you want?

[Sometime between now and the flag deployment at 118:21:26, Gene will put the hammer in a pocket on his right shin.]

118:01:09 Cernan: Okay, Bob. I'm getting the low gain (antenna) out now.

118:01:14 Parker: Okay. Copy on that. (Pause)

[During the traverses, the low-gain antenna will be used for voice communications with Earth. Because a voice signal doesn't have to carry nearly as much information as a TV signal, the broadcast strength can be weaker for voice and the antenna pointing doesn't need to be more accurate than about 30 degrees. Gene will fit the antenna mast into a socket on his T-handle.]

[Cernan - "The low-gain antenna was a tube about an inch and a half in diameter and about 2 feet long. There was a handle on the mast, right in front of me, and as I drove the Rover, I could point it generally in the direction of the Earth. We could drive and maintain radio contact the whole time, and it worked out real well. The high-gain antenna for the television was on the front of the Rover, as I remember, and we couldn't reach it (as we drove). We aligned it after we stopped; but, if it was, per chance, pointed at the Earth

and we were driving in a straight line, we could have gotten television as well. We talked about trying to do that, but I don't think we did. I think 15 or 16 transmitted some TV while they were driving."]

[Scott and Irwin made an unsuccessful attempt during the EVA 3 drive from Station 9 to 9a. Note, also, that Apollo 17 is the only mission with Earth far enough from the local zenith that the Commander has to sometimes re-point it while he's driving.]

118:01:30 Schmitt: (Referring to the Rover power-up) Felt like a Rover, huh, Geno?

118:01:34 Cernan: Beautiful. I just couldn't feel it murmur when I pressed the breakers in. I could feel life in it, but...

118:01:39 Schmitt: (Doing a W. C Fields impression) Hey, you let me down, sport. You let me down. There's a pin you didn't pull.

[Probably one of the deployment pins.]

118:01:43 Cernan: Okay, I'll let you get that; keep you honest.

118:01:47 Schmitt: Not only keep me honest.

[Schmitt - "It also kept me busy."]

118:01:49 Schmitt: There. (Pause) Okay. Where am I (on the checklist)? Okay. (Punning) Gnomon's an island. Actually, up here, it's a geometric reference for photogrammetry.

[Cernan - "This is typical of Jack, including the bad pun. I know that I talked out loud about what I was doing, and I still do it today: I play golf and I talk to myself."]

[A gnomon is a short stick used for throwing a shadow, say on a sun dial. Although there are gnomons on many of the ALSEP instruments, here Jack is referring to the geologic gnomon which provides a shadow, a length scale for photographs, and also, because the shadow stick is gimbaled, a local vertical. The gnomon has a color chart and gray scale attached to one of its three legs and, for stowage, the gnomon legs fold together - rather like the stays of an umbrella - making a slim package that can be slid into a quiver mounted on the left side of the pallet, behind Gene's seat.]

118:02:20 Cernan: Would you believe that the doggone (logain) antenna...Here; Jack, when I bend this, pull the...

118:02:30 Schmitt: Okay.

118:02:31 Cernan: Pull the antenna.

118:02:32 Schmitt: Rather awkward.

118:02:33 Cernan: Pull the antenna. I got to open it up to get it out.

118:02:36 Schmitt: Okay. The connector, you mean.
 118:02:38 Cernan: Yeah, connector is wedged in there.

[Schmitt - "We're getting the low-gain antenna out of it's storage slot in the side of the MESA, and the connector - which may have been a separate piece - had gotten wedged."]

[This is probably the fitting for making an electrical connection to the LCRU.]

118:02:41 Schmitt: (Laughing) Well, that's probably the way it was designed.

118:02:44 Cernan: Boy, don't drop any of those connectors on the...(Discarding something) Look at that go. (Don't drop it) in the dust. We'll never clean them up.

118:02:55 Schmitt: Dum dee, dum dum dum. Good thing we're well-coordinated human beings.

118:03:06 Cernan: Man, I can't believe...Yeah, I can.

118:03:07 Schmitt: Okay, let's see. (Laughing) Do it right now.

118:03:10 Cernan: Yeah, I can.

118:03:13 Schmitt: See that?

118:03:16 Cernan: Yeah. (Pause) Which way are you going to put it on?

118:03:18 Schmitt: Well, I thought maybe I would put it on that way; so I will put it on this way, because that's probably right.

118:03:23 Cernan: If you put it on right, you're going to disappoint me.

[Jack is probably clipping the large dust brush on the LCRU.]

118:03:33 Schmitt: Oh, I hate to touch...I touched the old gnomon!

[The only touch-critical parts of the gnomon are the gray scale and color chart.]

118:03:38 Schmitt: I'll do my best to clean (it). Ray Batson will...

118:03:44 Cernan: Okay, Bob the low gain is...

118:03:46 Schmitt: ...will never forgive me.

118:03:47 Cernan: The low-gain is hooked up.

118:03:51 Parker: Okay. We copy the low gain hooked up.
 (Long Pause)

[Schmitt - "Ray Batson was the U.S Geological Survey/ Flagstaff expert on photogrammetry and was the Godfather of the gnomon. He developed it so they could quantitatively control the stereo pairs that we would take on the traverses. It provided a physical scale, a vertical reference, a gray scale and a color scale, and it's shadow gave an azimuthal reference."]

118:04:16 Schmitt: Da da, da doe! The rake is on the extension handle. (Pause)
 118:04:32 Parker: Roger, 17.
 118:04:33 Schmitt: My kingdom for a scoop. (Pause) The scoop is on the extension handle. Different extension handles of course.

[There were two extension handles, one for the scoop, one for the rake. After attaching the tool heads to the extension handles, Jack is fitting them vertically into brackets on the back of the gate. He will also fit a vise to the top surface of the pallet for the separation of drill stem sections and attach an SCB to the gate for additional sample stowage.]

118:04:52 Cernan: Go ahead Bob. Were you calling?
 118:04:56 Parker: Roger. And your exuberance is showing up on the BTU's. You're running a little high on those.
 118:05:03 Cernan: Okay.

[The accompanying figures show Gene's and Jack's heart rates for this first EVA. Note that the elapsed times are relative to the actual time of launch, rather than the planned time of launch which is used here in the Journal text. Times on the graph must be increased by 2 hours 40 minutes to correspond to Journal times. Note that, at the end of the test drive at 117:55 (114:15 on the graph), Gene's heart rate reached a minimum of 100 beats per minute and has been climbing while he and Jack have been setting up the Rover. At this moment (115:25 on the graph), Gene's heart rate is rising above 130 beats per minute. throughout this period, Jack's heart rate has generally lower than Gene's. This first EVA is their most strenuous because of the Rover deployment, the ALSEP deployment, and, most importantly, the fact that they won't be spending much time riding on the Rover.]

118:05:04 Schmitt: Exuberance! I've never been calmer in my life. (Garbled)
 118:05:09 Cernan: We'll take it easy, Bob. I think it's a great deal a part to just get accustomed to handling yourself in zero gravity.
 118:05:18 Schmitt: The only vise on the Moon.

[From Jack's tone of voice, this may be intended as a pun. He is talking about the vise which is mounted on the back of the Rover and which Gene will use to break apart the drill stem sections of the deep core Gene will drill at the ALSEP site. And, of course, there was - at least in 1972 - no vice at Taurus-Littrow.]

118:05:20 Parker: Rog. I thought you were at 1/6 g.
 118:05:25 Cernan: Well, you know where we are.

118:05:28 Schmitt: Whatever. (To himself) Okay, old sample bag...Sample containment bag...(correcting himself) Sample collection bag (number 2), or whatever, is going (on the gate) (Garbled) (Pause) (Singing) "What is this thing called crazy." Come on. (Pause) Okay, that's there. Some of the simplest things in the world you forget. (Pause) Okay, let's get this right this time.

[Schmitt - "I was having fun. You're there and you're doing what you planned to do; and you might as well enjoy it."]

118:06:28 Schmitt: You did a great job of parking (the Rover), so I was standing in a hole.

118:06:33 Cernan: Don't want to mess up all those good looking craters around here. (Pause)

118:06:46 Schmitt: Oop! Hang on there accessory staff. Accessory staff, huh? Most staffs are accessory, I've learned.

[Jack is attaching the accessory staff to his handhold. The accessory staff has attachments for a map clip and a Sample Collection Bag (SCB). At times during the traverses, Gene will stop the Rover so that Jack can grab a sample with the LRV sampling tool to be described later. Once bagged, the sample can then be put in the SCB hanging from the accessory staff. After Jack finishes attaching the accessory staff to his hand hold, he will put SCB-3 on it and will secure the top of the SCB in the open position by using a strap attached to the low-gain antenna lead. Apparently, this operation will take him a couple of minutes.]

118:06:54 Cernan: Okay, Bob the high-gain (TV antenna) is up and connected.

118:06:58 Parker: Okay. Copy that. Beautiful.

[Gene is at the bottom of CDR-10. The high gain is an umbrella-shaped antenna about a meter across. It will be used for TV transmissions to Earth and, because the pointing must be very accurate, it has a sighting device. Gene has mounted the high gain in a "locking collar" on the front of the lefthand battery.]

118:07:00 Cernan: And raised.

118:07:01 Schmitt: Okay.

118:07:02 Cernan: Cable is velcroed to staff. See if I can't get you a TV camera.

[Gene has attached the TV cable to the high-gain antenna mast, primarily so that it won't flop around. He is now getting the TV camera from it's stowage slot in the MESA and will mount it on top of the TCU. He is at the top of CDR-11.]

118:07:09 Parker: We're waiting with breathless anticipation.

118:07:12 Schmitt: Ah, let's keep them in...(Listens to Parker)

118:07:15 Cernan: Well, how's my cooling doing? I'd like to stay on Intermediate, Bob. I feel pretty comfortable. I'm not cold but I'm pleasant.

118:07:22 Schmitt: (Guffawing) Pleasant? He thinks he's pleasant?

118:07:24 Parker: You're fine, no problem; your option, Geno.

118:07:29 Cernan: Okay, I just don't want to run out of consumables (oxygen and cooling water) about 6 or 7 hours (into the EVA).

118:07:36 Schmitt: You're about as...Oh well. Okay. I don't think it makes any difference. You got to use (means "get rid of") the heat. Matter of fact, that's one of the little known facts of this business, Gene.

118:07:49 Cernan: Okay, here we go. Coming up. I've got the TV camera in my hand, Bob. (Pause)

118:08:02 Cernan: Oh, man. Hey, Jack, just stop. You owe yourself 30 seconds to look up over the South Massif and look at the Earth!

118:08:07 Schmitt: (Pretending surprise) What? The Earth?

118:08:09 Cernan: Just look up there.

118:08:10 Schmitt: Ah! You seen one Earth, you've seen them all.

118:08:13 Cernan: No you haven't, babe. When you begin to believe that...Come on camera, go in there. (Garbled)

118:08:23 Schmitt: Apparently still mounting an SCB on the accessory staff) I'll look in a minute, Gene. But I tell you, once I start this little operation, if I don't finish it, it never gets done.

[Schmitt - "Soon after we got back, somebody put out an environmental poster that said "If you've seen one Earth, you've seen them all."]

[Cernan - "Obviously, Jack and I have looked at the Earth differently. I think we had very different subconscious views of what we saw. That's always been true and it's probably true in all twelve guys. To me, the Earth was a very dominant part of our mission. It certainly made a statement. You could hardly not notice that it was visible. It was a dominant presence in our valley, without question.

"For Jim Irwin, going to the Moon was a religious experience and, for me, it was a spiritual experience in terms of being there and looking back at the Earth, realizing the significance of what was going on. The piloting part was very important for me to do well, better than it had ever been done before. That's the nature of a pilot. And, as for the science - although maybe I shouldn't say this - it was a part of our mission but it certainly was not the overriding part of me, and it's not the part that's overriding for me in my memory bank at all. Of course, for Jack, for a geologist,

the Moon was a utopia, a thing you would dream of your entire life. Well, I was not a geologist by trade or profession and, although I tried to be one for the moment, being on the Moon was more of a spiritual experience for me. Religion is what you make it, where you make it. But the mission did bring home to me, very clearly, that Science has a long way to go yet to find an answer for the creation of the small part of the Universe that I was privileged to see. It doesn't make any difference who your God is or how you address him; the Earth was just too beautiful to have happened by accident. There has to be somebody bigger than me who put it together. And when I say spiritual, that's what I mean.

"Charlie Duke is a born-again Christian and who is to say that that might not have happened if he hadn't gone to the Moon. Jim Irwin looks back at it as a very religious experience, but Jim was like that before he went to Moon. And Jack looks at it from a humanist point of view. What's important to Jack is what Man does with his life; and, although Jack's a very philosophical sort of guy, the creation of the Earth, from a philosophical point of view, is not something that he expresses himself on very strongly. But we all have different points of view. I had the experience of going to the Moon twice, of being able to go back and say 'Is this what I really saw? Is this what I really felt? Is this what it really looked like?' To have seven more days at the Moon to do that is a pretty unique experience in itself."]

[Schmitt - "On the trip out to the Moon, I had spent a lot of time looking at the Earth. I had this little program of meteorological observations that I wanted to undertake, so I'd already spent a lot of time looking at it, and so that's why I was acting a little more blasé."]

118:08:31 Cernan: (Talking to the TV camera) Okay, get in there. Okay, that's in there. That's in there. Camera is locked down. Okay. (Reading) TCU; sunshade to camera and then the cable. Okay, let me get the sunshade. (Pause)

[Unlike the TV cameras used on the early Apollo missions, this one is able to stop itself down in response to excessive light levels. However, the sunshade will minimize loss of information when the camera is pointed toward the eastern horizon.]

118:08:56 Schmitt: Whoo! That's always more of a job than it ought to be. However, SCB-3 is on the handhold. (Pause)

[What Jack means is that he has finished hanging SCB-3 on the accessory staff. Next, configure Gene's camera and, then, stow the spare film magazines and other gear in a fabric-enclosed space under the Gene's seat. He is starting checklist page LMP-11.]

118:09:07 Cernan: I think I'm getting smarter about 1/6 g.
(Pause)

118:09:13 Schmitt: That gate works great! Snaps in, snaps closed with the slightest flick of a coordinated wrist. Where is that (CDR) camera anyway? Oh, it's over here (on the MESA). (Pause) Oh, boy. (I can) just still barely see the scissors.

118:09:32 Cernan: (Chuckling) We ought to get those, before we go hungry.

118:09:35 Schmitt: I'm not sure I can.

118:09:36 Cernan: Okay, don't. Okay, we'll get them (the scissors) when we get the tongs out, Jack.

118:09:40 Schmitt: Yeah. There are some tongs in the Rover, and I'll come over and get them in a minute.

[Jack is getting the ETB off the ladder hook. He will take it to Gene's Rover seat and put film magazine Bravo (B) - also known as AS17-134 - on Gene's camera.]

118:09:42 Parker: Roger, Challenger. And we refrained from mentioning that to Ron.

118:09:50 Cernan: Tell him I hope he's enjoying our scissors. Okay, Bob, the TV is connected to the TCU, electrically. The sunshade is on. I've got to deploy the high gain. (Talking to himself) Okay. Now...Well let's see how smart you are. That was a pretty good attitude you parked at. Okay. Jack, is the high-gain away from my (PLSS) antenna? Can you see?

118:10:24 Schmitt: Let me turn around. (Pause) Ah...Yes; you're clear.

[The concern here is catching Gene's PLSS antenna on the hi-gain.]

118:10:29 Cernan: Okay, it's locked. Locked. Now let me see if I can find the beautiful big dot (that is, Earth) up there. I know what I'm going to have to do. I'm going to have to get the...Oh, I got it right there! Might be able to peak that but I got that.

[Gene is trying to find Earth in the high-gain viewfinder. The optical sight is positioned such that it is easiest to find Earth if the Rover is pointing in the opposite direction (roughly northeast) and Gene is standing in front of the vehicle sighting back across it to Earth. This is the reason why, at most geology stops, he points the Rover at a heading of 045. As will be seen when he parks the Rover at the VIP site at the end of the third EVA, alignment of the high-gain is very difficult when the Rover is pointed more or less at Earth.]

[Schmitt - "Earth is about four times as big in the lunar sky as the Moon is in the terrestrial sky; but you don't sense that because you have no other visual references for size. There are no trees or poles or houses or anything

between you and the horizon that you can use to estimate how big the Earth is."]

118:10:56 Schmitt: You hit (means "found") it, huh?

118:11:01 Cernan: Put my hand over it, so I could see it.

[That is, Gene shaded the sighting scope with his hand.]

118:11:03 Schmitt: Hey, that's an interesting problem. Your seat (bottom) won't stay up.

118:11:09 Cernan: How about that piece of Velcro there?

118:11:11 Schmitt: That's just what I'm working on. There. Great minds think alike. (Pause) Okay, that goes in there. (Pause)

[There are pieces of Velcro on the seat bottom and on the seat back so that the bottom can be held up and out of the way while Jack or Gene work with gear stowed under the seats.]

118:11:29 Cernan: The trouble is to reach it (the viewfinder), I've got to... (Pause)

118:11:44 Schmitt: (To himself) Okay, I'll bet you it (the checklist) says put MAG Bravo...

118:11:47 Cernan: Oh, Earth is in the circle. (Consulting checklist page 11) Okay. "Check LCRU. Deploy LCRU whip antenna." Okay. "Deploy the LCRU whip antenna. Blankets open 100 percent." (Pause) Come on, baby, open. Come on. There it goes. (Pause) Oh, are those mirrors nice. I hope they stay that way for a while. (Pause) They won't. (Pause) I know John (Young) and Charlie (Duke) know exactly what we're talking about.

118:12:38 Schmitt: Mark my words!

[The LCRU whip antenna is used to pick up signals from the backpacks for re-broadcast to Earth through either the low-gain or high-gain antennas on the Rover or the EVA antenna on the LM. Gene is opening the thermal blankets on the LCRU, exposing the radiator mirrors, and is about to power-up the TV.]

118:12:40 Cernan: Okay, I'm going to close the (LCRU) circuit breaker, Bob. Okay, circuit breaker is Closed.

118:12:47 Parker: Copy that.

118:12:48 Cernan: Power switch is Internal. Okay, let me give you some numbers. AGC (Automatic Gain Control) is about 3.4; temp is about 1.8; and power is about 2.1. Okay; Power to External.

118:13:20 Parker: We got those, Geno.

[There is a monitor switch and gage on the left side of the LCRU control panel. The numbers on the dial are translated in the small chart just to the right of the gage. A temperature of 1.8 corresponds to about 60F, and a power of

2.1 translates as a bus voltage of about 28. By going to Internal power, Gene was using internal LCRU batteries to power the monitoring devices. Once he has his readings, he switches back to the Rover batteries (External) for normal LCRU operation.]

118:13:25 Cernan: Okay, Power is External. Mode Switch is going to 2 - FM/TV. Okay. Man, did you peak out at signal strength of four-oh. I can't see right now, but I think I've still got you right in the center. (Pause) Okay, Power switch on the TCU. Okay, it's on the TCU. Okay, AGC and Power. Yes sir, Bob, I'm verifying at four-oh. That's a good Navy term, "four-oh" on the AGC.

["Four-oh" means "perfect" in Navy parlance. Gene has just finished CDR-11]

118:14:02 Parker: Copy that.

118:14:04 Cernan: And the TV is all your's...

118:14:05 Parker: Roger. Have you got a power reading there for us, Geno?

118:14:09 Cernan: ...I hope. (Responding to Parker) Okay, I'll give you a power reading, External, if you want it. I'll give you...Temp is still about 1.7 and Power is about 1.8 on External.

[TV on.]

118:14:22 Parker: Hey, we have a picture, 17. We have a picture.

118:14:25 Cernan: You have? Ah, beautiful, babe. It's all your's. I hope it moves now.

[The TV can be controlled from Houston.]

118:14:30 Parker: It does.

118:14:31 Cernan: I hope it moves. You'll find out...

118:14:35 Schmitt: Hey, it moves! It's alive!

118:14:37 Parker: And...

118:14:38 Cernan: Okay, Bob, I'm going to get SRC 1.

[Fendell starts a clockwise TV pan. Gene is starting checklist page CDR-12. The Sample Return Containers (SRC's) or "rock boxes", are machined from solid pieces of aluminum and are designed to hold an internal vacuum in the interest of returning samples to Earth without contamination. The SRC seal mechanism consists of a strip of soft indium metal - a few millimeters wide - in the rim of the lid, a matching knife edge in rim of the body, and O-rings outside both the indium strip and the knife edge. Prior to the mission, each of the boxes was packed inside a vacuum chamber so that there is now no internal pressure and no chance that the SRC will open explosively as Gene releases the latch. At the end of each of the first two EVA's, Gene and Jack will fill a rock

box with samples and seal it before taking it up into the cabin. The rest of the samples will be taken up in the Sample Collection Bags and will be exposed to cabin air and other contaminants as soon as the astronauts repressurize the cabin.]

118:14:40 Parker: Okay, could we have a EMU check on you fellows when convenient?

[The Extravehicular Mobility Unit is the combination of the suit and the PLSS and as Gene says, it is self-contained spacecraft. Here, Parker wants readings on oxygen quantity, pressure, and warning flag status. The oxygen gauge and warning flags are on the top surface of the RCU and can be read - as long as the lighting is adequate - merely by looking down. The pressure gauge is wrist-mounted. As Jack explains later, this request for an EMU check is also a disguised suggestion that they slow down.]

118:14:46 Cernan: Okay. Commander is 3.8 (psi) plus. I must be 80 percent (oxygen remaining) and no (warning) flags and no (warning) tones.

118:14:56 Parker: Copy that.

118:14:58 Schmitt: Okay, LMP is about 80...Let me see. (Counting marks on the gage) 75...About 80 percent (oxygen), and no flags, no tones. (Pause) I got 83 percent.

[Fendell pans past Jack, who is working at the left side of the Rover.]

118:15:22 Parker: Okay, copy that. And you've sure got a lot of stuff on the Rover already.

118:15:29 Schmitt: Yeah, Mag Helen has just gone into (that is, under) the seat.

[The magazines are labeled "AA", "BB" and so on and usually are referred to as "Alpha", "Bravo", etc. Here, Jack begins a verbal game of using female names and will do so throughout most of the mission.]

118:15:34 Parker: Copy that. (Pause)

118:15:45 Schmitt: Mag Cynthia is in there. (Pause)

118:15:53 Cernan: Okay, Bob, SRC-1 is open.

[Gene is removing SCB-1 from the rock box and, at 118:17:39, will hang the SCB from the tool gate. He is at the top of checklist page CDR-12.]

118:15:58 Schmitt: (Mag) Gail is in. (Pause)

118:16:09 Cernan: Jack, watch these SRC's. They don't like to lock on this table very well.

118:16:13 Schmitt: They never have. (Pause)

[There is a small stand or table on the MESA big enough to hold one of the SRC's. There are locks on the table to hold the SRC still while it is being packed or unpacked.]

118:16:24 Parker: Okay, and Jack, did you get mag...
 118:16:26 Schmitt: Okay.
 118:16:27 Parker: ...Charlie as well?
 118:16:31 Schmitt: That's affirm.
 118:16:32 Parker: Okay. And we did not copy your cuff gage reading (suit pressure) down here.
 118:16:39 Schmitt: Oh, you didn't? Well, maybe that's because I didn't give it to you. 3.9 (psi). No wonder that's so much work.

[Nominal suit pressure is 3.8 psi. Anything higher makes the suit even stiffer and the work correspondingly more difficult. Here, however, Jack is joking; the difference between 3.8 and 3.9 would hardly be noticeable.]

118:16:45 Parker: Go ahead. Copy that. (Pause)
 118:16:53 Cernan: Okay, Bob, SRC 1 is...(Pause) She sure won't stay in the MESA very...(Pause) There, let me try that. Okay, that will stay there. Okay, Bob. It's closed. It sure doesn't seem like it wants to stay there, though. And the organic sample has been sealed.
 118:17:16 Parker: Copy that.

[As on all of the missions except Apollo 11, each of the rock boxes contains an Organic Sample Monitor consisting of a small Teflon bag and, in the bag, rolls of very clean aluminum metal. At the top of the Teflon bag are two metal sealing strips, very similar to those in the individual sample bags described below. Here, Gene is sealing the bag by twisting the metal strips and folding tabs at either end. The aluminum will then be exposed to any contamination from the spacecraft and the PLSS's in much the same way that the lunar samples will be exposed, thereby allowing experimenters to correct for that contamination.]

118:17:17 Cernan: (Seeing the TV move) I guess you believe we're here now, huh?
 118:17:19 Parker: Now we believe you're here. We see you in person.
 118:17:20 Cernan: Okay. Bob, the SRC cover will not stay closed. It just slowly springs up. There's nothing I can seem to do for it. I might be able to set something - a blanket - on top or something.

[That is, a piece of the thermal blanket that Jack had previously removed from the MESA. The lid needs to be closed to keep the interior of the box from being heated by sunlight.]

118:17:35 Parker: Okay, stand by on that. We'll get back with you.
 118:17:39 Cernan: Okay. I'm putting... (Responding to Parker) Yeah, it just flops open. I'm taking SCB-1 to the Tool Gate.

[Gene goes to the rear of the Rover.]

118:17:47 Parker: Copy that.
 118:17:48 Cernan: I'll get me a hammer and I'll give you a gravimeter reading.
 118:17:51 Schmitt: No, you won't.

[The Traverse Gravimeter is sitting on the back of the Rover and needs to be still for three minutes to produce a good reading. Jack is mounting the Buddy SLSS (see below) behind Gene's seat; and, as he works, the Rover jiggles. Until he is done, the gravimeter measurement can not be started.]

118:17:53 Cernan: Not until you're done. I'll go get the (U.S.) flag then. Guess what? We're here again. (Pause)
 118:18:06 Schmitt: The Buddy SLSS is on the Rover. (Pause)

[Cernan - "I don't remember much about it, except that is was a buddy-breathing system - a set of hoses and stuff - that would let us share one of the oxygen supplies if the other one failed. It would have restricted our movements, but it also would have got us back to the LM."]

[The Buddy SLSS was actually a set of hoses which would have allowed them to share cooling water rather than oxygen. It was intended for use in the case of a failure of one of the PLSS cooling systems. As for the case of a dual failure of a PLSS and the Rover, it is an open question whether the two astronauts, connected by the BSLSS hoses, could have walked fast enough to get back to the LM from any appreciable distance. The chance of a dual failure was, however, remote enough that providing for a dual failure would have been a waste of precious weight allowance.]

[Schmitt - "It rings a very faint bell that we had something called a Buddy SLSS; and the fact that neither of us remembers much about it shows how much we felt we'd need it!"]

[Jack consults his checklist and goes to the MESA with the ETB.]

118:18:20 Schmitt: Okay, ETB...Okay, CDR's camera film magazine I had to work on a little bit to get it to work, but it's working.
 118:18:27 Parker: Copy that.
 118:18:28 Schmitt: (To Gene) If I get that camera (that is, Gene's camera, which is on his Rover seat), you can punch the gravimeter, I think.

[Jack goes back to the Rover.]

118:18:34 Cernan: Okay. Get the camera, and I'll give them a gravimeter reading. (Pause) Is that all you need? Because I'll go get the flag.

118:18:43 Schmitt: Okay, you'd better let that...Yeah, but why don't when you go...Let me get some tongs, too, (off the gate). We need to salvage those...

118:18:52 Cernan: Okay.

118:18:53 Schmitt: ...scissors. (Pause)

118:19:03 Cernan: Okay. Let me steady the Rover and punch (the gravimeter button). (Pause)

[Jack takes Gene's camera to the MESA.]

118:19:06 Cernan: Okay, Bob. Mark gravimeter and the light is flashing.

118:19:10 Parker: Okay. We copy that. (Pause)

[Gene begins the measurement by pushing a button marked "GRAV". The gravimeter will work if the outer case it is sitting within about 15 degrees of vertical; however, the actual gravity sensing assembly inside the case needs to be very level and, during the first stage of the measurement, a set of internal motors slowly rotates the assembly on three axes until leveling has been achieved. While this is going on, a light on the top flashes, warning the astronauts not to touch the gravimeter. Once the leveling is complete, the light stops flashing but then stays lit until the measurement itself is complete. Once the light goes off, the measurement is complete and the astronauts can read the measured value off a digital display. Gravimeter measurements will be made at the LM before and after each traverse as a check for instrument drift and measurement error. Measurements will also be made with the gravimeter both on and off the Rover, in part because, in the latter case, there would be no chance of the measurement being disturbed by motion of the TV camera.]

118:19:22 Schmitt: (Singing) "Oh, bury me not on the lone prairie. Where the coyotes howl, and the wind blows free." Okay, where am I? (More to himself than to Gene) You're doing a gravimeter (and) getting the flag. I've got your camera. I'm going to salvage the scissors.

[Jack takes the tongs toward the ladder. Gene is unstowing the U. S. flag. Jack is at the top of checklist page LMP-12 and Gene is in the middle of CDR-12.]

[Cernan - "The flag that we took to deploy was the one that had hung on the wall of the Mission Control Center during all the landing missions. And we also had another flag, which we brought back to replace the one that we deployed at Taurus-Littrow."]

[Jack remembers that the idea of taking the MOCR flag to the Moon was his.]

118:19:40 Cernan: Okay, get the scissors, and I'll be putting the flag in. And don't go near the Rover.
 118:19:46 Schmitt: Don't go near the water. That reminds me of a good book. (Long Pause)
 118:20:08 Cernan: Oh, boy.

[Jack now has the scissors, but doesn't have a place to put them. Jack is referring to the comic novel "Don't Go Near the Water", written by William Brinkley and published in 1956.]

118:20:10 Schmitt: I can't go near the Rover?
 118:20:11 Cernan: Let me tell you...No.
 118:20:13 Schmitt: I can't go near the Rover.
 118:20:15 Cernan: Why don't you set them...
 118:20:16 Schmitt: How about you letting me stick these in your pocket with your (hammer)...
 118:20:19 Cernan: No. (Pointing into the MESA) Set them up there. Just set them in there. We'll get them when we come back in.
 118:20:23 Schmitt: Okay. I'll tell you what I'm going to do.
 118:20:26 Cernan: Just set them inside the...
 118:20:29 Schmitt: Put them in the...Gonna hang them here on the hook (on the ladder).
 118:20:32 Cernan: Okay, that's good.
 118:20:34 Schmitt: Right there.
 118:20:35 Cernan: Okay, Jack. How about the flag right over here in this little mound?

[Jack returns to MESA. Gene is moving north of the LM to deploy the flag. The checklist suggests 30 feet out at 2 o'clock]

118:20:43 Schmitt: Which mound?
 118:20:44 Cernan: Well, let me take a look over here.
 118:20:46 Schmitt: How about right up there on that little high point.
 118:20:48 Cernan: Right up in here where I'm going.
 118:20:49 Schmitt: Yeah. Of course, your idea of a high point might be different than mine. I meant the North Massif! (Laughs)
 118:20:58 Cernan: That's probably the best place in the world for the flag, is right up on the top.
 118:21:03 Schmitt: Okay, let me come over and help you. Dum da dee. How about right...
 118:21:10 Cernan: (Laughing as he thinks about the possibility of hitting bedrock with the flag pole) (Garbled) how much regolith (soil) we've got in a minute.
 118:21:15 Schmitt: Hey, you're in the edge of the crater though. That's no test.

[It is a shallow, six-foot-diameter crater with a soft rim. Pushing the flag staff into the ground would be easy and would not tell them much about the depth or cohesiveness of the regolith.]

118:21:18 Cernan: Well, that's all right.

118:21:19 Schmitt: Move right over here near your tire tracks.

[They move a few steps west.]

118:21:22 Cernan: Yeah. This is a high point right here.

118:21:23 Schmitt: That's good.

118:21:24 Cernan: Right there.

[Jack pushes the staff into the ground by hand. He has his back to the TV and we can't see how far he got it in.]

118:21:26 Cernan: Well, that wasn't too bad. Okay, let me give it a few whacks. (Pause) Oh, baloney.

[Gene is having trouble opening the flap on his shin pocket. After getting the hammer out, he turns it so he can use the flat to hit the top of the staff.]

118:21:34 Cernan: Okay. Watch your fingers. Now that wasn't too bad. Want to make sure it stands up. That's getting pretty...What we could do...I don't know how far we could drill...

[Gene is thinking about the three holes he will have to drill at the ALSEP site. Sixteen whacks drives the staff about that many inches.]

118:21:48 Schmitt: Whang! I think we hit something solid with that one.

118:21:49 Cernan: No, it was still going.

[Cernan - "I don't know how deep it went, but deep enough that it was very firmly planted. Obviously, we hit something hard, momentarily, and then went through. Nothing's going to blow that flag over."]

[Indeed, the flag was still standing after Gene and Jack launched back to orbit and, therefore, will remain standing until somebody goes back and moves it or there is an impact very close by.]

118:21:51 Schmitt: Yeah, but did you ever see it vibrate like that?

[To the extent that the flag staff behaves like a pendulum between hammer blows, the frequency of oscillation is slower than it would be on Earth by a factor of 2.4, the

square root of six. To the extent that it is behaving like a violin string - for which the frequency is determined by string tension rather than gravity - it's behavior would be almost the same as it would be on Earth. Because Jack is still standing in the line of sight, we only get an occasional glimpse of the staff. The vibration isn't obvious in the TV picture.]

118:21:56 Cernan: No, I've never put a flag up on the Moon before.

118:21:58 Schmitt: (Incredulous) What!?

[Cernan - "There were two sections to the pole: the bottom section which had a hardened top on it so that, when you banged it into the ground, you didn't smash it in. The top section just telescoped down inside the section you banged into the ground, and that held the flag. The flag was on a two-section, curtain-rod type thing that was folded up. You unwrapped the flag, swung this curtain rod up, latched it at roughly 90 degree angle to the pole, and then extended the outer part of it. The flag looked all wrinkled, because it was folded up all wrinkled."]

118:22:02 Cernan: Pull that end.

[Jack jumps to grab the end of the flag.]

118:22:04 Schmitt: (Laughing) You're going to have to get it down to my level. You tall guys are all alike. (Pause) Wait, I'm not through.

[Gene is 6'0" and Jack is 5'8".]

118:22:13 Cernan: Okay. How about getting it stretched out?

118:22:18 Schmitt: I will. I just can't start forward as fast as I'd like to. (Pause) Hate to touch it, my hands are so dirty. (Pause)

[Jack pulls the lower corner taut.]

118:22:37 Cernan: Okay?

118:22:40 Schmitt: Well, it's going to want to curl. Maybe it'll...It sort of looks like it's waving in the breeze.

[Gene puts the upper half of the staff into the section in the ground.]

118:22:46 Cernan: Yes, sir. How about right there?
(Pause) (We'll) take a couple (of pictures) this way, and we'll take a couple that way. How's that?

[Jack backs up, going south to take pictures.]

[Schmitt - "You couldn't actually see your feet without bending over, but you could anticipate what was in front of you well enough. Going side-to-side or backwards, you just had to be sure there was nothing in the way."]

118:22:57 Schmitt: Oh, let me get over to the other side.

[Jack changes his mind, goes east of the small crater and winds up north of the flag.]

118:22:59 Cernan: We can get the Rover in the background.

118:23:01 Schmitt: Yeah, and the LM.

[Gene turns the flag so that it stretches out to the east.]

118:23:05 Cernan: It does wave when you do that.

118:23:09 Parker: We've got a beautiful picture of you guys up (on the screen) down there (in the front of the Control Room).

118:23:15 Cernan: Let me tell you, Bob. This flag is a beautiful picture. You see that?

118:23:20 Schmitt: Okay, it's partially covering the Rover, but I think it's a pretty good shot.

[Gene has been west of the flag, holding the staff; he now moves to the east side. This sequence of photos of Gene is AS17-134-20377 through 20380 and they show Gene's pockets, the hammer, his checklists, the dirt he has accumulated on his legs and, beyond the space between the LM and the Rover, Bear Mountain.]

118:23:25 Cernan: How's that?

118:23:28 Schmitt: Let me get the focus right. (Pause)

[Jack probably means "f/stop", rather than "focus".]

118:23:36 Cernan: I don't know how to put it. There you go. Wait a minute.

118:23:40 Schmitt: All right, I got you reaching for the flag.

[Gene takes hold of the corner of the flag with his left hand and salutes with his right.]

118:23:43 Cernan: How's that?

118:23:47 Schmitt: That's very good, Gene. Let me get it in stereo.

[Jack takes a step to his right. This photo is AS17-134-20379.]

118:23:51 Cernan: Houston...

118:23:52 Schmitt: That's beautiful.

118:23:53 Cernan: ...this has got to be one of the most proud moments of my life. I guarantee you. (Pause) (To Jack) Why don't you get a close-in one and we'll trade cameras.

[Gene steps to the west of the pole and salutes. Jack steps in to take a close-up (AS17-134-20380), then moves east to take a down-Sun photo (AS17-134-20381). Finally, he gives Gene the camera and they trade places.]

118:24:06 Schmitt: Houston, I don't know how many of you are aware of this, but this flag has flown in the MOCR (Mission Operations Control Room at the Johnson Space Center in Houston) since Apollo 11. And we very proudly deploy it on the Moon, to stay for as long as it can, in honor of all those people who have worked so hard to put us here and to put every other crew here and to make the country, United States, and mankind, something different than it was.

118:24:51 Parker: Roger, 17. And presuming to speak in behalf of some of those that work on the MOCR, we thank you very much.

[Gene waves Jack closer to the flag.]

118:25:04 Cernan: Jack, right where you were. I'll step to the right. Right there. (Pause)

[Jack salutes. This is AS17-134-20382.]

118:25:18 Schmitt: Well, that's all right. I'll keep it (his arm) down. (Pause)

[Gene moves to the east to get another Sun angle.]

118:25:33 Cernan: Stay there. (Takes a picture, AS17-134-20383) Get closer (to the flag).

118:25:35 Schmitt: I'm going to get on the other side. (Pause)

118:25:37 Cernan: Well, I want to get something here.

118:25:46 Schmitt: What's that?

118:25:47 Cernan: I want to get the Earth.

118:25:49 Schmitt: Okay. Let me get over here.

118:25:51 Cernan: Get around on that side.

[Jack had moved west of the pole, and now moves back. He overshoots his mark and sprays dust as he stops.]

118:25:54 Schmitt: I don't think it's going...You're a little close, maybe, to have them both in focus. That might do it.

[Gene almost gets down on his knees in order to get Earth in the picture along with Jack and the flag. This is

AS17-134-20384. After he gets up, Gene gives Jack the camera and they trade places.]

118:26:08 Cernan: Try that one time, then we'll give up and get to work. (Long Pause)

[Jack holds the camera in his hand and gets it as low to the ground as he can without kneeling.]

118:26:26 Cernan: Point it up a little...Yeah. (Pause)

[This is AS17-134-20385.]

118:26:32 Schmitt: Let me try it again.

118:26:33 Cernan: Okay.

This is AS17-134-20386. This photo shows the "red apple" actuator for the purge valve reasonably well.]

118:26:35 Schmitt: I don't know, Geno.

118:26:36 Cernan: Okay.

118:26:38 Schmitt: Let me get over here closer to you. (Pause) Okay. That might have got it.

[This is AS17-134-20387 and, in addition to having Earth in the picture, it show Gene's checklist and watch/mirror band on his left arm, the OPS actuator on the right side of his RCU, and the OPS antenna on the top of his PLSS. The red bands on the suit and helmet show that this is Gene and not Jack.]

118:26:45 Cernan: Okay, very good.

118:26:47 Schmitt: Okay. All right, let's do it. (Pause)

118:26:55 Schmitt: You think your gravimeter's ready so I can go back there?

[They go back to the Rover, putting one foot in front of the other as they walk.]

118:26:58 Parker: Roger, 17. The gravimeter's ready and a couple of words here. One, I presume you found the scissors, right?

[They stop to listen.]

118:27:07 Schmitt: Yes, sir.

118:27:08 Parker: Okay. Two...

118:27:09 Schmitt: Not Ron's, we found ours.

[Jack moves toward the Rover again.]

118:27:11 Parker: Roger. And the second thing is: we do want the SRC closed. And if you can partially latch it, I'm not sure that's easily done, that would be one solution. The

other would be to put something on top of it to hold it closed.

118:27:26 Cernan: (Heading for the MESA) Okay, Bob. I'll find something

118:27:28 Parker: Okay, copy that. One of the brackets off the MESA would be something, or a rock that's nearby; that's another possibility.

[Jack consults his checklist, then turns to Gene. He is in the middle of LMP-12 and his next task is to perform an inspection of the LM.]

118:27:40 Schmitt: Okay. Gene, what are you going to be up to now?

118:27:43 Cernan: I'm going to go get the...

118:27:44 Schmitt: The experiment pallet?

118:27:47 Cernan: ...pallet.

[Gene is at the top of CDR -13 and, for his next task, he will go to the northeast LM quadrant and unstow a pallet containing hardware for the Surface Electrical Properties (SEP) Experiment.]

118:27:52 Schmitt: (Starting toward the LM) Okay, why don't I give the old (LM) inspection bit here. (Goes back to the Rover) And I really ought to have my camera, shouldn't I?

118:28:00 Cernan: I need a...

118:28:01 Schmitt: Yeah.

118:28:02 Parker: Roger. That's affirmative.

118:28:03 Cernan: ...(garbled) on this (SRC lid).

118:28:04 Schmitt: What would you just...

118:28:05 Cernan: Well, I'll find something.

118:28:08 Schmitt: I'll take the old CDR's camera. Not a bad camera to take.

118:28:13 Cernan: Jack, I'm going to take the old gunny sack here and put it over (the SRC). That'll hold it down.

118:28:23 Parker: I presume you're talking about the big bag, Gene.

118:28:27 Cernan: Yeah, the big bag that was on the ladder hook. That's all it needs. It's just a little bit. There's just enough spring force in it.

[Jack moves north of the LM to begin his inspection. In order to look up at the radio antennas and other gear mounted at the top of the spacecraft, he must bend his knees and thrust his hips as far forward as possible in order to get his center of mass over his toes.]

[Schmitt - "This wasn't an unstable position because there was no tendency to fall over on your back; but you were straining to stay there. You were straining against the suit and that took energy. You had very little mechanical advantage over the suit and, any time you had to bend it, it was work. The Apollo suits were adequate, but there

certainly needs to be a major engineering effort on new suits."]

118:28:35 Schmitt: Okay, Houston. I think you've had all the good words about the LM. We have never flown a better LM. (Chuckles) I guess that's safe enough to say. The quads look great. The old steerables are aimed right at you. Rendezvous radar's in good shape. It's parked, looks like parallel to Z (that is, east-west). Just about perfectly. There's no visible...I'm on the 3 o'clock position, plus Y. No visible contamination. There's a little bit of discoloration of the plume shields below the thrusters. The engine bell never touched the ground. It's about, oh, 15 centimeters off the ground.

[Jack is now north of the LM. The Z-axis on the spacecraft is aft to fore, east to west. The Y-axis is left to right, south to north. The forward strut, plus-Z, is the west strut; the rear strut is minus-Z; the north strut, beneath Jack's station, is plus-Y; and the south strut, beneath Gene's station, is minus-Y. The radar is pointed at the western horizon.]

118:29:25 Parker: How's that for coming down gentle?

[Each strut contains a shock absorber which would partially crush during a less than soft landing and, among other things, leave the engine bell closer to the ground. Only on Apollo 15 did the bell touch, and then only because Dave Scott landed with one footpad in a moderately deep crater.]

118:29:27 Cernan: That's what you call "Okay, Number Three Wire", Jack.

[Cernan - "'O.K. Number Three Wire' is another naval-aviator, carrier-pilot's term. There's generally four wires on the flight deck and you can catch 1, 2, 3 or 4. Obviously, if you come out of a carrier landing alive, it's successful; but 'O.K., Three Wire' is a term the LSO (Landing Signal Officer) gives you if you just make a perfect, super landing aboard ship. He'll write down the wire he got; he might say, 'low in the groove, number one wire' or 'high and fast, number four wire' or 'slow at the ramp, number two wire' or 'FAB' - which means faster than a bastard - number three wire' or he could say, "OK, number three wire" and that's about as good a landing as you can make. Nothing compares to the challenge of a night carrier landing, not even the challenge of landing a LM on the moon. In a carrier landing, it's dark, you can't see anything, your target's moving around, and it's a small deck. Landing the LM, you've got lots of people helping you; and you've got ways to abort out of it. Anyone who has ever flown on a carrier will know what I'm talking about."]

118:29:32 Schmitt: Hey, we never heard what our landing parameters were.
 118:29:35 Parker: We'll worry about that later.
 118:29:36 Cernan: I don't really care, now that we're here.
 118:29:39 Schmitt: Oh, but they always give them to us in the simulator. (Pause)

[Gene has moved a step or two east of the North Strut and is removing the gold insulation blanket that covers the SEP pallet. He throws the blanket under the LM with an easy motion.]

118:29:51 Cernan: Hey, Bob, judging from what I see on my clock (his wristwatch), we're not but about 5 minutes behind.
 118:29:57 Parker: That agrees more or less with the way we read it.

[Cernan - "I had two watches: one inside my suit which I kept on Houston time, and the other on the outside which we started - probably at 12 o'clock - when we started the EVA and could compare with the planned times in the checklists. The timeline was important, and we tried to stay with it."]

118:30:03 Schmitt: Gene had a little forward motion as I think you heard us call. And that shows up in the forward footpad at any rate, or did (before the EVA started and Gene and Jack scuffed up the mark). It looks like he may have hit tail first a little bit. That's embedded to the full pad depth. I see no...By George, Gene, you may have had a first. I think you stroked that thing.
 118:30:30 Cernan: Stroked what?

[Gene pulls the SEP pallet out of its stowage position and tries to lean it against the strut. The pallet is about a meter long and a foot wide.]

118:30:32 Schmitt: The rear landing gear.
 118:30:36 Cernan: Well, we can measure it and find out.

[This is a matter of principle, since none of the other commanders compressed a landing gear shock. There is no indication in the mission report that there was any compression.]

118:30:38 Schmitt: I'll take a picture of it (and save time by letting the folks back in Houston settle the question after the mission.)
 118:30:44 Schmitt: May have stroked it. The lower orange Mylar, is folded a little bit.
 118:30:50 Parker: Roger. There's word floating around down here about typical Navy landings, but I'm not sure whether we believe it or not.

[This remark may be coming from former Air Force pilot Charlie Duke who, with John Young, is probably sitting with Parker. Duke and Young were the Apollo 16 landing crew and are now serving as the Apollo 17 Back-up Crew. Jack's picture is AS17-134-20388.]

118:30:59 Schmitt: He caught his tail hook. Hey, Bob...
 118:31:01 Parker: That's the best way.

[Cernan - "I had a firm idea in my mind about how I wanted to land. I wanted to bring that thing down as quickly as possible and then, when we got down within the 50 or 60 feet range, slow down to two or three per second and maintain two or three feet per second and a little forward velocity of a foot or so per second forward. You learned very quickly in the LLTV that if you tried to get it down at about one foot per second, all of a sudden you started hovering, or maybe you put a little bit too much thrust in and you started going up a little. So I tried to keep going down."]

[After resting a moment from the effort of getting the SEP pallet out of the LM, Gene goes to the Rover.]

118:31:10 Schmitt: Just behind the LM, in that fairly fresh crater, I picked up an example of the kind of gabbro I was talking about. And I'll stick it in the big bag, except the big bag has disappeared.
 118:31:32 Cernan: (To Parker) Okay, I've got to give you a (gravimeter) reading, Bob, if you're ready.
 118:31:34 Parker: Ready.
 118:31:36 Schmitt: You put the big bag up...

[Busy as they are, Gene and Jack don't always hear what each other is saying or remember what was just said.]

118:31:38 Cernan: 670, 003, 101. That's 670, 003, 101.
 118:31:45 Parker: Okay. We copy that.
 118:31:49 Cernan: Jack, I put that (big bag) there to hold the SRC down.
 118:31:52 Schmitt: That's all right, I just put a sample in it. It's in the bottom of the bag. It's about 8 by 5 centimeters by 3 centimeters. Slightly tabular.

[Jack goes to the Rover and, out of view of the TV, takes Gene's camera off and puts it down. He then leaves again. While at the Rover, he may have taken AS17-134-20389, which is good picture of the front of the vehicle and the LCRU, the LCRU mirrors, the TV camera, the TCU, the big dust brush, and some cup-type sample bags which, later, Jack will attach to his LRV sampler.]

118:32:03 Parker: Okay. We copy that. It's in the big bag.
 118:32:07 Schmitt: Yes, sir.

[This is probably the rock that disappears sometime between now and the end of EVA 2. Jack makes brief references to the disappearance at 123:40:07 and 147:36:11.]

118:32:14 Cernan: Okay, Bob. A Mark on gravity.

[Gene is now making a measurement with the TGE sitting on the ground.]

118:32:18 Parker: Copy that.

118:32:20 Cernan: And the light's flashing.

118:32:21 Parker: Copy that. (Pause)

118:32:31 Cernan: I've got to tell you, Bob. I haven't done everything there is to do in the Navy, but deploying that flag has got to be the most proud thing I'll ever do in my life. If you could see you (the Earth), and you could see it (the flag) from where we are, I know you'd feel the same way.

118:32:53 Parker: Roger on that, Geno.

118:32:54 Schmitt: Whoo! (Laughs)

[Jack has tripped.]

118:32:55 Cernan: God, he's pretty up there. God, you're pretty up there over the South Massif. Beautiful!

[Gene is looking at Earth.]

118:33:02 Schmitt: Hope nobody saw that (trip).

118:33:04 Cernan: Beautiful.

118:33:06 Schmitt: Oh, they were watching me. (Laughs)
Those finks.

[Jack can see that the TV camera is pointed in his general direction; however, he was moving too quickly for Fendell to follow and wasn't actually in the field of view when he tripped.]

118:33:09 Cernan: Okay.

118:33:10 Schmitt: You weren't doing anything with the gravimeter on here (that is, on the Rover), I hope.

118:33:13 Cernan: No, it's on the deck (that is, on the ground).

118:33:14 Schmitt: Okay.

118:33:16 Parker: Okay, you might grab me a frame count when you set it on there, Jack.

118:33:19 Schmitt: Too late, Bob.

118:33:20 Parker: Okay.

[At 118:31:52, Jack took Gene's camera off in preparation for offloading the ALSEP packages.]

118:33:23 Schmitt: I'll get that later.

118:33:24 Parker: We'll get it later. No hurry.

[Gene goes to the SEP pallet which is still leaning against the (north) strut; Jack goes to the MESA.]

118:33:26 Cernan: Okay, now if I can figure how to get this off.

[Gene is about to remove the SEP receiver package from the pallet.]

118:33:30 Schmitt: (To Parker) You've got to educate us again. We may not remember those. Oops.

[Jack is asking for a future reminder about the frame count.]

118:33:37 Cernan: Bob, the SEP's in hand.

118:33:39 Parker: Roger on that. (Pause)

[Fendell starts a TV pan. The SEP receiver/recorder is a box about one-foot square. Gene will mount the receiver and it's extendible, three-section receiving antenna on the geopost. After the EVA 1 traverse, he and Jack will deploy a low-frequency (a few megahertz) radio transmitter about 150 meters east of the LM and then, during the EVA 2 and 3 traverses will record signals which, having been altered by their passage through lunar materials, will give experimenters indications of the local structure down to depths of a few kilometers.]

118:33:55 Cernan: Okay. I'll give you a (SEP) temperature. Let's see whether it fits. (Pause) I'll bet it does.

(Pause) Come on; lock, baby. Okay, it's On...

118:34:23 Parker: Copy that.

118:34:24 Cernan: ...It's locked.

118:34:25 Parker: Roger.

[The SEP receiver is temperature sensitive. Later in the mission, the fasteners on the SEP receiver dust cover will fail, the radiator will get enough dust on it that Gene will never be able to get it properly cleaned, and the temperature will rise to the point that the instrument shuts itself off.]

118:34:27 Cernan: Okay. Bob, here's a temperature for you. Forty degrees (Fahrenheit).

118:34:33 Parker: Say again.

118:34:34 Cernan: Four-zero.

118:34:35 Parker: Copy that.

118:34:41 Cernan: (Reading CDR-13) "Close (SEP dust) cover." Okay, number 1. Something over here. Never did figure out what.

[Details of the SEP receiver antenna deployment are given on a decal.]

118:34:51 Schmitt: Okay, Bob, the "Shade" is deployed facing deep space. (Pause)

118:35:03 Parker: Oh, copy. Roger. Understand the cosmic ray.

[Jack is deploying the cosmic ray experiment, a cousin to the solar wind experiment flown on Apollos 11, 12 and 15. It is simpler version of the cosmic ray experiment flown on Apollo 16 as part of that ALSEP package. The Apollo 17 experiment consists of detectors referred to as "Sun" and "Shade". Jack is using a strap to hang the "Shade" detector - in the shade, of course - from one of the plus-Z (west) strut supports. He will then hang the "Sun" detector - in full sunlight - from one of the minus-Z (east) supports. Deployment of the cosmic ray package is optional at this point in the checklist (page LMP-12). Had Jack been seriously behind the timeline, he could have delayed deployment until the end of the second EVA (pages LMP-28 and CDR-30).]

118:35:12 Cernan: Okay, Bob. The (SEP receiver) antenna is deployed. It's not on the post yet, but it's deployed. (Long Pause)

118:35:40 Cernan: (Talking to the antenna) Oh, oh. Come on. Don't get all caught on something. (Pause) That's better. That's better.

118:35:53 Schmitt: Okay, Bob. I think (I've just about got) the "Sun" side deployed, just as perpendicular to the Sun as I think anybody could do.

118:36:06 Parker: Okay. Copy that. Good enough.

118:36:11 Schmitt: Okay, I don't have any pictures yet (because he doesn't have a camera with him), so you might put that down as something to get later.

118:36:15 Parker: Yeah, we'll catch that in the pan(orama) next EVA or something like that. (Pause)

118:36:27 Cernan: Boy, if that antenna doesn't get some noise from outer space, I don't know what will. If they are out there, and they are I'm sure. They'll see that one. That is even weirder looking out here than it is in the high bay.

[The "high bay" is in the Flight Crew Training Building at the Cape. Fendell finds Gene at the rear of the Rover, mounting the SEP.)]

118:36:39 Schmitt: Hey, Bob? Before I leave (with) the ALSEP, remind me to check the cosmic ray. I might hit it here in the process of deployment.

[Jack is about to remove the ALSEP from its storage compartment in the southeast quadrant of the LM, and is

afraid that he might hit the "Sun" part of the cosmic ray experiment. He is at the top of LMP-13 and his first task is to open the doors of the Scientific Equipment (SEQ) Bay.]

118:36:50 Parker: Okay, try not to.
 118:36:52 Schmitt: I got a little close.
 118:36:54 Parker: Okay.
 118:36:55 Schmitt: (Responding to Parker's "Try not to")
 Oh, I will. (Pause)
 118:37:04 Schmitt: Okay. The (SEQ Bay) doors are open!!
 Beautifully. I don't know what talent you have for landing
 in holes, Cernan, but once again I'll be doing all the ALSEP
 work in a hole. (Pause) Okay.
 118:37:25 Parker: Are you saying we should have kept the
 pulleys there, Jack?

[Cernan - "At one time, I think there was a pulley we could use to lower the ALSEP to the ground. We probably took them off. I didn't like all that extra garbage; I thought we could handle things quicker without all those crutches. It was just a matter of wanting fewer things to mess with. But Jack found himself, as he said, 'in the hole' and had to reach higher than he wanted."]

118:37:31 Schmitt: (Agreeing with Parker, but grudgingly)
 Yeah, I need the pulleys.

[Schmitt - "There were some pulleys originally, but we had more problems with them than they were worth. As it turned out, I don't think we had a great deal of problems getting the packages out."]

118:37:34 Cernan: You know, Bob, I've got a little bit of a problem here. I've got the SEP connector on. (Jack laughs)
 But...It'll slide down in, but the locking cover just won't go over.
 118:37:51 Parker: Roger, Geno. Understand. And it slides in far enough, and you think it's aligned, huh?
 118:37:59 Cernan: Yeah, I'm positive it's aligned. It just didn't appear to lock over, well not appear, it just won't lock over. I'm shoving it home. Okay, I got it.
 118:38:08 Parker: Okay. Copy.
 118:38:09 Cernan: I got it. Makes everyone happier.
 118:38:11 Parker: I'm glad we have the right solution to that one, Geno.
 118:38:16 Cernan: The right solution is the fact that you've got a man here doing it.
 118:38:19 Parker: (Laughs)

[Cernan - "This is a response to "should you send man or machine into space?" We've had a lot of controversy and comment on that over the years, and this was just a subtle little comment to reinforce man's usefulness in space, even for a seemingly simple operation."]

118:38:20 Cernan: (Looking at his checklist) Okay.
118:38:22 Schmitt: Hey, Bob. The ECA Temp Monitor switch is On.
118:38:27 Parker: Copy that. (Long Pause)

[The ECA Monitor measures the temperature of the ALSEP's radionuclide fuel element.]

118:38:54 Cernan: There's an easy way and a hard to do everything. Don't know why we don't pick the easy way.
(Pause; Fendell pans away) Okay.

[Schmitt - "Although we'd learned a lot of things from the prior crews, we'd never personally had a chance to do things in one-sixth gravity. One-sixth gravity is something you can take advantage of, and we learned very quickly. For example, because things don't accelerate as quickly, you just have more time to react. I often found that if I had something like the hammer in one hand, and I wanted to shift it to the other hand, rather than actually move my hands together, I could just flip it and catch it. Moving your hands together is a lot of work in the suit; but if you just flip something, that's not much work at all. Here, Gene may have instinctively done something the way he would have in one-gravity and realized there was an easier way to do it in one-sixth gravity; or he just forgot - as I often did, and I think we all did in the intensity of the moment - what was the best way to do something."]

118:39:16 Schmitt: RTG is on the surface.

[The Radioisotope Thermal Generator (RTG) is the ALSEP power generator and is the major piece of equipment in one of the two ALSEP packages. The fuel element is stored separately and Jack will extract it from its transport cask after he has prepared the RTG to receive it.]

118:39:18 Parker: Copy that.

118:39:19 Schmitt: Central station is...Hey, Bob; Gene's little pitch-up makes these things slide out by themselves almost.

118:39:29 Parker: Better thank him next time you see him.
(Pause)

[Jack is getting the other ALSEP package down. This one contains the Central Station and most of the experiment modules.]

118:39:41 Cernan: Okay. (Pause) Hey, Jack, you notice there's none of those guys up there holding those hoses as we go around the LM?

118:39:52 Schmitt: What do you mean? I saw one just a minute ago.

[Schmitt - "In the early days of EVA training, down in Florida on a not-very-well-simulated lunar surface we had outside the simulator building, we were operating with air cooling; we were just forcing (chilled) air through the suit. I was responsible for orchestrating a lot of the training, and I remember for Apollo 12 I got increasingly worried about the heat loads that were building up during this EVA training in the pressurized suits. Even with the light-weight backpack, Conrad and Bean were working awfully hard and getting awfully hot, just as I had in running some of the simulations. I was afraid we were going to hurt somebody because some of these guys, probably myself included, once they got involved in a task, were the sort who wouldn't say 'quit' until they passed out. And we certainly didn't need that. So I started to talk with the support crew and basically asked them if we could figure out a way to use ice water in the liquid-cooled underwear. Several guys went to work on that and what they did was add a water hose to the air hose we were already using and connected it to the liquid-cooled garment and then carried around a supply of ice water on their own backs. It made all the difference in the world; it was still tough, but at least you didn't get overheated. So there was always a guy around carrying your ice-water supply, but they were very good at staying out of sight behind you, and you had to turn real quick to know they were there. And that's what I was talking about."]

[Interested readers will find a second version of this story at 142:50:46.]

[Cernan - "As I read through this, I remember seeing a book or an article that somebody put together about how, on Apollo 17, we were visited by an outer-space alien. They took our lunar surface transcripts and pulled out unique parts of them which made it sound as if we were referring to somebody else being there. I remember one thing in particular: (at the end of EVA 1 at 123:28:30) we had a piece of foam rubber or something crack and sort of blow up in the sky, and I said "What's that?" And here, I'm saying, "Hey, you notice there's none of those guys up there holding those hoses. And we go around the LM and Jack says, " What do you mean? I just saw one a minute ago." And these people, or this guy, took these kinds of things out of our transcripts, out of context, and put a whole story together that was almost believable. If I hadn't been there myself, I would have thought that an alien spacecraft landed next to us and these comments were referring to that. It was amazing what you can do with editing."]

118:39:55 Cernan: Okay, Bob. You want (explosive charges) 4, 5, 6, and 7.

118:40:02 Parker: That's affirmative.

[Gene is at the top of CDR-14 and is offloading four seismic charges which are stowed in one of two carrying racks stowed in the Descent Stage. The other rack contains charges number 1,2,3, and 8. He will mount the rack on the back of the Rover and later, during the geology traverses he and Jack will deploy the charges at pre-planned spots. Eventually, after Gene and Jack have left the Moon, experimenters back on Earth will transmit detonation signals to the charges, one by one.]

118:40:03 Cernan: Okay, 4, 5, 6, and 7. It's coming off.

118:40:07 Parker: Roger on that.

118:40:11 Cernan: Okay. (Long Pause) Just took time out for a snack and a little water.

118:40:35 Schmitt: (To himself) Come on.

118:40:36 Parker: (Responding to Gene) Okay. (Pause)

118:40:45 Cernan: How's the TV working?

118:40:47 Parker: Beautiful. (Pause) To coin a phrase, it's a panoramic scene of beauty.

[Andy Chaikin believes that Parker is quoting something Charlie Duke said during training.]

118:40:57 Schmitt: Come on now, Bob!

118:41:00 Cernan: Say, Bob, what do you think of the terrain?

118:41:03 Parker: Looks flat. Looks very flat and smooth.

118:41:11 Cernan: That's why you're an astronomer.

118:41:13 Schmitt: That's why you're... (Laughs; Gene has beaten him to the joke). Oh, well.

[Cernan - "This was not an old joke; but here I am, on the lunar surface in this big, mountainous terrain, and he's telling me it looks flat and smooth!]

118:41:16 Cernan: Okay, I'll give you a reading on the TGE if you're ready.

118:41:20 Parker: Roger, ready.

118:41:24 Cernan: (Talking to himself) Don't kick dust on it. Hope I can read it down here. (Pause) Bob, you're going to have to bear with me. When I leaned over to punch it, I hit Gravity instead of Read, so I guess I got to wait it out.

[After the three minute leveling/measurement period is over, the digital display remains lit for twenty seconds and then goes off to conserve the internal batteries. Punching the Read button re-illuminates the display and shows the measurement values for another 20 seconds. This can be done repeatedly. The top of the instrument is about eight inches long and about four across.]

118:41:54 Parker: Okay. We'll start the timer again.

118:41:58 Cernan: Okay, I should have been more careful. Okay. (Reading) "Orient (SEP) pallet to the Sun." (To Parker) If you can see it, it's (pointed) directly at the Sun so that ought to be good.

118:42:09 Parker: Okay, copy that.

[Gene is making sure that the SEP pallet - which he had previously leaned against the north strut - is properly oriented in relation to the Sun so that the remaining equipment can warm up.]

118:42:17 Cernan: The SRC doesn't have to be all the way closed does it?

118:42:20 Parker: No. Not all the way. Just as long as it's most of the way closed. You can have a crack there in the top.

[All that is necessary is that the Sun not be shining into the interior.]

118:42:29 Cernan: Okay, that's what it is. (Pause) Man, I'll tell you. This thing (the MESA) got low all of a sudden. (Pause) How are you coming, Jack?

118:42:45 Schmitt: Great.

118:42:47 Cernan: You get it (the RTG) fueled yet?

118:42:48 Schmitt: Oh, no.

118:42:49 Cernan: Okay.

118:42:50 Schmitt: Coming soon though.

118:42:51 Cernan: Let me know if you have any problems with that.

118:42:54 Schmitt: All right, I will.

[The Apollo 12 crew had trouble removing the fuel element because of a too-tight fit in the transport cask. The design was modified before the Apollo 13 launch and no further problems of that kind were experienced by any of the crews.]

118:42:56 Cernan: Okay. Come on bag.

[Gene is getting out a storage bag for the sections of deep core they will obtain at the ALSEP site. He is in the middle of CDR-14]

118:42:57 Schmitt: You're all I got.

118:42:59 Cernan: Man. There we go.

118:43:02 Schmitt: Da da, dee dee. (Pause)

118:43:13 Cernan: Bob, that gravimeter went right to...It blinked once and went right to steady, so I don't expect it'll be too long.

[The gravimeter only shifted a little when he punched the Grav button the second time.]

118:43:20 Parker: Okay, I'll give you a call in a couple of minutes there. Ought to be done.

118:43:26 Cernan: Okay.

118:43:28 Parker: And Jack. I understand you have the RTG fueled?

118:43:34 Schmitt: Negative.

118:43:35 Parker: Okay.

118:43:36 Schmitt: I'm supposed to call you when I have it fueled.

118:43:40 Parker: Okay.

118:43:42 Cernan: Jack, do you have a.. Am I missing a map I should have up here?

118:43:46 Schmitt: There should be two maps. They're under the seat. I put them in there so they wouldn't bounce off. I'm sorry. I forgot to tell you.

[Gene is working at the right side of the Rover. He reaches under Jack's seat for the maps. These are copies of photos taken from orbit by the Apollo 15 crew. Contour maps are printed on the back showing the planned traverse routes.]

118:43:51 Cernan: Okay, I got them. (Pause) Hello, Houston.

[Gene waves into the TV.]

118:44:07 Parker: Hello, Challenger. (Pause)

[Cernan - "In listening to the tape just now, I knew before he said it that Parker was going to come back with 'Hello, Challenger.' That's just typical of both Jack and Bob: playing verbal games, having fun.]

[Gene has two maps in his hands and turns them a couple times, making sure he has the correct one on top and properly oriented. He then clips them in the holder on the accessory staff. This task is not on Gene's checklist. According to the checklists, Jack was supposed to have placed the maps on the LMP seat as part of the tasks on LMP-11 and, apparently, they were supposed to stay there until, after the ALSEP deployment, Jack clip them to the accessory staff. Apparently, Gene had gotten used to finding the maps on the LMP seat at this point in his activities and, not seeing them there now, asked Jack and then decided to take a few seconds to clip them to the staff.]

118:44:18 Cernan: I wish I could go back and make that landing about 6 or 7 times so I could take in all that I missed.

118:44:25 Schmitt: So do I! I might as well have stayed at the Cape.

118:44:31 Cernan: Okay. Let's see. (Starting toward the LM, looking at his checklist) Core/bore (bag), neutron flux, and I'll get the drill and then I'll go back and...

118:44:37 Parker: Geno, you might wander by the gravimeter. I think it might be done by now. You might just check the light and see if it's steady, or on or not.

118:44:48 Cernan: Okay. I'll go by there right now, Bob. (Long Pause)

[Gene goes to the MESA, then to the Rover, and finally to the gravimeter.]

118:45:26 Schmitt: For future reference, Bob, the dome removal tool (pause) doesn't...It'll turn. (Pause) Well, shoot.

[The "dome" is the removable lid on the fuel cask.]

118:45:51 Cernan: Okay, Bob; let's see. It's not lit. Can I take a reading?

118:45:57 Parker: Rog. If the light's out, give us a reading.

118:46:01 Cernan: Well, let's see if I can punch the right button this time. Okay, it's 670 017 201, 670 017 201. And it was about 75 percent in the shade of the Rover.

[The gravimeter has internal heaters to maintain a temperature environment constant to 0.01 degrees kelvin. That way, critical components don't change characteristics between one measurement and the next.]

118:46:19 Parker: Okay. I copy that. And now we're ready for "Bias".

118:46:23 Cernan: Now, you want...(Listens) Okay, a "Bias" coming at you - on the ground, correct?

118:46:27 Parker: Roger.

[By punching another button, marked "Bias", Gene activates a mechanism which, in essence, inverts the gravity sensing components and permits a determination of factors in the equation relating the instrument reading to an actual value for the local gravitational acceleration.]

118:46:30 Cernan: It's blinking, Bob.
 118:46:33 Parker: Okay. Copy that.
 118:46:34 Cernan: I've got the core bag and the neutron flux, and...
 118:46:35 Schmitt: Gene, I need your hammer.
 118:46:36 Cernan: Okay. You need my help. Okay, coming over. (Pause) What's the problem?
 118:46:46 Schmitt: Well, the dome removal tool never latched into the dome, but it turned it. I think it's pretty badly chewed up. I'm not sure what happened.
 118:46:56 Cernan: Oh, boy.
 118:46:57 Schmitt: Let me have your hammer because I'm going to have to pry off the dome.

[If the Central Station can't be fueled, none of the ALSEP experiments will work. The fuel element is under the dome, so the dome will have to be taken off if they are to fuel the ALSEP.]

[Schmitt - "The fuel element was in a graphite capsule hanging on the outside of the LM next to the ALSEP stowage area. You tilted it down to a horizontal position so that you could get at the dome to get it off. The theory behind the capsule was that, if you had a breakup during launch or a re-entry because of an accident in orbit, the capsule would separate and re-enter intact so that the element itself would not be exposed and put plutonium into the atmosphere. So you had to take the capsule apart by taking this dome off; we had a special tool to do that and another tool to latch onto the fuel element and extract it out of the graphite capsule. I don't think there were threads involved in the dome removal. If I remember correctly, it had three prongs and pins and you put them in slots and you screwed the pins in and that released the catches that were holding the dome in there. Clearly there was a turning that was involved and something had gotten stripped."]

[In a subsequent discussion (and a follow-up, 11/4/91 memorandum), Roy Zocher, a Los Alamos engineer who participated in the design of the Apollo SNAP-27 RTG, provided the following information about the fuel cask:]

[Zocher - "Originally, the SNAP-27 design was consistent with the earlier concept of high altitude (400,000 ft) dispersion of fuel in an orbital decay or re-entry accident. After the RTG program was started, new direction was received which dictated re-entry and earth-impact survivability for the plutonium heat source. That direction, in turn, inspired the design that was ultimately flown. In addition, there was an early design constraint to separate the heat source and

converter, since the launch loads were too high for the RTG if the heat source was flown in the converter.

"The heat source canister was located on the exterior of the LM to afford a free release in a re-entry accident. (A free release) did occur with the heat source canister from the aborted Apollo 13 mission. That canister resides at the bottom of the ocean in the Tonga Trench, without release of fuel. The fuel canister location on the LM was not related to radiation considerations. Radiation exposure to the astronauts (from the fuel element) was not a significant factor - from both time and source-intensity perspectives. The design concept of the heat source entering the atmosphere, and the subsequent hard-surface impact was proven by an extensive and well documented test program."

[It is no accident that the Apollo 13 fuel cask lies in the very deepest part of the ocean. Andy Chaikin tells me that, among the many things that had to be done during the Apollo 13 rescue was to design the return trajectory and LM jettison timing so that the fuel capsule would end up in the Tonga Trench.]

118:47:01 Cernan: Can't you...

118:47:02 Schmitt: No. I.....You see I...I've stripped it, I think. I didn't think I could do it.

[Jack rarely stutters.]

118:47:10 Cernan: No. Wait a minute, wait a minute, wait a minute. Let me...

118:47:12 Schmitt: See, it's stripped. See, but it's open. Wait a minute. See? No wait. See? Just put your blade in there. Don't touch it. Put the blade in there; and pry.

118:47:24 Cernan: It'll come. (Pause) I hope.

[Cernan - "To get the fuel element out, you tilted the cask and used this removal tool. You didn't want to get too close to the fuel, because it was radioactive (and, more importantly, was thermally hot enough to damage the suit); so, once you had the dome off, you would use the tool to pull the fuel element out. Well, with the dome threads stripped, we were going to have to use the sharp point of the hammer to pry the dome off."]

118:47:32 Schmitt: Be careful. Here, let me get it once from this side.

118:47:35 Cernan: Wait a minute.

118:47:36 Schmitt: Gene, don't get so close. Move your hand. There, you got it. Nice work.

118:47:44 Cernan: Okay, it's off. It's off.

118:47:47 Schmitt: Nice work.

118:47:50 Cernan: Whoo!

[They have averted the loss of a major mission objective. Gene goes to the ladder, puts the hammer back in his shin pocket, turns a checklist page, and reads.]

118:47:51 Parker: Roger. Once again we have the right solution.
 118:47:54 Schmitt: I'm not sure, Bob, what happened. You might ask them that if you only partially get the dome removal tool on, if you can strip the whole thing out?
 118:48:06 Parker: Okay, we'll look at it (garbled).
 118:48:07 Schmitt: It won't make much difference any more.
 118:48:08 Parker: We'll make sure its changed on the next dome removal tool. (Pause)

[The following is extracted from the Apollo 17 Mission Report. "The socket on the removal tool can engage the nut on the dome before the pins on the tool lock into the recess in the dome (Fig. 15-22). the LMP did not verify that the pins were locked. In this configuration, rotating the tool clockwise will rotate the nut on the dome. A 90-degree rotation of the nut releases the dome retaining straps, as noted by the crew. This release allows the dome to rotate when the tool is rotated another 60 degrees, thus disengaging the threaded dome/cask interface. However, with the pins not locked into the dome recess, the dome could be cocked but not withdrawn. The dome was easily wedged off the cask with the hammer. The sequence can be duplicated with either broken pins or by incomplete insertion and locking of the pins."]

118:48:20 Cernan: Bob, I'm just taking a breather.
 118:48:22 Parker: Okay, we're watching you.
 118:48:23 Schmitt: That was a strange one, Gene. Did you see how I mangled that thing?
 118:48:28 Cernan: Yeah.
 118:48:30 Schmitt: Okay, RTG (fuel element) is out.
 118:48:32 Cernan: Don't trip (and get it dirty).
 118:48:34 Schmitt: Wouldn't think of it.
 118:48:35 Cernan: Okay, where was I? I've got to go back and get the drill, if I'm not mistaken. (Looks at his checklist) Yes sir; and then I'll be caught up with the TGE.

[Gene makes his way to the MESA.]

118:48:48 Schmitt: Okay, Houston. The RTG is inserted. The fuel element, that is.
 118:48:52 Parker: Okay, we'll copy that. (Pause)
 118:49:00 Cernan: Bob, I'll give you my word. Before we leave here, I'll make sure that the SRC is closed.
 118:49:06 Parker: Okay. Copy that. As long as it's got only an inch or two showing there, it should be no problem. That looks fine...
 118:49:16 Cernan: Man, I've got to put something on it to get it down to that far.
 118:49:19 Parker: Okay.

[One of the many advantages of the TV is that, in cases like this where there is a question about the configuration of some piece of equipment, experts on the ground can actually see what the astronauts would otherwise have to describe verbally.]

118:49:25 Cernan: Oh, that (drill) came out like a dream. Man, is this MESA low when you go...Come on, baby.

[Gene is kneeling at the MESA, removing the drill. Getting up again is relatively easy because he can hold on to the MESA.]

118:49:33 Schmitt: SEQ (Scientific Equipment) Bay doors are closed.

[The SEQ is the ALSEP storage compartment. Closing these southeast-facing doors prevents the interior of the descent stage from heating.]

118:49:35 Parker: Roger. Copy that.

118:49:36 Schmitt: And I'm checking out the cosmic ray. Cosmic ray looks good.

[That is, he didn't bump into it while getting the ALSEP packages out.]

118:49:42 Parker: Beautiful.

118:49:46 Cernan: Oh! I snuck a queek...quick peek at the drill, and it does work.

118:49:56 Schmitt: (Hearing a burst of radio noise) What in the world is that?

118:49:57 Cernan: That's Ron!

118:49:59 Schmitt: Ron?!

118:50:01 Cernan: That's Ron.

[The TV jiggles, indicating that Gene is putting the drill on the LMP Rover seat.]

118:50:02 Schmitt: Got his VHF on, that fink.

118:50:05 Cernan: (To Houston) Hey, you might tell Ron we can hear him. (Pause)

[Evans, in the Command Module, and the surface crew both have VHF transmitters and receivers. During most of the three days of surface operations, Evans will have his VHF transmitter powered down. Evidently, he is inadvertently transmitting the carrier signal at this point and interfering with comm on the surface.]

118:50:18 Cernan: Okay. "Drill to LMP seat." With seat belt. Bob, you still with us? (No answer)

[Gene will take the drill out to the ALSEP site on the Rover and is strapping it into Jack's seat.]

118:50:28 Schmitt: Okay, ALSEP is put together in the barbell mode. And Charlie Duke, I have checked it; and it is locked.

[On Apollo 16, one of the two ALSEP packages fell off of the carrying handle while Charlie Duke was walking out to the ALSEP site. Jack is now at the top of LMP-14 and will carry the ALSEP packages about 300 feet west of the LM.]

118:50:40 Cernan: Hello, there, Ron. If you read, we're reading you. (Pause)

118:50:53 Schmitt: (Picking up the ALSEP package; singing) Well, "We're off to see the Wizard." Hey, do you need me, Gene?

118:50:59 Cernan: Nope.

118:51:00 Schmitt: I'm going to go deploy an ALSEP.

118:51:03 Cernan: Have at it.

118:51:04 Schmitt: First, I've got to find an ALSEP site.

118:51:07 Cernan: Don't fall into Camelot. (Pause) Okay, Bob. I'd like to read a TGE.

[Jack comes around the south side of the LM and heads west.]

118:51:15 Parker: Roger. You're ready to read the TGE, or we are.

[Jack has been carrying the ALSEP with palms down; now he switches to palms-up, one hand at a time, with slight tosses of the bar.]

[Schmitt - "The ALSEP turned out to be a lot harder to carry than you would have imagined, mainly because your forearms were already tired from doing so much work. You had to grip that handle and carry it some 300 feet to a reasonable site and that was almost the last straw; you didn't know if you were ever going to recover and be able to use your hands again. It weighed about 350 Earth-pounds. On the Moon it was only 60 pounds; and the problem was gripping that handle of the barbell."]

118:51:20 Cernan: Oh, you won't believe it.

118:51:25 Schmitt: You did it again.

[Jack is guessing that Gene hit the wrong gravimeter button.]

118:51:26 Cernan: No!! There goes a fender.

118:51:28 Schmitt: Oh, shoot!

[The hammer in Gene's shin pocket has just caught under the left rear fender, ripping off the rearward extension.]

Gene remembers that, although the suit reduced his tactile sensitivity a great deal, he did feel the hammer catch but was unable to stop himself before the damage had been done. During Apollo 16, at Station 8 near the end of the second EVA, Charlie Duke and John Young were at the back of the Rover, near the right-rear fender, changing each other's sample bags. Houston was looking at them with the TV. John had the hammer in his shin pocket and, as soon as Charlie finished changing his bag, started around the back of the Rover to go to his seat. John's right leg - and, most likely, the hammer - caught on the fender and ripped it off. In his 1990 book, *Moonwalker*, Charlie inexplicably says that it was he who knocked the fender off but also adds that "it had happened so many times in training that we didn't think anything of it." A plausible explanation for this statement is that Charlie was remembering a training incident. Like the 17 crew, they soon realized that the loss of the fender would force them to spend far more time dusting and doing other housekeeping chores than they would have liked. Among other things, after the EVA they were both covered with dust and, despite efforts to clean themselves, took a great deal into the cabin. There, they had to wrap their suit legs in bags in a effort to keep the dust from fouling closures and, of course, in the process of getting out of the suits, they got their hands very dirty and, because they had no way to really clean themselves up, got dust on everything they touched.]

118:51:31 Schmitt: Say, Bob, I'm moving down-Sun.

118:51:34 Cernan: Well, I'll get that (fender) in a minute.

[Jack is walking at a rapid pace, albeit far more flat-footed than he had been walking unburdened. He is kicking up more dust and his bouncing stride has gone for the moment.]

118:51:36 Schmitt: I'm moving down-Sun (west), and where we've walked, we stir up darker material - just slightly (darker) - but it's darker. The same old thing that most regoliths have.

118:51:50 Parker: Okay, copy that.

[Schmitt - "Recently, a lot of us have been trying to figure out why it is that, when you stir up the surface near the LM, it seems darker while, away from the LM, you don't see that. And my conclusion at this point is that the winnowing effect of the descent engine effluent increases the frequency of small rock fragments compared with dust in the area around the LM, and that, in turn, results in a higher than normal albedo. Rock fragments give you a higher albedo than the dust does. And so, when you walk over it and stir it up, you bring up the normal regolith on top of this winnowed material. And as you move farther and farther away from the effects of the descent engine, you see less and less of that happening. The samples taken near the LM and

underneath the LM never showed any chemical contamination or any other reason for that lighter-colored albedo. Yet the visual effect was so marked that you could see a landing site from orbit. We could see ours after we were back in orbit, and we could see Apollo 15 when we flew over it later in the mission."]

[The light color of the soil around the LM is visible in photographs taken from Station 6, on the lower slopes of the North Massif, about 70 meters above the LM and 3 kilometers distant. The best of these is AS17-139-21203. An example of the darker color of disturbed soil near the LM is 134-20462, a down-Sun picture taken at the end of EVA-3 - which also shows the SEP pallet leaning on the north LM strut. A typical photo showing the lack of color change of disturbed soil well away from the LM is AS17-134-20500 which was taken down-Sun at the ALSEP site, also at the end of EVA-3.]

118:51:52 Parker: Have you got a bias reading there, Gene?

118:51:54 Cernan: Yeah, I'm giving it to you right now.

337, 454, 001. That's 337, 454, 001

118:52:05 Parker: Okay, we copy that.

118:52:06 Cernan: And I hate to say it, but I'm going to have to take some time to try...I'm going to have to try to get that fender back on.

118:52:13 Parker: Okay. Was it the rear fender, Geno?

118:52:17 Cernan: Yeah. Caught it with my hammer, and it just popped right off. (Pause)

[During this exchange, Jack stops to rest, but moves again in eight seconds. He then walks about 20 steps before putting the ALSEP down. He looks back toward the Rover.]

118:52:24 Cernan: Bob, for future reference, it's a piece of cake putting the TGE on and off (the Rover).

118:52:28 Parker: Okay, copy that. (Pause)

118:52:35 Cernan: Jack, is the tape under my seat, do you remember?

[This is a roll of very ordinary, grey duct tape.]

118:52:38 Schmitt: Yes.

118:52:39 Cernan: I may need it. Okay. Lithium hydroxide canister to middle.

[Gene is probably referring to his cooling control. The PLSS does contain a lithium hydroxide canister which will be replaced after every EVA. However, there are no PLSS controls related to the canister.]

118:52:45 Schmitt: I'm in MAX cooling.

[Jack lifts the ALSEP, palms down, to knee height. Carrying the ALSEP is the hardest work Jack will do during

the mission. His heart rate will peak at about 140 beats per minute at about 119:00.]

118:52:49 Cernan: Man, you're wobbling around like a...How are you doing?
 118:52:53 Schmitt: Oh, fine. It's just...It's work going out here!
 118:52:56 Cernan: Yeah, I'll bet it is. Just take it easy.
 118:52:58 Schmitt: I am.
 118:52:59 Cernan: I'm going to be a little bit behind you (on the time line) if I have to work on that fender, anyway.
 118:53:01 Parker: Yeah, you can walk a bit more slowly than you're walking, Jack.
 118:53:03 Schmitt: Okay, more and more...(Hearing Parker) What's that?
 118:53:08 Parker: I said that you can walk more slowly than you started out, anyway.

[Because he has to go around small craters, Jack is not walking a straight line out to the ALSEP site.]

118:53:15 Schmitt: (Breathing heavily) Bob, texturally, some of these rock that I believe are the gabbros have a texture not unlike a welded tuff (a rock made from volcanic ash which fuses because of its own internal heat). I know they're not. But they've got some mottled characteristic to them that I haven't yet figured out. (Long Pause)

[Schmitt - "This 'mottled' appearance was probably the result of the small, whitish halos that were produced around every one of the micrometeorite impacts. The shattering of the plagioclase made it lighter colored than it had been to begin with."]

[Jack hoists the ALSEP to chest height, apparently switching to a palms-up or elbow-crook carry in the process. It is impossible to tell from the TV picture which he is using. Jack believes that he did go to an elbow carry.]

118:54:10 Cernan: Well, if it wasn't for that fender, I'd be ready to go. Makes me sort of mad! (Long Pause)
 118:54:33 Parker: I say there, Jack, that looks like a big rock there beyond you.
 118:54:40 Cernan: That's the one we were talking about. Earlier.
 118:54:43 Parker: We believe you now. (Pause)

[This is Geophone Rock, the one they described from inside the LM after landing. Jack has walked into a swale and only his head and shoulders are visible. He stops and looks around, putting the ALSEP down.]

[Schmitt- "Walking down-Sun, the swale wasn't obvious until you got there. Looking up-Sun from the other side, it probably was fairly obvious from the photometric shading that occurs when the sunlight strikes at a glancing angle."]

[Cernan - "I don't remember noticing the swale during the descent. And if I did, it wouldn't have bothered me. All it would have done was pitch us forward a little bit, and what I was really looking for was the holes and boulders.]

[Photo AS17-137-208670 is part of a panoramic sequence taken at the start of EVA-2 and readers will note that the dark Rover tracks disappear into the swale.]

118:54:51 Cernan: Well, I've done this in training. I can't say I'm very adept at putting fenders back on. But I sure don't want to start without it. (Long Pause)

[Gene means that he used tape at various times during training, albeit not to repair a fender. The purpose of the fenders is to keep the wheels from throwing dust forward. Dust is a threat to the Rover itself and to other pieces of equipment because surfaces covered with it tend to get hotter and because dust can get onto camera lens and into moving parts. Even with the fenders intact, at each stop Gene will have to spend a few minutes dusting critical surfaces such as the battery covers. Without the fender, the dusting chore would take even longer.]

118:55:22 Cernan: Well, shoot! (Long Pause)

[Jack disappears from view.]

118:55:41 Schmitt: Okay, Bob. I think I'm going to move a little bit to the northwest of my present position in order to get a little farther away from that big rock.

118:55:54 Parker: Okay, Jack.

118:55:55 Schmitt: And to get out of a shallow depression...

118:55:59 Parker: Roger.

118:56:00 Schmitt: ...get out of a shallow depression that's here.

118:56:03 Parker: Roger. It's not so shallow. You disappeared out of sight from the last (garbled).

[Evidently, Jack has taken a short break; he is beginning to get his breath back. Cuff Checklist page LMP-15 is a schematic of the planned ALSEP layout and, as he discusses below, he needs to keep some of the pieces of equipment well away from large rocks and out of craters and depressions.]

118:56:10 Schmitt: Well it's shallow relative to other depressions I've been in. (Pause) You know, this ALSEP is almost as heavy as what we had at the Cape! (Pause) Uh oh! I lost one of my blocks. Oh well, I'll get it on a rock.

[Schmitt - "These were gross-leveling blocks. The idea was that, if your site wasn't quite flat, you could put one under a corner of the ALSEP package and get your initial level. Why we ever had them I'll never know; there were

always plenty of rocks you could use. People working in a non-real environment came up with the idea."]

118:56:39 Cernan: Or I'll retrace your steps.

118:56:40 Schmitt: Don't worry about that. I'll be able to...There are enough rocks around. I can use it.

118:56:45 Parker: Copy that, Jack. And Gene, if you're having trouble with that fender and you think it might be easier with two guys, you could wait until you get out to the ALSEP site.

118:56:57 Cernan: No sir, I got it on, but a little piece of the rail is cracked off. And I'm just going to put a couple of pieces of good-old-fashioned American grey tape on it...(and) see whether we can't make sure it stays. Because I don't want to lose it. (Pause) Except good old-fashioned grey tape doesn't want to stick very well (because of the dust).

[The TV camera jiggles as Gene works.]

118:57:27 Schmitt: I've not seen any sign of layering in any of the craters. In their walls.

[Jack reappears.]

118:57:39 Parker: Okay. Copy that.

118:57:41 Schmitt: The rocks still seem to be the pinkish-grey gabbro out here.

[Jack first remarked on the pinkish coloration of the basalts at 117:21:16.]

[Schmitt - "The pinkish color could be the result of one of two things. Any exposed rock surface has a thin patina or coating that looks a little like desert varnish. However, desert varnish is caused by chemical precipitation, while this is a thin, semi-continuous splattering of brown glass from the micrometeorite impacts. The patina may have looked pinkish to me at this point. Or, the clinopyroxene in the rock might have been giving it a pinkish cast in the full Sun."]

[Fendell pans the TV in order to find Gene.]

118:58:03 Cernan: Good old-fashioned American grey tape doesn't stick to lunar-dust-covered fenders. One more try.

[Cernan - " Because there was dust on everything, once you got a piece of tape off the roll, the first thing the tape stuck to was dust; and then it didn't stick to anything else."]

[Gene discards the piece of tape he's been trying to use. He grabs the roll to tear off another piece.]

118:58:14 Cernan: I think it'll stay, for an indefinite period of time, right now. (Pause) (Tearing a piece of tape off the roll) Not bad for EV gloves.

[Cernan - "The suit made using the tape more difficult than it would have been otherwise. You don't have as much dexterity with your hands and fingers to get the tape off the roll and tear it. We used the old trick of folding over a little piece of the end so that that piece wouldn't stick back on the roll; otherwise, you'd never get it off."]

118:58:33 Schmitt: Can you see me, Bob?

118:58:36 Parker: We're watching Gene, right now. You disappeared out of sight a long while ago. (Pause) Hey, you just came into sight again, Jack.

[Gene turns to look toward Jack before calling to him.]

118:58:53 Cernan: Hey, leave me enough room to deploy the heat flow.

118:58:55 Schmitt: I'm going to, I'm looking for a place. Away from craters and rocks.

[Most of the experiments have constraints of one kind or another about proximity to rocks and/or craters and also to the Central Station, the RTG, and to each other. For example, the heat flow experiment is designed to measure temperature gradients in the soil down to a depth of about 2.5 meters. Craters and rocks, because they absorb and radiate heat differently than a flat surface, can influence the temperature gradients to depths equivalent to their own dimensions.]

118:59:02 Cernan: That's why I didn't land up there. (Pause)

[Geophone Rock, which hadn't been noticed in the pre-mission photos, is about 70 to 80 meters northeast of the planned landing point.]

[Fendell pans to Jack, who is resting with the ALSEP on the ground.]

118:59:11 Schmitt: Okay, I think I've got a place. And I think it'll also give you a spot for the neutron flux that's sheltered from the RTG.

[The neutron probe is designed to measure the natural flux of neutrons due to the decay of radioactive elements in the soil and due to interactions between the soil and cosmic rays and the solar wind. Because the RTG is powered by a plutonium fuel element, it produces enough neutrons that the neutron flux experiment has to be shielded by placing it either in a depression or behind a rock or, preferably, both.]

118:59:20 Parker: Okay. You say you have a place like that, Jack?
118:59:25 Schmitt: Well, pretty much, I think, Bob.
118:59:29 Parker: Okay.
118:59:31 Schmitt: Let me work on it here a little more.

[Schmitt - "Through the years I had deployed versions of the ALSEP enough times that the geometry was pretty well fixed in my mind. I could look at an area and, in my imagination, place where everything was going to be and try to pick a compromise site. Nothing was going to be perfect; there were too many variables. But it's one of those things that you can do fairly easily with enough practice that would also be tough to automate. The main problem with the ALSEP was that it took a lot of time to deploy. Much more than it needed to had we designed it to minimize time initially. It got off to a bad start and never fully recovered. Before my time, Walt Cunningham had told the Bendix people 'Give us something to do on the Moon.' And they did. The other extreme was when Bill Anders saw it and said, 'I want a big red button and when I punch it, it gets deployed.' And we ended up in the middle somewhere, still taking an awful lot of time and effort to deploy it. Not the best use of human time on the Moon. Deciding where to deploy is a good use of people; but the actual deployment should have been far more straight-forward than it was."]

118:59:36 Parker: Okay, and right now you're about 10 minutes behind the time line, Jack.
118:59:46 Schmitt: Okay.
118:59:48 Cernan: Bob, I'm only going to spend another minute or two on the fender.
118:59:53 Schmitt: We'll catch up. (Pause)
119:00:00 Cernan: I never thought I'd be out here doing this.

[Jack bends his knees and picks up the ALSEP.]

119:00:03 Schmitt: Boy, I'll tell you, Geno. (Turning south) Okay, I'm going to go back this way. Central Station can be near a crater. (Pause) It will be pretty good, that'll put the LEAM (Lunar Ejecta and Meteorite Experiment) right out over there (25 feet southeast of the Central Station) which is probably all right.

[Jack stops and then turns to look north. His heart rate is at a maximum of 140 beats per minute somewhere in this interval just before he puts the ALSEP package down for the last time.]

119:00:20 Schmitt: The gravimeter out over there (25 feet west of the Central Station), which is probably all right. Going to put your drill holes a little too close to that

rock, though. Bob, ask Mark if he's worried about rocks as much as craters.

[The gravimeter Jack is referring to here is the Long Period Gravimeter, designed to look for gravity waves. Marcus (Mark) Langseth is the Principle Investigator on the heat-flow experiment. Gene will drill two heat flow holes, one 18 feet east and one 18 feet west of a point 30 feet north of the Central Station.]

119:00:37 Parker: Okay, stand by.

119:00:38 Schmitt: I've got a rock about 2 meters in diameter, partially buried, that one of the probes (the westerly probe, as it will turn out) may be near.

119:00:48 Parker: Stand by and define "near".

119:00:53 Schmitt: Well, it could be 10 feet.

[Jack puts the ALSEP down and looks north.]

119:00:56 Parker: Okay. (Pause)

119:01:04 Schmitt: Well, I can move a little more south, I guess.

[Jack picks the ALSEP up again.]

119:01:07 Parker: Okay. And Jack, it seems (that), if you're about 3 meters from the rock, that's no problem.

119:01:14 Schmitt: Okay. (Pause; as he moves south about 15 to 20 feet) Okay, this is it.

119:01:21 Parker: Okay. Copy that. (Pause)

119:01:30 Schmitt: I tell you, the block (Geophone Rock)... (Pause) Let's see, the Sun's (garbled), this way. South of east. Okay. (Pause) Well, shoot! (Pause)

119:01:56 Cernan: What's wrong?

119:01:58 Schmitt: Well, it's just about impossible. Bob, it looks like the (heat flow) probes are going to be in a shallow depression. I'll try to improve that a little. It's not a real crater; it's just a shallow depression.

[Jack moves another ten feet south. He is talking distinctly louder to Houston than to Gene, despite being about 200 meters west of Gene and the LM.]

119:02:14 Parker: Stand by. Stand by on that, Jack, a minute. That may be okay. Okay, shallow depression's all right, Jack, don't worry about it.

119:02:20 Schmitt: It's not more than a meter deep.

119:02:22 Parker: That's okay, Jack.

119:02:23 Schmitt: Okay.

119:02:24 Parker: Stay there.

119:02:28 Schmitt: All righty. It looks pretty good to me.

119:02:32 Parker: Okay. Good enough.

[Measurements of the apparent size of the LM in photos taken from the ALSEP site indicate that Jack has picked a spot about 185 meters from the spacecraft. He is about 40 meters north of Geophone Rock and, from Rover navigation readouts Gene will report later in the EVA, the ALSEP azimuth from the LM is about 27 degrees north of west. Fendell pans to Gene, who is still taping.]

119:02:33 Schmitt: Bob, it's really, in detail...The meter and half-meter scale relief is a little more than we can stand here for a good site. But I think this will be all right.

119:02:50 Parker: Okay, copy that. We're ready to press on with ALSEP interconnect.

[That is, it's time to begin the ALSEP deployment.]

119:02:55 Parker: And Geno, how are you doing on that fender?

119:02:59 Cernan: Bob, I am done! If that fender stays on...I'm going to take a picture of it because I'd like some sort of mending award. It's not too neat, but tape and lunar dust just don't hang in there together.

[He jiggles the fender. He doesn't have a camera on at the moment and never does take a close-up picture of his repair job.]

119:03:15 Parker: Okay. Copy that.

119:03:22 Cernan: Well, let's hope. Keep your fingers crossed, and I'll be more careful around the fenders.

[Gene moves around the rear of the Rover. At the end of EVA 3, he will remove two fender sections, albeit not the broken section, and bring them back to Earth. They are on display at the Johnson Space Center in Houston.]

119:03:26 Parker: Okay. Copy that.

119:03:32 Schmitt: Whoops. (Pause)

119:03:39 Cernan: Bob, I'm going to do one other thing real quick here. I've got to dust my visor off.

119:03:42 Schmitt: Gene, do you want me to do that?

119:03:43 Cernan: No, I can do it. I'll just do it right here. Only have to do it in a couple of places right in front of me. (Pause) That didn't do much good, did it.

Someone should have told me that. That's just really screwed it up. Okay. Bob, you might ought to be thinking of a good way to clean that visor when I get in the cabin.

119:04:15 Parker: Okay, we'll put someone on that.

[Gene is out of the field of view and we don't know if he used the big brush, the lens brush, or his glove.]

119:04:20 Cernan: (Reading very quickly, page CDR-15)
 Okay, LRV equipment check. Blankets are open 100 percent;
 TV/sunshade is on; SEP receiver/antenna, nav cable; we've got
 4, 5, 6, and 7 on the (seismic) charges; TGE...I've got three
 measurements complete; I've got the drill, the bag, and the
 neutron flux. The TV camera...(To Houston) I'm taking it
 away from you.
 119:04:39 Parker: Okay. Roger. (Pause)
 119:04:47 Cernan: Sorry about that, Ed. Okay. MODE switch
 is going to 1.

[Ed Fendell is operating the TV camera from Houston. He
 started panning toward Jack but Gene took the TV in hand,
 pointed it inboard and aft, and is turning it off.]

119:04:49 Parker: Roger.
 119:04:53 Cernan: Okay. MODE switch is 1. I'm ready to
 drive to the ALSEP site. Still want to park 60 - east and
 north.

[That is, he plans to park the Rover 60 feet northeast
 of the Central Station.]

119:05:xx Parker: Okay, Geno. And before you leave the LM
 there, how about giving me another Batt(ery) Temp(erature)
 reading. Those were a little high and we'd like to try and
 verify some of that stuff.
 119:05:xx Cernan: Boy, oh boy. Yeah, I get you Bob.
 (Getting on the Rover) Boy, oh boy. You just got to be
 careful where you kick dust.
 119:05:xx Schmitt: That's right.
 119:05:xx Cernan: (To himself) Boy! Don't do that again.
 119:05:54 Cernan: Yeah, Bob, I thought they (the battery
 temperatures) were a little high, too.
 119:05:56 Parker: Roger.
 119:06:02 Cernan: Okay. Batt Temps are 100 and 120, right
 now.
 119:06:12 Parker: Okay. How about tapping the meter a
 little bit for us?
 119:06:19 Cernan: Well, I think the meter's been tapped
 since we've been working on the Rover. (Pause) Yeah; 100
 and 120.
 119:06:29 Parker: Okay. (Pause)
 119:06:36 Cernan: Okay. (Pause) Get this baby started.
 (Pause) Okay. I'm going to be heading west. The low gain
 is 270. (Pause)
 119:07:05 Cernan: Okay, Jack, I'm on the way.

[Cernan - "We had the low-gain antenna set up with a
 heading indicator; and we'd done some work with it in
 training. I knew generally what my heading was going to be,
 and in this case it was going to be west. So, rather than try
 and sight the antenna while I was going, in this case I just
 set the low-gain on the 270 mark. I never had to worry about

the elevation because it was just about always the same no matter where we were."]

[The low-gain antenna is mounted on a two-piece staff, with the upper section seated in a sleeve in the lower section. The antenna, itself, has to be pointed to within about 30 degrees of Earth and that means that, as Gene turns the Rover, he has to re-point the low gain. The low-gain staff is mounted on his T-handle, just forward of the Rover control handle and more or less in his line of sight with the instrument console. There is a short handle attached to the upper section of the staff which Gene can use for pointing. On the upper staff-section there is also a fixed arrow and, mounted on the lower section, a heading indicator in the form of an aluminum collar attached with a set-screw. The numbers on the collar increase in the counterclockwise direction, the reverse of the heading card on the Rover instrument panel. Because Earth remains fixed in the local sky, the collar could be positioned prior to launch from Earth at an orientation such that, as he turns to a new Rover heading, Gene needs only turn the antenna so that the arrow points to that new heading.]

119:07:07 Parker: Okay, and Geno, we'd like to vary the parking a little bit because of this. We'd like to try and get those batteries cooled down. We'd like to have you park about 60 feet north of the Central Station. And facing east. Facing down-Sun. And then we'll open the battery covers.
119:07:34 Cernan: Hey, Bob, I can't read you, but "facing east" and "down-Sun" are not the same.

[Because it is early morning at Taurus Littrow, the down-Sun direction is just a little north of west.]

119:07:41 Parker: Well, approximately there.
119:07:45 Cernan: Jack, you need your block? I got it right here.
119:07:48 Parker: Facing...
119:07:49 Schmitt: You're on the Rover, aren't you?
119:07:50 Parker: Facing...
119:07:51 Cernan: I got it, wait a minute.
119:07:56 Parker: Hey, Geno, we mean up-Sun. Sorry about that. (Long Pause)
119:08:13 Cernan: I got your block coming, Jack.
119:08:14 Schmitt: Okay. (Long Pause)
119:08:34 Cernan: Boy, it doesn't take much to get those battery covers dirty. (Garbled under Parker)

[Gene got off the Rover to get the block Jack had dropped and, then, as he got back on, probably kicked dirt on the battery covers.]

119:08:40 Parker: Okay, Gene, did you copy me that we meant facing up-Sun?

119:08:50 Cernan: Yeah, Bob. (Pause) (To himself as he fastens his seat belt) What did I do, get fatter? Okay; must have got fat. (Pause)

119:09:06 Schmitt: Bob, the shorting plug meter is 90 percent scale to the right.

119:09:16 Parker: Okay, copy that.

[Schmitt - "Because the RTG was producing power when we hadn't yet hooked up any of the equipment, they had what was called a shorting plug that basically allowed current to flow out of the RTG and then back into itself. And, obviously, some resistance had been put somewhere in the circuit it made so that the power source wouldn't burn itself out."]

119:09:21 Cernan: Okay, Bob, give me that parking heading again, would you?

119:09:25 Parker: Okay, we'd like you to park facing the Sun. How's that for being definite.

119:09:32 Cernan: Okay.

119:09:33 Parker: About 60 feet north of the Central Station.

119:09:37 Cernan: Sixty feet north of Central Station. I can't park a little northeast? Huh? Now, okay, and you want the battery covers open?

[Houston wants him to face the Rover into the Sun so that, by opening the battery covers he will put the battery radiators in shadow, and let them cool. By parking north of the Central Station, Houston would still have good TV coverage of the ALSEP deployment, despite the new Rover orientation. As it turns out, Gene will follow the checklist and will park 60 feet northeast of the Central Station but with the vehicle facing east. The TV coverage is still pretty good.]

[Cernan - "As I remember, if I was at the front of the Rover facing the back, the battery covers would open toward me. So if you parked the Rover facing east, the covers would shadow the batteries from the Sun and let them cool."]

119:09:44 Parker: That's affirmative, Gene. And that means you will have to dust them before you open them.

119:09:51 Cernan: Yeah, I guess so. Man, am I glad I didn't land up here, Jack!

119:09:57 Schmitt: So am I. (Pause)

[Compared with the landing site, the ALSEP area has many more large rocks and a bit more relief.]

119:10:04 Schmitt: Okay, ALSEP is connected; RTG is connected.

[After positioning the Central Station pallet, Jack moved 10 feet east with the RTG pallet and removed a reel of connecting cable. He then walked back to the Central

Station, deploying cable as he went. The shorting plug is on the end of the cable and, after reading the shorting plug meter, Jack plugged the cable into the Central Station.]

119:10:07 Cernan: Is that where you're going to have the Central Station, huh?

119:10:09 Schmitt: Well, Geno, that's the best I can do without spending a lot more time.

119:10:12 Cernan: Yeah.

119:10:14 Schmitt: And let me talk to you about it. I asked them about this depression.

119:10:22 Cernan: Yeah.

[Jack is referring to a small, local depression rather than the swale.]

119:10:23 Schmitt: Your (heat flow) probes are all right out in here. And if you get in the bottom of it for the...either this one, or go out there - essentially in the straight line between you and me now - (there's) another depression (that) would be good for the neutron flux. (Pause) You need to be over that way...you're just a...

119:10:42 Cernan: Yeah, they want me to park about here where...

119:10:45 Schmitt: You need to be over here.

119:10:46 Cernan: Where's Central Station, right there, huh?

119:10:48 Schmitt: You need to...

119:10:50 Cernan: Yeah, I've got to park in the Sun for the batteries.

119:10:52 Schmitt: Oh, okay.

[Obviously, Jack had been busy with his own work during the parking discussion and hadn't consciously heard what Parker said.]

119:10:54 Parker: Okay, 17, for your planning...

119:10:54 Cernan: Okay, about 60 feet northeast. How does it look behind me.

119:10:57 Parker: Okay, 17, for your planning, we're now about 20 minutes behind the time line.

119:11:01 Schmitt: (Talking to Gene, who is maneuvering the Rover) That's good, Gene. That's good. (To Parker) You're cutting out, Bob. You'll have to wait. (Pause)

[While he is busy parking the Rover, Gene isn't adjusting the low-gain antenna, so communications with Earth are momentarily bad.]

119:11:10 Cernan: What are you, Bob?

119:11:12 Parker: Roger, we're about twenty minutes behind the time line, two-zero minutes.

119:11:17 Cernan: Okay. Well, I guess it could be worse, considering a couple of things. Okay, about time I got those

batteries. Okay, Jack, let me give you this first, so I can get to work.

119:11:36 Schmitt: Oh; the block.

119:11:37 Cernan: Yeah.

119:11:38 Schmitt: I'm sorry, I forgot you had it. (Pause)

Thank you. (Long Pause)

119:12:02 Cernan: Okay, where are we? (Reading at the bottom of CDR-15) Park (at) sixty (feet) north heading...Okay, 15 Volt is Off. Let me double check that while I was thinking of something. Wouldn't want this Rover to go rolling over the terrain without me. Okay, it is Off. Mode switch, position 3. Dust TV/TCU, and the whole works, huh? (Pause) Okay, there's TV Remote. (Long Pause)

[The TCU is the Television Control Unit, the assembly which controls camera operations. A good image of it AS17-134-20476, a picture of Gene and the Rover that Jack took late in the third EVA. The TCU is the box at the top of the mounting post and below the camera itself.]

119:12:54 Cernan: Okay, Bob. You're aligned on the high gain.

119:12:56 Parker: Okay, we copy that.

119:13:01 Cernan: And you're in (Mode switch) position 3.

119:13:02 Parker: Copy that.

[TV on. Fendell pans past Jack.]

119:13:05 Cernan: Okay, let me get these (battery) covers dusted. (Pause) Well, that's a consolation. It's not as hard to get at the covers as one might think. (Long Pause)

[The batteries are permanently attached to the forward chassis section. In order to dust the covers from the front of the Rover, Gene would have to lean over the LCRU whereas, from the side, he has a shorter distance to lean over the wheels and, when he can be seen dusting the covers, he is always to the side.]

119:14:05 Schmitt: Okay; I'm working on the LEAM connection now, Bob.

[The Lunar Ejecta and Meteorites Experiment is designed to measure the size, speed, and direction of flight of very small impactors. The experimenters expect to see about one impact per day. All of the ALSEP experiments except the heat-flow and the LEAM are in the same transport package as the Central Station and are already connected to it electrically. At the moment, Jack is making the LEAM electrical connection. He is on page LMP-16.]

119:14:08 Parker: Okay. I copy that, Jack.

119:14:13 Schmitt: Say, it's hard to hit that garbage pile.

[Schmitt - "We established one place in the deployment site where you'd put all the discards, all the things that were designed to isolate vibrations, to assist in packing: shims, dust covers, and other things that people felt were necessary to protect the equipment. The idea of having a garbage pile was partly to keep the site neat, but also to keep things from being under foot. I'm throwing things toward the pile and often not hitting it, usually throwing things too far."]

119:14:17 Parker: Roger. Understand you also have the heat-flow connector connected by now?
 119:14:23 Schmitt: Yes, sir. (Pause)
 119:14:34 Cernan: I'm a little late, Jack, 'til I get these battery covers opened.
 119:14:38 Schmitt: Okay. I got the heat flow for you.
 119:14:39 Cernan: Okay. (Pause)

[Jack has connected the heat-flow electronics package (HFE) to the Central Station and has put it on the ground about ten feet to the west. Normally, Gene would have detached the HFE from the RTG pallet and made the electrical connection to the Central Station, but he is running a little behind the timeline because of the fender. The mission planners anticipated the possibility - if not the cause - that Gene might arrive late and included the heat flow offload and connect as an optional task in Jack's checklist, page LMP-15.]

119:14:45 Schmitt: Well, the old LEAM connector doesn't connect - just like usual - or lock.

[Schmitt - "This statement seems to imply that during training it was hard to get the pins lined up. But, apparently, perseverance succeeded."]

119:14:52 Cernan: Okay. I'm not going to touch the batteries. The covers are clean, and the batteries themselves are clean. The LCRU has been dusted and...
 119:15:05 Schmitt: Okay,...
 119:15:06 Cernan: ...so has the TV.
 119:15:07 Schmitt: ...it's locked.
 119:15:08 Parker: Okay. Copy that.
 119:15:09 Schmitt: LEAM's locked on. (Pause) Okay. I'm going to use this. (Long Pause)

[Jack's next task, at the bottom of LMP-16, is to do a rough alignment of the Central Station.]

119:15:42 Cernan: Okay, Bob. The battery covers are in the shade.
 119:15:46 Parker: Okay. Copy that, Geno. (Long Pause)

119:16:02 Cernan: Well, well, well, well. Okay; I hope that helps. Whoo! I'm going to go to Max (cooling) for a minute here. Do you buy that?

[Gene has been working hard dusting. Fendell points the TV in his direction just in time to show him reaching back for the cooling control on the bottom right of his PLSS.]

119:16:16 Parker: Okay, Geno. We copy.
 119:16:18 Schmitt: It seems hot in the valley of Taurus...
 119:16:20 Parker: Okay.
 119:16:27 Cernan: Okay. Oh, man, is that (cold)...Whoo! Yeah, I'm going back to Intermediate.

[Cernan - "It felt like a shot of ice water."]

119:16:33 Parker: Okay. Copy that.

[The cooling control is a round knob with a thumb flange sticking out on one side.]

119:16:35 Cernan: Okay, Bob. I'm ready to go to work.
 119:16:37 Parker: Good.
 119:16:39 Cernan: Okay. I'm going to push the gravimeter.
 119:16:41 Parker: Roger, mark. (Pause)
 119:16:51 Cernan: Okay. You have a mark.
 119:16:55 Parker: Copy that.
 119:16:56 Cernan: It's blinking, and remember what I said, it's a piece of cake to take on and off (the Rover).
 119:16:59 Parker: Okay. Copy that. (Pause)

[Gene has just finished his last task on CDR-15. CDR-16 is a schematic of the ALSEP layout, identical to LMP-15. Gene next task is to deploy the Heat-Flow Electronics package 30 feet north of the Central Station.]

119:17:04 Cernan: Okay. This is north over here, huh?
 (Long Pause) Okay. (Reading) "Offload heat flow, 10 (garbled) northwest."

[As mentioned previously, Jack has already disconnected the heat flow package and placed it 10 feet northwest of the Central Station. Gene reaches the Central Station and gets one of the two Universal Handling Tools (UHT). Jack is using the other UHT. Each of the UHT's is a meter-long tool with a handle jutting out at ninety degrees from the top and a pull trigger which retracts pin fasteners at the tip.]

119:17:26 Cernan: You (that is, Jack) got the connector connected. (Reading) "Carry heat flow 30 (feet north). Place on ground, experiment up." Okay. I'm going to do that, Jack. Keep your eye on cables. (Pause)

[Out of sight of the TV, Gene picks up the HFE and carries it 30 feet north to the place where he will drill the two heat-flow holes.]

119:17:xx Cernan: Oh, man, all I could do is go downhill over here. (Pause) Jack, do you read?
 119:17:53 Schmitt: Yeah.
 119:17:54 Cernan: Okay.
 119:17:55 Schmitt: I'm just trying to level (the Central Station)...
 119:17:56 Cernan: Are you going to move that very much?
 119:17:59 Schmitt: No, I'm just...I'll be working with it to try to level it. That's going to be a major task.

[Schmitt - "In those days, they were saying that the missions each cost a half billion dollars, half for the hardware, half for operations. If you spread that over the two of us being out on the surface for twenty-two hours, it comes out to about \$200,000 per EVA minute."]

119:18:04 Cernan: Okay, there's 30 feet, I'll get this thing squared away when I...Okay, Boyd-bolt time.

[Jack flicks away a small object with the UHT.]

119:18:22 Schmitt: Ha, whee! That really went.
 119:18:27 Cernan: Man, these things are just like they are at the Cape. You can feel every one of them.

[Schmitt - "We had originally had things called Calfax fasteners holding the equipment together, but they were far too complicated. I made a stink about that early on, way back in the mid-sixties. So they invented or found another way to do it and replaced all the Calfax fasteners with these Boyd bolts. The Calfax you had to turn several times; and these you only had to push in with the UHT and then turn a three-quarter turn and it would pop loose.

"The change from Calfax fasteners to Boyd bolts occurred well before the first ALSEP. We changed that at Bendix as soon as I got involved. As I've already mentioned, Walt Cunningham, on a visit to Bendix early in the history of the ALSEP program - not knowing that there was going to be lots of things to see and do and describe and photograph - told them to give us something to do. So Bendix put as many fasteners on this thing as they could. But when Bill Anders and I showed up there - probably in '67, maybe late '66 - we saw this monster that they had constructed with over fifty of these Calfax fasteners. I think it took two-and-a-half turns on each of them to get them loose. So we yelled and screamed. Well, not 'yelled and screamed'; but we suggested to them that they try to find a better fastener and reduce the number as much as they possibly could. To be fair to Bendix, the contractors sometimes had a hell of a time responding to astronaut inputs. They felt like they ought to

respond and so they had responded; and then the guy who made the input disappears - Cunningham was off working on Apollo 7 by this time and was out of the picture - and a couple of more come on who have different ideas.

"On my first visit to Bendix in Ann Arbor with Bill Anders - we flew up there in a little T-33 - I think we went through a shirtsleeve deployment of the mock-up that they had at the time. And that's when we just about raised the roof on how long it was going to take and how much was required physically. We really forced them into a whole redesign on the packaging and deployment. The issue of the fasteners is the one that sticks in my mind because they were so egregious, but I'm sure there were lots of other change orders written. I spent a lot of time trying to work with Bendix because I didn't want to use up any more time deploying the ALSEP than was absolutely necessary. There were so many other things that I wanted to do, and wanted the rest of the guys to do - mostly collecting samples - that I wanted to minimize the amount of time we spend on the deployment. Deploying the ALSEP is exactly the kind of thing that robots generally ought to be used for, except for certain things like getting seismometers deployed and leveled. Things like that are tough to do automatically and is probably cost effective to have a man do it. But a lot of this other stuff could have been done robotically, even in those days. It's just that the program didn't try to do it that way."]

119:18:40 Cernan: Hey, Bob, has Ron been able to see the LM?

119:18:44 Parker: Stand by. I'll find out. (Pause)

[Jack is unfastening bolts that hold the Long-Period Surface Gravimeter onto the ALSEP package. He inserts his UHT in the top of the LSG and lifts it free. This is the gravity-wave experiment. He is at the top of LMP-17.]

119:19:00 Schmitt: Oh, oh...

119:19:02 Parker: Watch it, Jack.

[Jack has been working east of the Central Station. He starts moving sideways to the north, watching the LSG ribbon cable come loose. In the process, he catches a foot on the LEAM cable going off to the southeast. He hops free.]

119:19:06 Schmitt: First cable hook.

119:19:08 Cernan: You all right?

119:19:09 Schmitt: Yep. I'll straighten it up in a minute. Okay. The LSG is going out.

[Jack moves west and a little north.]

119:19:20 Parker: Okay. Copy that, Jack.

119:19:21 Schmitt: I hope this does the things that we want it to for (us). (Pause)

[Jack gets to the end of the LSG cable and puts it in tension before removing and discarding a cover.]

119:19:33 Schmitt: Bob, I'm not doing too badly on keeping things clean. The base of the Central Station (has) got some stuff (dust) on it, but, otherwise, it's pretty good.

[Gene is now visible between Jack and the Rover.]

119:19:46 Parker: Okay, Jack. We appreciate your efforts, and we understand you got the LEAM connected eventually.

119:19:55 Schmitt: Yes, and it locked; (it) just took some diddling. Okay. Sun's over there. (Pause) Oops, I forgot my Boyd bolts. Let's see.

119:20:07 Cernan: Now, I never drilled a hole where there's not a can.

[Schmitt - "As I recall, in order to train with the drill, you wanted to drill in a lunar soil simulant. So we had a big can or drum or bin filled with the stuff - dry and tamped down - and when we got to this point, Gene would go over and drill his hole in the can of simulant."]

[Gene has deployed the HFE 30 feet north of the Central Station and is backing away from it to the east, paying out cable for the first of the two probes.]

119:20:16 Schmitt: Boyd bolts are Off. (Pause) Bob, does it bother him (Joe Weber, the LSG Principle Investigator) that the base of the LSG is touching soil? Because this is pretty soft. (Long Pause)

[Gene drops the first heat flow probe to the ground 16 feet east of the HFE, and then goes back to get the other probe.]

119:21:04 Schmitt: Bob, did you give me an answer?

119:21:06 Parker: (Having missed Jack's most recent question) Roger. Ron thinks he has seen it (the LM). We haven't had a confirmation on the last orbit when you were talking to him, but he thinks he saw it the previous orbit.

[Again, it is a little puzzling that Houston does not pass along the fact that Evans' observation put them just north of Poppie.]

119:21:15 Schmitt: Hey, hey, Bob. Hey, Bob.

119:21:17 Parker: Go.

[Gene moves west with the second probe.]

119:21:19 Schmitt: Can the base of the LSG be touching the soil?

119:21:22 Parker: Stand by on that. (Pause) Roger, Jack,...

[Jack hasn't moved much through all of this. He is unfolding the LSG's diamond-shaped sunshade before setting the instrument on the ground.]

119:21:29 Schmitt: Well, it's very soft and it's going to be very hard to level...(Stops to listen to Parker)

119:21:31 Parker: Roger, Jack. The base can be touching the ground.

[Gene drops the second probe.]

119:21:37 Schmitt: Okay. It's leveled, aligned, the sunshield is shaded inside. The level bubble is just touching the outer circle, or the "one" circle. (Pause) And I improved that. It's perfectly centered now and I'm going to uncage. (Pause) Whoops. (Pause) The experiment moved.

[Schmitt - "There was a level bubble and a little gnomon, and I would have seen movement too small to see in the TV picture."]

119:22:17 Schmitt: It's still (a) pretty good level. Okay, it's uncaged; the gimbal is swinging.

119:22:24 Parker: Okay. Copy that.

[Had the LSG actually detected gravity waves, the achievement might well have resulted in a Nobel Prize in physics. As it turned out, a design error - which Jack discusses in more detail below - prevented the balance beam at the heart of the experiment from completely uncaging.]

[Schmitt - "As I remember, it did partially uncage and, eventually, they learned how to use the instrument as a seismometer."]

[Gene has returned to the HFE. He looks at checklist page LMP-17, gets his UHT, and starts releasing bolts.]

119:22:26 Schmitt: The gimbal is swinging.

119:22:27 Parker: Copy that. And Jack, you're still in Max...

119:22:28 Schmitt: The bubble is back just touching...(Listens) Yeah, I know...

119:22:34 Parker: Okay.

119:22:35 Schmitt: ...I've been working, man.

[Jack changes his cooling.]

119:22:37 Parker: Okay.

[The more cooling that either Jack or Gene use, the sooner they will run out of cooling water and have to terminate the EVA. Hence the reminder. Based on the experience of prior missions, relative high usage is expected during the ALSEP deployment; only prolonged operation at maximum cooling is a real concern.]

119:22:40 Schmitt: Okay. I went to "pseudo intermediate," between Minimum and Intermediate. The (level) bubble (on the LSG) is just touching the circle, and the Sun alignment is good.

[Jack heads toward the Central Station. Fendell follows him.]

[Schmitt - "Because we were at 23 north latitude, and because the Sun was already up maybe 8 to 10 degrees, it wasn't exactly east of us. There was probably a mark on the device that took that into account and showed me how to place the gnomon shadow so that the whole experiment would be properly aligned relative to east-west."]

119:22:55 Parker: Roger. Copy that. Thank you. (Pause)

[At the Central Station, Jack turns to look at Gene.]

119:23:03 Schmitt: Okay, Gene. You've got some good slack here (in the cables), if you can leave it that way. You shouldn't have the cable draped across anything; that's good.

[Schmitt - "Generally, you didn't want the cables taut but, rather, with a bit slack so that they could drape over craters. But you also didn't want them to drape over rocks."]

[Jack turns away.]

119:23:10 Cernan: Okay. I want to try and get this thing in there. It won't...There it is. (Long Pause)

[Jack reaches very low, perhaps to adjust the thermal skirt on RTG. He doesn't quite kneel, then uses the handle of the UHT to drag the RTG a couple of feet east. When he finishes, he turns to look at Gene again.]

119:23:48 Schmitt: Can I help you, Gene?

119:23:51 Cernan: No. I got a little dust in this mirror, though. I want to make sure I...Bob, I got a little dust on the white surface - not on the mirror - of the heat flow (electronics package). You got any recommendations?

119:24:06 Parker: Stand by on that, Jack - (correcting himself) - Gene. Is that on the heat reflector?

119:24:13 Cernan: Yeah, it's on the north side.

119:24:14 Parker: Okay. As long as it's not on the mirror, it's okay, Gene.

119:24:19 Cernan: Well, let me take another look. I'll double check.

[In response to Gene's manipulations of the HFE, it's cable comes off the ground at the Central Station.]

119:24:27 Schmitt: Watch it. You're pulling pretty hard.
 119:24:29 Cernan: Yeah, I'm watching...
 119:24:30 Schmitt: You're pulling...
 119:24:31 Cernan: I'm watching; I'm not pulling. Okay.
 The mirror's clean.
 119:24:33 Parker: Okay; then, it's good enough.
 119:24:35 Schmitt: Give me some more slack up here, you're draped.
 119:24:36 Cernan: Okay. (Pause) Okay. That's where it's going, Jack. Right there.
 119:24:43 Schmitt: Can you...Okay.
 119:24:44 Cernan: How's that?
 119:24:45 Schmitt: That's good.

[Jack reaches down with his UHT, apparently to reposition the cable.]

119:24:48 Cernan: Got enough?
 119:24:49 Schmitt: This way just a little, Geno. That's good. Doesn't take much.

[Jack starts to release the geophone assembly from the pallet. He will deploy the module 30 feet south of the Central Station and then will emplace the four geophones at the following locations. No. 1 will go 150 feet east of the module; No. 2, 150 feet west; No. 3, 88 feet south and not quite as far as Geophone Rock; and No. 4, 260 feet south, well beyond Geophone Rock. He is in the middle of LMP-17.]]

119:24:55 Cernan: Man, we sure didn't need blocks or anything out here. There's enough soil here to level almost anything.
 119:25:02 Schmitt: But it's so soft, though, it's hard to get a best level. (Pause) Whoops! (Pause)

[Jack reaches down and pulls the geophone off by hand. A small object flies off.]

119:25:24 Schmitt: That's strange. I think I did something wrong.

[Parker is told that the geophone dust cover has released prematurely but will not cause any problems.]

119:25:29 Cernan: What's that?
 119:25:34 Schmitt: Pulled the pin at the wrong time.
 119:25:36 Cernan: Okay. The heat flow (electronics package) is level; the gnomon is good. And, Bob, I verified

that that dirt is not on the mirror. It's on the white stuff that, you know, is horizontal to the (top) surface of the box.

[Jack does a high, two-footed kangaroo hop over a cable and heads south.]

119:25:52 Parker: Okay. Copy that, Gene; that's okay.
 119:25:54 Cernan: The mirror's clean.
 119:25:56 Parker: Roger. Thank you.
 119:25:58 Cernan: Okay. (Pause) Okay, I'll give you a TGE reading.
 119:26:08 Parker: Roger. We're ready.
 119:26:17 Cernan: Okay; 670, 002, 601. 670, 002, 601.
 119:26:27 Parker: Okay. We copy that.

[Jack stops and, one at a time, pushes five orange-colored geophone flags into the ground. A geophone cable reel is visible in his hand. The flags will be used to make the geophone locations visible in the photographs and also to help Gene to keep from running over the geophones with the Rover. In addition, as Jack emplaces the four geophones at the ends of long N-S and E-W lines centered on the geophone module, he can sight across the central module to a flag at the opposite end of an arm and keep his lines straight.]

119:26:31 Cernan: Bob, was that (TGE measurement taken) with the (TV) camera running?
 119:26:34 Parker: Roger. The camera's been running all this time.
 119:26:38 Cernan: That's beautiful.

[Again, there is some concern that movement of the TV camera might upset the TGE. The successful completion of this measurement indicates that there will be no problem.]

119:26:40 Cernan: Okay. Your temperatures are down to 100 and maybe a skosh under 120, so maybe those batteries are cooling off.
 119:26:48 Parker: Okay; good.

[If there has been any cooling, it has only been a fraction of a degree. By the end of the ALSEP deployment at 121:35:00, the temperatures will be down to 96 and 110 degrees.]

119:26:53 Cernan: It's sure good. I don't want to walk on that third EVA.
 119:26:59 Parker: Roger.

[Schmitt - "I don't recall that we had developed any contingency plans for walking traverses. I think the idea was that, if it ever came to that, you'd develop plans in real time, depending on what you'd gotten done before the

Rover failed. With all the redundancy built into the Rover, and with two successful Rover missions completed, they figured that it wasn't much of a risk. If we'd had to, I think we could have probably gotten to our main objectives almost as fast loping as we could driving. You could move pretty fast, and it wasn't an effort, that I recall. I don't think they would have let us go all the way to Station 2, but I think we could have made it up the Scarp. It would have been tough climbing, but we probably could have done it climbing side-hill, zig-zagging up. The main problem was the lack of flexibility in the hip. It wasn't hard to stretch your leg, but lifting your thigh was difficult."]

119:27:02 Cernan: I'm getting to like driving this machine.
 119:27:05 Cernan: Okay, pull pin 2. Pin 2 always comes after... (fixing his joke) comes before pin 1.
 119:27:12 Schmitt: I think that's in the NASA documents now.

[Jack uses UHT to lift off the geophone heat shield. Gene is now assembling the drill and is consulting a decal on the drill to make sure he does it right.]

119:27:17 Cernan: What's that?
 119:27:18 Schmitt: "Pin 2 comes before pin 1."
 119:27:20 Cernan: (Laughs) Okay.
 119:27:23 Schmitt: "Reel 3 comes before reel 1 and 2", also.

[Jack tosses the heat shield toward the trash pile.]

119:27:29 Schmitt: (Pause) I think I overdid that one.
 119:27:32 Parker: Yeah, it went clean out of sight.

[Fendell pans to follow the heat shield; only catches the shadow of it landing.]

119:27:35 Parker: But by all means, "watch reel 2".

[This may have a private joke between Parker and Schmitt.]

119:27:40 Schmitt: (Laughing) Oh, you think you're so clever. (Pause)

[Schmitt - "The Support Crew had all sorts of clever little sayings and pictures and stuff like that that they would put into the checklist. Bob's favorite, since our motto was 'the end of the beginning', was 'this is the end, not the beginning'. And he had some little pink patches he called "Rover patches" as distinct from the flight patches; and there may have been something like that in the checklist at this point. Some of it you couldn't repeat over the airway. Or maybe this was just another part of the private joke."]

[Jack does not turn a checklist page here, so it must be another part of the joke.]

119:27:51 Schmitt: Believe it or not, Bob, I'm anchoring the geophone module.

119:27:55 Parker: Hey, Jack, it looks to us on the TV as though you're anchoring the geophone module with a flag.

[Jack pushes one of the five flags into the ground next to the module.]

119:28:04 Schmitt: Yeah, that's what I'm doing. (Pretending neither of them is hearing the other) I'm anchoring the geophone module with a flag. (Pause)

119:28:14 Cernan: Okay; one leg, two legs, three legs. And none of them (fell off)...

[Gene is pulling out the three legs of a stand on which he will rest the drill stems and hang his wrench. He is on the top of CDR-18. Jack, who is still in the TV picture, has run back to the Central Station and is now releasing the Lunar Mass Spectrometer. this task is at the top of LMP-18. The LMS will measure the density and composition of the very tenuous lunar atmosphere. Because the LM releases enough gases during depressurization and during launch to overwhelm the instrument, like many others of the ALSEP gear, except for a brief checkout after installation, the LMS will be shut down until after liftoff.]

119:28:25 Schmitt: Hey, Bob, remind me to police the garbage pile.

119:28:28 Parker: All right.

119:28:30 Schmitt: The garbage pile is turning out to be just like every other ALSEP deployment. It's hard to control.

119:28:39 Parker: And I understand all your legs came out okay, Geno, or didn't come out.

119:28:43 Cernan: Okay. (Answering Parker) Yes, sir; they all came out okay.

[Schmitt - "The legs on Gene's drill-stem rack were packed unextended and when you extended them, they popped out with a spring. In training, they may have actually fallen off."]

[Bob Parker agrees with Jack's recollection.]

119:28:51 Schmitt: Okay. LMS ring is pulled.

[The Central Station jumps a little.]

119:28:55 Parker: Copy that.

[Jack carries the LMS eastward.]

119:29:02 Cernan: Amazing. Amazing. (Long Pause) Okay, Bob. I've got my tools of the trade right here. I'm ready to go to work. Now, I put a mark in the deck...(Looking for a spot he scratched on the ground to show where he wanted to drill the first hole) There it is; right there. (Pause)

[Fendell pans to Gene who is carrying a wrapped bundle of drill stems, a stem rack, and the drill. He positions the rack southwest of his mark.]

119:29:48 Schmitt: Hey, Bob, what have I forgotten? The package won't rotate.

119:29:53 Parker: Try rotating the UHT (Universal Handling Tool).

[Gene is holding the drill by a loop handle which allows him to set it on the ground, handgrips down, without bending over very far.]

119:29:58 Schmitt: No, I'm serious. (Pause) Oh, rotate the UHT, huh?

119:30:06 Cernan: Yeah, remember that one?

119:30:07 Schmitt: No...That's right. I'm sorry. (Laughs) I knew it! I knew it would happen!

[Schmitt - "I was probably supposed to put the UHT in a socket and rotate it; the instrument was probably locked unless you put the UHT in and rotate it. Obviously, I had forgotten to do that in training and had forgotten again on the Moon."]

119:30:16 Cernan: Where's your garbage pile, Jack? I can't find yours...

119:30:19 Schmitt: Well, don't worry about my garbage pile. It turns out it looks very much like the ALSEP.

[Gene removes and discards the top of the quiver-like drill stem bag; and then leans the bag on the rack.]

119:30:27 Cernan: Okay. I made a mark over here that says that should be about cable length...

119:30:35 Schmitt: What am I doing over here? You're awfully close.

119:30:39 Cernan: No, I'm going right in here, Jack. Right here.

119:30:45 Schmitt: Okay.

119:30:46 Cernan: I can move it further...

119:30:47 Schmitt: No. That's all right.

119:30:47 Cernan: ...further north.

[Gene removes the initial, four-foot-long drill stem from the quiver. This one is longer than any of the others that will be used on this hole. The total hole depth will be 2.5 meters or about 8 feet.]

119:30:49 Schmitt: No, this will be all right. I just want to keep away from you there. (Pause)

[Schmitt - "We had done the deployment often enough in training that I had a feel for how far away he was supposed to be."]

[In the deployment plan, Gene was to have put the heat-flow electronics package due north of the Central Station and the holes due east and west from the package. However, as indicated in the as-built ALSEP map, the HFE was a bit east of due north, and the eastern hole a bit south, bringing him much closer to the LMS than usual. Without bending over, Gene fits the stem into the drill chuck and then twists it with his fingers to try to get it threaded in properly.]

119:31:04 Cernan: We shall soon see how tuned (sic) we are. I'm anxious to see what's under this mantle.

119:31:13 Parker: So are we. (Pause)

[The stem comes loose from the chuck.]

119:31:20 Cernan: Well, Bob, I hope I can drill you a couple of good holes...

119:31:23 Parker: How about three?

[Gene will drill two heat flow holes and one for a deep core.]

119:31:25 Cernan: ...and I know you do, too.

119:31:28 Schmitt: Okay, Bob, the arrow (on the LMS) is east/west, pointing west. The bubble is in the center. (Pause)

[Gene has the stem partially threaded; however, as he lifts the drill by the stem, it falls off. The threads make a complete circle of the stem in about a half inch of rise and, in a shirtsleeve environment, the stem sections are very easy to join.]

119:31:41 Schmitt: If I'm lucky, it'll stay there. (Pause) I'm more like east-northeast. I'm trying to keep a little further away from Gene.

[The stem finally seats properly.]

119:31:56 Parker: Okay. Copy that.

119:32:00 Schmitt: Break seal is Open.

[The Lunar Mass Spectrometer is also known as the Lunar Atmosphere Composition Experiment (LACE). In operation, any gas molecules entering the device will be bombarded and ionized by electrons given off by an internal source. Ions of different species are then separated magnetically and

counted. During deployment, the entrance port is covered by a nylon dust screen which will be pulled back - by radio command - only after the crew has left the Moon and the seismic charges have been detonated.]

[Schmitt - "This was probably a safety seal that held down the cover on the port. I had to remove it so that, when they later sent the Open signal, the screen would come off. You'll notice that I've moved well away from the LMS by this point. Often we did that - wait to brief them on something that had already happened - because it wasn't convenient to break in."]

119:32:05 Cernan: Okay, that was my mark (on the ground). Let me see. Double check that cable length. I'd sure hate to drill a hole that was outside of the length of the cable.
 119:32:22 Schmitt: Okay, Bob, the LMS is deployed. I'm policing the site. The screen is over the port.
 119:32:33 Parker: Copy that.

[Gene uses the drill stem to straighten the cable. He then plants the drill, and then removes and discards a protective cover.]

119:32:34 Schmitt: I'm going to move one big rock. (Pause) What am I doing down in here?

[Schmitt - "I may have been in a deeper depression than I had expected, although the pictures certainly don't show anything dramatic."]

119:32:49 Cernan: What were you doing down in there? (They both laugh)

[Gene leans forward and starts to drill. The stem is sufficiently angled that people in Houston are concerned about loads Gene may be putting on it.]

119:32:55 Schmitt: And Bob, there's a little bit of dust adhering to the sides of the LMS. And a few particles (covering), oh, less than half a percent of the surface on the top. But, of course, you're going to clean that one off (by removing the screen); so that's all right.

119:33:17 Parker: That's affirm on the top.

119:33:20 Schmitt: The north side has about a 10- or 15-percent dust cover(ing).

119:33:30 Parker: Copy that. And, Geno, you're leaning pretty heavy forward on that drill.

119:33:37 Cernan: Okay, Bob. She's going in like she's in some pretty dense stuff, and then I hit some rock here. I'll watch it; I won't lean forward. I'm not putting too much pressure on it.

119:33:53 Parker: Okay.

[Cernan - "Because of the weight of the PLSS, you had a tendency to lean forward and put a little torque or bending motion on the drill stem. The worry was having it bind up as a result.]

[Schmitt - "There may also have been some consideration of optimizing power usage. The motor would have been more efficient at medium power levels than at higher power levels."]

119:33:54 Cernan: It sounds to me like she's chipping away through rock. (Pause) May be just a little-longer-drilling hole than it was at the Cape. (Long Pause)

[Gene stops drilling to give his hands a short rest. In order to grip the drill handle - which also serves as the on/off switch - Gene is having to squeeze his fingers closed against the pressure of the suit and that is very tiring. The top of the stem is at about knee height. He starts drilling again. Meanwhile, now that he has removed all of the experiment modules, Jack has begun to do a final leveling and alignment of the Central Station. This will prove to be a time-consuming task. He is at the bottom of LMP-18.]

119:35:11 Cernan: Bob, she's going in; but not without a little bit of resistance.

[The vibration of the drill produces a good deal of suit vibration and, thereby, a noise audible to listeners on Earth. Gene is wearing a Snoopy helmet which covers his ears and deadens any sounds except those coming through his earpiece.]

[Cernan - "Thinking about when I said 'it sounds like she's chipping away', you have to remember that sound and feel are very closely related, just like in the lift off of the Saturn V. Do you "hear" the noise or do you "feel" the noise? In this particular case the "noise" or the vibration traveled from my hands up into my suit. So was I hearing it or was I feeling it. Probably feeling it; but sound and feel are very closely related when you're in an environment like that."]

119:35:17 Parker: Roger. We're observing that, Geno.

119:35:19 Cernan: Every once in a while she breaks through a soft spot.

119:35:25 Parker: Good. (Long Pause)

[Gene stops for a moment, releasing his grip, then drills a final few inches before going to the rack for the wrench. Jack is in the background, still trying to level the Central Station.]

[Schmitt - "In drilling those holes, it was nice that fifty percent of the regolith is particles smaller than 100 microns. The chances of hitting a large rock were pretty small, in spite of what you see scattered around on the

surface. Because you're looking across the surface at a very low angle, you get a distorted view of how many rocks there are."]

119:35:45 Schmitt: Bob, I'll tell you, this Central Station's a bear - a bear - to get level. (Pause) Well, I just got dust on it now. (Pause) It (the ground)'s just too soft.

[The process of getting the equipment level is a matter of finding a level position on the uneven ground, rather than smoothing and leveling the surface itself. The soil can be pushed out of the way or piled up with a boot, although care must be taken not to get any dust on thermally-sensitive surfaces. Here, Jack is leveling the base of the Central Station, prior to raising the top and the attached thermal curtains. Meanwhile, Gene leans over the stem rack to get the wrench but gets his center-of-mass too far forward and stumbles. Once he has the wrench in hand, he goes to the drill, does a deep knee bend without quite kneeling and attaches the wrench to the stem with his left hand. He rises and uses his left foot to brace the wrench while he turns the drill counterclockwise to release it.]

119:36:39 Cernan: Boy, that sure was drilling in hard stuff because it took a lot to get it (the drill) off (the stem). (Pause)

[Gene takes the drill by the loop handle and sets it on the ground.]

119:36:56 Parker: Okay, Jack. And we could certainly stand (tolerate) a little bit of dust, at least, on top of that Central Station sunshield.

119:37:05 Schmitt: Yeah, I guess the level's important.

119:37:08 Parker: Roger.

[Schmitt - "By leveling the Central Station and getting it aligned relative to the Sun, I could then use pre-determined coordinates for pointing the antenna."]

[The pre-determined antenna settings are printed on cuff checklist page LMP-20. Meanwhile, Gene does another deep knee bend to try to remove the wrench but can't get a solid grip and lurches forward. On his second attempt, he goes down quickly, swipes at the wrench and manages to get it off before lurching forward again.]

119:37:14 Cernan: I can just see what John (Young)'s thinking right now. That's what makes the difference. That's where you expend your energy. (Pause)

[Cernan - "We knew they were watching a lot of things on the television, so when we made a statement, we didn't necessarily make a complete statement because we knew they're

looking at what we're talking about. In this case, I was talking about the difficulty of getting the wrench off."]

[Gene gets a two-foot drill stem out of the quiver.]

119:37:32 Schmitt: Bob, I don't know that I'm going to be able to do that without a lot of time. It (the level bubble)'s hanging against the south edge.

119:37:44 Parker: Say again there, Jack.

119:37:48 Schmitt: I don't know whether I'm going to be able to level the Central Station. (Pause)

119:38:02 Cernan: (Without looking) Anything I can do, Jack? (Pause)

[Gene threads the second stem into the one in the ground. Behind him, Jack tries to free the bubble by jerking the Central Station to one side or the other every few seconds.]

119:38:10 Schmitt: Okay. I got it off the edge.

[Gene picks up the drill and hits it with his hand to knock some dust off.]

119:38:13 Parker: Okay; maybe we better just leave it there. (Pause)

119:38:27 Schmitt: Ahh! Well, I'm making it worse by getting dust on the top.

119:38:35 Parker: No, the dust on the top is not as important as getting it leveled, Jack. But if you get it (the bubble) broken off the edge, that ought to be good enough. (Long Pause)

[Gene attaches the drill and looks at the pressure gage on his wrist.]

119:39:02 Cernan: Bob, I'm riding at about 3.82 (psi suit pressure).

[Gene uses his hand to shade the gages on the top of his RCU.]

119:39:05 Cernan: I've got, oh, I guess about 80...Well, no; (counting gage marks) there's half. I guess, 60 percent (oxygen); no flags and no tones.

119:39:16 Parker: Okay. Copy that, Geno. (Pause)

[Gene starts drilling; the vibration knocks a lot of dust off the drill. Gene is breathing heavily and, according to the plotted record of his heart rate (about 117:00 on the graph), he is at 130 beats, per minute, climbing toward a peak of 145 beats per minutes, which he will reach in about 15 minute, about the time he finishes emplacing the first heat-flow probe and starts the second hole.]

119:39:24 Schmitt: Okay, Bob. It's touching the second ring; the gnomon is aligned, and I'm going to leave it alone.

[That is, a gnomon shadow is falling on a mark etched or painted on the top.]

119:39:29 Parker: Roger on that.

119:39:35 Schmitt: Yeah, I think I lost all the time I might have made up.

[The drill sharply twists Gene's hands by a couple of inches.]

119:39:39 Cernan: Hey, Bob, it's obvious that I'm going through some pretty tough stuff - (through) consolidated material, like rock fragments - and then it breaks through; and then it jumps for about 3 or 4 inches and then I hit some more fragments.

119:39:53 Parker: Roger. We're seeing that Geno. Looks interesting. (Pause)

[Gene stops and looks down to see how far he's gone into the ground.]

119:40:09 Cernan: Oh, me. I got too low on that one. I thought I had that gaged. (Pause)

[Ideally, he would have left about a foot of stem sticking out of the ground, but he has left himself only 3 or 4 inches. He gets the wrench from the rack and looks over at Jack.]

119:40:23 Cernan: (When) you deploy that (No. 4) geophone, you'll go out of sight. (Long Pause)

[Gene holds onto the drill for leverage as he bends his knees to attach the wrench.]

119:41:17 Cernan: Bob, there would be absolutely no way of breaking this drill from those bores without that tool, I guarantee you that.

119:41:27 Parker: Okay. We copy that, Geno. (Pause)

[Gene twists the drill off the stem and puts it on the ground next to the stem. Now he leans forward on the drill, without bending his knees, so that he can get the wrench off. This procedure works well and he easily pushes himself upright without stumbling.]

119:41:40 Cernan: I think I found a way to get this off, though, with a little help. Okay, number 3 coming up.

119:41:47 Parker: Roger. The third and last one on this hole.

[Jack is still trying to fine tune the Central Station alignment and leveling.]

119:41:51 Cernan: Yes, sir. (Pause) Oh, boy! Time out.
 119:42:02 Parker: Okay.
 119:42:06 Schmitt: Don't work too hard.

[Gene stands motionless next to the drill rack, his arms out in front of him in the rest position, knees slightly bent.]

119:42:07 Parker: Roger.
 119:42:11 Cernan: My fender's still on; which makes me happy. (Pause; then he starts working again)
 119:42:22 Cernan: I'll tell you, if you could come and sprinkle the whole area with water and get rid of some of this dust...
 119:42:29 Parker: Okay, Geno. And can you remember if those heat flow cables are not crossed as they come out of that box?

[Crossed cables might interfere with each other electrically.]

119:42:35 Cernan: Yes, sir. I very definitely made a point of not crossing them.
 119:42:39 Parker: Okay; very good.
 119:42:45 Cernan: They are not crossed.
 119:42:48 Parker: Good. (Long Pause)
 119:43:06 Schmitt: (Laughs; then assumes an oratorical tone) Oh, ho, ho, ho. "Where do we find such men?"

[Jack is referring to his prowess in leveling the Central Station. Gene starts drilling again.]

119:43:11 Cernan: How's it coming, Jack?
 119:43:13 Schmitt: Oh, slow. This leveling is really throwing me behind the power curve; but I know they're serious about it, so, if I can keep it where it is now, I'm in like Flynn. It's perfectly centered. Even the gnomon is aligned within a shadow width. (Pause)
 119:43:46 Cernan: Man, is that thing biting.
 119:43:50 Schmitt: Really working down there, are you?
 119:43:52 Cernan: Oh, you betcha, man. I'm in something tough down there now. Whew!

[Cernan - "It was tough drilling. You had to hold the drill to keep it from turning in your hands and you had to put pressure on it. As I remember, it was during the drilling that I got heart rates up to 120 or 130. It was hard work, and that's why I had to rest every once in a while. You can hear how hard a job it was in the sound of my voice."]

119:43:56 Schmitt: Well, what bore are you in?

[Gene stops for a minute. He's been leaning over the drill and straightens up to rest. His heart rate is over 130 beats per minute. In comparison, Jack's heart rate is the 90-110 range throughout the deployment.]

119:43:59 Cernan: Number 3. If I let go of that drill, and it kept running...If that drill kept running and I wasn't anchored to the ground, (he chuckles) it would throw me over the Massif. In tangential turns. (Pause)

[Cernan - "If you hold a drill, the motor turns the drill stem and the bit. But if the bit gets hung up, and you let go of the drill, the motor spins the drill. It was very difficult to keep the drill from rotating; you really had to work at it. Here on Earth, in your back yard or in your garage, you've at least got full Earth gravity holding you down; but on the Moon, even with the weight of the PLSS you weigh a lot less and it's harder to hold onto the drill when it binds."]

[Gene starts drilling again. Meanwhile, Jack is probably releasing Boyd bolts holding down the Central Station Antenna. He will not mount the antenna until after he has raised the top of the Central Station and, with it, the thermal curtain which shades the east, west and south sides. He is on LMP-19.]

119:44:27 Parker: Okay, Geno...

119:44:28 Cernan: I think I'm in the mother lode down there.

[Gene stops and gets the wrench.]

119:44:30 Parker: Gene, if its getting really tough and you're not making much progress, we'll be happy with it where it is. (Pause) Well, it looks like you really...

119:44:37 Cernan: No, sir, you're going to be happy with it where it's supposed to be; and that's where it's...

119:44:41 Parker: You were hiding it from us...

119:44:42 Cernan: Yes, sir.

[Gene has been standing southwest of the Rover with his back to the camera and the drill in front of him.]

119:44:43 Parker: We couldn't tell how deep in you were.

119:44:46 Cernan: I wanted to surprise you. They're going in all the way, and they're both going to work. (Pause)
Gets a little tough looking into the Sun.

[Gene turns away from the Sun and, without quite kneeling, attaches the wrench.]

119:44:58 Schmitt: Yeah. (Pause)

[Gene tries to turn the drill but it takes quite a bit of force before it suddenly releases.]

119:45:10 Cernan: Oh, Manischewitz! (Putting the drill on the ground) I don't know where I picked that word up)Jack chuckles), but it's better than some (pause), I guess. Now if I can use my little lean-tool here. (Pause)

[He leans on the drill to remove the wrench. The B. Manischewitz Company has long been a major American producer of kosher foods and, at least during the 1950's and into the 60's, heavily advertised its wines with the phrase "Man, oh, Manischewitz. What a wine." Here, Gene is using "Manischewitz" instead of cursing.]

119:45:40 Cernan: Oh, man, that works great! That works great. Put this out of the way. (Pause; putting the drill about ten feet north) Bob, I'm into the white marks; it depends on what you want to call the surface. You know, give or take 6 or 8 inches. (Pause)

[Gene tamps dirt around the stem with his boot, then hangs the wrench on the rack.]

119:46:11 Parker: Yeah, something like that will do, Gene, I guess. We can measure it (garbled, but means "from the photos").

119:46:15 Schmitt: Gene, is the stuff (the drill cuttings) coming up changing color on you at all?

119:46:20 Cernan: No, Jack. It isn't changing color. I can't even tell where it's coming up.

119:46:30 Schmitt: (Laughing as the top of the Central Station springs up; Gene turns to look) Ho ho. Ho ho.

119:46:31 Cernan: (Looking back at his work) I don't think it (the cuttings) is coming up. I think I'm just pushing it aside.

119:46:34 Schmitt: Boy, I'll tell you...

119:46:35 Parker: I saw something come up then just then, Jack.

119:46:36 Schmitt: ...the old ALSEP central station. Yeah, it deploys itself; it turns out.

[Checklist page LMP-19 contains the phrase "guide C/S up" which suggests that, in training, the Central Station raised itself in a reluctant manner. Here, it sprang up to full height without any hesitation. Photo AS17-134-20491 shows raised Central Station from the east. Jack has not yet attached the antenna and gimbals. Note the attachment points on the top where the various experiment modules were mounted. The LSG is in the background at the right. AS17-147-22586 show the Central Station from the North. Notice how the south edge of the bottom seems to be thrust into the soil. This is an indication of the lengths to which Jack had to go

to get it leveled. The trash pile is at the left edge of the photo. The geophone module is between the Central Station and Geophone Rock; and Bear Mountain is the dark dome beyond and slightly to the left of Geophone Rock. The South Massif emerges from the center of the southern horizon and rises toward the west.]

119:46:43 Parker: Roger on that. That was...
 119:46:44 Schmitt: Bob...
 119:46:45 Parker: ...pretty amazing.
 119:46:50 Schmitt: Okay. I finally leveled it in the bull's eye. I don't know whether you heard me or not, but it was perfect. So it's okay. It's got about 20-percent dust cover on the top.
 119:47:08 Parker: Okay. (Pause)

[Gene has picked up the heat flow probe and removes it from its protective bag. The bag has kept the probe clean, despite the amount of dust that Gene has kicked around while drilling the hole.]

119:47:13 Cernan: Sure glad you've got that probe covered.
 119:47:19 Parker: And, Jack, ALSEP says that that's okay; that twenty percent's no problem.

[Fendell starts to pan away from Gene; Experiments tells Flight they'd like to continue watching the heat-flow deployment.]

119:47:29 Schmitt: Okay. (Pause) I put a rock under the northwest corner. Oops. Guess what happened? (Laughs) Just like in training, Geno.
 119:47:46 Cernan: What happened?
 119:47:47 Schmitt: The old geophone cable caught on the corner. (Pause) Okay. Oops, I'm not ready.
 119:48:00 Cernan: (To himself) That says F4B on that; that's an airplane! (Long Pause; he discards something) Houston, there's no dust on the (heat flow) probe except that which was on my hands.

[Gene goes to the heat-flow hole he just drilled. Jack's next task, on the bottom of LMP-19, is to secure the thermal curtains that cover the east, west, and south faces. They are secured with patches of Velcro.]

119:48:30 Parker: Okay. Copy that.
 119:48:36 Cernan: That must be solar wind. (Pause)
 119:48:45 Schmitt: Sorry not to be more talkative, but this is taking all the concentration I got.
 119:48:57 Cernan: I'm going to have to push this down, I can see that.

[Gene has trouble getting the tip of the probe to go into the drill stem. After maneuvering it like a fishing

line for a while, he finally does two quick knee bends so that he can push the probe in with his hand.]

119:49:04 Schmitt: You know, this Velcro doesn't hold any better here than it did in training.

[Schmitt - "The four corners of the thermal curtain were sealed with Velcro, and it never worked very well. Because of the Apollo fire, we had to have Teflon Velcro; and that just isn't very good Velcro."]

119:49:12 Cernan: (Talking to himself as he reaches for something on the rack) Oh, don't lose that, Geno. Don't lose that. Don't lose that. Notice how you talk to yourself out here?

119:49:21 Schmitt: (Chuckling) Who, me? (Pause) "Help", I says. "You is getting farther and farther behind."

[Gene does a discus throw of a bag or box from which he has just removed a rammer. He almost spins out of control and almost falls.]

119:49:37 Cernan: Well, I've had my "whoops" for today.

119:49:41 Schmitt: Your one what?

119:49:42 Cernan: Well, I just did my "whifferdill."

119:49:46 Schmitt: Oh, did you fall?

119:49:47 Cernan: No. It's funny how for every action there's an equal and opposite reaction, isn't it?

[Gene telescopes the rammer from an 18-inch length to about four feet.]

119:50:00 Schmitt: Hey, I've heard that before. Okay. (Reading) "Secure thermal curtains". Thermal curtains are secured.

119:50:10 Parker: Okay. Copy that.

119:50:15 Schmitt: How far behind am I, Bob?

119:50:18 Parker: Stand by. (Pause) Roger. We're showing Gene just about 20 minutes; and Jack just about 25. Between 20 and 25 (minutes) for both of you.

119:50:39 Schmitt: Okay. (Pause) How are our consumables?

119:50:48 Parker: Stand by. (Pause)

[Jack is concerned that they won't have much time to devote to geology. His next task, on LMP-20, is to release the Central Station antenna gimbal assembly from the LEAM pallet and then mount it and the antenna on the Central Station. Meanwhile, Gene is having trouble getting the tip of the rammer in the hole. It seems to have a cable slot.]

119:51:00 Cernan: Oh, if this thing isn't going to work better than that! (Long Pause)

[Gene gets the rammer in the stem.]

119:51:32 Cernan: Bob, just like the book says, it's down to Papa 1; and it hooked.

119:51:36 Parker: How about that. (Long Pause)

[Papa 1 is a mark on the heat flow cable indicating how far the cable has gone into the drill stem. The bottom heat flow drill stem has a closed drill bit so that the stems would remain clear for insertion of the probes. The heat flow probe contains multiple sensors and Gene is emplacing thermal shields between them. He is in the bottom paragraph on CDR-18. Meanwhile, Jack polices the trash pile, moving outlining items onto the main part of the pile, and then returns to the Central Station.]

119:51:54 Cernan: Oh, boy! The old fingers really suffer on these.

119:52:00 Schmitt: Take it easy.

[Cernan - "I remember that, at the end of the day, my fingers and forearms were very tired. You were always moving your fingers against the pressure in the gloves."]

[Gene removes the rammer from the hole, reattaches it to the cable at a higher position, and pushes it down the hole again. The cable has a number of sensors attached to it.]

119:52:02 Cernan: Okay. Now this one down to F1. Would you believe (it's down to) F1?

119:52:12 Parker: I believe you, Gene. (Pause)

119:52:31 Cernan: Bob, in this soil, best number I can give you is about an inch below the white spots, or Bravo 1.

[Here, Gene is probably telling Houston how far the top drill stem is in the ground. Fendell pans the TV, finds Jack, and zooms in.]

119:52:39 Parker: Okay. Copy Bravo 1. (Pause)

119:52:46 Cernan: I got a better way of putting that last thermal shield on, though. (Long Pause)

119:53:35 Cernan: Okay, Bob, you're looking at it coming out to the south, but I don't expect it'll stay that way unless I put some dirt over the cable. How's that grab you?

119:53:49 Parker: Stand by, Gene.

[The last thermal shield minimizes the amount of heat the cable carries into the hole. It is visible in AS17-134-20497. Note how Gene has positioned the cable so that it extends south from the hole for a foot or so before turning west toward the electronics package. The heat flow cables have retained some loops and waves from the days of storage in the LM. In the weak lunar gravity field, this "memory" is retained longer than it would on Earth. On Apollo 16, John Young caught a foot under a heat-flow cable near the Central

Station and tore it loose. Here, Gene wants to cover the cable with some dirt to hold it down.]

119:53:54 Cernan: You like that thermal shield the way it is? Okay. That's coming out south. That's in good shape. I'm pleased with that.

119:54:03 Parker: Dirt's okay, if you want to put it on there, Gene.

119:54:04 Cernan: I'll tell you, I'm happy with it. I'm moving on.

119:54:05 Parker: Okay.

1189:54:09 Cernan: Now, the thermal shield is on there, Bob. I got them all on there.

[Fendell returns to Gene as he picks up the stem quiver and, in the process, knocks the wrench off the rack. He retrieves it relatively easily with the rammer.]

119:54:12 Parker: If you want to put some dirt on there to hold it down, that's okay.

119:54:18 Cernan: Oh, okay. Well, I got it down without the dirt.

119:54:21 Parker: Okay. Good enough.

119:54:23 Cernan: I'm just finding all sorts of good ways to make life easier out here. (Pause)

[Gene picks up the rack and moves west and a little north.]

119:54:32 Cernan: (To himself) Stay away from the cables. (To Parker) Bob, and I didn't forget the last measurement either.

119:54:40 Parker: Roger that.

[Cernan - "One thing I ought to mention here, in case I forget it, is that on the first day you never felt any heat soak into your gloves. But I remember that on the third day you could feel the heat soaking in. That's because the Sun was 26 degrees higher than it was on the first day. You couldn't feel it on your body because you had the liquid-cooled garment; but your hands had no liquid cooling on them and, also, your hands were sitting out in the sunshine a lot of the time."]

119:54:46 Cernan: Hey, can you see this big mound that's just... (correcting himself) not a mound but the depression that's just to the north of me?

119:54:53 Parker: Roger, 17; Houston sees it.

119:54:55 Cernan: It's probably behind the Rover.

(Listens) Okay. Well, how's that look for the core?

[Gene puts the drilling gear down.]

119:55:06 Parker: Stand by. (Long Pause) Geno, can you give us a distance estimate to that? Does it look like it's 80 feet or so (from the RTG)?

119:55:28 Cernan: Yeah.

119:55:29 Parker: Okay. Then that sounds good.

[After Gene drills and extracts the deep core, he will emplace the neutron flux experiment in the resulting hole. The experiment is designed to measure background levels of neutrons produced by the natural radioactivity of the soil and by cosmic rays. Gene needs to be at least 80 feet from the RTG so that the neutrons it emits will not overwhelm the "natural" signal.]

119:55:31 Cernan: Oh, shucks!

[Gene has dropped the wrench again; he retrieves it with the rammer.]

119:55:35 Schmitt: Hey, Bob, is there any way a level bubble can fail? (Gene laughs)

[Jack is referring to one of two level bubbles on the set of Central Station antenna gimbals.]

119:55:41 Parker: Hey, Jack, remember that's on top of those wobbly springs there. And with the thing not being straight, you shouldn't really expect the level bubble to be level after the thing's been deployed. That happened at the Cape a couple of times, remember?

[Parker thinks that Jack is talking about the level bubble on the top of the Central Station, the one that Jack was using before he raised the top and curtains. In fact, he is referring to another level bubble, on the antenna/gimbal assembly. Meanwhile, Gene goes to retrieve the drill from the first heat-flow hole.]

119:55:56 Schmitt: Yeah; but Bob, I've moved this practically all the way down the full throw and that bubble won't move, and I can't get it to move by tilting it; and I was leveled. And the bubble on the top of the Central Station is still level.

[Gene has the drill in hand.]

119:56:11 Parker: Okay. You're talking about the level on your other one, huh? Stand by on that.

119:56:16 Schmitt: The gnomon, yeah...Both of them? (Pause) I can't get it to move to the other side of the fluid.

[Gene is back at the second heat flow hole.]

119:56:28 Cernan: Keep working. That thing shouldn't fail.
(Pause)

[Gene threads a long section of drill stem into the drill chuck.]

119:56:39 Schmitt: Well, I've gone full throw. That's not level. That bubble's stuck in there, somehow. In both of them. That's not even pointing close to the Earth. Okay, I'm going to have to tweak it up...Let them see the signal strength and tweak it.

[Gene picks up the drill.]

119:57:00 Parker: Okay. Why don't you try and manually point it; try and level it and see what you can do toward getting it (pointed) towards the Earth.

119:57:09 Schmitt: I will, Bob. That bubble's just not working. I can't figure that one out.

[Cernan - "With the station not level, you would just try to get the antenna pointed more or less in the right direction and see if you had an acceptable signal strength."]

[Gene has to get on tiptoes, his hands above the top of his helmet, to get the stem vertical. He starts drilling.]

119:57:14 Parker: Okay. Just go ahead and use the...

119:57:15 Schmitt: Okay. Maybe I jarred it loose here.

119:57:18 Parker: Okay.

119:57:20 Schmitt: I think I jarred it loose.

119:57:22 Parker: That's another first.

119:57:25 Schmitt: Don't ask me how.

119:57:26 Parker: Okay, we won't. (Long Pause)

119:57:44 Schmitt: Okay. And I got the other one loose. That's very strange! A sticky level bubble. (Laughing)
Never heard of it.

[Schmitt - "Whatever fluid they used evidently had surface tension in excess of the 1/6 g buoyant forces that was trying to move the bubble to the center, at least when the bubble was over at the edge. It took a jarring motion of some sort to break that surface tension."]

[Unfortunately, we have been unable to identify the fluid in the bubble level. Gene stops drilling and looks at the TV camera.]

119:57:54 Cernan: Hey, Bob...

119:57:55 Parker: Go ahead, Jack...(correcting himself)
Gene.

[Gene gestures with his left hand, pointing north.]

119:57:56 Cernan: ...If you're looking at me, what I'm talking about is this depression in here for the core. Oh,

maybe 15, 20 meters out in here. Jack, what did you have in mind for the neutron flux?

119:58:09 Schmitt: Either the one you're down in, there; or next one over behind that rock in front of you over there.

119:58:15 Cernan: Oh yeah, I can go way over there.

(Grasping the drill) That's not too far probably for...

119:58:18 Schmitt: Well, either way I think is fine, Gene. But I would suggest behind the rock.

119:58:22 Cernan: For a neutron flux, huh?

[By putting the detector in a depression and behind a rock, Gene will reduce the contaminating neutron flux from the RTG's plutonium source. Photo AS17-147-22575 is one Jack will take after Gene has finished drilling the deep core hole. The picture is taken looking to the northeast and shows Gene at the Rover, with the east heat-flow hole between the Rover and the place where Jack is standing. The rock in question is beyond the Rover to the left and the drill stem rack is just visible over the top of the rock. The RTG is behind Jack and this picture shows that the rock is providing shielding. AS17-134-20503 was taken from just north of the core hole and shows the treadle-and-jack that Gene will use to extract the core. The shielding rock is in the middle distance and, beyond it, we can see the Central Station. The dark object to the left of the Central Station is the RTG. Geophone Rock is beyond the RTG.]

119:58:23 Schmitt: Yes, sir; and the core.

[Schmitt - "In analyzing cores, people had look for and found radioisotopes which had been formed by the absorption of cosmic-ray neutrons in the lunar soil. If you knew the neutron flux and spectrum, you could use the abundance of these isotopes to determine ages and turnover rates for the soil. There had been estimates made of the neutron flux and, and there were also a lot of arguments about the estimates. This experiment was designed to give a direct measurement."]

119:58:25 Cernan: Well, I thought they wanted a core in that depression.

119:58:28 Schmitt: Well, there's also one over there.

119:58:34 Parker: Okay, and 17...

119:58:35 Schmitt: We can give them a choice.

119:58:36 Cernan: I'll go behind that rock; that looks good from here.

119:58:38 Parker: And, 17, we think you guys are in by far the best position to judge that; far better than we are. You know what the requirements are on shielding and...

119:58:45 Cernan: Okay.

[Gene stops drilling, looks at his watch on his left wrist, and then resumes.]

119:58:46 Parker: ... (you know that the distance from the RTG needs to be) greater than 50 meters... (Correcting himself) 25 meters.

119:58:54 Cernan: Okay, Bob. (Pause)

[Gene completes the drilling and reaches for the wrench.]

[Schmitt - "I suspect that we had practiced this specific ALSEP deployment a half dozen times. I had done the Apollo 15 deployment a few times as part of the Back-up Crew training; and Gene had done the Apollo 14 deployment. You didn't want to train for it too much, because each situation was going to be different. You needed to know it just well enough to be able to adaptable, and a half dozen times seemed about right."]

119:59:07 Cernan: Okay. The long bore is in.

119:59:09 Parker: Okay. Copy that, Gene. Looked like that one went in fairly well.

[Gene opens the wrench.]

119:59:14 Cernan: Well, probably about like the other one did. Not too bad.

119:59:18 Parker: Okay.

[Gene leans on the drill to attach the wrench.]

119:59:21 Cernan: Oh, I must be getting old. I expect the next two are going to be a little harder. (Pause)

[Gene has the drill off.]

119:59:31 Schmitt: Bob, I'm not very happy with this (antenna) level. But I'll turn it on. Have me come back a little bit later, when they've warmed up some more, and let's see what it looks like.

[Schmitt - "The fluid surrounding the level bubbles was probably an oil that wouldn't freeze when it got cold in the LM Equipment Bay. We'd been in the barbecue mode on the way out, rotating the spacecraft to get uniform heating, but there wasn't any active heating in the Equipment Bay and it would have gotten pretty cold. I was probably thinking that the fluid was still a little viscous from having been cold. Maybe that was why the bubble stuck."]

[Gene takes some care in positioning the drill so that he can lean on it in removing the wrench. He learned a great deal from drilling the first hole and does this second hole much more efficiently.]

119:59:45 Parker: Okay. We'll do that. Give me a mark when you turn it on, and we'll see what kind of signals we get.

119:59:53 Schmitt: Okay. The gnomon (shadow) is aligned;
I'm going to turn the shorting plug on.
119:59:57 Parker: Copy that. (Pause)

[By turning the shorting plug "on", Jack is letting current flow from the RTG into the Central Station - rather than through the shorting plug itself. Jack notes that the phrase "turning the shorting plug on" is a misnomer.]

120:00:05 Schmitt: It's On.

[Gene has the wrench off.]

120:00:06 Parker: Roger.
120:00:11 Schmitt: And the needle is full scale left.
120:00:18 Parker: Copy that. (Long Pause)

["Full-scale left" usually means "off", and the needle is undoubtedly indicating that there is no current flowing through the shorting plug and, implicitly, that the current is now flowing into the Central Station. Gene has the second stem out of the rack and is bracing the one in the ground with his right foot, toes up and on the stem, heel down and on the ground. Next, he giggles and twists the stem with his right hand.]

120:01:21 Cernan: I can't believe that.
120:01:24 Schmitt: What's the problem?
120:01:25 Cernan: Well, that whole bore turns in the ground, it's so loose. You know how those threads sometimes stick on you a little bit. (Getting the wrench again) I got one stuck halfway down and the whole bore is turning, so now I've got to use a wrench on it.

[Gene needs the wrench to hold the first stem still while he threads the second into it. He leans on the drill to attach the wrench.]

120:01:43 Parker: Okay, Jack. And we have...
120:01:44 Schmitt: Bob, I've got a rock about 10 feet southeast of my LEAM location. I can move a little more north and get, oh, 15 feet from that. That okay?
120:02:08 Parker: How big is the rock there, Jack?
120:02:13 Schmitt: Oh, it stands...It's a meter wide and stands about a third of a meter high.

[This is the rock beyond the garbage pile in AS17-147-22584. The RTG is in the foreground on the left side of the picture. Notice the deep shadows on the west face of the East Massif on the far horizon. Geophone Rock is at the right edge of the picture and the geophone module is in front of it. The large rock beyond and to the right of the LEAM is one that Jack will examine at 120:22:42, after deploying the

east geophone. Details of the LEAM deployment can be found on LMP-21.]

120:02:19 Parker: About a third...about a foot high?
120:02:21 Cernan: Bob, how's that for...(Listens)
120:02:25 Schmitt: (Lecturing tone) A third of a meter.
120:02:28 Parker: Okay.

[The Lunar Ejecta and Meteoroid Experiment is designed to catch and count both small meteoroids and ejecta from lunar impacts. Ejecta from small, local impacts would tend to have rather flat trajectories and a nearby rock would "shadow" ejecta from beyond it. Jack wants to emplace the experiment far enough from the rock that it's shadow will be unimportant. AS17-134-20500 is a good picture of the LEAM with the trash pile, the Central Station, and the LSG beyond it. The RTG is to the right of the Central Station and the white box beyond the RTC is the Heat Flow electronics package.]

Gene has been trying to brace the stem with his foot and with the wrench; he finds that he can lift the stem out of the ground.]

120:02:30 Cernan: Bob, how's that for soil mechanics? I pulled the first bore right on out trying to get this thing on right.

[Fendell pans away from Gene, looking for Jack, who is southeast of the Central Station deploying the LEAM and apparently releasing the stool legs.]

120:02:36 Parker: Well, put it in before your hole fills up there, Geno.

120:02:42 Cernan: Yeah. Right now I'm interested in getting this second bore on. (Pause) Now, let's see if I can get it back in! (Pause) Well, not quite as far, but high enough for me to reach the (drill handle). It still feels, Bob, like there's a lot of fragmental material down there.

120:03:12 Parker: I copy that, Geno. Good luck.

120:03:14 Cernan: That was an interesting little exercise. Well, I got the bore on right, anyway. (Pause)

120:03:25 Schmitt: Well, shoot. (Pause)

120:03:39 Parker: Okay, Jack. As long as it's only 1 foot high and 10 feet away, that's satisfactory.

120:03:48 Schmitt: Okay. (Long Pause)

[Jack sets the LEAM on the surface and rocks it with the attached UHT to find a level position.]

120:04:49 Schmitt: Okay, Bob, the LEAM's deployed, aligned, and the level bubble is just touching the inner ring.

120:05:03 Parker: Copy that.

[Having removed the UHT, Jack kicks the ribbon cable, perhaps to remove some dirt.]

120:05:08 Cernan: (Wanting to know if Houston is getting data from the Central Station) Hey, Bob. Did you get anything from the ALSEP yet?

120:05:10 Parker: Watch that cable, Jack. (To Gene) Roger. We started to tell you that when you had the question there, and we're getting a good lockup on the data.

120:05:18 Schmitt: Well, keep an eye on it (that is, on the signal from the Central Station, because I'm not happy with the level.

[Jack is near the RTG and moves the LEAM cable a little with the UHT.]

120:05:22 Parker: Okay. We'll get back with you on that.

120:05:24 Schmitt: I'll check. Make me check it. (Pause) I found a way to get over cables. (He makes a little jumping noise as he kangaroo-hops over the cable) Bee-doop! (Laughs) (Pause)

[Jack uses the UHT to pick up the heat-flow pallet for use as a base for the seismic array antenna.]

120:06:01 Cernan: Oh, Manischewitz. Whew!

120:06:05 Schmitt: There you go again.

120:06:06 Cernan: I know. Let me get this one off and take a bite of candy here.

[The pallet falls off of Jack's UHT. Apparently, the UHT locking pins had not seated properly in the receptacle on the pallet.]

120:06:15 Schmitt: I'm kind of having trouble with UHT's today. They just don't want to lock in when you get dust in there.

[Schmitt - "Anything that is not hermetically sealed is just not going to work very long."]

120:06:23 Cernan: Hey, Jack. Be careful with that UHT on the heat flow because it was aligned, real good.

120:06:29 Schmitt: It was what?

120:06:30 Cernan: The heat flow electronics, when you go over there for that UHT, was aligned.

120:06:35 Schmitt: Oh, yeah.

[Schmitt - "There were two UHT's. Gene had used his to carry the heat flow electronics box and align it; and then just left the UHT in the heat-flow box. So he's warning me not to disturb the alignment when I go to get his UHT later on."]

[After spending a short while trying to engage the UHT pins, Jack gives up on what we might call the hi-tech end of the tool, turns the UHT end for end, and hooks the handle - which we can call the lo-tech end - under a strap or handle and lifts the heat-flow pallet off the ground.]

120:06:38 Cernan: Bob, I'm going to take a zap of cold (cooling) water.
 120:06:40 Parker: Okay. Sounds good to me.
 120:06:46 Cernan: Whee! Almost looks like it's getting dark out. Is it? Guess not.
 120:06:55 Schmitt: (Laughing and doing an Amos and Andy impression) Hope not, or "we is in trouble".

[Cernan - "When you stop working and take a rest, you have a chance to look around. Earlier, when I was taking a rest from drilling the first heat flow hole, I had a chance to get ahead and talk to the ground about a place for the core hole, which I wasn't going to do for a long time yet. When you took a rest, that was the only chance you had just look around; otherwise, you got so involved with what you were doing that you had tunnel vision and your perspective was very limited. So I looked around and said 'Oh, looks like it's getting dark.' Well, I probably had been facing all this bright, reflective soil while I was drilling the hole and all of a sudden I stopped and looked around and things didn't look so bright."]

[During our review of the mission, Gene and I thought at first that his "Whee" indicated that he was feeling the effects of the maximum cooling. However, as we will discover in a moment, he actually changed his cooling to Minimum. Then we thought that he may have taken a drink of water - which is certainly possible or even likely. However, it seems most likely that his "whee" is simply relief from being able to let go of the drill for a moment.]

[Jack returns to the Central Station, removes the LSPE antenna and its cable, discards a small object and backs off to the west, paying out cable. During the geology traverses, Jack will deploy a total of eight explosive packages. Each is designed to be fired at a preset time - roughly 90 hours - after deployment and, therefore, well after Gene and Jack are safely off the Moon. A timer in each of the packages prepares it to receive a detonation signal transmitted from the Central Station, and what Jack is now deploying is the whip antenna through which those signals will be transmitted. AS17-136-20705 shows the antenna mounted on the pallets, the LSG immediately behind it and Geophone Rock and Bear Mountain in the distance.]

120:07:05 Cernan: I think I may have gone the wrong way. I did. I went to Min instead of Max. Here it comes. (Pause) Oh, boy! Oh, boy. (To Jack) Man. Watch it. Okay, Jack. You're all right. Still deploying.
 120:07:22 Schmitt: Huh?

[Gene is telling him that he hasn't gotten to the end of the cable.]

120:07:23 Cernan: Still deploying. Nothing; you're all right.
 120:07:24 Schmitt: It's coming out a little hard. (Pause) Wouldn't you know it?
 120:07:36 Cernan: Okay. I'm back in Min, Bob.
 120:07:41 Parker: Okay. Copy that.
 120:07:48 Cernan: By any chance (do you) have any heat flow data yet?
 120:07:53 Parker: No, Geno. We don't have the heat flow turned on yet.
 120:08:01 Cernan: Oh, that's right. Okay. (Pause) I think that's right. Okay. I'm about to give you your number...Oh, god darn it! (Jack laughs) (Pause)

[Gene knocks the drill over and then picks it up by going to one knee in a quick down-and-up motion.]

120:08:23 Cernan: (To himself as he runs the drill for a second) Crank it a couple of times. (Pause) Clean as a whistle! Clean as a whistle.
 120:08:35 Schmitt: Well, just like I thought; the antenna doesn't want to go in. (Pause)

[In order to keep the socket clean, it is covered with a piece of aluminum foil which, rather than tearing easily, is resisting Jack's efforts to push the antenna through. See Jack's debrief comment at 126:38:56.]

120:08:47 Parker: Is that the number 3 section there, Geno?
 120:08:52 Schmitt: There, it's in.

[Jack uses the UHT to push the antenna into the socket.]

120:08:54 Cernan: (Responding to Parker) Yes, sir, Bob.
 120:08:55 Parker: Roger. Beautiful.
 120:09:02 Cernan: Well, it's the last one I got. (Chuckles) I guess we'll find out when I put the probe in. I think they're all in there.

[Gene starts drilling. Fendell pans to Jack who is now at the Central Station.]

120:09:15 Schmitt: Okay. I'm about ready to deploy some geophones.
 120:09:18 Parker: Okay, Jack. Did you get the antenna into that sub-pallet okay, eventually?
 120:09:25 Schmitt: Yes.
 120:09:26 Parker: Good enough.

[Jack picks up a piece of the Central Station pallet and drops it on the trash pile.]

120:09:33 Cernan: Bob, I occasionally hit stuff and it spits this whole drill back at me. Knocks it back about a half an inch or so, and then it will bite through it.

120:09:46 Parker: Okay.

120:09:53 Cernan: My general impression is that there is an awful lot of fragments I'm busting up down there.

120:10:00 Parker: Okay. (Long Pause)

[Cernan - "When the drill's spinning and it hits something, it kicks the drill and spits it back at you. Not vertically, but rotationally. It was tough drilling. I was pushing down and all of sudden it hit something solid; the motor was still running but the bit stopped, so something had to turn. So, the drill turned backwards."]

[Jack continues policing the trash pile, using the UHT to push things around. He is hopping easily from foot to foot, changing directions and pace without difficulty.]

120:10:26 Cernan: I'll tell you, Bob, (in) that last 6 inches I really came into something hard; but it's down all the way.

120:10:31 Parker: Beautiful, Geno. (Pause)

[In the deep core hole, which Gene will drill next, he runs into rock-strewn layers at intervals throughout the 3.2 meters of drilling. X-radiography performed after the mission shows an abundance of rock fragments from about 25 cm depth to 110 centimeters, presumably representing ejecta from the Camelot impact. Layers of fragments at 120 and 130 centimeter depths are probably associated with other nearby impacts, such as Poppie. The core then has relatively few fragments to a depth of about 190 cm, with the interval presumably representing reworked ejecta. Fragment layers are then encountered at depths of 250, 280, 290, and 310 centimeters. Although there are certainly differences in the details between the rock fragment distributions with depth at the core and heat-flow holes - dependent on the placement of individual rocks in the various ejecta blankets - a general correlation is likely. However, the fact that the deep core is in a shallow depression - coupled with the random horizontal distribution of rocks in the various ejecta blankets - makes it difficult to identify his "hard layer" with a particular fragment zone in the core.]

[Jack is running toward the Rover, using what looks to be a very efficient foot-to-foot gait. At one point, he gets his center of mass too far to the right and starts to lose his balance. He hops on his right foot a couple of times to get himself centered again.]

120:10:37 Schmitt: Oops, there's a heat flow probe.

[Jack does a high kangaroo hop to avoid the first heat-flow hole.]

120:10:39 Cernan : What happened?
 120:10:40 Schmitt: (Laughing) I messed up...
 120:10:42 Cernan: Man, don't hit that. Give me heart failure after all that drilling.
 120:10:45 Schmitt: No, I just walked too close to it. I apologize for that.
 120:10:48 Cernan: I don't care how close you walk to it...
 120:10:50 Schmitt: Well, Mark (Langseth) does.
 120:10:55 Cernan: Just don't step on it. (Pause)

[Because of John Young's accident, no heat flow measurements were made on Apollo 16 and this is the last chance to confirm the Apollo 15 data. Marcus Langseth is the Principle Investigator.]

120:11:01 Schmitt: I do that (pause) in training, though.
 (Pause)

[Gene has the wrench attached to the stem and is trying to twist off the drill; but he has to get down to reposition the wrench. The TV jiggles as Jack works at the Rover. He is getting his camera and the gnomon so that he can document the geophones as he deploys them.]

120:11:13 Cernan: Ooh. (Grunting and breathing hard) Hey, Bob, just out of curiosity, what kind of heart rates has this drill been producing on me?
 120:11:23 Parker: Stand by. (Pause)
 120:11:45 Parker: Okay, you've been running at 120 flush, Gene, with peaks of 140 to 150 from time to time.
 120:11:53 Cernan: Okay. (Pause)

[Gene has the drill off.]

120:12:02 Parker: And there goes the last heat flow hole on the Moon.
 120:12:04 Cernan: Oh...(Listens)

[Gene positions the drill, leans on it, and removes the wrench.]

120:12:08 Cernan: Yes, sir. I tell you, if you learn how to use your instruments in this 1/6g - you take your time and you get around - it's frankly phenomenal. But if you try and bend over without some help; (it's) not so phenomenal. (Long Pause)

[Gene has the wrench off and hangs it on the rack. He moves the drill out of the way. The TV has stopped jiggling, so Jack is probably on his way to the geophone module. He is on checklist page LMP-22.]

120:12:49 Cernan: Boy, what a ride that Challenger gave us coming down. What a ride. (Long Pause)

[After a couple of unsuccessful attempts, Gene uses the wrench to pick up the heat flow probe. He removes the cover which he then drops accidentally.]

120:13:29 Cernan: (Talking to himself) Oh, you dummy. You dummy. (Pause) Jack, you still with me?

120:13:42 Schmitt: Yeah.

120:13:43 Cernan: Okay.

[Gene now drops the wrench as he tries to hang it on the rack.]

120:13:46 Cernan: Boy, I'm getting dropsies now. Getting dropsies.

120:13:51 Schmitt: Don't push it.

120:13:53 Cernan: Getting dropsies.

120:13:54 Schmitt: Take a rest. (Long Pause)

[Schmitt - "Except for the little things, the ALSEP deployment went pretty much like training; and many, if not most, of the little problems had already happened in training. The only physically difficult part of the deployment was carrying the ALSEP out to the site, and then using your hands. All the manipulation just wore out the forearm muscles. You went slower and slower and slower, and then you got to the point where you started dropping things."]

[Gene tosses something off to the north, and then comments on how far it's flying with so little effort.]

120:14:35 Cernan: Unbelievable. Unbelievable. (Long Pause)

120:15:11 Parker: Okay, Geno. And the (first) heat flow's on and looking good.

120:15:19 Cernan: That's good news, Bob. Let me give you another one here. (Pause)

[The probe goes in fairly easily.]

120:15:31 Cernan: While it's dirty, I'll tell you I'm in to the bottom of the white marks. (Pause) And that's, oh, about Bravo 1 again.

120:15:42 Parker: Okay, I copy. Papa 1, Foxtrot 1, and Bravo 1?

[Parker was talking to the Experiments people in Houston and didn't fully heard Gene. Gene is on checklist page CDR-19.]

120:15:48 Cernan: No, sir, Bob. No, the bore stem is in to the top of the white marks; I'm still putting the probe down.
 120:15:57 Parker: Okay, copy that.
 120:15:58 Cernan: And the top of the white marks is about Bravo 1.
 120:16:02 Parker: Copy that.

[Gene attaches the rammer to the cable.]

120:16:03 Cernan: About Bravo 1. Okay. Here goes the probe. (Pause) Pick a number you'd like to hear. How about Papa 1?

[This is the mark indicating the deepest and most desirable penetration.]

120:16:23 Parker: How about Papa 1 there, Geno.
 120:16:29 Cernan: Bingo, babe, you win; and it locked in.
 120:16:32 Parker: Roger. I think Mark won on that one, too.
 120:16:34 Cernan: Papa 1.

[Gene removes the rammer from the hole and re-attaches it to the next higher probe.]

120:16:35 Parker: Roger. (Pause) And, Jack, I gather you are probably traipsing across the landscape with a geophone about now, right?
 120:16:51 Schmitt: That's affirm.
 120:16:52 Parker: Okay. And let me ask you...
 120:16:53 Cernan: Good gravy! You know how big that (Geophone) rock...
 120:16:54 Parker: Stand by. Go ahead.
 120:17:00 Cernan: Go ahead, Bob.

[Fendell pans away from Gene. Jack is emplacing Geophone 3 eighty-eight feet south of the geophone module. Gene is looking in his direction and, with Jack in the foreground, is getting an appreciation for just how big Geophone Rock is. It is 3 meters tall, about 10 feet.]

120:17:03 Parker: (To Jack) Okay. I gather...You said that the LEAM was leveled and aligned, and I gather that meant it was on the black decal on top. Do you happen to remember what a number was on that?
 120:17:17 Schmitt: Well, I'll check it! But I think you know where that decal is.
 120:17:21 Parker: Well, okay. Good enough.

[Fendell finds Jack as he deploys Geophone 3. He is thirty meters south of the module and about 20 meters northeast of Geophone Rock. For future reference, the gnomon is visible in the TV picture. AS17-147-22549 is a documentation photo of geophone number 3, which Jack will

take at about 120:38. Note the geophone flag and the gnomon at the left side, just in front of the partially buried boulder. Note, also, that Gene is at the Rover.]

120:17:28 Cernan: Okay, Bob. The little thermal shield went to Fl.

120:17:34 Parker: Hey, that's another bingo.

120:17:36 Cernan: And it's coming out to the south.

(Listens) I'm coming out to the south.

120:17:41 Parker: Roger. (Long Pause)

[Schmitt - "By running the heat-flow cable southward out of the hole, you got more uniform heating than you would if the cable ran east or west. That way you could calculate more easily the error that cable heating introduced into the measurements."]

[Jack returns to the Geophone Module near the RTG . He runs using a foot-to-foot stride and, as he gets close, plants both feet in front of himself. The 30 meter run takes about 25 seconds, including a few steps at the beginning to get himself up to speed and a few at the end to stop. His average speed is 4.3 kph. For future reference, he has left the gnomon next to Geophone 3. He took it out there, as planned, to take some documentation pictures, but forgot all about taking them.]

[Schmitt - "Although it doesn't look like it on the television, you actually had to rotate your hips a little bit to get your feet to stick into the ground."]

120:18:07 Cernan: And the thermal shield is in place.

120:18:11 Parker: Roger. Copy that. (Long Pause)

[Jack turns to the east and shields his eyes to find a predetermined point on the East Massif which he will use as a horizon marker so that he can take the east geophone out in the right direction.]

120:18:27 Cernan: Well, it was until I moved it. (Pause) (thinking about throwing the rammer) Do I need my javelin anymore?

120:18:35 Schmitt: You might.

120:18:38 Cernan: Yeah, I might.

120:18:40 Parker: One never knows, Geno.

120:18:42 Cernan: I think I'll save it until after I drill the core. (Pause) Oh, me oh my.

[Cernan - "I called the heat-flow rammer a 'javelin' because what I really wanted to do was give it a heave-ho on the Moon and see what it would do."]

120:18:52 Schmitt: Take it easy, Geno. You sound like you're...

[Jack picks up a geophone and starts running east.]

120:18:54 Cernan: No, I'm doing fine. (Probably looking up) That Sun is just bright! I ought to put those visors down, I suppose; those other visors. Okay. Let me take a look at my list and see whether I've got everything. (Reading) Measured, measured; height, height; you've got all the (thermal) shields; you're coming out south; verify heat flow is level and aligned. It is aligned and gnomon was good; UHT to the LRV LMP seat; and then what do I do? (Turning to page CDR-20) Let me see. Deep core prep. Jack, I'm going to leave the UHT in the heat flow in case you need it.

120:19:27 Schmitt: Okay.

[Cernan - "The checklist pages were made of fairly stiff paper and were about two-and-a-half inches square. They lay flat on your wrist because they were bound with a spiral wire hinge that forced them to bow up. As soon as you turned a page, the hinge put a stress on it and it would lay flat. The tabs that you used to turn the page weren't very large, but even in the gloves it wasn't really hard to get them turned."]

120:19:30 Cernan: Okay. I'm going to go behind a rock over there.

120:19:33 Schmitt: (Admonishing) Now, now.

120:19:36 Cernan: In that depression. Bob, you do want the core in a depression, right?

120:19:42 Parker: Roger. That's affirmative, Geno.

120:20:19:48 Cernan: Okay, nobody touch my heat flow. It's the prettiest job I've ever done. Okay, I'm going behind a boulder over here. (Pause) Bob, I've got about 3.85 (psi) and I guess about fifty percent (oxygen). I can't see it too well.

120:20:14 Parker: I copy that, Geno.

[Jack reaches the end of the east geophone cable. He is part way down in the swale; the LM is in the background. In looking at the television picture, it appears that the LM is below the ALSEP site and, indeed, at several points in the mission it looks as though the Rover is sitting on high ground when, as is the case here, there is actually no elevation difference. Here, the fact that Jack is down in the swale may contribute to the impression.]

[Gene sounds fairly playful now.]

120:20:15 Cernan: And no flags and no tone; and I'm on intermediate coolant and I feel great.

120:20:22 Schmitt: Likewise; and I'm...

120:20:23 Parker: Roger.

120:20:24 Schmitt: ...and LMP is five-six percent.

120:20:30 Parker: Okay. Copy that.

120:20:31 Schmitt: What are you, Geno?

120:20:32 Cernan: Well. I can't see it. The Sun was...(Pause) I don't know, Jack. I can't...I'm on about...Yeah, about 55 or 54.

[Fendell pans away from Jack.]

120:20:44 Schmitt: Okay.

120:20:45 Cernan: Now, this (boulder) ought to shield that thing (the neutron probe) from the doggone (RTG)...

120:20:52 Schmitt: Pressure's 3.85 on the LMP. (Pause) Bob, one comment on getting the geophones within a few degrees of vertical. In this undulating terrain (chuckles), I think they're pretty good; but it's not real easy to tell what vertical is.

120:21:21 Parker: Roger, Jack. (Pause)

[Schmitt - "Each of the geophones was a cylinder that came to a point at one end. You put the point in the ground and then just stepped on the geophone to push it down into the surface."]

120:21:26 Cernan: Well, this is right in line with the...(It's in a) shallow depression and it's right in line with the RTG, with a rock in the middle.

120:21:35 Parker: Okay, Geno. As long as you're drilling behind the rock from the RTG, that's great.

120:21:45 Cernan: That's where you're going to get it. Let me see what I need. "Drill, rack, core bag. Drill at 1 IPS (inch per second)." Okay. Let's go do it right. (Pause) Okay. Let me see, I'm going to put it right in this depression. Right in it.

120:22:30 Schmitt: Yeah, get the middle of that.

120:22:32 Cernan: It's a shallow one. If I go over there, I'm not shielded, Jack.

120:22:36 Schmitt: No, that's good. Get in the middle. Get it in that place.

120:22:38 Cernan: Right in this little...It's only about a 4-meter (diameter) depression.

[Fendell finds Jack again. He is looking toward Gene.]

120:22:42 Schmitt: Oh, wait a minute. Oh, you're on the other side of the rock. Okay.

[On his way back to the geophone module, Jack stops at a meter-high rock due south of the Rover. He leans on it for a few seconds to examine the minerals and then goes to get the next geophone. The rock appears on the right side of AS17-147-22549, taken near Geophone 3, and is in the center of AS17-147-22584, taken near the RTG.]

120:22:45 Cernan: Yeah, yeah. Yeah, I want to get back here.

120:22:49 Schmitt: That's good.

120:22:51 Cernan: Oh, man, go slow. (Long Pause)

[The sound of Gene's drilling can be heard. After examining the rock, Jack makes his way to the geophone module, describing the rock to Parker as he runs.]

120:23:31 Schmitt: Bob, all of these big boulders around here that I've looked at are the same rock type. (Talking to himself) Ooh. Who pulled over the geophone module? (Pause) Can't imagine. (Pause) Okay. That sounds like the title of a book. (Long Pause)

[Jack puts the geophone module upright, picks up another geophone, and looks west.]

120:24:23 Cernan: Oh, oh. There it went.

120:24:26 Schmitt: What happened?

120:24:28 Cernan: Oh, I lost my vise. I see it. I see it.

[Gene is looking for his wrench. Later, he will take it back to the Rover and, with it attached to the geopallet, will use it as a vise to decouple the deep core sections.]

120:24:37 Schmitt: Hope I took (geophone) number 1 in the right direction. (Pause) Yep. Okay, number 4 will be a little hard to pick up.

120:24:48 Cernan: Boy, all these little craters are filled with glass. (Probably talking to the errant wrench) Come on back here. I've got to chase this thing over the lunar surface.

120:24:57 Schmitt: I've seen glass covers.

[He means "glass-covered crater bottoms". He is standing on the geophone 1 cable about 10 feet east of the geophone module, sighting across it to the western horizon.]

120:25:00 Schmitt: (To himself) Oh, about out towards there, I guess. (Long Pause)

[Jack picks up a flag and heads west, talking as he runs. He is now on LMP-23.]

120:25:21 Schmitt: As I was saying, Bob, all these big blocks that I've looked at look like the gabbroic rock that I was talking about: possibly upwards of 50-percent plagioclase rather than 30 like the mare, but an intermediate gabbro of some kind. And one big block, there, had very-sharply defined, parallel parting planes. I think there is a foliation of minerals that parallel that parting, but I'll have to check it out.

120:26:08 Parker: Okay. Copy that, Jack.

120:26:13 Schmitt: Those parting planes (pause as he reaches the end of the geophone line) go through the whole boulder -

(the boulder being) on the order of at least 3 meters long - in "outcrop". (Long Pause)

[Schmitt - "For various reasons, you sometimes see places in a rock where it's splitting and coming apart. In this case I was saying that I thought the splitting in the rock I'd just examined was produced by the alignment of prismatic habit minerals parallel to that plane; and that's called a foliation. What that implies is some kind of stress during crystallization, either a flow stress as in a volcanic rock, or a shear stress during re-crystallization. By 'outcrop' you'd usually mean something attached to bedrock; in this case there would have been no evidence of that but, for some reason, probably just the size of the boulder, I used the term."]

[The term "prismatic habit" is a reference to elongated minerals with three or more edges parallel to the axis of elongation. Jack emplaces the geophone, tamping dirt around it with his foot.]

120:27:01 Schmitt: How is it going, Gene?

120:27:03 Cernan: Fine. I'm on my second stem, here. Or I'm starting on it. How are you coming?

120:27:11 Schmitt: Okay. I'm just about ready to pick up the biggy, geophone 4.

[Jack goes back to the Module, taking long running strides. He covers the 50-meter distance in 33 seconds for an average speed of 5.4 kilometers per hour. He takes about 30 strides, each about 5.5 feet in length. Geophone 4 will be emplaced 90 meters south of the Module.]

120:27:21 Cernan: (Guffawing) Have a good time.

120:27:24 Parker: Okay. And Geno, how are you doing? We've been watching Jack traipse back and forth across the Moon.

120:27:33 Cernan: I'm getting there, Bob. I'm trying to fit...

120:27:36 Schmitt: Talk about seven league boots.

120:27:41 Cernan: ...Put stem number 2 on.

[Schmitt - "By now I'm taking longer and longer strides and the running technique is getting to be very much like cross-country skiing. On future missions, either for recreation or for an emergency walkback, you ought to have ski poles available for stabilization. At this point I wasn't breathing hard and I think that, with poles, you could go faster than the Rover can drive (10-12 km/hr on a level surface) without expending much energy. And that way you could greatly extend your driving distance with a Rover. I also think the recreation of choice will be getting out and taking long 'skiing' trips. Just like with cross-country skiing, I think you could almost keep it up indefinitely. And if you had a suit with more hip-and-ankle mobility I

think you really could do 10-15 km/hr, a good cross-country speed on flat terrain."]

[Jack's peak heart rate through this period is about 120 beats per minute at about 120:35 (in graph coordinates, 117:55), while he is running south with Geophone 4.]

120:27:49 Parker: And, Jack, how's the visibility back to the center geophone (Garbled)

[Fendell pans to find Gene, who is northwest of the Rover.]

120:27:55 Schmitt: How's the vis?

120:27:57 Parker: Yeah. Are you...

120:27:58 Schmitt: Not bad.

120:28:00 Parker: Okay. You're not having to worry about extra photos yet?

120:28:06 Schmitt: No; I've been checking it. (Pause) Bob, my biggest problem is that the flags don't anchor.

120:28:16 Parker: Okay. Copy that.

120:28:22 Schmitt: In general, the lines are following the contours. Whoops - whoops - whoops. (Long Pause)

[Schmitt - "I don't remember why, but we didn't want the geophone cables to be suspended above the surface as they went across craters and depressions but, rather, wanted them to follow the contours."]

[Fendell finds Gene, who is laying the core stem on the rack.]

120:29:20 Cernan: Well, try another one. Doggonit.

120:29:25 Parker: What's the problem, Geno? It won't screw on?

120:29:30 Cernan: Oh, yeah. It's no problem. You know, it's the same problem you always have. You get these threads...You get a little side force on them and, you know, with the helmet and gloves and what have you, you can't...Sometimes they go on easy; sometimes they don't.

[Gene starts threading another core stem.]

120:29:50 Parker: Copy that. (Long Pause)

120:30:04 Cernan: Okay. I got this one on now.

120:30:05 Parker: Roger. (Long Pause)

[Gene leans on the drill to remove the wrench.]

120:30:27 Schmitt: Boy, do I have a ball of spaghetti here. But the geophones are going in the right direction. I hope you don't have an EMI (electromagnetic interference) problem. Can the geophone lines cross, Bob?

120:30:40 Parker: Stand by on that. (Pause)

[Gene picks up the drill.]

1 4 0 2 0 4 1 4

120:30:52 Parker: Okay; no problem, Jack.

120:30:57 Schmitt: Okay. Hey, if you see me start to pull over that (geophone) module there...

120:31:07 Cernan: Hey, don't do that.

120:31:08 Schmitt: No, I mean...Oh, I won't hurt it. It's just that it stretches the other geophones tight.

[When Jack got to the end of the west geophone line, the cable pulled taut; and, if the geophone module - to which the cables were all attached - had moved, it would have put tension on the remaining cables.]

120:31:16 Parker: Okay. Well, right now we're watching Gene.

[Gene attaches the drill and starts drilling.]

120:31:21 Schmitt: Okay. Don't worry about it. I'll watch it. (Pause) The anchors are completely unsuccessful - on the module, anyway. (Pause)

[Schmitt - "We had anticipated that if any of the lines got pulled and the module moved, one or more of the geophones would get pulled out. So we equipped the module with an anchor of some sort, to keep it stationary. Obviously, the anchors wouldn't hold in the loose soil."]

[Gene has started drilling.]

120:31:47 Parker: That looks pretty good, Geno.

120:31:51 Cernan: Not too bad, Bob. The first core was awful loose. I think I could have pulled it back out with my hands.

120:31:59 Parker: That's not the idea.

[Comm Break. Gene completes the stem, attaches the wrench, removes the drill, and rests for a moment.]

120:33:02 Cernan: Oh boy, oh boy! (Tired) Speaking of "boy, oh boy" (meaning Jack), are you a long way off.

[Cernan - "As I said earlier, when you stop and take a rest, that's when you have a chance to look around. You've got a second or two to yourself. You take a deep breath, take a rest for a second, and look around, and that's when you begin to enjoy your environment, look at what Jack's doing, look at the beautiful Earth, or notice just how high the mountains are. These are the times you can steal for yourself. But that first "oh boy" here definitely referred to how tired my hands were from working with the drill."]

[Comm Break. Jack is running south with Geophone 4. Gene gets another stem and can't get it seated. He actually gets down on his knees, with his right hand on the drill for stability. He hops up, knocking the drill over. He rests for a second, retrieves the drill, kneels again to remove the wrench, but then has to get up to rest.]

120:35:06 Cernan: Okay! Going to stop for a second, Bob.
 120:35:10 Parker: Okay. We've observed your problem there getting the wrench off, Geno.

[Cernan - "In addition to getting tired in the hands and forearms, the other thing that was tiring was getting down and getting up. In training on Earth, with all the weight of a full backpack in full gravity, it was damn near impossible to get down and get back up. That's why, a lot of times in training we used lightweight backpacks with hoses supplying oxygen and cooling water so we wouldn't have to carry that weight. And in 1/6 gravity, even though it easy enough to get up and down, you were bulky, you were still heavy, and the suit was cumbersome. That's why you're going to see a lot of this 'Going to take a rest for a minute.' You just got physically tired. At the end of the day, particularly that first day, we were really tired."]

120:35:16 Cernan: Well, I had to get down to get that third stem aligned and get it on there. This is the easy part, but I just got myself behind the power curve for a second.
 120:35:29 Parker: All right. (Pause)

[Cernan - "The drill stem was sticking out of the ground maybe eight or ten inches or so. Here on Earth, I could take that third stem and stand above the one in the ground, put those locking thread down in it, twist it, and get it locked. But on the Moon, with the stiffness of the suit and the lack of dexterity, if you got it slightly misaligned, the threads would cross, even though they were big threads. We'd thought about all sorts of things so we wouldn't get them crossed; but it still got wedged. So you had to get down, probably on two knees, so that you could get your hands right down there where the action was and get that thing in and aligned. And then, after you were up, then you had to get the drill and put it on. All those things were physically taxing. The getting up, getting down, and the little intricate work you had to do with your hands."]

[Gene positions the drill, but knocks it over again.]

120:35:40 Schmitt: How's the time, Bob?
 120:35:42 Parker: Stand by. (Pause) Okay. Presuming you're taking photos now on geophone 4. Having to finish geophone 4, Jack, right now it looks like you're about 15 minutes behind.
 120:36:02 Schmitt: Okay.

[Checklist page LMP-22 indicates that Jack was to have taken a documentation photograph at Geophone 3, the first one he deployed and then take documentation photographs of the others only if he couldn't see the geophone 3 flag. In fact, he hasn't taken any geophone photos, not even at geophone 3; and it is only with this reminder that he takes one at

Geophone 4. The picture is AS17-147-22528. It doesn't have the gnomon in it because, as can be seen in the photo he left the gnomon at Geophone 3. On his way back to the geophone module, he will take several photos of a small crater lying between Geophone 4 and Geophone Rock. These are AS17-147-22529 thru 22532. After he examines Geophone Rock, he may also take documentation photos and a pan at Geophone 3.]

120:36:09 Parker: And no problem on the time line so far.

120:36:11 Schmitt: I'm not...

120:36:15 Cernan: Darn it! You know, Bob, one of the problems is I'm working in a small crater; and it's just a little difficult to work on these slopes. Okay. It's on. I'm ready to put the drill in.

[Gene hangs the wrench on the rack. His breathing is a bit labored. His heart rate (at 118:00 hours on the chart) is over 140 beats per minute again.]

120:36:26 Parker: Okay, Geno.

[Gene picks up the drill.]

120:36:31 Cernan: Okay. Let me get the dust out of the bit by blurping it (that is, by running the drill motor for a second). (Pause) Oh, man; okay.

[Gene attaches the drill to the stem.]

120:36:47 Cernan: How am I doing, Bob, on the time?

[Parker is involved in a discussion about the length of the EVA and does not answer. Fendell pans away from Gene. Comm Break.]

120:37:57 Cernan: Jack, do you read me?

120:37:59 Schmitt: Yes.

120:38:00 Cernan: Okay, because I don't see you.

120:38:02 Schmitt: I'm out by the big rock.

120:38:04 Cernan: Oh, okay; I got you. (Long Pause)

120:38:36 Cernan: Man, I hope that hole doesn't collapse. I'm going to be awful disappointed. (Pause) I think I could drive that heat flow flux ... (correcting himself) or heat flow...or neutron flux in, at least for one probe, without any problem. (Pause)

[Gene is saying that, even if the hole does collapse, he thinks he could push the probe in at least a couple of feet. Fendell finds Jack examining Geophone Rock. Note that the gnomon is still visible near Geophone 3. Jack takes photos AS17-147-22533 thru 22536 during this stop.]

[Schmitt - "I'd been doing 'instrument science' for several hours at this point, and I wasn't going to pass up a rock that size. It was my first chance to look at the

detailed texture of a big rock and to get some idea of how much I was going to be able to see if, and when, we got a chance to do some geology. The ALSEP always did cut into the time for exploration and I spent an awful lot of my career as a troubleshooting astronaut trying to cut down the amount of time it would take people to deploy that thing. And, although we had some successes, as the ALSEP's got more complicated, the amount of time spent in deployment always seemed to grow.

"Geophone Rock was probably ejected from Camelot but, even if it had been thrown into the valley from a long way off, it gave you a chance to see if there were any textures on scales larger than you could see in a hand specimen, changes in the character and structure of the rock over distances of more than a few inches. At Station 6, for example, examination of the big rocks there showed us some clear cases of intrusion by one breccia into another; and the chances of seeing something like that in a hand specimen are very small. Geophone Rock was also a chance to do some geology standing up. As soon as you had to bend down or squat down or lie down to see something, the physical stress became a distraction from your mental work.

"As I recall, Geophone Rock was my first chance to convince myself that I could distinguish several of the minerals in these relatively coarse-grained basalts. In particular, I could see pyroxene and plagioclase, the plagioclase being most obvious because it gave white haloes around the micrometeorite impact craters - called 'zap pits' - on the rock surface. It was also my first chance to look at the patina which had been identified as a splatter covering of brown glass produced by those same impacts. Each zap would knock off patina right around the impact point, but would also add brown glass elsewhere, so, over a large rock surface, it was a steady-state process."]

120:39:05 Cernan: Okay. Bob, if all goes well in the next few short moments, you'll have the final, unleaded (pause) core stem - automatic - in this area. On Apollo 17.

[Gene sounds tired; he and Jack have been awake for 15 hours at this point. By "unleaded, automatic" core stem, Gene means "A-1, top quality". During the mission review, Jack raised the possibility that there had been concern about lead contamination from the core tubes, themselves, during Apollo 15 and/or 16 and that there had been a design change as a result. Lee Silver of the Caltech and Jim Papike of the University of New Mexico were both intimately involved with the analysis of the deep cores and are quite certain that there was no such concern nor any design change to which Gene might have been referring. They agree with Gene's interpretation that his "unleaded, automatic" meant "first-rate".]

120:39:26 Parker: On a Monday evening;, Roger.

[Fendell pans away from Jack.]

120:39:31 Cernan: Yeah, on Monday evening. That is what it is, isn't it? Hey, who's winning the football game?

120:39:39 Parker: Stand by; we'll find out. (Long pause, presumably while somebody makes a phone call. Most likely, nobody in the MOCR is watching the game)

[In 1969, the American Broadcasting Company began broadcasting a weekly, Monday night National Football League game. Prior to this time, almost all NFL games had been played on Sundays and, for a few years at least, Monday Night Football was immensely popular.]

120:40:08 Parker: Okay; and, Jack and Gene, the score is 10 to 10 at the half.

[It is about 9:33 p.m. Central Standard Time on Monday, December 10. The games started at 8 p.m. CST and, therefore, the first half has probably just ended.]

120:40:18 Cernan: Yeah, that's Oakland and who?

120:40:21 Parker: (New York) Jets. (Pause)

120:40:30 Cernan: Not Kansas City. What am I thinking of?

[Comm Break. Public Affairs reports that the EVA is also at the half and that the oxygen use rate is a little high. Houston is projecting a 6 hour, 45 minute EVA. Fendell finds Gene, just as he starts to drill the final stem. He stops drilling with the top of the stem about 3 feet out of the ground. He looks west, adjusts his sun shade, rests for a few seconds, then continues drilling. As per checklist page LMP-23, Jack is probably at Geophone 3, taking documentation photographs and a pan. Note that photo AS17-147-22549, which is part of Jack's Geophone 3 pan, appears to show Gene at the Rover. However, an examination of the relative locations of Geophone 3, the Rover, and the deep core hole are consistent with Gene being at the deep core hole when this picture was taken. In addition, Gene doesn't go over to the Rover until about 120:48 and, at that time, Jack is taking another pan consisting of frames AS17-147-22569 thru 22588.]

120:43:14 Cernan: Hey, Bob, would you settle for about 8 inches out of the ground? (Breathing hard) It's about as low as I can get.

120:43:22 Parker: Okay...

120:43:23 Schmitt: I haven't heard from them recently.

120:43:24 Parker: Okay, Geno. We'll give you A minus for that.

120:43:25 Cernan: (Responding to Jack) I know.

120:43:26 Schmitt: (To Gene, having heard Parker) There he is.

120:43:27 Parker: But it's still an A.
120:43:30 Cernan: Well, I'll go lower if I could get an A plus. But I am going to accept an A minus, because I'll never get the wrench on it if I go any lower.

[Gene removes the wrench from the rack.]

120:43:37 Parker: Roger there, Gene.
120:43:38 Cernan: I'm within an inch of the white stripes. How's that?
120:43:42 Parker: That sounds great to me...
120:43:43 Cernan: An inch of the white stripes, Bob.
120:43:44 Parker: Roger. And they're worried up here that you didn't clear the flutes, Geno. You want to tell them that so they'll be happy?
120:43:51 Cernan: Yes, sir. I'll tell them I did clear the flutes.

[Gene let the drill run for a few seconds without letting the stem penetrate deeper in the ground. This lets the flutes bring all of the cuttings to the surface, a process that should reduce friction when Gene extracts the stem with a jack and treadle.]

120:43:54 Parker: Okay. And, Jack, where are you lost on the plains
120:43:55 Cernan: (Still discussing the clearing of the flutes) Yeah, I did. But if you want me to do it some more, I will.

[Gene attaches the wrench.]

120:44:02 Parker: No, if you cleared, that's sufficient. And, Jack, where are you lost on the plains of Taurus-Littrow, there?
120:44:10 Schmitt: (Calling dramatically, like Marley's ghost in Dickens' A Christmas Carol) I'm over here.
120:44:14 Cernan: He's 180 (degrees) from where your camera (is pointing)...from where I am.
120:44:19 Parker: Okay.
120:44:20 Cernan: Right across the Rover.

[Gene starts to remove the drill.]

120:44:21 Parker: Okay. Are you getting ready to take geophone photos or ALSEP photos?
120:44:27 Schmitt: I'm getting ready to enable the old geophone.
120:44:30 Parker: Okay. I take it that means you've taken the geophone photos.

[Gene has removed the drill, starts to put it down, but then re-attaches it.]

120:44:35 Schmitt: Oh, yes, sir; and I forgot the gnomon!
Ha, ha, ha.

[Evidently, Jack didn't remember to bring the gnomon back with him after he finished the documentation photos and the pan at Geophone 3.]

120:44:38 Parker: Ha, ha, ha. Hey, Jack. How about giving me a couple of quick readings here to satisfy some people. One, was there a decal on the LEAM that you aligned it with? There's some controversy down here that there's no decal there; and the question is, if there isn't they want a reading out of the degrees. But we keep saying there's a LEAM decal, and we can't prove it.

[In an effort to save time, Gene tries pulling the core out by the drill handles. The stem doesn't move far enough for the motion to be obvious in the TV picture.]

120:45:04 Schmitt: I'll go prove it, Bob. I'll go by there. Stand by.

120:45:08 Parker: Okay.

[Gene removes the drill again.]

120:45:09 Schmitt: What's the other question?

120:45:11 Parker: And the second question is, is there a decal and was it aligned on the shade...(correcting himself) the 20-degree decal on the LSG. Was that also aligned?

120:45:21 Schmitt: Yes, sir.

120:45:22 Parker: Okay. Copy that.

120:45:23 Schmitt: The orange one.

120:45:24 Parker: Roger. Agree.

120:45:26 Schmitt: As per drawing.

120:45:27 Parker: Roger, sir.

120:45:28 Schmitt: As per drawing.

120:45:29 Parker: Roger. You don't have to prove it to me.

120:45:34 Schmitt: Yes, I do. Okay.

[Gene removes the wrench, but with a little struggle.]

120:45:38 Cernan: Okay, Bob, I was able...

120:45:39 Parker: Okay; and, Jack, how far...

120:45:41 Cernan: ...to pull the core out...

120:45:45 Parker: Okay, go ahead.

120:45:47 Cernan: ...with the drill. (Stops to listen to Parker) I was able to pull the core out with the drill, about 3 inches. And it's all jacking material from there out.

[That is, Gene will have to use the jack to extract the core.]

120:45:56 Parker: Okay, copy that, Geno. And we finally got some word from the Cape to prove to people that there's a decal on the LEAM, so you don't have to go back by that, Jack. Just at the right time.

120:46:07 Schmitt: I already have. It's reading three-zero. And here's the decal.

120:46:15 Parker: Okay. Copy that. (Pause)

120:46:25 Schmitt: Okay. I guess I take ALSEP photos.

120:46:31 Cernan: Good. (Pause)

[Gene gets a core plug from the rack. His "good" has the flavor of "I'm glad that it's you that has to do it."]

[Schmitt - "Either one of us could have taken the ALSEP photos, depending on who was ahead in the timeline. I can't remember why it was so onerous a job; but, apparently, neither one of us really wanted to do it."]

[The ALSEP photoplan appears on cuff checklist pages LMP-25 and CDR-23. Although the photos were nominally Jack's responsibility, Gene's page CDR-22 indicates that had he been ahead of Jack in the timeline, he was to help with the geophone deployment and the ALSEP photos, as appropriate. The complexity of the photoplan explains why neither of them was eager to do the task.]

[Cernan - "We had done some cross-training on the deployment, but we specialized in certain things; like I in the drill, and Jack in the ALSEP deployment. But, because we trained together on them, I think I could have deployed the ALSEP, just like he could have handled the drill or even the Rover for that matter. I sort of got into the systems maybe a little bit more than he did, and he got in the ALSEP a little bit more than I did, but I wouldn't have had any problems, nor would he. It would have taken a little longer, maybe; but we could have gotten the job done."]

[Schmitt - "As I remember it, we did a little bit of cross-training, but mostly for the case that one of the PLSS's wouldn't work and we had to do a one-man EVA. Actually, I don't know if they would have allowed a one-man EVA. NASA was pretty conservative by this time. As another example of that conservatism is that, if we had started planning early enough, we could have had consumables enough to stay on the Moon for four days with some reserves. But they wouldn't let us plan for it. There would have been trade-offs. In order to meet the margins, you probably wouldn't have been able to take some of the equipment, but you could have done it."

"I remember that right after Bill Anders replaced Mike Collins on Apollo 8, probably in August '68, Alan Shepard - who was head of the Astronaut Office at that time - assigned Aldrin and myself to pull together a briefing for the President's Science Advisory Committee: Charlie Towns' committee. They had been asked to be briefed on NASA's plans for the first lunar landing mission. The trouble was that nobody had put together a plan since the time when the Design Reference Mission was defined prior to the RFP's (Request for

Proposals) being issued for the lunar module. But by '68 we had to get realistic. So I pulled together the time line - working with a small group of people - for what eventually became Apollo 12. And it was in that process - in defining the first mission with an ALSEP deployment - that we realized that the chances of a first mission having more than one EVA and having weight margins to carry the ALSEP with confidence had very remote possibilities. That's when I first raised the issue of designing a smaller ALSEP - the ESEP - that included only a seismometer and a corner reflector. That was what eventually flew on Apollo 11; and that was put together in a hurry. When we briefed the PSAC, some of our viewgraphs indicated that we didn't think that the mission we'd put together could be the first lunar landing mission because of these problems. On the first mission you probably wanted all the weight margins you could get, and, at the time, it seemed as though the weight of the LM was growing and we realized that the 300 lb ALSEP was going to be a lot easier to kick off than a 100 lb alternative. Also, it was the first time anybody had put together a lunar-surface timeline, and we had to consider things like one-man versus two-man EVA's because they were still taking about doing umbilical EVA's rather than PLSS EVA's. Deke (Slayton) was very helpful in that he put his foot down and said Flight Crew Operations Directorate demanded a two-man EVA, and said that we weren't going to be constrained by umbilicals because they were too dangerous."]

120:46:40 Schmitt: Once more I tempt the fate of the god of the cables.

[Jack is also beginning to sound a little punchy.]

120:46:46 Parker: Okay; and, Jack, we're getting ready here to try and save a little bit of time. And we're saying that why don't we just take two stereo pans for the ALSEP photos. The first stereo pan will be in the vicinity of the original stereo pan; and the second one, they suggested, will be to the northwest of that original one.

120:47:12 Schmitt: Northwest. Okay.

120:47:13 Parker: Yes, and I suggest that you go far enough so that you can see the LEAM past the Central Station.

120:47:19 Schmitt: Yes, sir.

[Gene uses the drill as a support to get low enough to insert the core plug.]

120:47:24 Cernan: Hey, Bob, (laughing) you'll be interested to know (that) I just put a plug in the top of that core; and it disappeared from sight down the center of the core. I'll put a cap on it, too; but I want to plug it first...I want to get the rammer to plug it down.

[Gene goes to the Rover.]

120:47:43 Schmitt: Hey, Bob, where do you want the focus on the pan to be?
 120:47:47 Parker: Stand by on that.
 120:47:49 Schmitt: About 15 feet?
 120:47:54 Parker: Stand by. (Long Pause)

[Gene reaches the Rover.]

120:48:14 Cernan: Where's my rammer? There it is. (Pause)
 Hey, Bob, that's strange. That plug was too small for the core. (Long Pause)
 120:48:41 Parker: Hey, Jack. You've got to focus it some what short...Well, between 74 feet...(that is), just a little short of 74 feet?
 120:48:52 Schmitt: I've already taken it at 15, Bob. I think that's pretty good.
 120:48:56 Parker: Okay. We couldn't get an answer.

[From the evidence of the pan, itself, Jack is currently in the middle of taking it and doesn't want to start over. The pan consists of photos AS17-147-22569 thru 22588. Frames 22575 and 22576 show Gene at the Rover getting the jack-and-treadle with which he will remove the deep core from the ground. Frame 22577 show him leaving the Rover]

120:49:02 Schmitt: It's not a calibrated detent, but I don't think you need it here.
 120:49:06 Parker: Okay. (Long Pause)

[Schmitt - "On the camera focus, we had a number of detents that you could feel. They were calibrated for photogrammetric analysis but, in this case, I was assuming - correctly or incorrectly - that they didn't do photogrammetry with these pictures. A fifteen-foot focus of the ALSEP site sounds a little short to me now, but that's what I did."]

[Gene leaves the Rover, carrying the treadle-and-jack.]

120:49:45 Schmitt: How far northwest (does Houston want the next pan)? (Pause)
 120:49:51 Parker: Go ahead, 17.
 120:49:54 Schmitt: About the same position as the heat flow down-Suns...(Correcting himself) or, Up-Suns?
 120:50:02 Parker: Stand by.

[Gene leans on the drill to drive the plug with the rammer. Jack is referring to LMP-23. The drawings suggest that Jack is supposed to take cross-Sun (south-looking) and down-Sun (west looking) photos of the two heat-flow holes, but no up-Suns (east looking).]

120:50:09 Cernan: Okay, Bob, I was able to...
 120:50:13 Parker: Yes. That sounds pretty good to me, Jack.

120:50:19 Cernan: Bob, I ran that plug three-quarters...(Correcting himself) two-thirds of the way down the rammer, and it hit solid paydirt.

[This is something of a surprise. Lunar soil is generally very compact at depths of more than a few centimeters, so a void in the top of the core is unexpected.]

120:50:26 Parker: Okay. That sounds good.

120:50:27 Cernan: And I'll put a cap on it for you, too.

[Gene leans on the drill, holding the cap. He may be kneeling again.]

120:50:29 Parker: Okay. That'll make people happy. And did you copy me, Jack, that (garbled)...

120:50:34 Cernan: I knew it would. And that...

120:50:35 Parker: ...pan

120:50:42 Schmitt: Roger, Bob.

[Jack's pan starts with AS17-147-22589 and ends at AS17-147-22606. Frames 22598 and 22599 show Gene at the deep core hole.]

120:50:47 Parker: And, Jack, would you confirm for the ground that you got the LSP enabled?

[Parker is asking if Jack has enabled the seismic experiment; Gene picks up the treadle.]

120:50:50 Cernan: That's cap Alpha.

120:50:53 Schmitt: No, I didn't. You interrupted me. Good boy. I was on my way, and the LEAM interrupted me. I'll get it.

120:50:59 Parker: Roger.

120:51:01 Schmitt: Keep after me. (Long Pause)

[Jack is asking Parker to make sure that he completes all of his tasks. Gene fits the jack handle to the treadle, and telescopes the handle out to about waist height. He then moves the drill.]

120:51:30 Cernan: Bob, that's cap Alpha that's on the core.

[Gene fits the treadle over the core stem.]

120:51:39 Parker: Say again there, Geno. (Pause) Jack, you're taking your second pan, right?

120:51:51 Cernan: (To Jack) I'm not sure they're hearing us all the time.

[Gene tries holding the treadle down with his right foot.]

120:51:57 Schmitt: (Responding to Parker) Yeah, but the camera just stopped. (Pause)

[Jack has just run out of film. At this moment, Ron Evans is passing overhead and has the following conversation with Houston.]

[CapCom: Did you have any luck locating the LM area in the landing site this time?]

[Evans: Yes, I didn't even see the bright spot there anymore. I know...I know where to look for it and I don't even see it.]

[CapCom: Roger. Understand.]

[Evans: Well, (the) South Massif just went into a hole, too, so...]

[CapCom: Roger. Our best estimate of their location down here, Ron, is 83 - Delta Mike 83. Delta Mike 83.]

[Evans: Delta Mike 83, huh?]

[CapCom: Yes, and that's seen on the southeast sheet - the SE sheet with the landing site and the first EVA on it. The 25,000 grid, one of those you had put in at the last minute, there.]

[Map coordinate DM 83 is about 250 meters south and 100 meters south of the LM. Ron's previous estimate - at 115:09:01 - of DN 83.3 is much better than Houston's. This is Ron's last report on the landing site.]

120:52:10 Cernan: (Breathing hard from the first strokes of the jack) Oh, man!

120:52:12 Parker: Okay, what...

120:52:13 Cernan: Oh!

120:52:14 Parker: ...was your question, Geno?

120:52:17 Cernan: I just said that was cap Alpha on the core. And let me tell you, (chuckles) it's coming, but this thing is really in something. (Straining) Oh.

[Cernan - "It was a lot of hard work; and not at all easy."]

120:52:33 Schmitt: Would you believe I'm out of film, Bob?

120:52:37 Parker: Okay. I'm afraid I'll have to.

120:52:42 Schmitt: Why didn't I look at the number?

120:52:45 Parker: You want to give me a frame count, Jack?

120:52:46 Schmitt: Mag Alpha is empty.

120:52:47 Parker: Okay. Copy that.

[Mag Alpha is also magazine 147 in the overall Apollo series.]

120:52:51 Schmitt: It's 158.

120:52:54 Parker: Copy, 158. (Long Pause; Gene's breathing is clearly audible)

[During this interval, there is a discussion in Houston about the film magazines. It, along with a subsequent

discussion is reproduced here to illustrate what was going on in Houston throughout the EVA.

[EVA: Flight (Director), EVA (Team).]

[Flight: Go ahead.]

[EVA: Okay, when we change, we're going to need to go to H.]

[Flight: Magazine Hotel.]

[Parker: Okay, and do we want them to take the next one (the next pan) at 74 (foot focus)?]

[EVA: Yes, that's right.]

120:53:14 Parker: Okay, Jack, we're recommending magazine Hotel (a black-and-white magazine, number 136 in the overall Apollo series), and we also suggest you take the second pan, when you retake it, at 74 feet.

120:53:22 Schmitt: Okay.

120:53:25 Cernan: Man, it didn't feel like this stuff was that hard. (Pause)

[To begin a stroke, Gene stands facing the Rover with the core at his right foot. With his left hand, he raises the handle to the vertical position, seats it against the core stem and pushes the handle across to his left to about the 45 degree position, at which point the jack bites against the stem. He then pushes the handle down another 15 or 20 degrees. Because the fulcrum is very close to the stem, he only raises the stem about an inch. After a couple of tries, he moves further from the core to his left so that he can get a longer stroke.]

120:53:36 Schmitt: What's the problem, Geno? You need some help?

[Gene is now almost going to his knees with every stroke, one every five or six seconds.]

120:53:38 Cernan: No, nothing you can do. Just jacking away. See if I can get this thing out of the way. (Rests, breathing hard) See if I can get it out, is what I'm really saying. I may be jacking the treadle down into the surface. (Pause)

[The jack is mounted on a treadle, a flat platform about a foot long and maybe six inches wide. In principle, the treadle provides a big surface for spreading the force of the jack lifting the core tube. However, the soft soil tends to shift under the pressure and the treadle is trying to bury itself.]

[Schmitt - "The undisturbed regolith is well-packed and fairly dense, with a density of about, if I remember correctly, 1.9 grams per cubic centimeter. But, as soon as you start to stir it up, it loosens. So you can work things down into it, gradually, even though you don't sink into it when you walk on it."]

120:54:00 Cernan: (To himself) Change hands. (Long Pause)

[Gene has raised the core about one foot; and he now kneels, with his back to the Rover, so that he can push the handle all the way to the surface with his right hand.]

[Cernan - "I was only able to get it out an inch or two at a time. The core was eight or nine feet long, so I was pumping the jack for a long time. I'd jack the core up a little bit and then I'd have to get the jaws back on the core tube with the other hand so that they wouldn't slip when I jacked again. I can still remember doing this, right down on my knees. It was a lot of hard work, as you can tell by the way I'm breathing and by the way I'm talking. My 1/6th gravity weight was holding me down enough to give me leverage, but it was still difficult because it required all forearm work and finger dexterity work."]

[In Houston, there is a renewed conversation about the pan and the film magazine.]

[Experiments: Flight, Experiments. (No answer)]

[EVA: Flight, EVA. (No answer)]

[Parker: Experiments, this is CapCom.]

[Experiments: Go ahead.]

[Parker: Are we going to come back and take all the same photos over again on the second]

[EVA...(correcting himself) the third EVA? If so, we're kind of gilding the lily with two pans here.]

[Flight: EVA, you called?]

[Experiments: (To Parker) We're not going to duplicate anything.]

[EVA: (To Flight) That should be magazine Golf in lieu of Hotel.]

120:54:26 Parker: Okay, Jack, if you haven't put magazine Hotel on, we want to recall that and make it magazine Gulf...(Correcting himself to follow Jack's lead in using women's names) Gail.

120:54:35 Schmitt: Well, Bob, I've already got it on.

120:54:37 Parker: Okay. Sorry about that.

[Schmitt - "The guys in the Control Room were as deeply involved in the exploration as anybody and had a lot to do to make it possible. Sometimes, although not very often, they just couldn't come to a decision fast enough. It was tough to do. You've got two guys hopping around on the Moon making their own decisions and, to make a recommendation about which film pack to use, you've got to talk to the people who can give you an informed answer; and that takes time. The way that people worked in and with the Control Room is an important part of the story. We knew that these conversations were going on back in Houston because we'd been in the control room or the science support room on other missions; but, of course, we couldn't hear - and wouldn't have had time to hear - what was going on."]

[The TV jiggles as Jack works at the Rover.]

120:54:39 Schmitt: Is that okay?
 120:54:41 Parker: Leave it on.
 120:54:42 Schmitt: I know what you want. You want color.
 120:54:45 Parker: That's affirm.
 120:54:46 Schmitt: Well, anyway, that's black and white also. (Pause) Gail is not...You mean Charlie! If you want color, you want Charlie.
 120:55:11 Parker: Stand by, Jack, if you're still at the Rover.
 120:55:17 Schmitt: Well, I'm still here, but I got Hotel on.
 120:55:21 Parker: (Having consulted the Flight Director) Okay. Leave Hotel on. We goofed. (Garbled).

[Gene stops to rest and stands up. He has been raising up off his knees and then dropping down to put more force on the jack.]

120:55:28 Schmitt: Well, okay. We don't have much time; otherwise I'd change it. I should have thought of that myself.

[Schmitt - "It's amazing to see Gene get right down on his haunches in this sequence, almost with his backside on his heels. There's no way I could have done that; I just couldn't bend my suit that much. Maybe Gene could because he is tall, because he's got longer legs."]

120:55:37 Parker: Well, we couldn't get...
 120:55:38 Cernan: We got a little time because I've got a lot of jacking to do. (Pause) Man!

[In Houston, Parker is being told that it is unlikely that they will be doing complete ALSEP pans on EVA 3.]

120:55:46 Schmitt: Let me finish the pan and come and help you.
 120:55:49 Cernan: Well, there's not...not a lot you can do, Jack.

[Schmitt - "We had the treadle-and-jack because of the trouble Dave Scott and Jim Irwin had in pulling the Apollo 15 core out by hand. But, at least on our mission, it looks as though it took up just as much time and energy. I was offering to put in a shift at the jack but, thank god, he refused it. I don't think I could have done as well as he was doing; he could get down to it."]

120:55:52 Schmitt: I'll get the neutron flux ready.
 120:55:55 Cernan: (Guffawing) Well, thanks a lot. (Pause)

[Jack's offer to prepare the neutron probe could save a little time, but won't help with Gene's basic problem of

removing the core. Gene kneels east of the core, using his left hand to work the jack. Meanwhile, Jack Schmitt has probably started taking his pan. It consists of frames AS17-136-20683 to 20710. Frames AS17-136-20694 to 20696 show Gene kneeling east of the core.]

120:55:59 Cernan: (To himself) Okay! Come on, baby. I'm going to get this thing out, now that I got it.
 120:56:11 Parker: Boy, Geno, that's what you call getting down into your work.
 120:56:20 Cernan: Bob, I'll save my comments 'til later. I hope this core is appreciated.
 120:56:31 Parker: Roger, Gene. And I have word from the back room that it is appreciated.
 120:56:37 Cernan: Yeah, that makes me feel warm. I'll get it! You're going to have to bear with me. Man, I don't know what it's in.
 120:56:53 Schmitt: I was afraid that would happen, with all those rocks.

[That is, Jack has been suspecting that there is only a shallow layer of regolith, which would mean drilling into rock, or least, fractured rock.]

120:57:00 Cernan: Yeah, but it didn't go in that hard.
 120:57:05 Parker: Hey, Geno, how about slacking off for a minute there. You're going pretty hard.

[The Surgeon reports that Gene is running at about 150 heart beats per minute and a metabolic rate of about 2000 BTU/hr, about twice the average expected for ALSEP deployment.]

120:57:12 Cernan: Okay. One more turn and I'll get up. I've got to hit an easy spot sooner or later.
 120:57:23 Parker: It seems that way.

[Gene uses the core stem, now about waist height, as a crutch to get up.]

120:57:30 Cernan: Aghh. You're right, Bob. I'm going to take a rest. You betcha.

[Cernan - "I'm almost getting tired just from listen to this. I'm going back to those moments; and the comments and the sound of my voice really show how tired I was and how hard it was to get that thing out."]

120:57:35 Cernan: (Breathing quite hard) Man, I hate to say it, but I had that 25 percent of the way there. I can feel it (his heart) ticking now. (Pause) I'm going cold (that is, to maximum cooling).
 120:57:56 Parker: Okay. (Long Pause)

[Gene reaches back to change the cooling setting. He has been standing with his arms out in front of him. This is a natural rest position of the inflated suit and Gene can stand like this for a long time without appreciable effort. Friction in the bearings, along with a cabling system, let the wearer maintain an arm or leg in other positions without great effort but, in order to reach the cooling control on the bottom of his PLSS, Gene has to flex the shoulder joint about as much as is possible and, indeed, has to wave his right arm down and back twice before he can reach the diverter valve. Gene and Jack will use this "double wave" motion throughout the mission to reach their controls.]

[Cernan - "The suits were very integral machines. We had arm bearings and elbow joints and wrist joints in the Apollo suits. But we have yet to be able to devise a suit where you incorporate everything from the fingers, to the fists, to the hand, to the wrists, to the elbow, to the shoulder in one motion. Unencumbered by a suit, we can move our arms in any direction using a combination of simultaneous joint movements. To reach for something on a desk behind you, you twist in your chair, turn your head, and move most of the joints in your shoulder and your arm; and you do all those things at once. In a suit you can eventually position your arm or your hand almost any way you want but you're limited to maybe two movements at a time. You can't just incorporate a rotation, an extension, and an arm-bearing movement all at one time. You have to do one or two of those actions, and then do the others. I hate to say it, but it was almost like being a robot sometimes. God made the human machine and we have not been able to make a mechanical device which will incorporate all those movements at the same time"]

120:58:19 Schmitt: Okay, Bob. I got your pans and a couple pictures of the heat-flow probes.

120:58:26 Parker: Okay ...

[Jack's three photos of the heat-flow holes are AS17-136-20711 to 20713.]

120:58:27 Schmitt: Now, let's see.

120:58:28 Parker: Okay, Jack. If you've got the two separate pans there, we're suggesting that since the CDR is still working on the core recovery, we suggest that you sample the large boulders and (also) loose material on top of some of the smaller large boulders in the vicinity. Let's do some sampling here while Geno's pumping on the old jack. Unless you've got something that...

120:58:52 Schmitt: You want me to help him?

[Gene switches to Intermediate cooling and then starts jacking again, this time left handed from his standing position north of the core. Surgeon reports his heart rate is down to 133.]

120:58:54 Parker: Well, unless you guys...Okay. If you'd let me finish. Unless you guys think that two guys can do that better than one. I'm not sure.
 120:59:02 Schmitt: Gene, you want me to spell you a little?
 120:59:05 Cernan: Jack, I don't think there's a lot you can do.

[Gene stops jacking.]

120:59:08 Cernan: Come on over here one minute. Let's see if I can...
 120:59:10 Schmitt: Well, I can use up some of my (cooling) water.

[While drilling and operating the jack, Gene has been using much more cooling water than Jack has and, if the imbalance remains, they might have to re-enter the LM with Jack still having cooling water in reserve. By spelling Gene, Jack might help extend the EVA a few precious minutes.]

120:59:13 Cernan: Let's see if I can't get a bigger bite. You on one end, and let me stand on the treadle and we might be able to get a bigger bite. See, I can't get a very big bite. That's one of the problems.
 120:59:25 Parker: And, Jack, could you verify we have the LSPE Enable on (garbled)...
 120:59:28 Cernan: I just hope that jack doesn't break.
 120:59:31 Schmitt: (Responding to Parker) No, I'll get it. I knew there was something I needed to do.

[Jack reaches the core site; he has yet to push a button at the bottom rear of the Central Station - one of a row of about five or six one-inch diameter buttons - which will turn on the Lunar Surface Profiling Experiment (LSPE), the seismic experiment.]

120:59:36 Cernan: Get the jack end over here. Other side. Let me put some weight here. See what kind of bite you can get. (Pause)

[Gene stands on the treadle; Jack moves from south of the core to northwest and kicks over the drill-stem rack in the process. He starts jacking.]

120:59:48 Schmitt: Oh, man!
 120:59:49 Cernan: Yeah, that's what I've been doing. See if you can get a bigger...(Pause)
 121:00:02 Schmitt: (Marveling at the effort required) Oh, no! (Pause)
 121:00:07 Cernan: It's coming, though. (Pause) Here, let me get my foot down there and you get the jack. See, that's the key. (Pause) Now, I think I can...(Pause)
 121:00:20 Schmitt: Okay. If I do it that way...Get her way down there.

121:00:24 Cernan: Okay. Now try it. (Pause) See, if we can get a couple of inches at a throw, (then) we're all right. There you go. Do that for a little bit. (Pause)

[Jack now has his right hand on the core for balance while he literally falls forward on the handle with his left hand. He has his toes as far out behind as he can, and his knees are bent at the thirty-degree position that is built into the suit.]

[Schmitt - "I was trying to get all of my weight on the handle, just to get it to move. Gene was just heavier and could get it to go."]

121:00:31 Cernan: Okay. Let me put my foot on it.

121:00:34 Schmitt: Okay, ready?

121:00:35 Cernan: Yup. (Pause) It's got to loosen up sooner or later. (Pause; Jack uses his full weight again to push the handle to the ground) Okay. That's another good one. When you're tired, I'll do that and you can do this. See, this way, you can get a bigger throw. Okay. Let me know when and I'll do that.

121:00:53 Schmitt: Oh, that's all right.

121:00:59 Cernan: Does it feel like it's loosening up at all?

[On this stroke, Jack pushes so hard on the handle that his toes come up about a foot off the ground.]

[Schmitt - "I'm was putting every bit of weight and momentum into it that I could."]

121:01:02 Schmitt: Not yet. (Laughs) Excuse me.

121:01:05 Cernan: No, go ahead. (Laughter)

[Jack loses his balance and spins to the ground; he kicks the rack again on the way down.]

121:01:11 Cernan: (Both laughing) Okay, okay, okay.

[Cernan - "This part - where Jack spins around and falls ass-over teakettle - was the funniest thing in the world."]

121:01:14 Cernan: Stay there. Stay there.

[Jack is on his hands and knees. Gene grabs hold of the back of his PLSS and tells him to rock back onto his feet.]

121:01:17 Cernan: Okay, back.

[Jack rocks back on his knees and pushes up with his legs onto his feet, with Gene helping him balance.]

121:01:20 Schmitt: Thank you. (Pause) Oh, my UHT (is on the ground); among other things. Okay. Let's try that again.

121:01:30 Cernan: You want to get over here and I'll do that for a while.
 121:01:32 Schmitt: Oh, that's all right. I just lost my balance. Can I hold there?
 121:01:36 Cernan: Yeah. You can hold there, and I'll hold it, too.

[They both hold the core, Jack is now effectively doing pushups on the handle. During this interval (about 118:20 on the graph), Jack's heart rate peaks at about 135 beats per minute. Throughout the core drilling and extraction, Gene's heart rate has been running over 130 beats, with excursions to 145.]

121:01:42 Schmitt: That seems like a little easier.
 121:01:45 Cernan: Yeah. That looks to me like it should be getting easy. Just hold on to me and...
 121:01:51 Schmitt: What was that?
 121:01:52 Cernan: Huh?
 121:01:55 Schmitt: I had a tone. It was probably a...
 121:01:57 Cernan: You still got it?

[The warning tone raises the possibility that Jack damaged his PLSS when he fell. But he didn't.]

121:02:00 Schmitt: Gone. Momentary. I probably got a...
 121:02:06 Cernan: You get over here. Get over here, Jack.
 121:02:07 Schmitt: Pressure's all right.
 121:02:08 Cernan: No, let me get over there.
 121:02:10 Schmitt: It's coming now. (Pause)
 121:02:17 Cernan: Why don't you come over here? Come on.
 121:02:19 Schmitt: One more.
 121:02:23 Cernan: I think we're going to get it.
 121:02:24 Schmitt: Okay.
 121:02:25 Cernan: Come on over here and hold your foot against that thing.

[They trade places.]

121:02:33 Cernan: Just hold that little thing down. That's the main thing. Ready?
 121:02:42 Schmitt: Yeah. (Pause) We're getting it now.
 121:02:45 Cernan: I need your foot on that thing. See if...

[Gene kneels west of the core with his thighs about thirty degrees past vertical and over his calves. He has his right hand on the core, which is now out of the ground to waist height, and is working the jack handle with his left hand. Jack is southeast of the core holding it with his right hand and with his right foot on the treadle.]

121:02:46 Schmitt: There you go.

121:02:55 Cernan: I don't know what kind of hole we're going to have (for the neutron probe). (Pause)
 121:03:01 Cernan: Okay. Get your foot down on that thing again.
 121:03:06 Schmitt: Wait a minute. Let me...Okay.
 121:03:10 Cernan: I jacked the treadle down about 6 inches. (Pause) Okay. It's loosening up a little bit. I keep saying that, don't I?
 121:03:22 Schmitt: No. It changed while I had it there. (Long Pause)

[The core is now coming up relatively easily. Gene is making good progress with short, rapid strokes.]

121:03:38 Cernan: I can get it. Why don't you go get your pan.
 121:03:40 Schmitt: You got it?
 121:03:41 Cernan: Yeah, why don't you get your pan and your...
 121:03:42 Schmitt: I've got that. I got...
 121:03:43 Cernan: ...LSPE, and I'll...
 121:03:44 Schmitt: I'll get that and a few samples, maybe.
 121:03:45 Cernan: Okay. Go ahead and do that. I can get it. (Pause) Whee! Let me tell you, Red Rover, let me tell you! (Pause) I know whose face is smiling back there. (Pause)

[Andy Chaikin suggests - and I agree with the suggestion - that Gene's reference is to Apollo 9 crewman Rusty Schweikart. During that mission, Schweikart did an EVA on the LM porch, primarily as a test of the PLSS. During that EVA, his call sign was "Red Rover", a reference to his bright red hair. Here, Gene may have used "Red Rover" without really thinking about his word choice but, then, immediately after he said it, realized what he'd said and imagined Rusty's reaction.]

121:04:14 Cernan: You don't suppose this is why we didn't have much dust from the LM, do you?
 121:04:18 Schmitt: I think it is. (Laughs).
 121:04:20 Cernan: (Laughing) I saw all the way to the ground during landing.
 121:04:23 Schmitt: Yeah.

[Gene is referring to the apparent compactness of the soil as a possible explanation of why they didn't seem to kick up much dust during the landing. From the descriptions provided by the various crews during their post-mission technical debriefings, the 14 and 17 crews experienced the smallest amount of dust obscuration and the 12 and 15 crews experienced the most.]

[Armstrong (7-31-69) - "I first noticed that we were, in fact, disturbing the dust on the surface when we were at

something less than 100 feet; we were beginning to get a transparent sheet of moving dust that obscured visibility a little bit. As we got lower, the visibility continued to decrease. I don't think that the altitude determination was severely hurt by this blowing dust, but the thing that was confusing to me was that it was hard to pick out what your lateral and down-range velocities were, because you were seeing a lot of moving dust that you had to look through to pick up the stationary rocks and base your translational velocity decisions on that. I found that to be quite difficult. I spent more time trying to arrest translational velocities than I thought would be necessary. As we got below 30 feet or so, I had to select the final touchdown area. For some reason that I am not sure of, we started to pick up left translational velocity and a backward velocity. That's the thing that I certainly didn't want to do, because you don't like to be going backwards, unable to see where you're going. So I arrested the backward rate with some possibly spastic control motions, but I was unable to stop the left translational rate. As we approached the ground, I still had a left translational rate which made me reluctant to shut the engine off while I still had that rate."]

[Conrad (12-1-69) - "As soon as I got the vehicle stopped in horizontal velocity at 300 feet, we picked up a tremendous amount of dust; much more than I had expected. I could see the boulders through the dust, but the dust went as far as I could see in any direction and completely obliterated craters and anything else. All I knew was there was ground underneath that dust. I had no problem with the dust determining horizontal or lateral velocities, but I couldn't tell what was underneath me. I knew I was in a generally good area and that I was just going to have to bite the bullet and land, because I couldn't tell whether there was a crater down there or not...(At 100 feet), the dust was bad enough and I could obtain absolutely no attitude reference by looking at the horizon and the LM. I had to use the 8-ball. I had attitude excursions in pitch of plus 10 and minus 10 (degrees), which happened while I was looking out the window making sure that the lateral and horizontal velocities were still nulled. I would allow the attitude of the vehicle to change by plus or minus 10 degrees in pitch and not be aware of it, and I had to go back in the cockpit and keep relevering the attitude of the vehicle on the 8-ball. I was on the gages in the cockpit doing that at the time the Lunar Contact light came on. I had that much confidence in the gages."]

[Shepard (2-17-71) - "I believe that we had less problems with dust than they've had before. I think it's because, as we comment later on (in the 14 transcript), the surface of the general area in which we landed was less dusty - that is, exclusive of the dust around the rims of craters. The general area appeared to have less dust and we certainly

had no problem with dust at touchdown...The dust was obvious, but you could also see the rocks through the dust. We had no problems here."]

[Mitchell - "I might add that, looking at the film of the descent last night, the dust problem appears a lot worse on the film than it appeared to me out the window. I thought I could see it (the ground) a lot better."]

[Shepard - "You probably would, in any event, because the camera is only looking at one spot and you don't have the more general feeling that your eyeball gives you."]

[Mitchell - "Right; but just looking out the window, you can see the dust is not a great problem at all."]

[Scott (8-14-71 - "(At 150 feet) I could see dust - just a slight bit of dust. At about 50 to 60 feet, the total view outside was obscured by dust. It was completely IFR (Instrument Flight Rules). I came into the cockpit and flew with the instruments from there on down...I think if you had to move from one point to another, you could do it quite well. I would recommend maintaining an altitude of at least 150 feet so you don't get into the dust problem. I think dust is going to be variable with landing site."]

[Young (5-5-72) - "From 200 feet on down, I never looked in the cockpit. It was just like flying the LLTV (Lunar Landing Training Vehicle); your reference is to the ground outside. You had another thing that nobody has ever remarked about before, and that was the (LM) shadow. I really didn't have any doubt in my mind how far above the ground we were with that shadow, coming down. I had no scale of reference to the holes; but, with the shadow out there in front of you and coming down, it really takes all the guesswork out of it. For that kind of Sun angle, if the radar had crumped (failed), I don't think you'd have had a bit of trouble in just going right in and landing just like a helicopter. First, we could see the thing all the way to the ground; second, the shadow was right there to help you out with the rate of descent. When Charlie says (in the transcript) 'you stopped and you're hovering', there wasn't any doubt in my mind that I was hovering. I could look out the window and see that we're hovering just like a helicopter. We were well into the dust - maybe 40 or 50 feet off the ground - when we're doing that."]

[Duke - "It started at about 80 feet, John."]

[Young - "Yes, 80 feet. Certainly, it started there and it got a lot worse; but you could still see the rocks all the way to the ground. The surface features, even the craters, and with something like that...Which really surprised me. I was expecting two things: either the dust would be so bad we couldn't see anything, or there probably wouldn't be as much dust as there was. Possibly, it's the 15-degree Sun angle that did all that. Because there's certainly plenty of dust down there to blow, and there's nothing thin about the regolith around the LM."]

[Cernan (1-4-73) - "We started to get dust somewhere around 100 feet."]

[Schmitt - "In my window, I didn't see dust until about 60 or 70 feet."]

[Cernan - "The dust layer was so very thin that I could definitely see through it all the way down. It didn't hamper our operations at all."]

121:04:24 Schmitt: Okay, Houston. Mark it, enabled.

[Jack has pushed the LSPE button on the back of the Central Station, probably with the UHT.]

121:04:29 Parker: Okay, finally. Thank you.

121:04:31 Schmitt: (Talking to Houston) Whoops, I moved your Central Station. I've got to realign on your antenna.

121:04:36 Parker: Stand by, Jack. Wait a minute. (Pause)

121:04:45 Schmitt: Well, the gnomon's still aligned. I thought I moved it.

121:04:50 Parker: Okay. Well, let it be.

121:04:51 Cernan: We should have raised the flag on this thing.

[Gene means they should have used the core stem as the pole for the U.S flag, because it is so firmly planted. About 8 feet of the stem is now out of the ground.]

121:04:56 Schmitt: It (the gnomon shadow) looks just the same as when I left it, but I thought I moved it.

121:04:59 Parker: Okay, Jack.

121:05:06 Schmitt: Is it okay, Bob? (Pause)

121:05:14 Parker: Okay. Leave it alone for right now, Jack, and we'll get a reading on it...

121:05:18 Schmitt: Okay.

121:05:19 Parker: ...for a minute or so. (Pause) And,

Jack, I guess right now, you might get some fairly rapid samples in the area, since you're probably almost ready to leave. And can you tell us what you saw there in the vicinity; you were giving us a description of the boulders there and plate-iness and alignment of the crystals...the plag(ioclase). You want to amplify that a little bit?

121:05:42 Schmitt: Okay...(Listens to Parker's final remark) I will as soon as I get back over there with a sample bag. Bag 10 Echo - one-zero Echo - is a sample of the very large boulder (Geophone Rock) that's just beyond Geophone 3. Just west...just south.

[Jack has collected a rock fragment and has put it in one of the small Teflon bags used to pack individual samples. Each of them is marked - in this case "E-10" - so that there will be no confusion as to which sample was taken where. The checklist calls for Jack and Gene to mount a pack of 20 sample bags on each of their 70-mm cameras when they start

preparing for the geology traverse at 121:26:32. In this case, Jack has used one of the "dixie cup" sample bags described in greater detail at 141:23:00, probably having taken one off of the stack stowed on the geopallet. Sometime in the next few minutes, Jack will mount a pack of sample bags on his camera.]

121:06:02 Parker: Copy that, one-zero Echo, and boulder east of which geophone?

121:06:09 Schmitt: South of geophone 3...(Correcting himself) Southwest. And I got a few photos to document the boulder. I'm not sure I documented the sample, though.

121:06:21 Parker: Okay, copy that.

121:06:22 Schmitt: It's the same kind of rock I saw near the LM. And...(Pause) It's a gabbro. I'm beginning to lean towards 50 percent plagioclase, though.

121:06:45 Parker: Okay. (Long Pause)

[Schmitt - "A higher percentage of plagioclase indicates a higher proportion of silica, calcium, and aluminum in the lava. We were looking at relatively coarse-grained rocks formed from an extrusive lava flow and the higher proportion of plagioclase suggests that the flow might have differentiated, with the plagioclase-rich crystals having floated up toward the top of the flow."]

[Fendell pans away from Gene.]

121:07:13 Cernan: Bob, I had to remove the treadle from the hole and I'll tell you later why.

121:07:21 Parker: Okay, go ahead.

121:07:23 Cernan: Oh, me! (Responding to Parker) No, I'll tell you later why. I'm just figuring, oh me, how am I going to get all this stuff now?

[Fendell pans past Gene. The core is now completely out of the ground. Gene mentions his reasons for removing the treadle at 121:14:14 and 121:15:36, albeit not with any great clarity.]

121:07:34 Cernan: I'm going to lose my hole. Okay, it was right there. In our fiasco over here, we knocked everything over.

121:07:39 Schmitt: Did I ruin something?

121:07:41 Cernan: Nope, I've just got to stoop over to get things and that's a major, major effort these days.

[The Experiments people in Houston want Fendell to watch Gene.]

121:07:48 Schmitt: Can I help you?

121:07:49 Cernan: No, I got it here. I've got a delicate core in one hand, and I'm trying to get some core caps in the other. (To Parker) You'll be glad to know it's full (at the bit end), Bob. And while I'm the only one to see the bottom

end right now, I'm going to tell you (that) it looks like what I'm walking on, but it's obviously not powdery. It's obviously very cohesive, because the bottom of the core is not smooth. It's very jaggedy, and fragmental-like.

121:08:25 Parker: Okay, copy that, Geno. Very good.

121:08:31 Cernan: Well, I'm being very careful with your core here, but I've got to do a few little housekeeping chores first.

[Fendell pans past Jack, who is running southeast, away from the Rover.]

121:08:36 Parker: Okay. Have you got that neutron flux over there in the vicinity, or is it still back at the Rover?

121:08:43 Cernan: No, sir, I already got it.

121:08:45 Parker: Okay; good enough.

121:08:46 Cernan: You haven't been looking.

121:08:48 Parker: And Jack, in your travels there, while you're doing some sampling, if you happen to wander by in the approximate vicinity of the deep core, you might get us a Rover sample of the soil there.

121:09:03 Schmitt: Okay.

[Because Jack has used one of the dixie-cup bags, Parker is under the impression that Jack has assembled the LRV Sampler.]

121:09:05 Cernan: Bob, the core is filled to within an eighth or certainly less than a quarter of an inch from the bit.

121:09:12 Parker: Okay. Sounds good to me. Sounds like a good candidate for a cap.

[Fendell returns to Gene, who has picked up the rack and drill. The core is laying in the rack.]

121:09:20 Cernan: Yes, sir, and it's got Bravo on and the plug has been discarded.

[The plug would have been inserted into the tube and forced in against the end of the core had the bit end not been full, thereby preventing movement of the core material in the tube and also preventing destruction of evidence of layering.]

121:09:23 Parker: Copy that.

121:09:29 Cernan: Now, let me see what else I can get here, before I get too upset. I need my...The drill, besides performing admirably, is a tool of necessity to lean over and pick things up with.

[Cernan - "I used the drill as a cane so that I didn't have to get all the way down on my knees. Without it, the only way you could get something off the ground was to get

down on your knees because you couldn't bend over. But, if you had a short cane like the drill - the drill was probably 12 or 18 inches high - you could lean on it and then reach over with the other hand to pick things up. It's hard for people to understand the kind of problems you had getting up and down, reaching down to pick things up from the ground. On Earth, we take for granted our mobility and our motion capability. Plus we take for granted the full force of gravity. In lunar gravity, when you were leaning on the drill, you don't lose your balance as quickly as you would on Earth, so that was an advantage. But when you're being held down by Earth gravity you can handle a lot more torque than you can being held down by 1/6 gravity. It's those kinds of things that made this a difficult task. It was just very difficult to flex that stiff suit."

[Gene tries to reposition the drill, but it falls over.]

121:09:45 Cernan: Except when you let it fall down.

121:09:49 Parker: Okay. And our next priority is to put the neutron flux down the hole, we hope.

[Gene picks up the gold-covered probe. He is on CDR-21.]

121:10:02 Cernan: Well, we shall see. Man, I don't even know if I can find the hole. It's in the shadow now. I guess I can see it down there. (Pause)

[Gene unwraps the lower section of the probe.]

[Cernan - "Remember, this was a disturbed surface, a very beat up area. There were footprints all over. And it was basically all one bland color. I had just drilled the hole a couple of inches in diameter, I'd gone four or five feet away, had come back, and then had to find the hole. If I hadn't left something close to the hole, so I'd know where to look, it probably would have been very difficult to find. You were looking across the entrance to that hole, and you were still looking at the same color in the wall of the hole. The low Sun would give you a shadow close to the top, but you wouldn't have seen that unless you were almost on top of the hole. And I'd drilled the hole in a hummocky crater, a little depression, that had some slopes on it. So, I was afraid of going back and not finding that hole to put the experiment into."]

[Schmitt - "I'm still amazed that, after everything we did around that hole, that it was still open and that Gene was able to find it. The ground had really gotten chewed up and, by all rights, the hole should have fallen in, at least near the surface."]

121:10:11 Cernan: There it is. Okay. You asked, and with a little bit of luck, you shall receive. (Pause) Listen, I'm earning my three and a quarter a day today. (Pause)

[Bob Parker says that \$3.25 was the prevailing per diem rate with government-furnished meals and lodgings.]

121:10:37 Cernan: (To himself) Oh, boy, I don't want to lose the rammer either. Let me get that before that gets lost in the shuffle. We don't want to lose that, for sure.
(Pause)

[Gene tries use the probe to pick up the rammer. He flips the rammer up to head height but gives it enough motion away from himself that it flies almost out of the TV picture. Gene moves forward to retrieve the rammer.]

121:11:04 Cernan: (To Houston) I bet you all think I'm stepping on that hole, don't you?

121:11:10 Parker: I don't. (Pause) John (Young) doesn't, either.

[This time, Gene gives the rammer a little inward motion, flipping it upward with the probe in his right hand. This time, the T-shaped head of the rammer hooks on the probe tip and he catches it with his left hand. He then hangs the rammer on the rack and activates the lower section of the probe. In brief, the neutron probe consists of targets containing either boron or uranium-235 which, upon capturing neutrons, emit alpha particles or fission fragments which are then captured by plastic or mica detectors. The instrument consists of an outer tube containing the detectors and a central core containing the targets. Because the targets and detectors do not cover the whole surfaces of the core and tube, respectively, the core can be twisted so that the target/detector pairs are either next to each other or 180 degrees apart. In the latter case, very few alpha particles or fission fragments are captured by the detectors and, therefore, the instrument is "off".]

121:11:19 Schmitt: Bob, I see no clear alignment of plagioclase or pyroxene in this rock. That's the one with the parting in it. It looks as if - integrating what I've seen here and over at the big rock, the geophone rock - the layering or the foliation or the parting, whichever it is, is the result of variations in vesicle concentrations. The sample 10 Echo is a sample of the more coarsely vesicular rock. I could not get one of the more finely or non-vesicular fragments. But I got pictures of it.

[Schmitt - "An alignment of elongated minerals such as plagioclase or pyroxene is called a lineation, and generally indicates that there has been a flow or some stress in the direction of alignment. The term 'foliation' is usually reserved for a situation where the orientation of tabular minerals creates a planar variation in the rock. A 'parting' indicates how the rock breaks, usually along foliation planes."]

[Gene is doing some detailed finger work on the neutron probe.]

121:12:05 Parker: Okay, copy that. And do you see any...
 121:12:08 Schmitt: I'm having trouble getting...(Listens to Parker)
 121:12:10 Parker: Go ahead.
 121:12:13 Schmitt: Go ahead.
 121:12:14 Parker: And, do you see any evidence of soil on top of some of these medium-sized boulders?
 121:12:21 Schmitt: There's soil. A little bit of dust in some of the holes. But there's not enough to sample at this point. I may find some later.
 121:12:33 Parker: Okay, copy that. (Pause)
 121:12:43 Schmitt: Vesicle walls do not seem to be as shiny (as in other Apollo lavas).. Most of them seem to have dust in them.
 121:12:54 Parker: Copy that.
 121:12:55 Schmitt: The vesicles are not cleanly (that is, smoothly) spherical. They're spherical but they have fairly rough outlines. They look as if there's been some recrystallization.
 121:13:10 Parker: All right.

[Schmitt - "In molten rock, vesicles usually start out being roughly spherical in shape but, once the rock has solidified, if it stays warm for long enough, there will be a tendency for crystals to grow and destroy the smoothly spherical outline. If the rock cools slowly enough, the vesicles would start to look like 'vugs', with the crystals growing right into the void."]

[Gene removes top section of the probe from its sheath and threads it into the lower section.]

121:13:12 Cernan: Bob, I will verify that the lower section is On (that is, activated).
 121:13:16 Parker: Okay, thank you, Geno. (Long Pause)
 121:13:30 Schmitt: I picked the wrong rock to sample with a scoop, I'll tell you that. (Long Pause)

[Jack's sample is too big for the scoop. He has taken photos AS17-136-20714 thru 20717. Gene uses the probe to pick up the empty sheath, and then lays the sheath on the rack.]

121:13:50 Cernan: Boy, I'll tell you, housekeeping is the key to the world right now.
 121:13:52 Parker: Okay, Geno and let's...
 121:13:54 Cernan: Okay, another key to the world is whether the...(Stops and listens)
 121:13:56 Parker: Geno, stand by. Hold it.
 121:13:59 Cernan: Yeah.
 121:14:00 Parker: Okay, make sure that the top of it doesn't go down through the hole, too, and disappear, either

by putting it through the treadle, or if you're sure that the...Or whatever.

[The neutron probe is a self-contained unit and, among other things, has no cable connecting it to electronics on the surface, a cable that would prevent the probe from falling out of reach to the bottom of the core hole. At the end of the third EVA, Jack will return to the ALSEP site and retrieve the probe so that he and Gene can bring it back to Earth for analysis.]

121:14:14 Cernan: Boy, Bob, that sure is a good thought. You know, I had to take the treadle off because the jack (handle) wouldn't go down and there's no way I could put that treadle...Well, let me turn (the top section) on first. That was a good thought. It may go down that hole. That would be terrible.

[Gene may mean that, after he got the core out of the hole, he tried to push the jack handle into its shortened, stowage position and couldn't. However, the problems he foresaw in emplacing the probe through the treadle aren't apparent.]

121:14:32 Parker: How big's the hole look, Geno?

121:14:33 Cernan: See, the jack wouldn't...(Listens) Well, looks big enough to put this down. Let me use my judgment on it. (Pause)

[Gene uses the probe to pick up the treadle.]

121:14:46 Cernan: And a little ingenuity. (Long Pause) I verified the top (section) was On (that is, activated), by the way.

121:15:08 Parker: Okay, thank you. (Long Pause)

[Gene uses the jack handle to position the treadle over the hole but doesn't yet set it on the ground. He puts the probe through the hole in the treadle and then puts the tip of the probe in the hole and lowers it about a foot or so without lowering the treadle. He then drops the treadle to the ground and, finally, he lets go of the probe, which falls into the hole until the top catches on the treadle.]

121:15:27 Cernan: Shazam!

[Schmitt - "As I remember, Captain Marvel, the comic book hero, was a handicapped newspaper boy who, when he said 'Shazam', turned into Captain Marvel."]

121:15:28 Parker: How about that! Loud applause, loud applause.

121:15:36 Cernan: (Excited) See what happened, here, to that treadle, Bob? I couldn't get the jack (handle) to go

down and it made the hole oblong when I...But it's all right now.

121:15:42 Parker: Okay; beautiful, beautiful.

[Apparently, with the handle upright, the opening through the treadle has an elongated shape. However, the probe was able to fall through until the top caught.]

121:15:44 Cernan: I mean, it ended up all right.

[Gene seems to be covering the top of the probe with the gold sheath.]

121:15:46 Parker: Okay. And why don't we get you two guys together again, now, and break down the core and press on. And we've got a little revision here to the EVA. I'll get with you in just minute, as soon as I find out what it is.

[Parker asks the Flight Director for a briefing on the EVA plan.]

121:16:05 Cernan: Bob, I feel pretty good about that. That makes me feel pretty good.

[Cernan - "It was a lot of hard work; and it was very satisfying to get it done."]

121:16:11 Schmitt: (Sample) bag 174...(correcting himself) 474 (is) soil from next to this big rock. It's the fillet. I can't get a chunk of the rock.

[Here, Jack is using one of the flat sample bags, suggesting that, although the checklist calls for Gene to mount packs of bags on the cameras during the upcoming geo-prep period, Jack already has a pack on his camera. At 121:26:54, he indicates that he had mounted a pack on his camera sometime prior to that time. Jack takes a stereo pair of this sample location, AS17-136-20718 and 20719.]

[Schmitt - "The sample bags were reasonably clear Teflon, with a little metal double-spring that held the lip open a little bit. They also had tabs on either end, and what you could do was push against those tabs to open it up even more, get your sample in it, and then pull them closed and then twist the tabs down. It wasn't a vacuum seal but it wasn't a bad mechanical seal to keep the sample from falling out."]

121:16:22 Parker: Copy. (Missing Jack's correction) 174, fillet beside the big rock. And, Jack, while you coming back here to the Rover, why don't you get one more Rover sample in the vicinity of the deep drill, while you and Gene get ready to take on the core stems. And because of being a little bit behind here, what we're doing is, we're getting prepared to drop Station 1 in favor of doing Steno (Crater). Over.

[Fendell pans clockwise, away from Gene.]

121:16:50 Parker: And I'll get with you on more details on that in a minute.
 121:16:54 Schmitt: Well, how far behind are we?
 121:16:57 Parker: Stand by. (Pause) You're between 35 and 40 minutes. And part of the problem is that we're a little short on oxygen on Gene's PLSS. It looks like it's a 6 hours and 45 minute EVA from that point of view (rather than seven hours as planned), which means that we'd have to leave Station 1 too early (to get very much useful work done). (Pause) Which is the reason to curtail Station 1, apart from just (being) behind which is what the hooker was.

[They will actually have a 7 hour, 12 minute EVA. The work load and, consequently, the oxygen use rate will drop significantly once they start the traverse. Station 1 was to have been a stop at the east rim of Emory Crater, an impact feature 650 m in diameter. Fendell pans past Jack, who is returning to the Rover from the south, scoop in hand.]

121:17:38 Cernan: Okay, Bob, I'm approaching the rear of the Rover. I've got the core, the cap, the wrench, and the rammer.
 121:17:44 Parker: Okay. (Pause)

[Gene is on checklist page CDR-22 and is about to separate and cap the core sections for transport back to Earth.]

121:17:55 Cernan: Well, I didn't mean to breathe up all that oxygen.
 121:17:58 Parker: Well, there's some things you can't help. Even the (Flight) Surgeon agrees with me on that one. And for your thinking, Jack and Gene, what we're doing is planning on going to the west side of Steno and that boulder field that's part way out to Station 1.

[A number of boulders on the west rim of Steno could be seen in blowups of pictures taken from the Apollo 15 Command Module. These are indicated by X's in the traverse map. Readers might want to note that Geophone Rock, which is near the planned landing site, was not noticed in the Apollo 15 pictures. The boulders at Steno can be seen in the accompanying blow-up of the relevant section of a frame taken with the Pan camera aboard the Apollo 17 Command Module.]

121:18:20 Schmitt: (To Gene) Okay, you want to break that (core) and I'll go get this sample, Gene.
 121:18:24 Cernan: Yeah; I'll break this, Jack; no sweat.

[Jack will get a surface soil sample from the deep core site while Gene separates the sections of core stem for later

packing. Gene will put the core in a small vise mounted on the top of the geopallet and use the wrench to twist off one core section at a time.]

121:18:30 Schmitt: Gene has pretty well chewed up the ground. I helped him (chew up the soil). Do you want me to get a little ways away from it?

{Jack's photo of the deep core hole and the associated hardware is AS17-136-20720.]

121:18:36 Parker: Stand by. I don't think we're interested in a surface sample in the last top little bit, I think. It's just the top...Just a surface sample. Stand by, though. (Pause) Anything there in the dirt, Jack. It doesn't have to be a skim sample of any sort. (Pause)

[The surgeon reports to the Flight Director that, during the first four hours of the EVA, Gene's average metabolic rate has been 1170 BTU/hr and Jack's 1120. These compare with the predicted averages of 1050.]

121:19:06 Cernan: Okay, Bob, I'm breaking down the core at the tail end of the Rover, here.

121:19:09 Parker: Okay, congratulations.

121:19:14 Cernan: Well, don't do it yet, I haven't gotten it broken down yet (without spilling anything). (Pause) But I got it out of the ground with a little help. (Pause) Okay, first piece of three sections. Bob, it's full.

[Fendell finds Jack, who is sampling near the core hole.]

121:19:40 Parker: Okay, beautiful.

121:19:41 Cernan: And I have to tell you which end I'm taking it from. I don't remember which end I've got here.

121:19:45 Parker: That's all right, since we got the cap and Alpha on one end and Bravo on the other end. (That's cap) Bravo.

121:19:55 Cernan: Man! There's a cap that's going to be tough to get on. I put that on with a hammer. Oh, boy!

121:20:03 Schmitt: Okay, Bob, there's a mixture of soil and a rock in (sample bag) 475.

121:20:08 Parker: Okay, copy 475.

[Experiments wants to continue watching Gene. So, Fendell leaves Jack and pans clockwise, looking for Gene. He has to pan through almost a complete, 360 degree circle.]

121:20:09 Schmitt: The soil came from about 0 to 5 centimeters (depth).

121:20:19 Parker: Okay, copy that. Beautiful.

121:20:21 Schmitt: And it's about 3 meters from the hole. Well...

121:20:31 Cernan: Hey, Bob, cap Charlie is opposite Alpha. That was the first 3-section.
 121:20:38 Parker: Okay, copy that. (Pause)
 121:20:46 Schmitt: Bob, it's about 3 meters from the hole. I got a stereo "before" at 11 feet and one "after" at 11 feet.

[Contrary to his statement, Jack apparently took a single "before" picture of the sample site. The before and after pictures are AS17-136-20721 and 20722, respectively.]

121:20:55 Parker: Okay, copy that. And how about a frame count there, Jack.
 121:21:01 Schmitt: Stand by. (Long Pause)
 121:21:33 Cernan: I tell you. (Pause)
 121:21:40 Schmitt: (Can I) help?
 121:21:42 Cernan: No, I can get it. Boy, this system works good. (Pause)

[Gene is referring to the vise/wrench. Fendell finds him at the back of the Rover, using the wrench to turn a stem section. It detaches very easily.]

121:21:55 Schmitt: Okay, let me see. Let me configure the old LRV sampler, here. (Long Pause)

[This is the so-called "dixie cup" sampler made up of a UHT fitted into a holder for a stack of cup-shaped sample bags. The sampler will allow Jack to collect rock fragments and soil during the Rover drive without dismounting. Jack has returned to the Rover, carrying one of the two UHT. He goes to the gate where he will get the cup holder for attachment to the UHT.]

121:22:19 Cernan: Oh, boy; oh, boy; oh, boy; oh, boy.

[Gene is expressing his heartfelt relief that the drilling job is done. He puts a cap on the core section and hammers it on with his glove.]

121:22:22 Parker: Jack, this is Houston. Over.
 121:22:25 Schmitt: Go ahead.
 121:22:26 Parker: When you took those two pans at the ALSEP, was one at 15 feet and one at 20 feet?
 121:22:33 Schmitt: One was at...Focus was at 15 and 74.
 121:22:37 Parker: Okay.
 121:22:38 Schmitt: There's a partial pan on mag A (Alpha or 147), which was taken at 15 (feet focus).
 121:22:46 Parker: Okay. Understand.

[Gene removes the wrench and takes the core section to Jack's seat so that he can get it out of the way.]

121:22:53 Cernan: Okay, Bob...I can't see what it is. I guess Delta and Echo is the 2-section core. Delta being adjacent to the first section of 3.

121:23:08 Parker: Roger. Copy that, Gene. (Pause)

[Gene returns to the vise and puts a cap on the now open end of the core.]

121:23:19 Cernan: Okay, baby, just go on there nice. The last one is Foxtrot. (Pause; Gene hammers the cap with his fist) And it's on tight. (Pause) Ow.

121:23:52 Schmitt: Arms tired?

121:23:53 Cernan: That hurts. Oh, me; oh, my. I'm going to take a big drink of water here.

[Gene takes the core to Jack's seat.]

121:24:00 Cernan: We got them three cores; we got the neutron flux down; and we got two heat probes, and an ALSEP. I don't care if we are 30 minutes late. (Pause)

[Cernan - "Maybe we were 30 minutes late, but at least we got the job done and we got it done right. I think that was the feeling we had. A feeling of satisfaction. That's what we went up there to do during that period of time and we did it. It was a lot of work, probably more work than people anticipated because we ran into problems in getting the core out, but we got it all done."]

[Schmitt - "I was not quite so satisfied as Gene was at this point because of the time we were losing for exploration. The difference was natural. Gene was very pleased with having gotten the ALSEP properly deployed, while I was concerned that we hadn't spent much time yet learning about the Moon."]

[Gene is sounding livelier than he had while he was struggling with the drilling and the core extraction.]

[Cernan - "If you expend energy at a high rate and you're not careful, frustration can set in. Fortunately, when I was a little kid, I used to work with my dad in building things: rebuilding automobile engines, building garages, fixing plumbing, or whatever it was. These kinds of things were fundamental things to me. My dad used to always say, "Do it right, or not at all." And it certainly applied to what we we're doing here, because we only had one chance to do it."]

121:24:17 Cernan: Bob, did I give you the last cap?

[Gene consults his checklist. He is about finished with CDR-22. Readers who have been following along in the checklists should note that CDR-23 is a duplicate of LMP-25, the ALSEP photo plan, and is not reproduced here.]

121:24:19 Parker: That's okay, Gene. We don't really need it. The way they're broken down, there's no problem. The 3-

2-3 stands out and the Bravo on the bit end. There's no problem there.

121:24:31 Schmitt: Hey...

121:24:34 Cernan: What do you need, babe?

121:24:35 Schmitt: Can you pull that off?

[Jack hasn't gotten the LRV sampler attached properly to the UHT. During the following exchange, Jack asks Gene to grab the sampler head and pull it off - with Jack still holding on to the UHT - so that they can get it properly aligned.]

121:24:36 Cernan: (Confirming what Jack wants him to do) Pull this off.

121:24:37 Schmitt: Yeah. Rotate it 180, there. (Pause) No, no, no, just the...The total thing. That's good. There you go.

121:24:45 Cernan: Like that?

121:24:46 Schmitt: Yeah.

121:24:50 Parker: Okay, and, 17...

121:24:51 Schmitt: Okay, I have to line it up.

121:24:52 Parker: Go ahead.

121:24:54 Cernan: Okay. I'll hold it. You do it.

121:24:56 Schmitt: I got it.

[Jack returns to the gate.]

121:24:57 Cernan: Okay. Let me give you a (gravimeter) reading, Bob, before you speak. Wait a minute, let me get it over with.

[Gene goes to the rear of the Rover to read the gravimeter. For this reading, he had not taken the instrument off the Rover.]

121:25:06 Cernan: It's 670, 002, 601. That's 670, 002, 601.

121:25:16 Parker: Did you punch Grav a second time? That's identical to the first one.

121:25:24 Cernan: It (checklist page CDR-22) just said to read it. That's what you want, isn't it?

121:25:26 Parker: Yeah, but did you punch Grav after the first reading you gave me there at the ALSEP? Or are you just reading me the same measurements you did before?

[Gene was supposed to have punched the Grav button when he was at the Rover getting the treadle. That was on CDR-21 and, in his eagerness to get the core out of the ground, he forgot to do that task. See Gene further comment below at 121:35:53.]

121:25:37 Cernan: Bob, I called them out every time. (Listens) Bob, I'm reading it right here. Everywhere I punched Grav, you've got it written down somewhere.

121:25:48 Parker: Yeah, and I didn't copy your punching Grav, but the one...

121:25:53 Cernan: Bob, I did not. When I went to get the treadle and the neutron flux and rammer, I did not punch Grav.

[Jack is working at Gene's seat.]

121:25:58 Parker: Okay. So that's the same as the first one. Never mind, thank you. And guys, we're ready for you guys, as you go along here, to do the Geo Prep and press on. As I say, we'll go to Steno and come back from there and do the S.E.P. Over. Any questions about that? (Pause)

[The Surface Electrical Properties Experiment (SEP, usually pronounced "Sep") measured variations in the conductivity of near surface materials and gives an indication of the subsurface geologic structure. It consists of an antenna, receiver, and data recorder mounted behind Jack's seat and a transmitter and associated antenna which they will deploy 150 meters east of the LM. As soon as they finish with the ALSEP deployment and their preparations for the geology traverse, Jack will run back to the LM, get the SEP transmitter, and then will carry it out to the deployment site. After the geology traverse, they will then deploy the transmitter and lay out the transmitter antenna.]

121:26:18 Parker: We'd also like to know if you have the gnomon, back at the Rover?

121:26:24 Cernan: No, we're just...(Listens to Parker's final question)

121:26:25 Schmitt: Yes, we do (have the gnomon).

[They are both now at the back of the Rover. They are about to prepare for the geology traverse. Details of the Geo Prep are on LMP-26 and CDR-24.]

121:26:28 Cernan: (Reviewing checklist page CDR-21, which he has completed) Okay, "lay cores in..." (Finding the right page) Okay...

121:26:29 Schmitt: Can you put that in that sampler tool bag, there?

121:26:32 Cernan: Yes, sir. (Pause) We're configuring for geology now, Bob.

121:26:38 Parker: Okay, copy that.

121:26:44 Schmitt: Bob, right now, 10 Echo is in my suit pocket, I hope.

121:26:50 Parker: Okay.

[They each have a pocket on their right shin and on their left thigh.]

121:26:54 Cernan: Okay. (Reading CDR-24) "Mount 20-bag dispenser (from) SCB 1." Let me get at them.

121:26:57 Schmitt: I've got mine on.

[The sample bags come in bundles of twenty which are hung from hooks at the bottom of the 70-mm cameras. That way, the bags were always in easy reach. The sample bags have been stowed in Sample Collection Bag (SCB) number one. The SCB's are much larger bags made of laminated Teflon cloth and are each 42 cm high, 22 cm wide, and 15 cm deep. Each of the astronauts will wear one on his PLSS. After a sample is sealed in one the small, clear Teflon bags, they will put it in one or the other of the SCB's. Gene swings the gate closed; from the perspective of the TV camera, the top of it is about level with the top of his helmet.]

121:26:59 Cernan: Okay. (Pause) Oh! ("Rats!") This probably goes under the seat, doesn't it? (Pause) Get the camera...Where the devil mine is? Excuse me. Oh, I see the gnomon!

[Gene goes to his seat, carrying a packet of sample bags. The gnomon is on his seat.]

121:27:29 Schmitt: I put it there so I wouldn't forget it.
121:27:31 Cernan: (Laughs) Okay. I tell you, dexterity is the key. Look at those cover gloves.

[The cover gloves are dark brown from the impregnating dust. To prepare the gnomon for stowage, Gene grasps the legs which, rather like umbrella stays, collapse onto the central axis. He then puts the gnomon in its stowage sheath behind his seat.]

121:27:45 Schmitt: I guess we can take those off. I don't know whether we ought to or not.

[Cernan - "The cover gloves had fingers that were cut out, rather like a golf glove. They went over the regular glove and covered the palms. Because of all of the drilling and such, we just wanted to put a little more protection on our regular gloves. We were only going to use them for the first EVA, because that's where all the manual labor was; the rest was all traverse work. You've seen how hard we worked with those things up to this point; and they were just ripped up and torn up and really battered. Most of the damage was a result of abrasion."]

121:27:47 Cernan: I'm going to leave mine on for a while. I changed my mind. I want to look at my gloves before I take them off. (Pause)

[Gene has decided not to discard the cover gloves until, once back in the LM, he's had a chance to examine his suit gloves for wear. Jack is at his own seat, fiddling with his camera.]

121:28:03 Cernan: (Consulting his checklist) Okay, where are we? You got your camera, obviously. This is my camera. I'll get the bag dispenser on it. (Pause) It's not a bad day's start. Bob, is the ALSEP working good?
 121:28:16 Parker: The last we heard, it was working great, guys. We'll check again, though.
 121:28:22 Cernan: Okay. (Reading) You got your camera. My camera is in the floor pan. Cap dispenser (from) SCB 1 to Gate. Let me get that.

[Gene is taking a core cap dispenser from SCB 1 - in which the sample bags had also been stored - and will put the dispenser in a storage slot on the gate. These are caps for short core tubes - called "drive tubes" - which they will hammer into the ground at several of the geology stops.]

121:28:30 Cernan: Jack?
 121:28:31 Schmitt: Yeah?
 121:28:32 Cernan: You haven't been on the Rover yet. It's real easy; but it's also very easy to kick dust all over those battery covers, so don't even get on it until I put those battery covers down.
 121:28:40 Schmitt: Yeah. Hey, I guess we ought to press on as if we're going to Station 1.
 121:28:45 Cernan: Yeah, you've got to walk back to the LM anyway. We got to...
 121:28:49 Parker: Roger. Guys, we are going to play it per the checklist. Jack will carry the things (the deep core sections) back. Gene will get the thing (the Rover navigation system) aligned. We'll go out to the SEP site. And then we'll press on from there down to Steno. Over.

[Jack removes his camera from the bracket on his chest and stows it under his seat.]

121:29:03 Cernan: Okay, very good.
 121:29:06 Parker: And right now...
 121:29:08 Cernan: Okay. (Reading) "Stow (rammer and hammer on) LMP". (To Jack) You want to come over here and I'll stow your PLSS?

[That is, Gene will put equipment on Jack's PLSS.]

121:29:11 Parker: Go ahead. Never mind.
 121:29:13 Schmitt: Yeah. (Pause)

[Jack goes to the gate.]

121:29:19 Schmitt: My camera's under my seat.
 121:29:22 Cernan: Okay, you can turn around.

[Gene starts working on the left side of Jack's PLSS.]

121:29:27 Cernan: Oh, man! (Laughs) What have you been in? Hallelujah. (Pause) I'll keep the hammer, I'll give you this. Can you reach the rammer? It's right in front of you. On the...

121:29:47 Schmitt: Oh, yeah.

[Checklist page CDR-24 calls for Gene to mount both the hammer and the rammer on Jack's PLSS, but he has decided to keep the hammer handy in his shin pocket. The rammer is a short, thin rod used to seat plugs in the drive tubes.]

121:29:49 Cernan: I haven't got that cap in, yet. There it is. Okay, the caps are in.

[Jack hands the rammer to Gene.]

121:29:53 Schmitt: If we ever come out here again, I want to get your hammer and get a sample...(garbled under Parker).

[Jack is probably thinking about getting a sample of one of the boulders. Only Gene's camera is loaded with color film. See the discussion following 120:54:26.]

121:29:53 Parker: Jack, you might give us a frame count on Hotel.

121:30:00 Schmitt: Okay, Bob.

121:30:03 Parker: And we're going to hand over stations. You might get a dropout momentarily.

[Because the Earth turns under the Moon in a little more than 24 hours, no one tracking station can keep continuous contact with the crew. There are three principle tracking stations - Goldstone, California, Madrid, Spain, and Honeysuckle Creek, Australia - which swap every eight hours or so. At this moment - about 10:20 p.m. Central Standard Time, December 11, 1972, the Moon is about to set in Spain and the handover is to Goldstone.]

[Schmitt - "Usually we wouldn't have noticed a handover. The one we did notice came right at liftoff from the Moon when they didn't get the handover done right away and we got a lot of static on the comm. They could hear us but we couldn't hear them."]

[As is discussed at 188:01:28, the initial comm loss at launch was actually due to the LM engine plume and, unfortunately, the operators at Goldstone waited far longer than was necessary to reacquire the spacecraft.]

121:30:04 Schmitt: (Responding to Parker's frame count request) Yeah, it (the camera)'s under the seat right now.

121:30:09 Cernan: Okay Rammer. I got the hammer. Turn around. I'll give you a SCB-2.

121:30:15 Schmitt: Okay.

[Jack turns 180 degrees so that Gene can mount SCB-2 on the right side of his PLSS. This will put the SCB outboard when Jack is seated on the Rover. The spare SCB's are stowed, folded and strapped, on the rear-facing surface of the geopallet, inside the gate.]

121:30:19 Cernan: Okay.

[Gene notices the TV pointed at them.]

121:30:22 Cernan: Now, guess who's watching to see how these hooks are going to work? (Pause) Oh, man. Like a charm, so far. Oh, except your doggone harness is off, too, Jack.

121:30:35 Schmitt: Is it?

121:30:36 Cernan: Yeah.

[As a result of problems experienced with John Young's SCB during Apollo 16, the attachment system was re-designed. At various times during Apollo 17, one or the other of the SCB's will come loose, an indication that the re-design was not adequate.]

121:30:37 Schmitt: Okay, you've got to undo the strap...

121:30:39 Cernan: Let me get at it.

121:30:40 Schmitt: You got to loosen that strap and then just put her underneath, and tighten it up again.

121:30:44 Cernan: This one here?

121:30:46 Schmitt: The one on my right. Yeah.

121:30:47 Cernan: Let me turn around then. I got to get on your...Oh, on your right. Right here.

121:30:51 Schmitt: I think it is; yeah. That's where it is on yours.

121:30:53 Cernan: Yeah, I'd like to make sure the other side is all right, though.

[Gene adjusts the lower right strap on Jack's PLSS.]

121:30:55 Schmitt: Oh, okay.

[Jack turn around and presents the left side of his PLSS.]

121:30:57 Cernan: Let me...Yeah, it's all right. Turn around.

[Jack presents right side again.]

121:31:03 Cernan: Let me just get it underneath. I got it so tight now, the Rover...Okay, now. I got it on.

121:31:12 Schmitt: Okay?

121:31:14 Cernan: Okay, now, I'll get this hooked.

[Gene gets an SCB from the gate and attaches it, top and bottom, to Jack's PLSS.]

121:31:17 Cernan: That hook's going to be a piece of cake, Jack. (Pause) That ought to keep it; and it's all on and locked. (Consulting his checklist) Okay, you got SCB 2. You got the rammer. You got a cap dispenser. Okay. You can secure SCB 1 (to Gene's PLSS).

[Readers following along in the checklist will note that, rather than mounting the hammer on Jack's PLSS, Gene has put it in his own shin pocket.]

121:31:34 Cernan: Doesn't this go under your...
 121:31:35 Schmitt: Not yet, I don't think. I think it stays there.
 121:31:39 Cernan: This (long can) does (go under the seat).
 121:31:40 Schmitt: That does. Yeah. That goes under the seat.
 121:31:42 Cernan: And this goes here.
 121:31:45 Schmitt: Yeah.
 121:31:46 Cernan: Okay.
 121:31:47 Schmitt: Bob, the long can's going under my seat.

[Jack goes to his seat. The long can is about 18 inches long and 3 inches in diameter. Later in the mission, at Station 3, Gene will seal one of the drive tube sections in the long can, protecting it from cabin gases or exposure to the Earth's atmosphere. Note that, in addition to the long can, Jack's camera will be stowed under his seat while he walks back to the LM with the deep core.]

121:31:49 Parker: Okay. Copy that, Jack.
 121:31:50 Cernan: They got a handover, I think.
 121:31:55 Parker: Handover's complete, guys.
 121:31:58 Cernan: Okay.

[Jack returns to the gate.]

121:32:xx Schmitt: (Garbled) which way to unlock those.
 121:32:07 Cernan: Okay, you can pull it off.
 121:32:09 Schmitt: It's unlocked.
 121:32:10 Cernan: It's unlocked. There it is.
 121:32:14 Schmitt: It's usually stiff.
 121:32:17 Cernan: Okay.

[They move to the left rear of the Rover. Jack has SCB-1 to attach to the left side of Gene's PLSS.]

121:32:19 Schmitt: For once, I have my camera off. (Pause)

[Schmitt - "With my camera off, I could get close enough to Gene to attach the SCB easily. With the camera sticking out a foot or so, you had to work at arms length."]

121:32:28 Cernan: Did you get the heat-flow pictures, by the way?

121:32:29 Schmitt: I got most of them. Not all of them. They revised the whole camera (sequence).

[That is, Houston had revised the list of photographic tasks.]

121:32:34 Cernan: Hey, Bob, is it going to hurt to leave the UHT in the heat-flow electronics?

121:32:37 Parker: Stand by.

[Jack's checklist gave him the option of configuring the LRV Sampler when he went back to the Rover after deploying the LSPE antenna at about 120:10. Had he done the task then, he would have used Gene's UHT, keeping his own for the Geophone deployment. His second option was to assemble the Sampler at the start of the Geo Prep, which he did at 121:21:55. Because he was done with his UHT, he used it as the Sampler handle rather than using Gene's.]

121:32:43 Schmitt: (To Gene) Wait a minute. I ought to get that, I guess. (Pause) That's one...(You're) tall.

121:32:55 Cernan: Here, let me lean down.

[Gene bends his knees, keeping his PLSS vertical.]

121:33:00 Schmitt: Two, and the hook's still hooked. Check for sure, here. Those hooks weren't designed for new bags.

[The SCB is about the length of Gene's upper arm, has a square cross section six inches on a side, and has sharp creases which will disappear with use.]

121:33:24 Parker: Okay, Jack...

121:33:25 Schmitt: Okay. I think that will ride all right.

121:33:26 Cernan: Okay.

121:33:27 Parker: ...they don't want it (the UHT) there (in the heat flow electronics package). If one of you guys can get to it and pull it out.

121:33:33 Cernan: I'll get it right now.

121:33:34 Schmitt: Okay.

[Jack goes to the gate; Gene to the heat flow site.]

121:33:35 Parker: Thank you.

121:33:36 Schmitt: Watch the alignment, as you said.

121:33:37 Cernan: Yeah. (To Parker) I sort of thought you might like it out of there. Let's stay away so I don't get a cable and I don't get dust in the mirror. The alignment is still good.

[Gene is no longer talking loudly to Houston when he is at the Rover and only increases volume a little when he moves away from the Rover.]

[Schmitt - "Part of this business about talking more loudly to Houston may be psychological distance; but I also notice that, when I'm describing something to them, I get more of an authoritarian tone. Certainly, when we were talking with each other, it was more buddy to buddy and we wouldn't have been thinking about anybody being a long way away."]

121:33:48 Parker: Okay.

121:33:50 Cernan: Now, if I can get it out.

121:33:53 Schmitt: Okay, I'm going back to the LM.
 121:33:57 Cernan: Okay, Bob, the alignment's good on the heat flow, and I've got the UHT out. Jack, do you need this (UHT)?
 121:34:03 Schmitt: You better...Save it. Save it.
 121:34:05 Cernan: I'm going to leave it right here by the ALSEP.
 121:34:07 Schmitt: Save it.

[Gene executes a flat throw; the UHT flies off, parallel to the ground, with no discernible rotation.]

121:34:10 Schmitt: Careful
 121:34:12 Cernan: Jeeminy, I just threw it right here in this little ditch!

[Fendell pans away.]

121:34:15 Schmitt: Yeah, right. Okay, the other UHT is by the ALSEP. We probably ought to have it with us, Geno. For the sampler.
 121:34:23 Parker: Have you got one...
 121:34:26 Cernan: Well, you've got one...
 121:34:27 Parker: ...UHT sampler?
 121:34:27 Schmitt: Yeah. That's all right.
 121:34:29 Cernan: (Garbled).
 121:34:29 Parker: Okay, we gather you're on the way back to the LM with the core stems there, Jack.
 121:34:38 Schmitt: Yes, sir.
 121:34:39 Parker: Okay.

[Jack, also, is no longer talking loudly to Houston. He probably leaves for the LM at this point. He is at the top of LMP-27. After Gene takes care of a few housekeeping chores, he will be at the top of CDR-25.]

121:34:44 Cernan: Okay, Bob, I'm going to take the TV away from you and get these battery covers squared away before I put the tongs and the camera on.
 121:34:53 Parker: Okay, Geno, and you guys have the gnomon in the little quiver, right?
 121:35:00 Cernan: Yes, sir. The temperature on the batteries are 96 and 110.
 121:35:05 Parker: Okay, thank you.
 121:35:06 Cernan: Can I close the (battery) covers?
 121:35:08 Parker: Roger.
 121:35:09 Cernan: Can I close the covers?
 121:35:10 Parker: Roger; Roger.

[Fendell finds Jack running toward the LM. The Rover seems noticeably higher than the LM. However, Jack is down in the swale and that may be helping to create the impression.]

121:35:15 Schmitt: Hey, you're turning our voice around, Bob.
 121:35:19 Parker: No, I said...
 121:35:19 Schmitt: We're getting a repeat.
 121:35:20 Parker: I said, "Close the covers, please."
 121:35:27 Schmitt: That's right. I heard what you said, but you're turning our voice around. (Pause)

[That is, they are hearing themselves in the ear phones after the communications has made the two-and-a-half-second round trip to Earth and back. As Jack runs, splashes of light are visible at his feet. The effect is due to sunlight reflecting off sprays of dust that he kicks up as he runs. The best example of this in the TV pictures of Gene running toward the Rover, from the east, just before they leave Shorty Crater on EVA 2.]

121:35:45 Schmitt: (Singing) I was strolling on the Moon one day...
 121:35:49 LM Crew: (Both singing)...in the merry, merry month of
 121:35:51 Cernan: May. Schmitt: December.
 121:35:52 Cernan: No, May.
 121:35:54 Schmitt: May.
 121:35:55 Cernan: May's the month this year.
 121:35:56 Schmitt: May. That's right.
 121:35:57 Cernan: May is the year, the month.
 121:36:00 Schmitt: (Singing) When much to my surprise, a pair of bonny eyes...be-doop-doo-doo...
 121:36:05 Parker: Sorry about that, guys, but today may be December.

[Schmitt - "We had worked hard, and our fingers, our hands, and our arms were very tired. But it was still fun. And, without the aches in our arms and hands, it would have been even more fun."]

121:36:08 Cernan: Okay, the battery cover...
 121:36:13 Schmitt: (Humming the same song) Da-da-da-da-da-da-da-dee-da-dee...

[Schmitt - "All this singing that I was doing illustrates that it was possible to run in the suit without expending a lot of effort. By using what can be described as a cross-country-skiing stride, I was keeping changes in the suit volume to a minimum. I was moving my legs back and forth, but that was about it."]

[A redesign of the waist joint - done so that the J-mission crews could sit on the Rover - made a big difference in running efficiency. The Apollo 12 crew ran distance of a few hundred feet at a speed of 5 - 6 kph and had to take a rest because their heart rates got up in the 160 beat/minute range. They also got a bit winded. It is important to note, however, that they, too, used a loping, foot-to-foot stride.]

By the time Jack reaches the SEP site at the end of this run, his heart rate will peak at 130 beats per minute.]

121:36:17 Cernan: Okay, Bob, the battery covers are closed. I'm ready to go MODE switch 1. I guess I'll just wave goodbye. You look pretty clean, so I won't touch you.

[That is, he won't dust the TV.]

121:36:30 Parker: Okay, thank you.

121:36:36 Cernan: Oh, man. It's even hard to move you (the TV camera) counterclockwise. Here we go.

[Gene swings the TV camera around so that it points aft. Jack has not yet reached the LM. He started running at about 121.34.38 and has covered something less than the 180 meters between the Rover parking place and the LM in two minutes. Therefore, his average, straight-line speed, is no more than 5.4 kilometers per hour, the speed he achieved on the 50 meter run from the west geophone at 120:27:11.]

121:36:41 Cernan: Counterclockwise, facing aft. Okay, I'm going to go Mode switch number 1. Okay, we're Mode switch number 1...

[TV off.]

121:36:56 Parker: Rog. We can confirm that.

121:36:57 Cernan: ...and you want me to leave those LCRU blankets open 100 percent, right?

121:37:02 Parker: Roger. That's affirm.

121:37:04 Cernan: Okay, now I got to mount my camera and tether my tongs (to the yo-yo).

[The yo-yo is a tool holder that Gene is wearing on the front of his suit, below the RCU and camera bracket. It consists of a length of wire, wound on a spring-operated reel, and a clip which Gene is attaching to his tongs. If Gene wants to use the tongs, he will just grab the handle and pull them away from his body, unreeling the yo-yo wire. When he is done, he can release the tongs and let the spring rewind the wire and pull the tongs back against his suit. Jack is wearing a yo-yo but has chosen not to wear his tongs. His usual tool will be the scoop and it cannot be attached to the tongs because the extension handle is too big around to fit into the clip.]

121:37:09 Cernan: Boy, Jack, I can't see you at all. Looking into the east is terrible. All I can tell you is that there's a LM there. Okay, "mount camera, tether tongs." See if my camera's going to work. Bob, I'm on Bravo - mag Bravo - and frame count 19.

[Magazine Bravo is Apollo magazine 134. Gene is finishing up the last items on CDR-24.]

121:37:39 Parker: Okay; copy that, Gene. (Pause)

121:37:50 Cernan: And for EMU status, I can give you about 36 percent, no flags, 3.85. And I'm still Intermediate cooling.

[They are 277 minutes into the EVA with 36% oxygen left. At this rate, they would have a 433 minute EVA with no reserves. The EVA actually ends at 432 minutes, but with reserves to about 540 minutes.]

121:38:09 Parker: Okay. Copy that.

121:38:10 Cernan: Okay, inventory. Camera, tongs, gnomon. Okay, I'm ready to get on. Ready to get on.

121:38:18 Schmitt: (To Parker) Okay, you want us to take the...(Jack stumbles) Oop! That rock by your front porch is really a major nuisance. (Pause)

121:38:31 Cernan: Oh, doggone it!

121:38:34 Schmitt: What's the problem?

121:38:35 Cernan: Oh! Every time I get on, I get dust around. I still haven't learned how to get on yet. (Pause) You'd think after three times, I'd know better. I know better, but it's...

121:38:53 Schmitt: Okay, I've got the (SEP) transmitter. I'm heading west...or east. (Laughing and correcting himself) Heading east. Sorry about that. (Pause) Bum bum bum bum bum.

121:39:11 Cernan: Okay, I'm Primary (Rover power). Okay, you want a nav initialize here, huh, Houston?

121:39:17 Parker: That's affirmative.

121:39:22 Schmitt: By the way, Bob, Station 6 is pretty obvious up on the hill. It's fairly high up. I don't know if we'll get to drive up there or not.

[Station 6, on the lower slope of the North Massif, will be the first stop on EVA 3. The position of the Station 6 boulders is best shown in AS17-141-21550, taken during the drive to Station 6 on EVA-3. Station 6 is about 550 meters east and 170 meters downslope from the very large, dark boulder with the prominent track. That boulder is quite a way up the slope of the North Massif on the left side of the picture. Turning Point Rock, which they will drive to on their way to Station 6, is above the TV camera, and Station 6 is to the right, with an elevation about midway between those of the dark boulder and Turning Point Rock.]

121:39:31 Parker: Okay. I think you can see the boulder and that's how you can tell, right?

121:39:37 Schmitt: Yep. And the crater (possibly a small crater just downslope from the Station 6 boulders). (Pause) A shame not to...Well, maybe that's the wrong one. I'll have to check the map. (Pause) A shame not to go to Station 1!

Sure is a shame. Why don't you consider Station 1 as a possibility?

[Emory Crater is 650 meters in diameter and is located at the southern edge of the apparent dark-mantle area of the valley. Indeed, from overhead photography, it appeared in pre-mission analyses that only part of the crater is covered with the mantle. Therefore, a visit to Emory promised clues as to the origin of the mantle. In addition, there were indications that the crater might have penetrated through the valley fill and dug up samples of the original valley floor, materials presumably similar to those making up the Massifs. However, evidence from the seismic profiling experiment and from the Command Module radar experiment suggest that the valley fill is about two kilometers deep. Because Emory would have penetrated only to a depth of about 150 to 200 meters, the possibility that Emory penetrated through the valley fill now seems unlikely.]

121:40:07 Cernan: Okay, Bob, let me give you some numbers (from the Rover instruments).

121:40:10 Parker: We're ready.

121:40:13 Cernan: Sun shadow is zero. I am rolled right 4 degrees. I am pitch zero. I can't be rolled right 4 degrees. That indicator can't be right. I question that. I might be rolled left a couple of degrees. (Pause) Are you happy with that, Bob? Roll indicator is indicating...Make it 3 degrees right.

121:41:03 Parker: Okay, and I copy...(Pause) Okay, torque to 279 will be the heading. 279.

121:41:19 Cernan: Okay. (Pause)

[The Sun-Shadow Device is mounted on the Rover console, and is usually folded down against the panel for storage. To use the device, Gene raises the arm until it extends out from the panel at a 90 degree angle. When the Rover is headed to within 15 degrees of down-Sun, a gnomon on the end of the arm casts a shadow on a scale affixed to the panel. During the last minute or so, Gene maneuvered the Rover until the shadow gave a zero reading. Because the position of the Sun in the local sky is known accurately, by using this procedure, Gene has put the Rover on a well-determined, true heading of 279 degrees (9 degrees north of west). He will now "torque" or precess the gyro until the heading indicator reads 279.]

121:41:37 Cernan: The heading when I put the Nav Power breaker In, Bob, was 234.

[The Rover navigation system has not yet been initialized on the Moon, so the heading of 234 may be a value preset prior to launch from Earth, possibly with some drift introduced during the flight and during deployment. Details of the nav initialization are given on a decal on the Rover, rather than in Gene's checklist.]

121:41:40 Parker: Okay, I copy that. We'll torque that to 279.

121:41:47 Cernan: Okay. I'm waiting for my minute and a half here.

121:41:50 Parker: Roger that. (Long Pause)

[Gene is waiting a minute and a half for nav system to power-up.]

121:42:19 Schmitt: By the way, Bob, LMP is at 39 percent (oxygen), 3.88 (psi), and no flags, no tones.

121:42:33 Parker: Okay. Copy that, Jack.

121:42:38 Schmitt: I'm at the SEP site (planned to be 100 meters east of the LM), and I found a place I think we can lay out a pretty good grid.

[At the end of the EVA, Gene and Jack will lay out a cross-shaped antenna pattern for the SEP experiment. Jack is actually about 140 meters east of the LM.]

121:42:45 Parker: Okay, Jack, and when you lay it (the transmitter) down there, we want to put it down with the gnomon side, the side you're going to face the Sun, you want to put that facing away from the Sun. We found out a thermal constraint this evening, just as the EVA started.

[The SEP, like many other pieces of equipment, has a short, shadow-throwing gnomon and an angular scale for orientation relative to the Sun.]

121:43:04 Schmitt: Okay. Away from the Sun. Gnomon...You want the gnomon side or corner?

121:43:13 Parker: The gnomon side away from the Sun. The side with the solar panels on it (has) to be in the shade.

121:43:20 Schmitt: Okay. (Pause)

[Jack will deploy the solar panels after the geology traverse.]

121:43:31 Cernan: Bob, everything's working fine so far. She's zeroed and I'm torqued. And I'm ready to press on. Reset is back Off. Okay, Jack, here I come.

121:43:42 Schmitt: Okay. You see me?

121:43:44 Cernan: No, I'm facing the other way. (Long Pause)

[Gene had to point the Rover west in order to initialize the navigation system; he now turns east, into the Sun.]

121:44:01 Cernan: Boy, I tell you, just about all you can see in that direction (east) is the LM. Boy, that's tough driving into the Sun!

121:44:06 Schmitt: Go right to the LM, and...or, a little bit to your left, to the left (north) of the LM.
121:44:15 Cernan: Yeah, I've got to go to the LM and give them a reading here (of range and bearing to the ALSEP site).
121:44:19 Schmitt: Okay.
121:44:20 Parker: That's affirmative, Gene.

[The Rover uses an internal navigation system which depends primarily on wheel rotation to provide indications of distance traveled and, when combined with heading information, estimates of the range and bearing to the last initialization point. During the Apollo 15 and Apollo 16 traverses, the system was shown to be accurate to about 100 to 200 meters over distances of a few kilometers.]

[Schmitt - "There were times when NASA would talk about us having trouble getting back to the LM; and that was ludicrous. We would always know where the LM was in a valley with as many distinctive features as this one had. And, of course, you could always follow your tracks back. So the safety aspects of Rover navigation were always exaggerated. The nav system may have been included originally in the Rover design for safety reasons; but, once we had it, it's prime usefulness was clearly in position location, in finding our way from the LM to the various geology stations."]

121:44:21 Cernan: (Making a general comment to Jack) You get that shadow (of the LM) up there (to block the glare of the Sun) and you're all right. Say again, Bob?
121:44:26 Parker: That's affirmative. We want the range and bearing at the LM. I'm glad you remembered.

[These Rover readouts will give a first estimate of the ALSEP location until a much more accurate determination can be made from the photographs of the LM taken from the ALSEP site and of the ALSEP taken from the LM windows. Because the sizes of these man-manned objects are very accurately known, measurements of the photographic images directly give distances. the task of reporting range and bearing to the ALSEP from the LM are on CDR-25.]

121:44:32 Cernan: Yes, sir, I'll give it to you. I even got...(To himself, coming up on a big hole) Ooh! Ooh, don't get in there. Whoo! (Pause) (To Parker) (I) even got the low gain (antenna) working for you. I don't know if you're using it.
121:44:50 Parker: I think we're using the LM right now.

[That is, Houston is picking up signals going from the backpacks to the LM and then to Earth, rather than through the low-gain antenna.]

[Schmitt - "It may have been that there were different frequencies for transmissions to Earth through the LM and the Rover low-gain transmitter. But, whatever the details, the decision as to which to use was Houston's; we had no control

or influence over that, except for pointing the low-gain antenna."]

121:44:58 Cernan: Boy, that LM is pretty. Whoo! (Pause)
 121:45:15 Schmitt: Bob, everything I've seen so far indicates that the so-called "subfloor" boulders - if we have gotten that deep - are this gabbro. I'm out here at the SEP site, and the large blocks are still the plagioclase pyroxene (gabbro) ...
 121:45:41 Cernan: Jack, let me give them a range. I'll be on my way out.
 121:45:43 Schmitt: Go ahead.

[Throughout the mission, Jack uses the term 'subfloor' and by it, means the valley-filling material underlying the regolith and the presumed dark mantle. To the uninitiated, 'subfloor' would seem a more natural name for the original floor, the material that was overlain by the lava fill; however, this is not the meaning of the term as used here.]

[Schmitt - "I never liked the term 'subfloor'. It was something that had come out of the US Geological Survey, from the lunar mapping people, and it had always seemed contrived."]

121:45:45 Cernan: Okay, bearing 292, (range) 0.2, and (distance driven) 0.2. I'm standing (parked) right in front of the MESA.

[That is, the ALSEP is 22 degrees north of west from LM and at a range of 0.2 kilometers. Gene has driven 0.2 kilometers since leaving the ALSEP. The three-digit range indicator changes from 001 to 002 at a range of 150 meters and the distance indicator changes to 002 at 200 meters. The formal indication is, then, that the LM is between 200 and 250 meters from the ALSEP. Because Gene has not driven in a straight line, the distance reading should be reduced by about ten percent. The actual range of the LM from the ALSEP is about 185 meters. Because Gene had parked the Rover 60 (20 meters) northeast of the Central Station, the Rover-LM distance was about 180 meters, which agrees nicely with the 180 - 250 meter range indicated by the nav system.]

121:45:50 Parker: Okay. Beautiful, Geno. Thank you.
 121:45:57 Cernan: Okay. I'm coming, Jack. (Pause)
 121:46:06 Schmitt: The zap pits have nice white halos, although, for the most part, the rock's too coarse to show them very well. Some of the larger ones have white halos. (Pause) We may not be down to the subfloor, but it's hard to say.

[Schmitt - "I wasn't actually looking at rocks at this point because, as I remember, there weren't any at the SEP site much over fist size. This was just a chance, while I was working on the SEP, for me to regurgitate some

observations I'd made up to this point. When I said that 'We may not be down to the subfloor', I think I meant that I hadn't seen anything yet that wasn't recycled regolith."]

[The details of the SEP transmitter deployment are given on LMP-27.]

121:46:27 Cernan: Hey, Bob, making 8 to 10 kilometers (per hour), and I'm barely moving.

[The terrain around the LM is rather flat and a speed of 10 km/hr - about 10 minutes to the mile - doesn't seem impressive. However, when they get out into rolling terrain, with the potential of finding small, deep craters to jar the Rover just over every ridge, the ride gets a bit more exciting.]

[Cernan - "The Rover just didn't move very fast. It wasn't made to go very fast, but it could sure save a lot of energy. You could pack a lot of gear and save a lot of walking time, and it allowed us to cover territory and ground we would never would have covered otherwise. I think probably we averaged 8-12 kilometers (per hour), and I think we hit a speed record of 14-15 kilometers coming downhill. It had four electric motors, one on each wheel for redundancy, and we would run with all four motors all the time. We didn't necessarily use both fore and aft steering all the time, but we always ran all four motors and 8-12 kilometers was about as fast as it could go. Your sensations of speed is probably what you would get down here. It didn't seem like you were moving very fast, and you really weren't. But you were moving, and it was nice to just sit back there and relax as you went from one place to another, as slow as it might seem. We weren't on a 400 mile trip, so it didn't matter how fast it was.

"Of course, it could still be very sporty driving. When you start getting one wheel in a crater, or you hit a bump, or you start driving on the side of a hill, you really do appreciate the 1/6 gravity. If you hit a bump, you'd go u-u-u-u-p and come down. It wouldn't just be bang, up and down. And on the side of a hill, you would start thinking that Rover was just going to tip over and fall over on you. You didn't feel like there's much holding you to the surface at all. It was good, sporty driving; just not very fast.

"The Rover had great maneuverability, particularly with the fore and aft steering - articulated steering, I guess it is. You could really maneuver it, really turn very sharp. You couldn't go real fast, but you could go. There is some film of John Young where he was kicking up dust and you'd think he was going 50 mph. He probably was going 10-12 kilometers at the most. On the lunar surface, it's a sporty little ride. It was fun.

"I don't know how fast you would really want to go up there, quite frankly. You can't see what's up ahead of you too well. You know, you're driving along and it's so bland. With the shadows the way they are, especially if you're

looking into the Sun, you just can't see much. You can't see where those holes are; you can't see what's ahead of you, and the next thing you know, wow, you're in a hole or you're up. You'll see us reacting to the little craters throughout here as we drive the Rover."]

[Schmitt - "I'm quite certain that, even at 10 kilometers per hour, there were times when we had all four wheels off the ground. That really made it sporty. And the worst direction to drive in, I thought, was away from the Sun, because you had a 'white out' situation. The lack of shadows made it hard even to see boulders. But, the glare off your visors did make up-Sun difficult."]

121:46:36 Cernan: Where've you got the SEP, Jack?

121:46:38 Schmitt: Right out over there.

121:46:41 Cernan: Okay, let me give them a bearing, distance, and range, and some numbers here (at the SEP transmitter).

121:46:45 Schmitt: Meet you over there.

121:46:47 Cernan: Okay. (Pause) Ohh! (Long Pause)

121:47:03 Schmitt: Bob, I did see a dense grey rock that's different than the others on my traverse out here. We'll try to find some of that, too.

121:47:12 Cernan: Okay, Bob, I'm reading 278, 003, and 003 at the SEP site.

[The actual range is about 330 meters from the ALSEP and about 140 meters from the LM.]

121:47:19 Parker: Okay. Copy that, Geno. And how about giving me amp-hours and batteries just as long as you're there?

121:47:30 Cernan: Yes, sir, it's coming at you. Amp-hours are 112 and 110; batteries are 92 (degrees) and about 112 (degrees).

[Cernan - "The needle width was at least a couple of degrees, so there was a little hesitation here as I decided what figure to give."]

121:47:45 Parker: Okay, copy that, Geno.

121:47:47 Cernan: Motors are all off-scale low.

121:47:51 Parker: Yeah, okay thank you.

121:47:54 Cernan: Nav is going to Reset.

121:47:57 Parker: Say again there, Gene. You're going to go to Reset, right?

121:48:01 Cernan: Yes, sir; going to Reset.

121:48:04 Parker: Okay. (Pause)

[Gene is re-initializing the Rover navigation system.]

121:48:08 Parker: Jack, you can be getting on. You won't need a bomb (seismic charge), and I guess you won't need the

LMP camera unless you want it. We'll be deploying the bomb at Steno.

121:48:21 Schmitt: (Laughing) I thought we were playing it by the checklist, Geno. (Giving the charge to Gene to hold while he climbs on the Rover) Here's the bomb.

[Jack will soon regret having ignored Parker's advice about not carrying a charge during the drive. Checklist page LMP-27 calls for Jack to carry a charge, but only because he was to have deployed it near Steno during the planned drive to Emory. According to the original plan, Gene would have stopped to Rover long enough for Jack, without getting out of the Rover, to put the charge on the ground. As Jack will discover, holding the charge will tire his hands, unnecessarily in this case.]

121:48:24 Cernan: Okay, give it to me.

121:48:25 Schmitt: The "charge".

[Schmitt - "During training, Bob liked to use the term 'bomb' and, here, I'm trying to get him to change it."]

121:48:26 Cernan: I've got it.

121:48:28 Parker: Yeah, it just happens that the station is at the place we were going to deploy the charge.

[Parker is saying again that Jack doesn't need to carry the charge.]

121:48:35 Schmitt: Okay, well, we got it off (the transporter on the back of the Rover).

121:48:36 Cernan: Okay. Do you know which side of Steno he wants us to go, Jack?

121:48:39 Schmitt: Not yet.

121:48:40 Parker: Okay, let me fill you in on the plan, guys. We're going to go to the west side of Steno, which is where you would have driven by anyway, and the stop will be at the 340/1.2, which is where you've got the little Delta for EP 6, in your checklist. And we will plan on spending about three-zero minutes there sampling, primarily boulders.

[A map of the planned traverse is shown on both LMP-28 and CDR-26. South is up, on these maps, and the unboxed numbers associated with each traverse segment are a heading and segment length. the boxed numbers associated with the turning points are bearing and range to the nominal SEP transmitter location. Because the navigation system gives the Rover's position relative to the initialization point at the SEP transmitter - then, to the extent that the absolute location of the SEP is known, the heading and range indications can be used to find the planned geology stations. With practice and a good map, visual navigation is sometimes possible, but the undulating terrain, combined with the basic problem of estimating sizes and distances, makes the

navigation instruments invaluable. At this point in the mission, the location of the LM and, therefore, of the SEP transmitter has not yet been pinned down and there will be some confusion. Based on the crew's site descriptions from the LM window, Houston is estimating that, at the west rim of Steno, the bearing to the SEP transmitter will be 340 degrees (twenty degrees west of north) and the range 1.2 kilometers. Relative to the actual SEP location, the bearing and range at the west rim of Steno is 352/1.5. Because of this fairly substantial difference, they will end up stopping just short of the northwest rim. Boulders are of interest since they are likely to be samples of the subfloor. Boulders that could be picked out in the Apollo 15 photographs are marked with crosses. Checklist pages LMP-29 and CDR-30 give details of the planned traverse. Pages LMP-30 and CDR-28 -which are identical and are included here for completeness) both show a schematic of Emory Crater and the original site of Station 1.]

121:49:15 Schmitt: Okay, Geno, west side of Steno, then.
 121:49:17 Cernan: Okay. I got it here (in the checklist).
 (Pause) Okay...
 121:49:24 Schmitt: You got a good feeling on how to head out of here?
 121:49:26 Cernan: Yeah. (Pause) I want to get around the back side - now that I'm down there - on the back side of Trident, and make sure that what I'm looking at is Trident over there.

[They are planning to drive into the Sun until they come abeam of the northeast corner of Trident and then will turn south toward Steno. Gene is hoping that, during the first part of the drive, he can clear up his residual doubts about where he's landed. He actually is, of course, about 100 meters north of Poppie rather than West Trident.]

121:49:39 Schmitt: Okay, let me try to get on this thing.

[This is Jack's first Rover ride of the mission and his first attempt to climb aboard.]

121:49:43 Parker: Okay. And, 17, just to fill you in a little bit more here. We're looking at a six (hour) plus four-five (minute) EVA. We've given you fifteen minutes to drive to Station 1; thirty minutes at Station 1; and fifteen minutes to drive back to the S.E.P., and then deploying the S.E.P. for two-two minutes. And then a four-zero-minute closeout at six plus four five.
 121:50:07 Cernan: I'm sorry, Bob. After 30 minutes at Station 1, what did you say?
 121:50:11 Parker: Okay. Then we're going to drive back. There's a 15-minute return to the SEP site; and then 22 minutes at the SEP site to deploy the SEP; and then return to the LM and 45 minutes for the closeout.

121:50:27 Cernan: Okay. Understand. (To Jack) Okay, you strapped in?

121:50:32 Schmitt: Yes, sir.

[The seat belts had been a problem on Apollo 15 because no allowance had been made for the fact that, on the Moon, the suits don't compress as much when the astronauts are seated as they do on Earth. The problem was easily fixed for Apollos 16 and 17.]

121:50:34 Cernan: Yeah, we've got to start getting in this Rover facing 90 degrees to the seats, I think. (Pause) I did the same thing.

121:50:40 Schmitt: Did I kick dust?

121:50:41 Cernan: Yeah, we both did.

121:50:43 Schmitt: I tried to knock it all off my feet.

121:50:44 Cernan: Yeah; that's impossible.

[Cernan - "Best way to get in was to face out from the Rover, sit in the seat, get down, and then kick your feet up and then throw them around. Here, Jack probably faced front, then tried to get one leg up and then another leg up. By starting out facing out from the Rover, you also cut down on the amount of dust you scattered on things."]

[Schmitt - "What I ended up doing most of the time was standing at the side of the Rover, facing front, and jumping, more or less straight up and over toward the seat; and then rotated my feet up and forward so that I came down in the seat."]

[There is good TV coverage of Jack's attempt to mount the Rover at the end of Station 3 at 145:03:17.]

121:50:46 Cernan: Okay, Jack. Let's see if we can't get around Trident East over here.

121:50:51 Schmitt: Well, I wish I didn't have this charge. Shouldn't have played it by the checklist. I wasn't paying attention.

[Jack has finally realized that there is no reason to carry the charge; it could have been left in its transporter on the back of the Rover. He is probably already noticing his hands getting tired from having to keep them closed around the charge against the pressure of the suit. He is probably also becoming aware that the charge is keeping him from using his maps and checklist efficiently. Although the checklist indicates that he hadn't planned to take any pictures during the drive, he will take sixteen frames, beginning with AS17-136-20723, an up-Sun picture taken about now. The next two frames, 20724 and 20725 are blurred.]

121:51:02 Cernan: We're on the move, Bob.

121:51:04 Schmitt: Okay, this is Trident, isn't it? So we're starting out...
 121:51:08 Cernan: Well, it's got to be.
 121:51:10 Schmitt: Yeah. So, you're starting out on the...You really want to head about 29...
 121:51:17 Cernan: No, no, no.
 121:51:18 Schmitt: No, wait a minute. Where are we?
 121:51:19 Cernan: We want to go southeast.
 121:51:20 Schmitt: 181...

[Jack is misreading the checklist map showing the planned traverse path from the landing site to Emory. Because the traverse is merely being truncated and they think they have landed virtually at the planned point, they plan to follow the checklist and drive east on a heading of 116 (ESE) for 600 meters to get around the east side of Trident and then turn south to a heading of 181 for the drive to the west rim of Steno. The planned bearing and range at the turning point are 296/0.5.]

121:51:23 Parker: 17, we'll start out on the same general traverse that you've been on. It's just that we'll stop it sooner.
 121:51:34 Schmitt: Yeah, we understand.
 121:51:35 Parker: Okay.
 121:51:36 Schmitt: We're just getting our bearings, Bob.
 121:51:38 Cernan: This (possibly Poppie) has got to be Trident East, right here, Jack. See that? That's got to be Trident East. That's the big one.
 121:51:43 Schmitt: On the right or the left?
 121:51:45 Cernan: On the right.
 121:51:47 Schmitt: Yeah.
 121:51:48 Cernan: And Poppie was just over about where...
 121:51:52 Schmitt: Watch your...
 121:51:53 Cernan: Yeah. I just want to get our bearings here. You can't look to the east. Okay. I've got to...(Pause)
 121:52:02 Schmitt: That's an awful big depression over there, isn't it? (Pause)
 121:52:10 Cernan: It (the map) says (to) go along this way. Boy, it sure is.

[Cernan - "When you're riding and not expending a lot of energy, it's a lot easier to look around and really see what's there."]

121:52:16 Schmitt: Whee! Watch it. Ho - ho - ho - hold it, hold it, hold it!
 121:52:20 Cernan: Got it, got it, got it (garbled). (Burst of static which clears after a few seconds) Boy, I tell you; I've got to get out (of facing) east. Stand by.

[Cernan - "We probably ran smack into a small crater - or maybe a boulder - that we couldn't see facing east and

looking right into the Sun. And when I said, 'got it, got it' I meant I had the situation under control. Running into little craters or over little rocks wasn't critical; it was just that we didn't want to run into something big enough to matter. Here, we probably went down in a little crater and came back up. We did that a lot; but we got a little more excited here because this is our first real ride together on this thing. The burst of static probably indicates that I made a turn to try to avoid the crater and lost the lo-gain lock.

"There are three things that I remember most about the Rover ride. Number one, when you were driving east into the Sun, it was almost impossible to see things ahead of you. When you were driving cross-Sun you had much better visibility and depth perception because of the shadows; and even driving down-Sun you could certainly see the boulders. Second was the fact that you often couldn't see small craters and they were important in the same way that potholes are to you when you're driving down the highway. The difference is that, in one-sixth gravity, when you do hit a boulder or you do drop one wheel in a small crater, you literally lift the Rover off the ground. I mean, you were literally driving on three wheels a good part of the time. It wasn't a choppy, sports-car feel, driving down the highway going bang-bang, bang. It was more of a waltz. Boom, and you go u-u-up and come down. Hit another one; u-u-up and come down. And, of course, not only did the Rover bounce but so did we. So it was a very good thing that we had snug seatbelts. Without them, we could easily have bounced out of the seats. And, lastly, the reduced gravity was particularly noticeable when you were driving on the side of a hill. I remember many times when we were driving on the side of a hill and Jack commenting that we were going to roll over. And indeed, because you have less gravity holding you down on the Moon, that was not a false perception; it was fact. You had to be careful on the side of a hill, because if you hit a bump with an uphill wheel, you could lift the thing off the ground and possibly become unstable and tip over. Of course, the situation was more obvious if you were in the downhill seat and I tried to keep Jack on the downside. It was much more comfortable on the uphill side; and that's a commander's prerogative when he's driving the Rover.

"Those were the three things that were most noticeable; and I don't know that it would have been advantageous to have had a Rover that could have gone any faster. You needed to be careful in driving and probably couldn't have used the additional capability. When we set a speed record of somewhere around 14 or 15 km/hr coming down a hill, we were really hauling the metal; we were really tearing. And, not being able to see all that well ahead, I don't think we would have wanted to come down much faster. Of course, we were traveling over uncharted terrain; and, if we'd been at an established lunar base with a yellow stripe down the middle of a 'paved' surface - or, at least, if we'd been on a

surveyed path with no boulders or potholes in the way - then we could have driven comfortably at a lot higher speed. But if we'd hit a boulder at 10 km/hr and smashed the hell out of the front end of the Rover, we'd have been out of business. We could have gotten back to the LM, but we wouldn't have gotten the job done that we'd gone to the Moon to do."]

121:52:30 Schmitt: Gene, I think...

121:52:31 Cernan: I'm going to head about one two zero (120 degrees) out of here.

121:52:35 Schmitt: You've got another hole on your right here.

121:52:37 Cernan: I got it.

121:52:40 Schmitt: Whoa, whoa. I'm not sure what's the matter. Why don't you go left there?

121:52:44 Cernan: Okay.

121:52:45 Schmitt: Go left around this thing.

121:52:48 Parker: And, 17; Houston. For your advice, we're trying to use the low-gain antenna on this traverse also.

(Pause) Might try and be good guys and turn it for us when you have to.

121:53:05 Cernan: Okay. Bob.

121:53:06 Parker: That's general reminder number 1.
(Static)

[On this traverse, Jack and Gene won't often be out of sight of the LM and could communicate through it to Earth. As a general rule, however, NASA prefers to use communicate through the low-gain antenna on the Rover, thereby decreasing the frequency and length of communications breaks.]

[Cernan - "Pointing the antenna was easy enough when you were parked, but the indicator was really useful when you were driving, particularly when you were driving with the Earth behind you or well off to the side."]

[The indicator on the low-gain antenna is described at 119:07:05.]

121:53:14 Schmitt: Gene, I think we need to head south.

121:53:17 Cernan: Yeah. We've got to go out here southeast. What's that big map look like in relation to Bear Mountain to you?

121:53:26 Schmitt: You mean the...(Pause) I'm not sure I can get to it.

[The traverse maps are clip mounted to the accessory staff mounted on Jack's inboard handhold. There are probably at least two maps, one showing the immediate area of this traverse, the other showing the whole valley. To look at the "big map", Jack would probably have to lean forward and to his left to lift up the local map.]

[Schmitt - "With that charge in my hands, I'm not sure I could have reached for anything. And I think the reason my voice is sounding so subdued in this section is that my

forearms are starting to get tired and I am mostly concentrating on not dropping the charge."]

121:53:34 Schmitt: Okay, I want...

121:53:36 Cernan: It's calling for 116 at 0.6 to (garbled) near the SEP.

[Gene is referring to a small map in the checklist, showing the first leg of the traverse being a 0.6 kilometer drive on a heading of 116, starting from the spot of his nav initialization at the SEP site.]

121:53:43 Schmitt: I ended up with this charge in my hand. There's a big...What are you headed now, south pretty much?

121:53:50 Cernan: Yeah.

121:53:52 Schmitt: I think you're getting...That must be Emory over there. See with all the blocks in the wall?

121:54:01 Cernan: Where you looking? Which way?

121:54:04 Schmitt: Southeast.

121:54:05 Cernan: Way over there.

121:54:06 Schmitt: Yeah.

[Cernan - "The helmet didn't turn; so you didn't have a good view. To see to the side, you had to turn your head inside the helmet; but because of the visors, that only gave you a little bit of a view to the side. The only other choice was to turn your body and, because the suit was so stiff, that was very difficult. Consequently, you didn't have a lot of peripheral vision."]

121:54:07 Cernan: This is very easily Steno right over here. Let's see, we're between the two big ones...That would be...

121:54:13 Schmitt: That would be Powell.

121:54:14 Cernan: That would be Powell on the right.

(Pause)

121:54:18 Schmitt: You think? Certainly doesn't look like the LNA yet.

121:54:21 Cernan: (Chuckling) No, it sure doesn't.

[Cernan - "I can remember playing in the simulator and going down and flying around the valley. It wasn't the same picture you got when you're were sitting in the Rover 2-3 feet above the surface. It was like taking an airplane at a couple hundred feet and flying around the different parts of the valley just to get a feel for what it looked like. I don't recall that that helped very much because when you're in a Rover, you're just really down among them; you're down in this rolling, hummocky terrain. It was different."]

121:54:22 Parker: How about a range and bearing, guys, I think we can help you.

121:54:27 Cernan: Okay, 330, 0.3.

121:54:34 Parker: Okay, it sounds like you're probably just driving by the East Trident or Trident 3.

[They are about 200 meters northeast of the rim of East Trident and have not yet learned to judge the sizes of craters.]

121:54:45 Schmitt: You think all that right there is Trident?

121:54:47 Cernan: My god, if it is, that's incredible. That's hard to believe.

121:54:51 Schmitt: Well, there...You're going to go in a hole with your right...No problem.

121:54:55 Cernan: I can't see the lip too well because of the...

121:54:59 Schmitt: Well, if that's Trident...

121:55:01 Parker: Okay. And, Jack, do you have your camera on...

121:55:03 Schmitt: Boy, I wish they'd caught me with this (charge before I got on the Rover)...

121:55:04 Parker: ...If so, could you give me a frame count some time?

121:55:08 Schmitt: Bob, I got my hands full with this charge.

121:55:11 Parker: Oh, okay, forgot about that one. Sorry about that.

121:55:19 Schmitt: Looks like four-five (45 frames).

121:55:22 Parker: Okay, copy that. Thank you. (Long Pause)

121:55:32 Schmitt: Boy, if that's Trident, whoo!

121:55:35 Cernan: Hey, you know that is...Don't you suppose that's Trident?

121:55:37 Schmitt: Well, it sure looks like it, doesn't it?

121:55:40 Cernan: Yeah. We were quite a ways from Trident.

[They are now near the east rim of East Trident.]

121:55:43 Schmitt: I bet you it is.

121:55:45 Cernan: If that's true... We're at 342/0.4.

That's about right; we're half a mile (means "kilometer")...That's about right. Boy, what I was looking at (as) Trident isn't any where near that big.

[East Trident is about 300 meters across while Poppie is about 70m.]

121:55:54 Schmitt: Okay, if that's true, then we want to go...

121:55:57 Cernan: Yes, sir.

121:55:58 Schmitt: ...we want to go 181.

[They want to be driving south on a heading of 181 degrees.]

121:56:01 Cernan: Yes, sir, we're all right now. That's got to be Trident. What we were looking at before...I've got to stop and see what that is. I've got to look at those maps when we get in (the LM after the EVA).
 121:56:12 Schmitt: Well, it's a triplet all right, with some septum between. (Pause) Well, wish I could take pictures. Take a few, but...
 121:56:26 Cernan: Well, let me get a few here.

[At this point, Jack may be taking AS17-136-20727 and Gene may be taking AS17-134-20390. During the next few minutes of the drive, Jack will take AS17-136-20728 thru 20734 and Gene will add AS17-134-20391 and 20392. In successive frames, individual boulders can sometimes be tracked as Gene and Jack drive toward them. However, on this traverse, Jack takes so few frames that the coverage of the drive is spotty.]

121:56:29 Schmitt: Well, you keep pressing. We can get them coming back. (Pause) (I can) take a few, but it's not continuous. My hands are giving out. I wish I hadn't said "follow the checklist". (Pause)
 121:56:52 Schmitt: Okay, we're at 0.5 and 346. And the surface has not really changed except slightly more hummocky and rolling, because of a larger number of irregular depressions or craters. The...Boom! (They've hit a small crater.) The rocks at first glance from the Rover look very much like what we had around the LM. That's the big ones.
 121:57:21 Parker: And, 17, you might be...
 121:57:22 Schmitt: There are occasional...
 121:57:22 Parker: - - Jack, you might be expecting water flag and a tone in a couple of minutes, to go to Aux.
 121:57:30 Schmitt: Okay.

[The main feedwater tank contained about 8.5 pounds of water, and the auxiliary tank 3.4 pounds. They are nearly 5 hours into the EVA and will close the LM hatch at 7 hours 12 minutes, each with about one pound of water remaining. The time they take to use up the main supply depends, of course, both on how quickly they are expending water and on the amount of water they had in the tank to start with. The accompanying table details relevant information about feed water usage derived from the Apollo 17 Mission Report.

Crewman/EVA	CDR/1	CDR/2	CDR/3	LMP/1
LMP/2	LMP/3			
Charge (lbs)	12.19	12.79	12.79	12.12
12.72	12.72			
Usage (lbs)	11.23	10.20	11.36	10.86
10.10	11.52			
Time on Cooling	7:05	7:30	7:09	7:06
7:31	7:09			
Rate (lbs/hr)	1.59	1.36	1.59	1.53
1.34	1.61			

Metabolic rate	1090	821	929	1074
835	942			
Time to Tone	4:58	6:30	5:45	4:53
6:28	5:33]			

121:57:34 Parker: And CDR('s tone) will be about 5 minutes after that.

121:57:36 Cernan: I'll get stopped here in a minute, Jack; as soon as I get...(Listens) Okay.

121:57:42 Schmitt: Okay. I think maybe that might be Steno over there...

121:57:45 Cernan: I don't think we're too far off.

121:57:47 Schmitt: Okay, there's my...I've got to go to Aux.

121:57:49 Cernan: Can you reach it?

121:57:50 Schmitt: I hope so. (Pause)

[The control is on the bottom of the PLSS and there is a cutout in the seat so that Jack can reach it.]

121:58:08 Schmitt: Okay, Houston, do you see me in Aux?

121:58:12 Parker: Stand by. Roger. We see you in Aux.

121:58:21 Cernan: I'm going to hit some of these (craters) broadside, Jack, and then we won't get any roll angle.

(Pause)

[Gene has decided that up-and-down motion (pitch) is more acceptable than side-to-side motion (roll).]

121:58:27 Schmitt: Okay, how far have you come?

121:58:30 Cernan: (Consulting the checklist) I've got to go about another 0.7 kilometers. I may be coming up on the edge of it. I don't know, I'm on the right bearing. Yeah, we're all right. Steno has got a dimple on the north. Boy, this is a heck of a way to start out our navigation because it's into the cross-Sun here...Not cross-Sun, but (into the) Sun. Now, that's got to be Powell, wouldn't you say?

121:58:58 Schmitt: Yeah. Must be. Must be.

[The nearest rim of Powell is about 0.5 kilometers southwest of their present location.]

121:59:01 Cernan: Listen, you...

121:59:02 Schmitt: Then that's Steno with all the blocks in it.

121:59:04 Cernan: Boy, am I glad we didn't land out here! Whew!

121:59:07 Schmitt: See this high point up here coming ahead?

121:59:09 Cernan: Yeah.

121:59:10 Schmitt: That should give us our bearings, I hope. (Pause) I can't hold that bomb any longer.

121:59:16 Cernan: What are you going to do with it?

121:59:17 Schmitt: I'm going to drop it at my feet.

121:59:19 Cernan: Okay. Okay, it's there. Keep it between your feet.

[Gene can see the charge at Jack's feet. Because of the bulk of his suit, the RCU, and the camera, Jack certainly can't see it.]

121:59:21 Schmitt: It will. My hands aren't going to be any good for sampling.

121:59:29 Cernan: Okay, that's Powell, huh? (Long Pause while Jack looks at the map)

121:59:47 Schmitt: Yes. (Pause) Okay, if that's Powell...Quite a ways over there, but I think the thing to do is get up on that little ridge there.

[The ridge is shown in AS17-136-20735 and 20736.]

122:00:05 Cernan: Yeah; I think we may end up looking right into Steno when we get up there. Bob, we're at 342/0.9.

122:00:13 Parker: Okay. Copy that. 340 and one point...(Stops to listen to Gene)

122:00:18 Cernan: Are you reading the low gain, by the way?

122:00:19 Parker: Yeah. Roger. Beautiful. 340 and 1.2 is where we expect the station to be. (Pause)

[This would actually put the station very close to the west base of the Steno "dimple".]

122:00:30 Parker: And it should be up on the top of a little bit of a rise. That you see coming up there. Almost to that rise. You ought to be in the vicinity of some very large boulders.

122:00:45 Schmitt: Houston, (pause as he listens to Parker) there are certainly a lot of big boulders...Whoop!

122:00:54 Cernan: Let me take a look into the Sun (east) here. That doesn't look what I thought Steno looked like. There's no dimple there. "One-point-two", he said. All right. This is it over here, though, I guess.

122:01:06 Parker: Yeah, Steno ought to be right at your 9 o'clock there, Gene.

122:01:15 Cernan: At my 9 o'clock. Yeah.

[The nine o'clock position relative to their current direction of travel is east. Steno is actually southeast of them.]

122:01:18 Parker: Either that or your 3 o'clock. I forgot which one it is.

122:01:19 Cernan: (To Parker) How do you know where we are? I think you're probably right, although it doesn't impress me as what I saw in the LNA.

[Cernan - "This is another reference to simulations where we used the Lunar Navigation Aid to fly the LM around our landing site to see what these places looked like from maybe 50 or 100 feet above the surface. But there were

obvious differences. In the simulator you didn't have the Sun problem and you couldn't get right down on the surface like you could in the Rover. From 50 or 100 feet in the air, things look grossly different and that's what I'm referring to here."]

122:01:30 Schmitt: How much time have we got to drive now, Bob?

122:01:33 Parker: Okay, stand by.

122:01:34 Cernan: I think that's probably Emory up there. That's Steno, I guess.

122:01:42 Parker: Yeah. Gene and Jack, we'd like you to...If you're in the vicinity, we think you're just about there. We were planning on you leaving the SEP and getting to this place at about 4 plus 58 (since depressurization) and we're showing about 5 plus 00 right now so you're right on time. And if you're at 340 and 1.2 in that vicinity, you must be at the station or very close to it where you can see. Over.

122:02:09 Schmitt: Well, it doesn't look real familiar, Bob, as far as Steno's concerned.

122:02:13 Cernan: Okay, I got (my tone and water flag)...

122:02:14 Schmitt: I think they can locate us if we work that block field right there.

[They will park about 150 meters short of the Steno rim, at about the 11 o'clock position on the rim relative to the 12 o'clock north that Parker will use in his next transmission. As with Shepard and Mitchell on their Apollo 14 climb to Cone Crater on Apollo 14, Gene and Jack won't actually get a look into Steno Crater, but they will sample boulders ejected from the crater. Their stopping place is in the right edge of AS17-136-20737.]

122:02:18 Cernan: Let me get my water.

122:02:19 Parker: Okay, on the map, Jack, that you're probably looking at, you're seeing that, with north being 12 o'clock, there are a couple of boulders at about the 09:30 position on Steno. And then there's a couple of more at about the 9 o'clock position on Steno. And we're putting the station right in the midst of all those boulders. Over.

[From this, we can estimate that Houston thinks the SEP transmitter is roughly 200 meters west and 300 meters south of its actual location. Parker's remarks have been slightly edited for clarity.]

122:02:45 Schmitt: Well, Bob, I don't know. It's hard to follow that that's where we are. I'm not sure. It doesn't look like what I expected Steno to look like.

122:02:54 Cernan: No, me neither.

122:02:56 Parker: Okay. What's the range and bearing one more time?

122:03:03 Cernan: Okay, 346/1.1.

122:03:05 Schmitt: I think it would almost be worth...
 122:03:09 Cernan: I bet that's Emory up on that hill.
 (Pause; brief static as Gene turns) It's got to be. Yep.

[Emory Crater is south of them, about another kilometer.]

122:03:25 Schmitt: Okay, well, let's...
 122:03:27 Cernan: We better park in this boulder field here. Get in this boulder field.
 122:03:33 Schmitt: I wish we could have gotten near one of the big ones (that is, near the big boulders Parker has been talking about) , but let's do it. We're going to run out of time.
 122:03:37 Cernan: Yep.

[AS17-136-20379 and AS17-134-134-20393 are taken - in that order - as they maneuver to park at what they will call Station 1, despite the changed location.]

122:03:38 Parker: That's affirmative, guys...
 122:03:39 Cernan: (Garbled under Parker)
 122:03:40 Cernan: Okay. You want me...
 122:03:40 Parker: ... There's no point in deviating around and spending 15 minutes trying to get a particular spot or down to a bigger boulder. You must be in the near vicinity. If you're really worried about it, I guess you might drive a little bit to the east to the rim of the...
 122:03:51 Schmitt: Okay. We got...
 122:03:52 Parker: ... crater, unless you're there. Over. Your judgment.
 122:03:55 Schmitt: No, we're okay. We got a good place.
 122:03:58 Parker: All right.
 122:04:01 Cernan: Okay, I'm parked 180 (facing south as per checklist).
 122:04:07 Parker: Roger. Stand by on that a minute.
 122:04:12 Cernan: You want us to get off? What do you mean?
 122:04:13 Parker: Okay. No...
 122:04:14 Schmitt: What heading?
 122:04:15 Parker: ...Okay. I was just wondering about where you were going to park. Go ahead and park 180. There was a question on whether they wanted us to park into the Sun, but don't worry.
 122:04:22 Cernan: Okay, I'm heading...
 122:04:24 Parker: 180 is a good heading.
 122:04:27 Cernan: Okay, I'm headed 182, 346 (bearing back to the LM), 1.2 (distance driven), 1.1 (range to the LM) , 110, 108 (amp-hours remaining on each of the two batteries), 100, and 118 (battery temperatures), and off scale low on all of the motors.
 122:04:51 Parker: Okay. I copy that. (Pause)

[They are about 150 meters from the Steno rim.]

122:04:54 Schmitt: Bob, can we deploy...(Long Pause)
 122:05:08 Schmitt: Okay. (To Parker) You want this charge deployed here?
 122:05:11 Parker: That's affirmative, Jack:
 122:05:13 Schmitt: I'll deploy it now.
 122:05:14 Parker: You can deploy it right now. That's good. (Pause)

[There are eight seismic charges in all, differing only in the amount of high explosive each contains and the preset runout time of the mechanical timers. This package, number six, contains 454 grams of explosive. There are three pins which must be pulled to activate the charge and prepare it to act on a fire signal from the LSPE antenna that Jack deployed near the Central Station.]

122:05:25 Cernan: Okay, the fenders are still on, thank goodness.
 122:05:27 Parker: Beautiful. We'll give you the Taper of the Year award.
 122:05:33 Cernan: Boy, you're going to have to give me the Duster of the Year Award after this.
 122:05:40 Schmitt: Pin 1, (static) 2. Mark, Safe. (Pause) Pin 3. Mark, Safe. (Pause) That will be in the pans, Geno.
 122:05:54 Cernan: Okay.

[Jack means that there will be no need to take locator photographs specifically for the charge deployment; the charge will be visible in a pan planned for the end of the station. He won't take a pan until 121:32:50. those photos are AS17-136-20744 to 20776 and show the site, the charge, and the Rover parking orientation.]

122:05:55 Parker: Okay, I copy that.
 122:05:57 Cernan: Bob, you got Mode (static)...

[Gene is turning on the TV.]

122:05:59 Parker: Just to confirm that is EP-6, right? (No answer) 17, Houston. Do you read? (Pause)
 122:06:16 Schmitt: Okay, Bob; we're about 15 meters from a 20-meter (diameter) blocky-rimmed crater. It's about 3 to 4 meters deep. All the blocks on the rim look like the pyroxene/plagioclase gabbro - the vesicular rock - (static) seen at the LM. At least all that I've seen so far.
 122:06:50 Parker: Okay. I copied that, Jack. And is this crater to the east or west?
 122:07:01 Schmitt: It's to the northwest of the Rover.
 122:07:04 Parker: Okay; copy that.

[TV on. In Jack's pan, the crater is shown in AS17-136-20749 to 20754. They will begin sampling with the large boulder on the left side of the near rim.]

122:07:06 Schmitt: The vesicle population varies from about a millimeter to one centimeter. It forms about 15 percent of the rock...10 to 15 (percent). And I've given you grain size for the rocks near the LM and that goes well for this one.

122:07:35 Parker: Okay, I copy that, Jack. Very good.

[Fendell pans counterclockwise past Jack, who is leaning over a two-foot-high boulder west of the Rover.]

122:07:43 Schmitt: There is the parting that I mentioned, still of somewhat unknown origin, and we'll try and get a sample along a parting plane. It's clearly evident in one of the bigger blocks.

122:08:03 Cernan: (Working at Jack's side of the Rover) Hey, Bob, just as we stopped the Rover, I went on Aux(illiary) water. Do you want me to turn my primary water off? I don't have to, do I?

122:08:13 Parker: No, no; no need to.

[Water from the Aux tank flows through the Primary tank.]

122:08:19 Cernan: That's what I figured. Just wanted to cover all bets. Okay, Jack. I think, I've got my housekeeping done.

122:08:28 Schmitt: Okay. Get your hammer. We're going to need it.

122:08:36 Cernan: I've been carrying it all day, it's about time I used it. Okay.

122:08:39 Schmitt: Bob, you're going to want a core at this site?

122:08:41 Parker: Roger. We'd like to get...Number 1 priority will be some block samples, including any dirt that was on the blocks, if there is such. And then the second priority is a rake soil sample; the third priority is a double core. Then, also in there, the pans, of course, and other documented samples. But the double core is there, although it is third priority.

122:09:04 Cernan: Okay.

[Gene and Jack are carrying two different varieties of drive tubes which they can push or hammer into the ground. The majority were "lower" sections which have a hardened bit to resist damage from buried rocks. The others were "upper" sections which can be threaded into lower sections to make double-length cores. When using either a lower section by itself or an upper/lower pair as a double core, they will attach an adapter at the top and then one of the extension handles. This way, they can hammer on the extension handle and then extract the core without having to bend over.]

[In the checklist, they have only generalized geology tasks listed, identically, on pages LMP-31 and CDR-29. On some of the early missions, the geology tasks were spelled

out in considerable detail; but it was soon realized that such decisions were better made in real time by the geologists in the Backroom, with input from the crew. Even so, for this first Apollo 17 geology stop, the listed tasks were designed for a longer stop at Emory and the list of tasks for this actual Station 1 has been considerably shortened.]

122:09:07 Schmitt: Gene, do you think...(Pause) Got your gnomon, huh?

122:09:10 Cernan: Yep, I've got my gnomon, and I've got to give them a TGE (reading). When you said "bring a hammer," I came (over without starting the Traverse Gravimeter reading)...

122:09:15 Schmitt: I'm sorry.

122:09:16 Cernan: No, no problem.

122:09:17 Schmitt: Well, I shouldn't have...

122:09:18 Cernan: The two go hand-in-hand.

122:09:20 Schmitt: Nothing disrupts your thought patterns more than somebody saying something.

122:09:23 Cernan: Well, listen, this is my first geology stop. I guess I'm entitled to do that; Bob, you ready for a mark?

[Gene is about to initiate the gravimeter measurement.]

122:09:30 Parker: Roger.

122:09:33 Cernan: Okay. Mark it. The light's flashing.

122:09:40 Parker: Copy that.

122:09:43 Cernan: Okay, you got one (a boulder) picked out?

122:09:45 Schmitt: Yes, let's see if we can work on that one. It's at the edge (of the crater), but we can chip at the parting plane. And that's one of the things that's come up that I think is of interest; we've got to figure out why they have that foliation in them.

122:10:00 Cernan: Boy, that rock is one of the more vesicular ones I've seen around.

122:10:02 Schmitt: Well, they're all about that, Gene. They're either that or mixed with that variety. In the same boulder you'll (sometimes) see a nonvesicular....or, relatively nonvesicular (component). Okay, that's the...

122:10:18 Cernan: Watch your shadow.

[Jack is photographing the sunlit face of the rock that they are about to sample. Gene, who is about to take a cross-Sun stereo pair from south of the boulder, is reminding Jack not to get his shadow on the rock. On the site map, this boulder is at about 7 o'clock on the crater rim, relative to a 12 o'clock north. Gene's cross-Sun stereo pair is AS17-134-20394 and 20395 and Jack's down-Sun is AS17-136-20739. Gene's photos show the crater quite well.]

122:10:22 Schmitt: ...that's the down-Sun. (Pause) Ooh, locator's right into the Sun. Okay.

[A locator is a photograph which includes an object of known size - the Rover or the LM - and/or an identifiable horizon feature which can be used to locate the sample site. Jack's locator is AS17-136-20740.]

122:10:31 Cernan: Right at that overlapping fracture, huh?
 122:10:37 Schmitt: Yeah. Let me get where I can maybe save the rock (fragment if it flies off). If you can hook your...
 122:10:42 Cernan: That's what I'm going to do. I'm going to try and get it right...Right up on top is where I'd like to...
 122:10:45 Schmitt: If you hit it on the right side, it'll go this way, maybe. (Pause) There you go. Good man.
 122:10:51 Cernan: Piece right there. (Pause) I can get another one, too.
 122:10:54 Schmitt: Try another one.
 122:10:56 Cernan: Don't lose that one. (Pause) Let me get that one for you.
 122:10:59 Schmitt: I can get it.
 122:11:01 Cernan: Got it?
 122:11:02 Schmitt: Whoops. (Pause)
 122:11:09 Cernan: Can you keep it in sight here for a minute? Is that it?
 122:11:13 Schmitt: Yeah. (Pause)

[At the end of his pan, Fendell finds them working at the boulder Jack had been examining earlier. Jack collects the first fragment with his scoop while Gene hammers on the top, northeast corner of the rock. It appears that Gene is standing a little downhill just inside the lip of the crater to their north.]

[Cernan - "You just had to get yourself in a stable position to be able to swing the hammer. Because of the restriction of the suit, there was basically only one pendulum plane in which you could swing the hammer; so you had to find a way to stand so that you could swing in that plane and be close to your work. You had some freedom to reach out a little farther, and some ability to rotate your wrist and swing more to the right or left, but not a lot. Generally, it was important to position correctly in three dimensions so that you could hit the spot you wanted and hit it with authority. And even then, you'd swing and just hit in the general area; it would have been really hard to hit a nail on the head."]

[Schmitt - "Although I had a lot to do with the design of the hammer, the handle was too big around for me. I couldn't grip it, and that was one of the reasons why Gene was the one who carried and usually used it. I had convinced myself that I would generally do better with the scoop. Also, Gene could put a lot more force into the hammer. He could grip it, and he also had longer arms. The thing it took Gene a long time to learn was that you don't hit rocks in the middle to break them. You hit them on the edges and

pieces break off much more quickly. By the time we got to the Moon, he was pretty good at it. But I remember that, early on in training, he would go after a rock right in the middle of it."]

122:11:20 Schmitt: Go ahead. (Pause) Try hitting (the edge)...There you go. Can you use the other end against the right side of the rock?

122:11:30 Cernan: I'm (garbled).

122:11:32 Schmitt: Oh.

122:11:34 Cernan: It's coming. (Pause)

[Gene hits the boulder with three sets of five blows. He manages to knock off a small fragment.]

122:11:42 Schmitt: That's all right.

122:11:44 Cernan: I'll get that one, wait a minute.

122:11:47 Schmitt: Be careful down in there.

122:11:49 Cernan: The whole thing is going to fracture off here, in a minute. Just want to...(Pause)

[Gene strikes the rock seven more times, a little below the first site. He then rests. He has been balancing on his right foot, with the edge of the crater just to the right of that foot and with his left leg stuck out to the side as he hammers on the north corner of the rock. It seems a very precarious stance, particularly so close to a rock-filled crater.]

122:12:01 Schmitt: Trying...

122:12:02 Cernan: It's trying to fall.

[Gene hits the rock five more times. The strokes are audible through his suit.]

122:12:05 Schmitt: Don't wear your hand out. (Pause)

[Cernan - "You had to hold onto the hammer and that meant you had to squeeze your finger against the pressure in the gloves. After you did that for a while, your hand and your forearm muscle would get sore. So you'd have to take a rest; not because your shoulder was sore or you were ought of breath, but because of your hand and forearm. We were in pretty good shape at the time; we did a lot of training that exercised our forearms before we started; but gripping was still very tiring."]

[In response to a question, Gene said that, while driving the Rover, he did not have to grip the handcontroller so much as curl his fingers, slightly, over the top of it. This took relatively little effort and, on the whole, he had a chance to rest his forearm muscles during the drives.]

122:12:09 Schmitt: That's good, Gene.

122:12:10 Cernan: Wait a minute. Let me give one more whack. The whole thing is...(Pause)

[He hits the rock three more times.]

122:12:16 Cernan: No, that's too tight. Let me get that other piece...

122:12:21 Schmitt: (Tipping the first sample out of the scoop into a bag) Okay. Bag 476 is the rock sample with a little bit of the soil near it. Of a chip...A chip off the rock, and it's the...Watch it, Gene.

[Gene has been standing inside the crater, north of Jack and a meter below him, picking up a chip.]

122:12:40 Cernan: Here's the other chip. (Pause) If I go down there, that thing (the crater) is about 15 feet deep.

122:12:49 Schmitt: Right. (Pause) Got it.

[Gene puts the chip in the bag Jack is holding.]

122:12:53 Schmitt: Okay? Now, do you think you can chip off the other side of that plane, up on the edge?

122:13:01 Cernan: Yep. Yep.

[Gene climbs easily out of the crater, then stumbles slightly on a fist-sized rock.]

[Cernan - "Because of all of the stuff in front of you - your PLSS controls, your camera, your sample bags - it took a concerted effort to see exactly what you were stepping on. Like everything else you did on the Moon, you had to plan ahead a little bit. Here, it was just difficult to get up that little incline and I had to take a lot of little choppy steps. That gave me better balance than trying to take a big leap.]

122:13:03 Schmitt: Then we'll get the soil, and maybe just a small rock, non-chipped.

122:13:09 Cernan: Let me tell you, my hands from that drill...

122:13:11 Schmitt: Yes, I'm sure they are.

122:13:12 Cernan: ...really know I've been out here today. (Pause)

122:13:19 Schmitt: (Sample bag) 476, Bob.

122:13:20 Parker: Copy that, Jack.

[Gene hits the south-top corner six times and knocks off a sizable sample.]

122:13:21 Schmitt: It's from the southeast side of the parting plane...

122:13:28 Cernan: There it is, a whole big slab, right there.

[It's a flat, hand-sized piece.]

122:13:29 Schmitt: Okay, very good.

122:13:30 Cernan: Oh, look at those dark minerals in there. Are those dark black?

122:13:33 Schmitt: Yeah, they may be ilmenite or fresh pyroxene. (Pause) We'll look at it.

122:13:36 Cernan: Gives the impression of pyroxene.

[Schmitt - "Both pyroxene and ilmenite are dark minerals because of their iron and magnesium content."]

[Jack has retrieved the sample with the scoop and is now trying to stick the scoop in the ground so that he can have both hands free.]

122:13:38 Cernan: Okay, you want my bag (that is, does Jack need to get at Gene's SCB)? (Pause) I tell you, if you work on any kind of slope, like this little crater...(Pause)

[Jack opens Gene's SCB and puts the sample bag in it.]

[Cernan - "Early in training, we learned from working together that when the other guy is wrapping up a sample, you should turn your back and lean over so that he can drop the sample in the SCB. If you just walk away to do something else, he's left standing there with his hands full. The reason you have to lean over is mostly because the suit makes it difficult to reach up very high. Now, Jack isn't the tallest guy in the world, but the suit made it even harder for him. You just can't get your hand much above your shoulder unless you rotate your body to the side."]

[Schmitt - "Once we got into operational training, we'd wear backpacks with SCB's even when we weren't wearing suits; and it quickly became second nature, a part of the routine, to turn and bend over so the guy wrapping the sample could put it in your bag."]

122:14:00 Schmitt: Okay, I'm going to leave it (Gene's SCB) open for a minute.

122:14:02 Cernan: Okay.

122:14:03 Schmitt: While we get that one. I'm going to have to...You're going to have to use your tongs on that one, I think.

122:14:08 Cernan: Okay.

122:14:10 Schmitt: I got it.

[Gene has handed Jack an empty sample bag. They are facing west, away from the Rover and the TV camera.]

122:14:13 Parker: And, 17, a reminder to factor into your thinking, this is only a 30-minute stop, and there's about two-zero (20) minutes remaining.

[Gene uses his tongs to grab the sample.]

122:14:21 Schmitt: Yes, sir. But we got to sample something.

122:14:24 Cernan: Here's a big one. Get him (Parker) the bag number, too.

122:14:27 Schmitt: Bag 454. Okay, and the flashes are from inside of vugs and recrystallized vesicles. They look like pyroxene flashes; they could be ilmenite.

122:14:45 Cernan: I'll get my "after" picture.

[Fendell pans away from them.]

122:14:48 Schmitt: Okay; and let me get in there and get some soil.

122:14:51 Cernan: Okay, let's get it first.

122:14:53 Schmitt: From the north side. Whoops. Okay, the bag tore around that; it's pretty jagged rock, but I think it'll hold.

122:14:59 Cernan: Pretty good slab.

122:14:59 Parker: Okay. Copy that.

122:15:02 Schmitt: (Having put the sample in Gene's SCB) It's in yours.

122:15:03 Cernan: Okay.

[Fendell has pointed the camera at them again.]

122:15:05 Schmitt: It's in Gene's sample collection bag. And a scoop sample...(Pause) You got a bag handy, Gene?

[Because of the stiff suits, holding a bag with one hand and pouring samples into it with the scoop held in the other hand is a bit difficult. Here, Gene and Jack are working as a team, Gene holding the bag while Jack works the scoop. At Station 3 on EVA 2, a revision of the station activities leaves Jack sampling on his own, at a noticeable cost of efficiency. Later in the mission, Jack devises a reasonably effective method of solo sampling. Jack moves west and a little below the rock. He bends his knee and gets a fillet sample with the scoop.]

122:15:17 Cernan: Okay, bag 455. Bob. Is from the west side of the rock. It's under a slight overhang of the rock.

122:15:26 Schmitt: (Finishing the thought) In a shadow, anyway.

[To receive the sample, Gene flexes his knees slightly; however he doesn't hold the sample bag very low, as Dave Scott often did on Apollo 15.]

[Schmitt - "There was a long-standing interest in the possibility of getting samples of permanently-shadowed soil so that the solar-wind chemists could look at material that hadn't been directly exposed for some period of time. I don't know if anything ever came of it, but we talked about it a lot over the years."]

[As of 1991, very little has ever been done with the shadowed soil samples. As it turns out, lunar soil saturates with solar wind products in a matter of decades and then is thrown around and mixed. Analysis of solar wind abundances in soils taken at the bottom of the deep cores showed little difference with abundances in soils collected at the surface or, presumably, in the shadowed samples. Had there been noticeable differences, the results would have been published and the lack of publications indicates an unremarkable result.]

122:15:31 Schmitt: Okay, that's from about 1 centimeter down...1 to 2 centimeters. And the next one is down to about 5...5 or 6. (Pause) And it's got some chips in it.

[Jack uses a one-handed scooping motion.]

122:15:53 Cernan: That's bag 456, Bob.

122:15:55 Parker: Copy that.

[Jack stumbles and spills some of the sample.]

122:15:56 Schmitt: Shoot. (Pause; Jack laughs)

122:16:10 Cernan: Yeah, I know. I know.

122:16:15 Schmitt: (Moving out of the field of view) Oh, shoot. (Pause)

122:16:21 Cernan: Hey! 1.2 kilometers is a long way from the LM. Look at the Challenger down there. Makes you get a feel for how big this valley really is.

122:16:29 Schmitt: I'd rather not. (Pause)

122:16:34 Cernan: Okay. I'll help you.

122:16:35 Schmitt: I got it.

122:16:36 Cernan: Turn around and let me help you get these in your bag.

122:16:38 Schmitt: I learned how.

[Jack has probably dropped the scoop and may, at this point, have devised the trick of stepping on the head to raise the handle to an easy-grabbing height.]

122:16:41 Cernan: You learn of necessity out here.

[Cernan - "You learned how to maneuver; you learned how to walk; you learned how to bend over to help each other; you eventually learned how to swing the hammer better; you learned how to pick up soil samples. You learned how to make your movements more efficient and productive."]

122:16:43 Cernan: (Putting the sample bags in Jack's SCB) Okay. See if we can't fill this up for Christmas. (Pause)
 122:16:52 Schmitt: Okay, let's...You happy there?
 122:16:54 Cernan: Yeah..
 122:16:54 Schmitt: Let's get your "after"..
 122:16:55 Cernan: Okay.
 122:16:56 Schmitt: And if we can, we might get just a block instead of breaking on it, and then we'll go to the rake. Let's go around to the...

[What Jack is suggesting is that, rather than pounding on the rock to break off another sample, they pick up a manageable piece off the surface. Gene retrieves the gnomon; Jack moves around to the east rim of the crater.]

[Schmitt - "A block is a rock of almost any size, as long as its big enough that it clearly doesn't fall into the general size range of particles in the underlying regolith"]

122:17:05 Cernan: Bob wants a core here, too, huh?
 122:17:09 Schmitt: Yeah, but the rake's next, as you might imagine. Geno, now this stuff here looks a little less vesicular. Why don't we try that one?

[Jack is standing at the east rim, gesturing at the rock around him.]

122:17:22 Cernan: Hey, look at this rock, where the vesicularity changes from a hummocky vesicularity to a very fine vesicular. Look at this.

[Jack goes toward Gene, who is out of the TV picture.]

122:17:28 Cernan: Let me try and crack...See that? The change?
 122:17:33 Schmitt: Yeah, that's what I'm after; that's it.
 122:17:36 Cernan: Let's see if I can't crack...
 122:17:37 Schmitt: That's it. That's what I saw in that other boulder.
 122:17:39 Cernan: Let's see if I can't crack the corner and get that contact.
 122:17:41 Schmitt: Yeah. Or get a piece of both. I think you can get...if you can reach down there.
 122:17:46 Cernan: See if I can't get a...(Pause)
 122:17:54 Cernan: That's a contact in a rock.
 122:17:56 Schmitt: Yep.

[They are between the Rover and the first boulder that they sampled. Gene has set the gnomon on the ground south of the knee-high boulder and is taking "before" pictures from the south. In general, a contact is a surface defining a change in rock character within a single rock mass. Here, there is a change in vesicularity across the contact. They are not as close to the rim as they were before. Gene has taken a cross-Sun stereo pair of the rock, and Jack has taken

a down-Sun. Gene's pictures are AS17-134-20397 and 20398 and Jack's is AS17-136-20741.]

122:17:58 Parker: Beautiful. And, do you guys see any 2-meter boulders around there?

122:18:06 Schmitt: We just sampled one.

[Houston is puzzled that the TV hasn't shown any of the large boulders (large enough to have been seen in the Apollo 15 pictures) at the place where Houston thinks they are. Jack is saying that they just sampled a boulder, albeit, one less than a meter high.]

122:18:08 Cernan: Well, I wish (garbled) get over here and try and knock it...

122:18:09 Parker: Well, if that one showed up in the photos, I wonder why those down near the ALSEP didn't show up.

122:18:17 Schmitt: No, we're not where you think we are. We're not sure where we are.

[Gene kneels east of the boulder and hammers it.]

122:18:22 Schmitt: Gene, can you get down into that? Need some help?

122:18:27 Cernan: Yeah, just give me the shovel to hold myself with. Give me a shovel. (Pause)

[Gene has been hammering right handed. He takes the scoop in his left hand and uses it as a cane.]

[Cernan - "Without the suit, I probably would have reached out with my left hand to brace myself on the rock, but that would have put me too close to the rock to hit it properly in the suit. So I used the scoop for support."]

122:18:42 Schmitt: How about that one? Yeah.

122:18:44 Cernan: Get that little piece.

122:18:45 Schmitt: Okay, I see it.

[Gene rises, apparently by pushing back against the scoop handle.]

122:18:48 Cernan: It's pretty hard. See if I can't...It's low and hard to hit.

122:18:56 Schmitt: How about coming around from this side?

122:18:59 Cernan: Well, I got the gnomon in the wrong place really.

122:19:01 Schmitt: Let me see your...

122:19:02 Cernan: Can you reach it?

[Jack takes the hammer.]

122:19:03 Schmitt: Well, I'm going to lean on the rock maybe.

[Jack leans on the rock from the southwest.]

122:19:06 Cernan: I got that other little piece in sight.

[Jack gives the rock a sharp hammer blow and a sample breaks loose.]

[Schmitt - "Note the value of geological field experience!"]

122:19:10 Cernan: Okay, I got that piece in sight, too. Let me...

122:19:18 Schmitt: Get them both with your...

122:19:19 Cernan: Let me get them both right now.

[Gene collects one fragment with the scoop.]

122:19:21 Schmitt: You can stick that (scoop) in the ground if you...(Pause) Okay, this is a sample of the more coarsely vesicular rock. (Pause)

[Still leaning on the rock, Jack closely examines the fresh face and knocks off another piece.]

122:19:34 Schmitt: You got it in your hand?

122:19:36 Cernan: I got them both. I think, actually, we got a sample of both sides; but I wouldn't bet on it.

[Jack delivers one sharp blow on the east face.]

122:19:45 Schmitt: Okay, I just got a chunk of that side. (Long Pause)

[Jack tries to change his grip by tossing the hammer upward; but he almost drops it. Gene collects the fragments with the scoop. However, because he is holding the scoop head in his left hand, he then has to walk his right hand down the handle toward the head before he can pour the fragments into the sample bag. By moving his hand down, he shortens the distance he has to raise his arm in order to pour.]

122:19:58 Cernan: Okay, I got both of these.

122:20:01 Schmitt: See that rock right over there on the little mound, just projecting out of the edge of it?

122:20:04 Cernan: Where are you looking?

122:20:05 Schmitt: Right over there.

122:20:06 Cernan: Here?

122:20:06 Schmitt: No.

122:20:07 Cernan: Here?

122:20:08 Schmitt: Where I'm pointing.

122:20:08 Cernan: (Moving the scoop a foot eastward)
There?
122:20:09 Schmitt: There you go; you just about touched it.
Right there, that piece.
122:20:11 Cernan: Okay, let me get these in a bag here.
(Long Pause)

[Jack hammers the rock four times without success. Even an experienced field geologist doesn't always get the piece he wants to break loose.]

122:20:25 Schmitt: Well...
122:20:26 Cernan: I'll get that piece.
122:20:28 Schmitt: And that's the samples from either side of the contact anyway.
122:20:30 Cernan: Can you get a bag...
122:20:31 Schmitt: They're pretty small. (Pause)
122:20:34 Cernan: Give me the hammer, and get a bag and I'll...
122:20:36 Schmitt: You take the hammer.
122:20:37 Cernan: I got these in my hand I want to put there.
122:20:39 Schmitt: Okay. Bag 477 is the coarsely vesicular rock.
122:20:43 Cernan: Are two of them there? I hope two of them fell in.
122:20:47 Schmitt: No, I only got one.
122:20:49 Cernan: Okay, here's that other one. It had to fall right here.
122:20:57 Schmitt: I don't think it ever...There it is; get your tongs.
122:21:02 Cernan: Right here?
122:21:03 Schmitt: Now you're full of dirt in the scoop; you just covered it up.
122:21:07 Cernan: (Using the scoop) Got it; I got it.
122:21:08 Schmitt: Here, put it in here with the dirt.
That's good. A little dirt never hurt anybody. (Holding the sample bag low) Got it.
122:21:15 Cernan: There it is.
122:21:16 Schmitt: Got it.
122:21:17 Cernan: Okay.
122:21:19 Schmitt: 477 are two chips. They're small, but I think they'll (tell you) if there's any compositional difference.
122:21:25 Cernan: But these two are the ones you saw? That right there? (Pause) That's what you pointed at.

[Gene uses the scoop to pick the fragment off the surface, trying to get as little soil as possible.]

122:21:32 Schmitt: Yeah, I think you got it.
122:21:34 Cernan: Okay. I'm going to take a close-up stereo on that contact.
122:21:37 Schmitt: Yeah. Definitely.

[Jack puts the sample bags in Gene's SCB, then gets another bag for the last sample. Before taking his close-ups, Gene takes a cross-Sun after (AS17-134-20399) and a locator back to the Rover (AS-134-20400).]

122:21:40 Parker: Okay; and, Jack and Gene, when you get done with that boulder, we'd like you to move on to a rake soil sample, please; and that'll be a kilogram sample, please.

[That is, they will collect about a kilogram of soil, about enough to fill one sample bag.]

122:21:50 Schmitt: Yes, sir; we're going to. We're going to. (Pause) In bag 478 is the chip from the more finely vesicular rock. Both of them are coarse. It's a small chip; but it'll tell the story, I think.

[Jack puts this sample bag in Gene's SCB.]

122:22:11 Cernan: Dust, dust, dust, dust. (Giving Jack the scoop) Here you are. I'll go ahead and get a close-up (garbled)...

122:22:14 Schmitt: Get a close-up, and I'll get the rake. I'll get started on the rake.

122:22:18 Cernan: Okay.

[Gene goes to the Rover; Jack goes to the Rover, out of the picture.]

122:22:23 Schmitt: Gene, if you can pick up one more rock in that picture, with your tongs, let's bag it.

122:22:30 Cernan: I'll get it.

122:22:33 Schmitt: As you come back.

[Schmitt - "I was just telling Gene to bootleg another sample. If he picked one up out of the area he'd just photographed, then Houston could probably identify it."]

122:22:37 Parker: And, 17; we'd like to have you guys...

122:22:40 Cernan: Sure wish I could read this (camera setting).

122:22:41 Parker: ...driving in 10 minutes, please.

122:22:45 Schmitt: Nag, nag, nag.

122:22:49 Parker: That's right, that's right, that's right.

122:22:50 Cernan: Boy, I can't see my camera (f-stop) setting, it's so full of dust.

122:22:56 Schmitt: (To Parker) Okay. I guess you want to sort of (get the rake sample)...out in nothing's land here, huh? (No answer from Houston) I can bag it for you, Geno.

122:23:12 Parker: Roger.

122:23:13 Cernan: That's all right. I want to get this close-up here.

[Fendell finds Gene again; he is taking pictures. His close-up photos of the second boulder are AS17-134-20401 to 20404.]

122:23:19 Schmitt: Okay, I've moved about 5 to 8 meters northeast of the Rover. And as soon as Gene gets here with the gnomon... (Pause)

122:23:40 Cernan: Coming, coming. (Pause)

[Gene gets a sample with his tongs. The operation of his yo-yo is clearly visible. Gene goes to Jack northeast of the Rover, out of the TV picture. Fendell pans to follow Gene.]

122:23:50 Cernan: Bob, I've got a sample that was laying next to that boulder. I did not get an after picture of it; but, as I was taking my cross-Sun pictures, it is on my side of the boulder just 4 or 5 inches, covered with the dark mantle.

122:24:08 Schmitt: I think we probably disturbed that one. It'll probably show up in the "befores".

122:24:13 Parker: Okay. Copy that.

122:24:13 Cernan: Okay, where do you want a rake. (Pause)

122:24:21 Schmitt: And that's in bag 479.

122:24:25 Parker: Okay.

122:24:28 Schmitt: Gene, let's rake right out there.

122:24:31 Cernan: Look, let's go ahead and bag that one (that is, put it in Gene's SCB); and I'll get the gnomon out there.

122:24:36 Schmitt: Okay.

122:24:37 Cernan: Bob, as you might have seen from the camera, up towards where we think Emory is you get a pretty high concentration of boulders up there.

122:24:47 Parker: Okay. And I think that that's where we thought we were, a little bit closer to Emory than you are.

122:24:55 Cernan: Well, we thought about going on up there; although we're in a pretty good area here, too, from the standpoint of boulders.

122:25:02 Parker: Yeah.

122:25:03 Cernan: Again, I think...(To Jack) Facing the Sun.

[Jack is just in view; Gene is reminding him to position the gnomon color chart so that it is fully sunlit. A photograph of Jack positioning the SEP transmitter (AS17-134-20438) is a good illustration of Jack's posture at this point.]

[Cernan - "It was even awkward to get the gnomon down on a level piece of ground. You didn't want to drop it from a foot or two up, so you had to bend one knee, get the other leg out to the side, and lean sideways, very much like you sometimes had to in order to use the hammer. It was another one of ways you learned how to do things easily and with

stability. You didn't really think about it; you knew when you were unstable and when you weren't, and you learned how to react. It's a normal reaction to a new environment."]

122:25:06 Cernan: I think for the most part, large and small, all the fragments seem to be filleted or even mantled by the dark material.

[Schmitt - "Filleting is a natural consequence of the continual gardening of the upper regolith layers by the impacts of small meteors. Any boulder that's exposed will have material thrown against it that will collect at the base. The original thoughts about the 'dark mantle' material was that it had been put down very late, that it was very young; and that it might have been filleting the boulders. Of course, the truth is that the regolith and the dark material were intimately mixed. The dark mantling proved to be the result of pyroclastic materials - which had been laid down on top of the valley-filling lavas - being mixed with the regolith as the regolith formed. At Shorty Crater (EVA 2), we found black and orange pyroclastics which had been protected by a late lava flow until the Shorty impact dug it up; but, in most places, the pyroclastics probably had been deposited after the lavas had ceased to invade the valley. What we saw at Shorty may have been the result of the sort of thing that happens on Earth when, after the gas that has been powering the pyroclastic eruption is depleted, you have a lava flow. At Sunset Crater near Flagstaff, the last thing that happened, except for a little bit of ash, was the Bonito (Lava) Flow. At Taurus-Littrow, the last of the lava flows may well have been the one that covered the pyroclastic deposit that the Shorty impact uncovered."]

122:25:20 Schmitt: Let me get out of your way.

122:25:21 Cernan: Boy, I've got to clean my camera; I can't even see. (To Jack) What area are you going to rake?

122:25:25 Schmitt: To your left of the...Well, ahead of the gnomon and to your left, there.

[Schmitt - "As with any of the other sampling procedures, you took a set of pre-sampling documentation photographs and then drug the rake basket through the regolith until you had a reasonable number of small fragments. Studies of samples from some of the early missions has suggested that, in the walnut-sized fragment population, you got more fragments from outside the immediate area than in any other size range. So the rake was designed to maximize the yield of these 'exotics'."]

122:25:31 Cernan: Okay, I got it.

[Fendell pulls back on the TV zoom, bringing both of the astronauts into the frame. Gene and Jack are both taking

"before" photos of the rake area. Gene's pictures are AS17-134-20405 to 20407 and Jack's are AS17-136-20742 and 20743.]

122:25:33 Parker: (Referring to Gene's remark about the prevalence of filleting) Okay, Gene, we copy that. That's a good observation. And I also gathered that most of the rocks look pretty much the same.

122:25:41 Schmitt: That's what I said.

122:25:42 Cernan: Yeah, except a change in vesicularity...

122:25:48 Parker: Roger.

122:25:49 Cernan: ...in terms of the size of vesicles, where I described one as being a more hummocky vesicular-type rock. The first time I've noticed any of the dark minerals was when we took that one big, flat chip off that boulder.

122:26:04 Parker: Okay; copy that.

[Jack takes the first rake swath, standing with his right foot forward and his body turned to his left, dragging the rake with his right hand as he moves backwards.]

122:26:06 Cernan: I didn't look at it that close to see what it was.

122:26:10 Parker: Copy that, guys.

[Jack finishes the first swath. The rake is not penetrating very far into the soil.]

122:26:14 Cernan: I'm going to get a pan, Jack, while you're doing that.

122:26:16 Schmitt: Okay.

122:26:17 Parker: Good idea, Gene. (Long Pause)

[Jack takes three more swaths, shaking dirt out between the tines after each one. Gene's pan is AS17-134-20408 to 20431. Frames 20425 and 20426 show Jack raking.]

122:26:41 Cernan: Man, are there some good targets for the 500(-millimeter camera) around here. (Pause) We've got to get those Massifs with the 500. (Pause)

[Jack takes swaths number 5 and 6; the bottom of his SCB is loose.]

122:27:06 Parker: And, 17; again, a reminder...

122:27:08 Schmitt: And, Bob, I'm really only penetrating about, at the most, 3 centimeters into this area with the rake. I've picked up a very good sample of boulders (fragments) but most of them were in that distance of the surface and projecting out of it.

122:27:28 Parker: Okay; I copy that.

122:27:31 Schmitt: You ready, Gene?

122:27:33 Cernan: A couple of more (pictures), Jack. (Pause) Okay, coming at you (with a sample bag). Bob, the pan is complete. I'll give you a frame count shortly.

122:27:44 Parker: Copy that, Geno.
122:27:45 Schmitt: There's two bags, I think.

[Gene is not in the TV picture.]

122:27:46 Cernan: Two bags full. First bag is 457...
122:27:52 Parker: Copy that.

[Fendell pulls back on the zoom so that Gene can be seen.]

122:27:53 Cernan: ...457. (Pause) Don't let me lose them. That's enough. Give me a couple of small ones.
122:28:03 Schmitt: Okay.
122:28:05 Cernan: Okay, that's good. That's good. Okay. (Pause)

[Gene puts the sample bag in Jack's SCB.]

122:28:16 Schmitt: Here, they are.

[Neither Gene nor Jack is sounding punchy any more.]

122:28:21 Cernan: (Getting another bag) Okay, and bag 458 is the rest of the rake sample. They're all fragments.
122:28:30 Parker: Copy that. Now we need the kilogram of the soil.
122:28:37 Schmitt: Yes, sir.
122:28:39 Cernan: Okay, Bob. All the fragments, of course, are completely covered with the mantle (meaning soil); and they are slightly...oh, maybe 20-percent vesicular. I just took a glance at them. But, for the most part, they appear to be rounded to subrounded fragments. (Pause)
122:28:58 Cernan: (To Jack) Okay. Let's get the kilogram. (Pause)

[Fendell pans up and then down; neither Jack nor Gene is in the picture when he finishes.]

122:29:10 Schmitt: Okay. (Pause) Aghh! Well, shoot. Start all over.

[Apparently, Jack has poured most of the soil onto the ground, not into the bag. The rake has solid metal sides so that, rotated ninety degrees, it can be used as a big scoop.]

122:29:20 Cernan: Try it again. 459 will get the kilogram, Bob.
122:29:25 Parker: Copy that.
122:29:33 Schmitt: (I'll) get some more.

[Fendell pulls back on the zoom again and finds Jack using the rake.]

122:29:35 Cernan: Okay, fill it up. (Long Pause)
 122:29:48 Schmitt: Can you close it?
 122:29:49 Cernan: Yeah, yeah, I can close it.
 122:29:51 Schmitt: That's a good kilogram.

[The sample bags are square and were designed to hold rocks up to 11 cm in diameter. The volume of such a rock is about 700 cc's and bags could clearly hold a greater volume of soil. Soil poured loosely into a bag would have a density of no less than about 1.3 kg per liter and, consequently, a kilogram would occupy a volume of no more than about 800 cc's.]

122:30:00 Cernan: Well, I just can't even read my camera anymore. I've got to learn how to control the dust. Okay, that's in (Jack's SCB).
 122:30:06 Schmitt: Okay; you get the "after"?
 122:30:07 Cernan: I tried to blow the dust off my camera!

[Not a very useful thing to try when wearing a helmet.]

122:30:11 Schmitt: I think it's going to be hard to get a double core here. We could try a single right there.
 (Pause)

122:30:18 Cernan: Bob, we got time to get the core?
 122:30:19 Parker: Negative. The core has been deleted. We'd like for you to get your second pan, Jack, and then we'll press on.
 122:30:27 Schmitt: Okay. (Pause)

[Jack retrieves the rake and goes to the Rover. Gene takes the "after" picture, AS17-134-20432.]

122:30:33 Schmitt: I'll get it over here (west of the Rover) where our two sample sites are in view.
 122:30:37 Parker: Copy that. (Pause)

[Jack mounts the rake on the gate, pushing the handle into a retaining bracket.]

122:30:49 Cernan: (Looking toward the northwest) Well, now I know why I felt that we were much too close to Trident than what I thought. We weren't really too close to Trident, because Trident is way out here. That makes me feel better. A guy would know if he landed 100 meters from a big set of craters like that. (Pause; going to the Rover) You know, on a landing site like this, you ought to know exactly where you are. (Pause) Anyway, I landed where I wanted to. (Pause) Okay, Bob, here's a (gravimeter) reading for you.
 122:31:34 Parker: Okay. Ready for it. (Pause)

[Fendell starts to follow Jack, but sees Gene's shadow, stops, and pans to find him at the gate. Fendell then pans

away again and stops to look at a split boulder. The LM may be visible in the TV picture as a bright dot.]

122:31:47 Cernan: 670, 012, 901; 670, 012, 901.
 122:31:55 Parker: Okay; copy that, Geno.
 122:32:03 Cernan: Okay, and no more (seismic) charges to deploy going back, right?
 122:32:07 Parker: No, we will deploy charge number 7 on the way back.
 122:32:13 Cernan: On the way back. Okay.
 122:32:14 Parker: Roger. It will be deployed at the same location we were originally planning on deploying it, which was in the checklist there.
 122:32:24 Cernan: Okay. Very good, sir. We'll get at it.
 (Pause)

[Fendell finds Jack taking the pan southwest of the Rover. These photos are AS17-136-20744 to 20776. Note that frames 20769 to 20772 show the rim of Steno Crater.]

122:32:36 Cernan: (To Houston) Okay. I'm taking your (TV) camera.
 122:32:43 Parker: Okay. And, Jack, you got the pan or getting it?
 122:32:50 Schmitt: Yes, sir.
 122:32:53 Cernan: And, Bob, CDR is on frame count 60.

[TV off.]

122:33:01 Parker: Okay.
 122:33:05 Cernan: (Garbled) switch one.
 122:33:08 Schmitt: And the LMP is on nine-five.
 122:33:13 Parker: Copy, 95.

[Jack has just taken frame AS17-136-20776. Details of the Station 1 closeout and of the drive back to the SEP transmitter are given, identically, on cuff checklist pages LMP-33 and CDR-31.]

122:33:17 Schmitt: Okay, Gene.
 122:33:19 Cernan: We need EP-7, Jack.
 122:33:23 Schmitt: You got the gnomon?
 122:33:24 Cernan: Got the gnomon.
 122:33:27 Schmitt: And the rake and the scoop?
 122:33:28 Cernan: The rake and the scoop are back on (the gate). Okay, get the charge. I'll set the low gain (antenna), and we'll be ready to do it.
 122:33:35 Schmitt: Bob, my impression right now is that the dark mantle may just be a...Well, at least in here, it's indistinguishable from a regolith that might be derived from these other rocks. It seems to be a little dark for that, but that might be the answer.
 122:33:55 Parker: Okay. We'll...
 122:33:56 Schmitt: (To Gene) EP-7?

122:33:57 Cernan: EP-7.
122:33:58 Parker: We hope to do (more) on that (dark mantle question) again tomorrow. And EP-7 is the charge, right?
122:34:08 Cernan: Jack, I figured out (that) if you mount the Rover at 90 degrees, when you kick up your feet, you'll miss the dust. (Pause) Let me hook you in before I do that.
122:34:23 Schmitt: Okay. (Pause)
122:34:27 Cernan: Just put your feet 90 degrees to it (the Rover).
122:34:30 Schmitt: Yep. (Pause) Boy, you certainly ride high.
122:34:35 Cernan: Do I?
122:34:36 Schmitt: Yeah. I'm surprised the belt fits.
122:34:39 Cernan: Yeah, it fits fine. Okay. I'm in.
122:34:45 Schmitt: Okay. (Pause)
122:34:51 Cernan: Oop...
122:34:52 Schmitt: Not too good, huh?

[Jack's seat belt is twisted, which makes it too short to latch.]

122:34:56 Cernan: Yeah. We're learning. I hope my bag was closed. Yours was. Did you get it?

[That is, did Jack close Gene's sample collection bag?]

122:35:06 Schmitt: Yeah, as a matter of fact, I did. I thought (of) that.
122:35:07 Parker: Okay, we mark you underway.
122:35:09 Cernan: You know, you ought to put that sampler (garbled)... (Answering Parker) Not yet.
122:35:13 Schmitt: It's not the sampler; it's these bags with memory.

[The sample bags hooked to the bottom of Jack's camera have apparently held the folds that they'd acquired in storage and are blocking his view of his seatbelt.]

122:35:18 Cernan: This thing is too high for you. You're hitting it all the time. (To Parker) No, we're not on our way, Bob.
122:35:23 Parker: Okay.
122:35:28 Cernan: Okay. And you want the charge deployed at 320/0.7, huh?
122:35:38 Parker: Roger. It will be 0.6 (km). We'll change that to 0.6 on EP-7; and it will really be just wherever you cross 0.6 on the range (that is, at about 650 meters from the SEP.)

122:35:53 Cernan: Okay.
 122:35:54 Schmitt: Well, it (the seatbelt) fit once.
 (Pause)
 122:36:01 Cernan: It's twisted, Jack, 180 (degrees). That took out some of your (length)...Wait a minute. Here.
 122:36:07 Schmitt: Which way?
 122:36:08 Cernan: Well, I can't see. Your left hand's in the way now. (Pause) Away from you. Twist it away from you 180 degrees.
 122:36:14 Schmitt: Like that?

[Jack turns the belt part way to find out if he's understood Gene correctly.]

122:36:15 Cernan: Yeah, now the other 90. (Pause) Okay, now try it. Well, let me see...You got it? That should do it.
 122:36:33 Schmitt: Okay.
 122:36:34 Cernan: Okay. (Pause) Here's your charge. I think we're learning, (and) that's half of the first EVA. Okay, Bob, we are rolling. Mark it.
 122:36:49 Parker: Okay, copy that, Jack..(correcting himself) Gene. (Pause)
 122:36:58 Schmitt: Okay, where did they want it deployed?
 122:37:00 Cernan: Six-tenths of a kilometer.
 122:37:02 Schmitt: Back, huh?
 122:37:03 Parker: Rog. It'll be at a range of 0.6, guys.
 122:37:10 Schmitt: You've got a block right ahead of you.
 122:37:12 Cernan: I got it.
 122:37:13 Parker: Okay. And remember you'll be taking photos coming back here, Jack...
 122:37:16 Schmitt: Okay.
 122:37:17 Parker: ...if you get a chance.
 122:37:21 Schmitt: Yes, sir. Thank you. I got a few going out, Bob, but they weren't too well spaced.

[Schmitt - "The basic use of the photographs was supposed to have been the location of observations, although nobody's ever done very much of that analysis. I think, also, that these traverse photos were added as a response to the problem that the Apollo 16 crew had in knowing where they were, at least on their first traverse. And, finally, if you weren't doing anything else but riding, you might as well take pictures and get more information and documentation. There was plenty of film. And some of that information proved to be very useful. The pictures I took when we were driving on the avalanche during the second EVA helped confirm my observation that there weren't many boulders on the surface, as you would expect if it had been a gas-lubricated avalanche."]

[During the drive back from Station 1, Jack takes a lot pictures. Up to this point, he has probably only taken AS17-136-20777, which shows Bear Mountain and the Steno rim and was probably taken as soon as he had his seatbelt fixed.]

122:37:28 Parker: Okay. And I assume you've got the low-gain antenna aligned.
122:37:33 Cernan: Yes, sir; it's aligned. Okay. That's got to be Trident, Jack, because that's too big for anything else. (Pause)
122:37:52 Schmitt: Okay, Houston. There's the classic raindrop pattern over this fine debris. I'd say that the surface definitely is sorted: the fine regolithic material forming one fraction and then the blocks another. The blocks are probably...Those blocks greater than 2 centimeters in diameter, in general, make up (that is, cover) less than 10 percent of the surface. But there are some big ones, fairly uniformly distributed. There are blocks a meter in diameter.
122:38:35 Parker: Copy that.

[AS17-135-20540 will be taken at the SEP at the start of EVA-2 and shows the raindrop pattern quite well.]

122:38:36 Cernan: Hey, Jack, that big crater out there at 2 o'clock (relative to his current heading, which is roughly north) has probably got to be Sherlock. That's got to be Sherlock over there.
122:38:44 Schmitt: Yeah, probably. I think the only place I've really identified that we can go to is to Station 6.
122:38:49 Cernan: Yeah, but we've got to get on a high vantage point here one of these days.
122:38:54 Schmitt: Yeah. (Pause) Well, I think we'll find Camelot without any problem.
122:39:00 Cernan: (Guffawing) Yeah.

[Cernan - "In looking at some of the pictures that Jack took on the way back to the LM, it's really obvious how difficult it was to know where you were in that three-dimensional environment. You could get up on high spots and orient yourself; and you always knew where you were in the valley - where you were in the 'big picture' - and where you were in relation to the LM. But the Rover nav system really allowed you to go where you wanted to go fairly precisely. Getting back to the LM would have been easy enough without the nav system. You could follow the Rover tracks back and, if that wasn't the most direct route, you could still get close enough to see the LM. There certainly weren't many things you could mistake for the LM. It was the only thing around that really reflected sunlight; it was also pretty big (23 feet or 7 meters tall) and would have been hard to miss. But in finding a particular crater when, as I say, you were 'down among them', the nav system really helped."]

122:39:01 Cernan: Okay, watch. I'm going through it.
122:39:03 Schmitt: Okay. No problem.
122:39:07 Cernan: No, I'd rather straddle or go through those little ones.

[Gene would rather have pitch motion than roll.]

122:39:09 Schmitt: Okay, Bob, here's another crater about the same size we sampled (at) the last station. And it doesn't have as many blocks, but it does have blocks. And from this distance, their vesicular texture and their light color shows up very well. I suspect they're the same general kind. There's a glass-bottom crater.

[Schmitt - "The glass-bottomed craters generally had a glass-lined central pit, a shelf surrounding that, and then the rim."]

122:39:28 Parker: Okay. You got a range and bearing, there, guys, please.

122:39:34 Cernan: 341/0.8.

122:39:35 Parker: Copy that.

122:39:36 Cernan: Did you take a picture, Jack?

122:39:37 Schmitt: Yeah.

122:39:38 Cernan: Okay. (Pause)

122:39:47 Schmitt: You're pointed right at Station 6, I think, Gene.

122:39:50 Cernan: I think you may be right. There's that boulder. I just want to get up here where I can (garbled)...

122:39:53 Schmitt: Not the one on the (boulder) track but the one over there to the right of that. (Pause) Unless the one with the track...I've got mixed emotions (as to) which is 6.

[They may be pointed at the dark boulder west and uphill from Station 6.]

122:40:04 Cernan: Look over there to the left. You see that. (Static)

122:40:07 Schmitt: Yeah.

[Gene probably turned the Rover to get a better view.]

122:40:10 Cernan: That's Trident. Man, I'll tell you.

122:40:12 Schmitt: Look at this thing. That looks like the same kind of rock except it doesn't have any vesicles.

122:40:19 Cernan: There's some white stuff in that rock.

Just let me take a quick pic (static, probably as Gene turns). See that one right in front of us? Take a picture of it.

122:40:27 Schmitt: Oh, you mean this one, here.

122:40:29 Cernan: Oh, that's a big zap pit, isn't it? Take a picture of that?

[Jack takes two pictures of the rock. AS17-136-20780 and 20781.]

122:40:35 Schmitt: Yeah, they're big zap pits. Same rock with big zap pits. (Pause) I've got to change the

(focus)...I was too close. Although there are...I think those are zap pits. It's a little hard to say.
 122:40:47 Cernan: Looks like a big chip out of the rock.
 122:40:49 Schmitt: They're white halos; it just has more of them.
 122:40:52 Cernan: But it's a big one; it's about an inch and a half or 2 inches across.
 122:40:54 Schmitt: Yeah. (Pause)
 122:41:00 Cernan: I tell you, I've got to go and get my size and geometry squared away.

[Cernan - "The further away things were, the harder it was to judge size and distance. Things always looked closer and smaller than they really were. After a while you began to recalibrate your brain, but it was always deceptive."]

122:41:04 Parker: Okay, 17, how about...
 122:41:05 Schmitt: Going through this one?
 122:41:06 Parker: ...range and bearing?
 122:41:07 Cernan: (To Jack) Yep. (Responding to Parker) Okay. 341/0.7. Bob, we're moving at about 11 clicks (kilometers per hour) right now.
 122:41:18 Parker: Copy that. Beautiful. Remember the charge goes off at 0.6.
 122:41:22 Schmitt: Doesn't sound like...(Answering Parker) Okay! (Pause)

[I'm still puzzled about photos 136-20778 to 20796 and when they were taken. Work it out.]

122:41:35 Schmitt: Okay, we want to...
 122:41:36 Cernan: Oh, there's the mantle. There's the white (means "light") mantle. Jack, look over there. Can you look to your left?
 122:41:39 Schmitt: Yeah, it does. Yeah.
 122:41:40 Cernan: That's the white mantle.

[A portion of the western valley floor is covered by light-colored material which, in overhead photographs, appears to be the result of a South Massif avalanche. During the second EVA, Gene and Jack will drive onto the light mantle and up onto the Jefferson-Lincoln-Lee Scarp, collecting samples and photographic evidence which will support the avalanche interpretation and give a 100 million year age.]

122:41:42 Schmitt: Swing around that way.
 122:41:43 Cernan: Call it a slide or not, but that's the white mantle. Whoo! That's my first real good picture of it. That is something!
 122:41:52 Schmitt: Okay, I got some of that. Okay, how are we doing?

[AS17-136-20797 and 20798 show the white mantle. AS17-136-20799 shows the LM.]

122:41:57 Cernan: I don't want to go in that crater (probably a fairly fresh, 30 meter crater southeast of Trident), that's what I don't want to do. Okay. We're at 0.6; how about 339/0.6?
 122:42:03 Schmitt: Okay. I got a couple of shots right out in there.
 122:42:06 Cernan: Okay. Coming right around to you.

[Unless I have the photo timing wrong, Jack takes AS17-136-20800 to AS17-136-20811 during a period of a minute or so. If so, they would have only move 200 meters and one ought to be able to track rocks in the series.]

122:42:08 Schmitt: Oh, that's good. Hold that heading. Whoa. That'll be good.
 122:42:12 Cernan: Right here?
 122:42:13 Schmitt: Yeah, whoa.
 122:42:15 Cernan: Okay. Let me get my...Okay, I got my "locator".
 122:42:23 Schmitt: Okay, now (for) this one we want me to get a partial pan until something's identified.

[Horizon features in the photographs can be used to triangulate the deployment site. Gene's locator shots are AS17-134-20433 and 20434. Jack's LRV pan photos are AS17-136-20812 to 20828]

122:42:28 Cernan: Okay. We'll do that. We've got to turn that way anyway.
 122:42:32 Schmitt: Okay, pin 1, pull, Safe. Pin 2, pull, Safe. Pin 3, Mark it, pull, Safe.
 122:42:43 Parker: Okay. And I copy that as charge number 7.
 122:42:48 Schmitt: That's affirm.
 122:42:53 Parker: Okay. And we'd like a frame number when you get done there, Jack, after you get it (the charge) on the ground.
 122:43:03 Schmitt: Okay, stand by. (Pause) (To Gene) Okay. I think we'll miss that.
 122:43:09 Cernan: Okay. Bearing (and range) is 339/0.6.
 122:43:12 Schmitt: Okay, start a pan around it, Gene...
 122:43:15 Parker: Copy that, Gene...
 122:43:16 Cernan: Okay, let me get it out...Okay, I'm going to start slowly around it.
 122:43:22 Schmitt: Okay.

[Gene is driving the Rover in a slow, clockwise circle while Jack takes pictures. Gene doesn't want to hit the seismic charge because, while there is virtually no chance of it going off, the antenna needs to be upright so that it can receive the detonation signal from the Central Station. As

Gene discusses at 141:36:23, the front-and-rear steering dictates a right hand turn to avoid the charge.]

122:43:23 Cernan: Going to miss it?
 122:43:24 Schmitt: Yeah.
 122:43:25 Cernan: Yeah; by a lot.
 122:43:27 Cernan: Okay, taking your pictures?
 122:43:28 Schmitt: Yes, sir.
 122:43:32 Cernan: (Static) (Garbled) wheels cleared it by...got to be a lot. (Pause)
 122:43:37 Cernan: Is my low gain dropping out? (Pause)
 How much are my wheels missing it by, going around?
 122:43:42 Schmitt: Lots. About a meter. Okay.
 122:43:44 Cernan: Okay. We're on our way. The low gain is set again. (Pause) Okay, we're heading on back to SEP.
 122:43:52 Parker: Okay, and a frame count there, Jack.
 122:43:53 Schmitt: Okay, the pan was more or less complete at 146.
 122:44:02 Parker: Copy, 146 on (magazine) Hotel. (Pause)
 122:44:12 Schmitt: Bob, you know, the more I look at this - watch out for those babies there - at this dark dust, if you will, the more it doesn't seem like the kind of thing you'd expect to have been derived from the underlying bedrock. But I think you're going to have to play that game in the lab right now.

[Schmitt - "By itself, the bedrock isn't dark enough to give you the dark mantle; and, if you grind it up, it's going to get even lighter in color."]

122:44:35 Parker: Okay, I copy that. Can you...
 122:44:37 Schmitt: We'll see how it works out later.
 122:44:38 Parker: Roger.
 122:44:45 Schmitt: It just seems dark and much too fine grain. You don't have the impression that you're getting the size distribution you'd expect to get by having all these blocks around.
 122:45:03 Parker: Okay, I copy that.
 122:45:04 Schmitt: (There is) definitely, I think, at least in my mind, two size populations...

[Schmitt - "Although I didn't know it at the time, I was beginning to see the fingerprints of the black, devitrified equivalent of the orange soil that we found at Shorty Crater."]

122:45:11 Cernan: Jack, that almost looks like bedrock exposed (over) in there. See that?
 122:45:15 Schmitt: Yeah, why don't you take a pass over that way. Get through there?
 122:45:19 Cernan: Yeah, I can get through there.
 122:45:21 Schmitt: Do you know where you are?
 122:45:23 Cernan: Yeah.
 122:45:24 Schmitt: In Trident?

122:45:25 Cernan: No, we're not in Trident. That's pretty steep down in there. I'd walk down there. I'm not sure I want to drive down there yet.
 122:45:31 Schmitt: No, I didn't mean down in there. I meant right over there.
 122:45:33 Cernan: Well, here's some right here.
 122:45:34 Schmitt: Yeah. (Garbled)
 122:45:35 Cernan: Take a picture of that?
 122:45:36 Schmitt: Yeah.

[A photo of the exposed bedrock may be AS17-136-20838.]

122:45:38 Parker: And how about a range and bearing when you stop to take the picture.
 122:45:40 Cernan: Okay (static)
 122:45:42 Parker: We need a...
 122:45:44 Cernan: 336/0.4.
 122:45:46 Parker: 336/0.4. Roger. (Pause)
 122:45:59 Cernan: Bob, I get a distinct impression that, as Jack says, it's going to be hard to tell whether this is regolith composed (means "derived") from the rock field we see around, but you can see that dark mantle over on top of almost all the rocks. Except we have fresh glass, possibly, in the bottom of some of these small craters.
 122:46:19 Parker: Okay.
 122:46:20 Cernan: Everywhere else there is actually mantle, I believe, in and around some of the crevices and in the vesicles and what have you.
 122:46:28 Parker: Okay, I copy...
 122:46:29 Schmitt: It's all material, though, that could be knocked in there by the local impact. (Pause)
 122:46:42 Parker: Okay; but I gather you find a lot of material on top of the rocks.
 122:46:48 Schmitt: (To Gene) I think we lost them. (Pause)
 Not a lot, Bob. Not a lot. It's there, though.
 122:46:52 Parker: Okay; copy that.
 122:46:53 Schmitt: They're not nearly as covered with dust as they get when you drop one. It's just really a salting or a scattering of debris in the depressions...
 122:47:07 Parker: Okay.
 122:47:08 Schmitt: ...on the rock. The projections of the rock are perfectly clean.

[Cernan - "When you drop a rock, it's like you've dropped a fresh fish in batter; the dust clings and the rock gets really coated."]

122:47:11 Parker: Okay. I copy that.
 122:47:13 Cernan: Yeah; but, except where rocks within the craters are evident, the crater (rims and walls) are subtly covered over with this mantle. You don't see any good sharp ridges or walls on some of these craters. Even the small ones.

[Gene struggled with this observation. The version given here has been heavily edited.]

122:47:37 Parker: Okay. Roger on that. (Pause)

[During the drive from the "exposed bedrock" at 122:45:36 to their arrival at the SEP at 120:50:36, Jack takes photos AS17-136-20839 to 20863.]

122:47:44 Cernan: Man, I tell you, you could lose the rear end of this thing in a hurry, if you'd like.

[Cernan - "When you were zig-zagging, if you weren't careful, the back end of the Rover could lose traction and swing around."]

122:47:48 Schmitt: I think you have lost a fender. I keep getting rained on here (with lunar dust).

122:47:51 Cernan: Oh, no!

122:47:52 Schmitt: Look at our rooster tail. Look what's ahead of us here.

122:47:56 Cernan: Yeah, that's probably it. It probably didn't stay. I can see it in the shadow.

[That is, they can see the shadow of the rooster tail.]

122:48:03 Schmitt: Sure, look at it.

122:48:04 Cernan: Oh boy, that's going to be terrible. That is really going to be bad.

[Without the fender, the Rover and all of the equipment will get thoroughly covered with dust, thereby increasing in the risks of both mechanical and thermal problems. Dust on the battery covers, for example, increases the absorption of sunlight and raises the battery temperatures. Dust coating on the visors reduces visibility and, when the astronauts try to clean it off, creates scratches and additional glare.]

122:48:12 Schmitt: I didn't see it. We probably lost it. I think I know when because I just started to notice it.
(Pause)

[Cernan - "We didn't go back to get the piece that fell off. But at the end of EVA-3, I broke off the other three fenders and brought those back to Earth along with the replacement fender that we made when we got back in the LM. Two of the fenders are on display at the Visitor's Center at the Johnson Space Center here in Houston, and the replacement fender is at the Smithsonian in Washington."]

122:48:25 Schmitt: Bob, I'm going to state what Gene said (at 122:47:13) slightly differently. There just aren't a lot of very sharp, bright craters, but there are some. All the craters seem to be pretty well formed. It isn't an extensive

mantle. Matter of fact, for example, hasn't filled the...(To Gene) Are we due to deploy that thing now?

[Jack is referring to the Surface Electrical Properties Experiment (SEP).]

122:48:41 Cernan: Yeah, I want to come in at a...
 122:48:45 Schmitt: (Finishing his thought) Hasn't filled the bottom of the craters.
 122:48:46 Cernan: I'm going to come in at a heading here and see if I can get on it for you.
 122:48:50 Schmitt: Okay, drop me off there. (Static as Gene turns the Rover and loses low-gain pointing)
 122:48:55 Cernan: Look at that fender. Look at the dust it's produced. Look at the L.C.R.U.

[The Lunar Communications and Relay Unit (LCRU) contains most of the electronics for the voice and television systems. Because it is particularly sensitive to overheating, it is covered with highly-reflective gold foil which, in turn, is now covered with dust. Here, Gene spells out the acronym. Often, he and Jack will pronounce it "luh-crew".]

122:49:02 Schmitt: Well, it's going to make things...
 122:49:04 Cernan: I don't know how to keep that thing on. (Pause) Make it west. Okay, I'm rolling west right now.
 122:49:13 Schmitt: That looks good. That looks good. Hold that heading.

[After letting Jack off at the SEP transmitter, Gene will re-initialize the Rover navigation system which he will use in laying out N-S and E-W tracks with the Rover wheels. He and Jack will then use these tracks as guides for laying out the four 35-meter-long arms of the SEP transmitter antenna.]

[The checklist calls for Gene to position the Rover so that he is pointing east. After initializing the Nav system, he is to drive east for 100 meters; then turn right to a heading of 210 and drive another 100 meters; and, finally, turn right to a heading of 360 for a drive of 200 meters north. This procedure would produce a cross of Rover tracks intersecting about 50 meters east of the SEP transmitter. Then, once Gene has the pattern laid out, Jack will carry the transmitter over to the intersection.]

[Cernan - "We came up with this during training; the Rover heading indicator let us get a very accurate layout."]

[Gene's statement that he is rolling west is open to several contradictory interpretations. One is that he has misspoken and means "east" rather than "west". A second interpretation is that Gene is going to lay out the pattern west of the transmitter, rather than east of it. A third interpretation is simply that he is going west of the

transmitter before coming back alongside it, headed east, to let Jack off. I prefer the last of these.]

122:49:18 Cernan: Boy, I don't like losing that fender.
(Pause) We're back at the SEP, Bob. I'm starting to lay out my first track.

122:49:31 Parker: Roger. Copy that. (Pause)

122:49:42 Schmitt: How's our time, Bob? (Pause)

122:49:47 Cernan: (To Jack) Okay, can you get out?

122:49:48 Schmitt Yeah.

122:49:48 Parker: Roger. You're about 5 minutes behind on the arrival time at the SEP. No real problem. And I assume that the range and bearing, when you got there, was about zero.

122:50:02 Schmitt: (To Gene) Okay, get...Let me leave my camera.

122:50:06 Cernan: (Responding to Parker) Let me read it. 252 (bearing to the place where Gene last reset the indicator), 2.5 (distance driven since the start of the traverse), and 0 (range to the last reset point). I'm resetting.

122:50:10 Parker: Okay. Copy that.

122:50:11 Schmitt: And the LMP frame count is 197, and it was still turning.

[That is, there still may be film left in Jack's magazine.]

122:50:17 Cernan: Amp-hours are 108 105, and batteries (temperatures) are 100 and 120.

122:50:25 Parker: Okay. Copy 100 and 120.

122:50:27 Schmitt: Okay. Oh, wait a minute! I need my camera, don't I?

122:50:31 Cernan: Yes, sir.

[Actually, Jack's checklist page LMP-34 does not call out any photos, only a couple of "Pose for CDR".]

122:50:33 Parker: I don't think it's much good to you with a (frame count of) 197 there, Jack.

122:50:36 Schmitt: Having looked at LMP-34) No, I don't. I don't need my camera.

122:50:41 Parker: Roger on that.

122:50:42 Cernan: (Garbled) deploying it.

122:50:44 Schmitt: No, you take the pictures. I don't need it. Go ahead, lay it out.

122:50:50 Cernan: Okay; you're right. Okay, here we go. I'm headed on (out).

[Here is where Gene starts to drive his pattern. At about the middle of Jack's description, Gene reaches the end of the E-W arm and turns right to a heading of 210.]

122:50:54 Schmitt: Okay, Houston. The location is in about the least cratered area I could find, between a large crater or a large depression that ranges from maybe 50 to 150 meters behind (that is, east of) the LM - that's maybe east-southeast - and it (the SEP)'s between that depression and another large depression that is really a doublet with a blocky septum between them. (Brief static as Gene turns) That's to the northeast of the LM about 200 meters; that's the start of that second depression. I think we can get a nice layout, although there'll be a general slope, I believe, towards the LM, of about a degree.

[Jack seems to be describing, first, a shallow, subtle depression between the LM and the SEP and, second, the large, unnamed crater north of the SEP.]

122:52:06 Parker: Okay, that's no real problem, Jack.
(Pause)

122:52:16 Cernan: Jack, am I about abeam of you? I can't see.

122:52:19 Schmitt: Yes.

122:52:20 Cernan: Okay, I'll turn in around this (small) crater.

[Gene has reached the southern end of the pattern and, having confirmed with Jack that he is south of the transmitter, is turning to a north heading.]

122:52:25 Schmitt: Hey, if you come right... (Long burst of static as Gene turns, an indication that Houston hasn't switched to feeding comm through the LM)

122:52:50 Schmitt: (Static clears as Gene re-aims the lo-gain) That depression to the northeast is at least a couple hundred meters in diameter, and it's joined with one that's probably of comparable size just to the northwest of the first depression.

122:53:10 Parker: Okay, I copy that too, Jack.

122:53:14 Cernan: Okay. How's that look, Jack?

122:53:20 Schmitt: Great.

122:53:21 Cernan: Far enough?

122:53:22 Schmitt: Yes. Yes. Come back!

[Gene has now reached the north end of the pattern and is turning to come back to the transmitter.]

122:53:28 Cernan: (Static; garbled) we head on to Station 2 without that fender and are we going to be full of dust.

Okay, there's no special...I can park 180 but... (Long Pause)

Okay, Bob, I've stopped, back at the SEP.

122:54:05 Parker: Copy that, Gene. (Pause)

[As per CDR-32, Gene is parking the Rover pointing south.]

122:54:12 Cernan: Dropped the...One came out, Jack.

[The SEP antenna wires are wound of four reels fastened to the north face of the SEP transmitter. "This thing" - in Jack's next line - may be a restraining device which proved difficult to open. In any case, Jack has just dropped one of the reels.]

122:54:14 Schmitt: Oh, yeah. This thing is a lot harder to turn than it was in training. (Pause; dropping another reel) Oops. Okay, that's the first two we've got to deploy. Can you bring your tongs?

122:54:37 Cernan: Yeh. Bob, do you want me to dust here? (No answer) I'll dust back at the LM. We're going to deploy the SEP. (Pause)

[Details of the transmitter and antenna deployment are on LMP-34 and CDR-33. Jack has positioned the transmitter - which has to be aligned so that its solar panels will get maximum exposure, but not leveled - and has released the reels holding the antenna wires. Next, they will deploy the east and west arms, followed by the north and south arms.]

122:54:52 Schmitt: God bless!

122:54:54 Parker: Okay. They all say to dust, Geno.

122:54:59 Cernan: (To Parker) Okay! (To Jack) You're going to have to wait for me, Jack.

[TV on.]

122:55:05 Schmitt: Well, I've got antennas all over the place here.

122:55:08 Cernan: Yeah, as a matter of fact, you do. Stand by one second. I'll make it (the dusting job) a quick one.

122:55:12 Schmitt: That's all right. No, I can handle it, I think, here. But we're going to need your tongs to pick them up and not get them all confused. Okay, where's the shadowgraph? There it is. Sun quadrant. That's the Sun quadrant.

122:55:39 Cernan: Yes, sir; we lost that fender. (Pause)

122:55:52 Schmitt: (Looking at his checklist) Okay, I'll deploy number 2 and 4. And, let's see, that's number 1. (Long Pause)

[Gene appears briefly in the TV picture; he is at his seat, holding the dust brush. The number 2 reel is the west arm and number 4 is the north arm. Number 1 is the east arm, and number 3 is the south arm.]

122:56:22 Schmitt: So this one must be number 2. It is. (Pause)

122:56:33 Cernan: Okay, I'm almost there, Jack. (Going to the front of the Rover) Let me run around and dust! (Pause) Let me tell you, this dust isn't going to be fun tomorrow!

[Cernan - "The dust on the battery covers and everything else was thick enough to write in. With a working fender you'd always got a light film of dust; but this was 'dirt' dust."]

[Fendell pans past Jack, who is now south of the Rover. His shadow appears to be 15-20 feet long.]

122:56:51 Schmitt: Okay, I won't bore you with details on why you see the antenna all over the ground (chuckles), but it has to do with 1/6 g. (Pause)

122:57:10 Parker: Roger, Jack. Understand you dropped a couple of the antenna reels.

[In Houston, Parker is being told that the antenna reels and wires can rapidly become a "Chinese Puzzle" unless they are untangled very carefully.]

122:57:13 Schmitt: You know, Bob, they're very... (Responding to Parker) More accurately, I dropped three of them. Bob, you know this fine-grained dust that we're in could be ground-up pyroclastic. It might grind more easily than other things, and the blocks are those that have been excavated from below that pyroclastic by the larger craters and some of the smaller ones in the area.

[Schmitt - "There was a great deal of fine material in the regolith and, as it turned out, much of that was due to the orange and black pyroclastic glass which was present throughout the dark mantle. Just from the appearance of the area in the overhead photographs, we had anticipated that there would be pyroclastics and, here, I was carrying that anticipation a little bit farther.]"

122:57:46 Cernan: Mark, gravimeter reading.

[Gene crosses in front of the panning TV; he is headed for Jack's position.]

122:57:48 Parker: Okay; mark that. (Pause)

122:57:53 Parker: (Responding to Jack's pyroclastic theory) Roger, Jack. That would make a nice story, wouldn't it?

122:57:53 Cernan: Okay, Jack, (garbled under Parker)

122:57:54 Schmitt: Bring your tongs, sir.

122:58:00 Schmitt: Well, you'd think glassy pyroclastic might turn into regolith a little bit faster than some of these other things. But we'll check that one out.

122:58:12 Parker: Okay.

122:58:13 Cernan: You want (antenna reel number) 2?

122:58:14 Schmitt: Two, and you get 1. Right there.

[Jack will take reel 2 and deploy the western arm; Gene will take reel 1 and deploy the eastern arm.]

122:58:16 Parker: And, Jack, did you get the reels
straightened out again?
122:58:23 Schmitt: Yeah, they're okay.
122:58:24 Parker: Thank you.
122:58:25 Schmitt: How can you stop a crew like this?
122:58:28 Parker: I don't know any way.
122:58:30 Schmitt: In all modesty, I mean. (Pause)

[Fendell finds Gene, who is picking up an antenna reel with his tongs.]

122:58:35 Schmitt: Okay, Geno, I'm on my way. Pull gently on that thing (the SEP transmitter) because it's awful easy to knock it over. I had that geophone module all over the place.

[That is, when Jack was deploying the geophones at the ALSEP site, any tension he got in the cables tended to move the central module.]

122:58:47 Cernan: I can't tell whether I'm pulling gently or not.

[Fendell is watching the SEP transmitter, which moves a couple of inches in Gene's direction. When Gene and Jack get to the ends of the wires, they will sight back across the transmitter at each other to make sure their lines are straight.]

122:58:49 Schmitt: Any time you feel a tug, stop. (Pause)

[The transmitter moves a couple of inches east again.]

122:59:01 Parker: (Seeing the motion) Careful, guys.
122:59:02 Schmitt: At least we're pulling at the base.
(Pause)

[The antenna wires may be attached low on the unit; it shows no signs of tipping over but, rather, just slides through the soil.]

122:59:14 Cernan: I better watch what I'm backing into. There's a lot of holes around here. (Pause)

[The two remaining antenna reels are visible in the TV, hanging from the north face of the transmitter. Fendell pans counterclockwise away from the transmitter, and then reverses direction.]

122:59:28 Schmitt: Well, it happened, Bob. I'm glad we Velcroed those tabs. (Pause)

122:59:42 Cernan: Okay, I'm at the end, Jack. Are you having...
 122:59:45 Schmitt: Well, what happened was (that) which we thought might happen. It twisted on my...I'll be there in just a second.

[Neither Cernan, Schmitt nor Parker remembers what it was they "thought might happen."]

122:59:56 Cernan: Okay, I want f/11 at 1/250 (of a second exposure) and 74 feet (focus). (Pause) Well...Ah, ah, ah, ah. Ah, ah, yes; you're pulling it over.
 123:00:19 Schmitt: I'm not. You are.
 123:00:20 Cernan: No, I'm not. I've got all sorts of slack in here.
 123:00:22 Schmitt: Okay, it's okay. (Pause) All right.
 123:00:29 Cernan: Are you out there?
 123:00:31 Schmitt: Yes.

[Fendell gets as far as the South Massif in his clockwise pan and reverses direction again.]

123:00:32 Cernan: Okay, let me back up a skosh and take the slack out. And I would say, offhand...Oh, boy. That's about as close to a 1/6-g orthogonal...at least, not orthogonal yet, but straight-lined. (Pause) That's it Jack, here. Stay there, and I'll take a picture.
 123:01:04 Schmitt: I thought you did.
 123:01:05 Cernan: No. Okay, I got it now.

[Fendell pans past Gene, who standing up-Sun of the Rover. His picture of Jack and of the east/west antenna arms is AS17-134-20435.]

123:01:12 Cernan: Hey, if you try and stick that thing (the reel) in (the ground), Jack, you're going to fall over. Just set it down, and we'll stay away from it.
 123:01:16 Schmitt: Yup. You talked me into it.
 123:01:21 Cernan: That was a good idea, but...That's a good straight line.

[They head back to the transmitter. There is no evidence that there were any anchors or flags for the ends of the SEP antenna wires. Jack suspects that they had decided, late in training, to stick the reels into the ground to serve as anchors and/or markers. Evidently, the attempt to use them as anchors was unsuccessful. Gene remembers that they planned to use the reels as markers. Parker agrees.]

123:01:25 Schmitt: (Singing) We were strolling in the (pause) park one day...Well, we've had lots of good ideas in our time.

123:01:39 Cernan: Oh, boy; the thing that makes me sick is losing that fender. I can stand a lot of things, but I sure don't like that.
 123:01:56 Schmitt: Okay, I get (reel) number 4.
 123:02:00 Cernan: Where is it? Is that the one on the ground?
 123:02:01 Schmitt: It's probably the one on the ground. Got it? (Pause)
 123:02:12 Cernan: Is that the right one?
 123:02:16 Schmitt: Well, 3...No, this is yours.
 123:02:18 Cernan: No. Take it; doesn't make any difference.

[Fendell finds both of them at the transmitter. The checklist calls for Jack to take reel 4 to the north and Gene to take reel 3 to the south. However, reversing roles will not matter at all.]

123:02:19 Schmitt: Okay, I'm deploying the...The LMP's deploying reel 3 for your photography purposes.
 123:02:28 Parker: Roger. Copy that.

[Jack heads south; Gene drops his antenna.]

123:02:29 Cernan: Oh...
 123:02:30 Schmitt: (Turning to face Gene) Hey, push that (?) in.
 123:02:33 Cernan: (Garbled)
 123:02:34 Schmitt: (Taunting) Ha, ha, ha. Ha, ha, ha. Serves you right. (Pause)

[Jack returns to the transmitter; Gene retrieves the antenna with his tongs.]

123:02:48 Schmitt: This doesn't push.

[Jack doesn't remember what "this" was; nor what "that" might have been at 123:02:30.]

123:02:50 Cernan: Okay, I'm ready to stroll. (Long Pause)

[Jack heads south again. Gene goes north. Fendell follows Jack, who lopes directly away from the transmitter. The dust he kicks up scatters sunlight toward the TV. Jack seems to be going down a slope away from the Rover, but probably isn't.]

[Cernan - "The TV camera was mounted about chest high (about 45 inches), so it's hard to say if that has any effect on your impression. Maybe it's just difficult to get a perspective on the surface. You don't have anything familiar to help you get a reference. For example, if you've got a little rise in front of you, it can be hard to tell that the ground drops away beyond it. You see a hill, you see a massif; but you don't have anything like a road

disappearing to tell you that there's a drop off in between. You don't have trees to show you the slopes. You can't tell where a local horizon ends, except for where it makes a line on something in the distance and, on the Moon, there aren't a lot of times when those lines are obvious. It's just difficult."]

123:03:20 Schmitt: Da da, dee do.

123:03:25 Cernan: (Pleased with himself) I found a brown rock that I'm going to bring back!

123:03:31 Schmitt: Please do.

[Jack stops and looks back.]

123:03:34 Cernan: I think it's the back side of a piece of glass, but it's brown.

[As we will discover at 123:28:18 and following, this is actually a piece of foam packing which protected the Rover high-gain antenna during the trip from Earth. Ever since Gene discarded the pieces of foam near the LM, gas trapped in the foam lattice has been heating in the sunlight. Evidently, at some time since then, one or more pieces exploded and/or vented, throwing at least one fragment the hundred meters out to the SEP site.]

123:03:39 Schmitt: (Looking back) Well, I think I'm more or less on your (Rover) track. It wiggled a little bit.

123:03:45 Cernan: Well, we're...(To himself) Oh, oh, oh, ooh, stop, Geno. Okay, Jack, wait a minute. That looks orthogonal to me.

123:04:02 Schmitt: Got your picture?

123:04:03 Cernan: Will have in a sec. Wait a minute. Every time I do something, I change the setting. Okay, I got it. (Pause)

[Jack drops the antenna on the ground, and heads back toward the transmitter. Gene's picture is AS17-134-20436.]

123:04:20 Cernan: I straightened the line out a little bit better after I took the picture...(It had) a few kinks in it.

[Schmitt - "The Principle Investigator must have loved this statement. The picture was supposed to document the way you left things, not the way they were before you made some final adjustments.]

123:04:28 Cernan: Now where's my brown rock? I saw it when I was driving with the Rover! I knew I'd be able to come back here because of the tracks. Looks like an old piece of bread.

123:04:39 Parker: Is that the one that came out of the hatch?

123:04:42 Cernan: Where the heck is that? (Hearing Parker, not remembering the piece of bread that had flown out the hatch when they first opened it) Huh? Well, it's a piece of glass, all right, part of it crumbled. I got to get that in a bag.

[Jack arrives at the transmitter, having made a three second stop along the way. The distance is 35 meters and Jack covered it in 37 seconds.]

123:05:10 Cernan: Oh, man, is that a nice piece of glass. Just laying out there all by itself. Jack, you got a bag handy while I take my pan? I can't reach a bag; I got this sample in the wrong hand.

123:05:17 Schmitt: I don't have a bag.

[Jack repositions the transmitter by picking it up and setting it down again.]

123:05:18 Cernan: You don't have...Well, take one off of mine and give it to me. I'll take it back to the Rover. (Going to Jack) Wa, wa, wa! Watch it; you've got a wire under your foot.

[Jack takes a bag off of Gene's camera bracket. It is not obvious why Gene couldn't get a bag. Whatever the reason, this bit of action gives Jack a chance to look at the "Sample".]

123:05:30 Schmitt: Bag number 460.

123:05:33 Parker: Copy that. 460 has brown glass.

123:05:35 Cernan: It was about half way out on the north course...

123:05:40 Parker: Sorry about that.

[Parker is apologizing for the interruption.]

123:05:41 Cernan: ...about halfway out on the north course of the SEP.

123:05:47 Schmitt: It's brown vesicular glass. (Pause)

[Jack continues leveling the transmitter; Gene goes to the Rover, closing the sample bag as he goes to put it in his footpan.]

123:05:59 Schmitt: Sort of a yellow-brown, as a matter of fact.

[Schmitt - "I remember thinking that it was a piece of foam and that Gene was pulling a joke on the scientists by putting it in a sample bag. So I was going along with the joke, not realizing that he was serious in thinking it was a piece of brown glass."]

123:06:01 Cernan: Okay, it (the checklist) says (Pause) "take locator photo to LM". I thought I took a pan here. The LM was...Okay.

[A photo of the LM will, from the size and orientation of the LM image, give a very accurate indication of Gene's location - 150 meters east and slightly north of the LM. Jack raises the SEP solar panels.]

123:06:17 Parker: Yeah, the "locator" is really all you need; but a partial pan to show the area would be appreciated.

123:06:24 Cernan: Yeah, I'm here (in the checklist). I'm going to get a partial pan, Bob.

123:06:27 Parker: Okay.

[Gene's pan consists of frames AS17-134-20437 to 2046. Note that frames 20438 to 20440 show Jack unfolding the solar panels on the SEP transmitter.]

123:06:32 Cernan: (Kidding Parker) The only reason I'm doing it is I know it would be appreciated. (Long Pause)

[Jack is unfolding - in book fashion - two solar panels, each about 1 foot square and one on each side of the similar-sized central panel.]

123:06:59 Cernan: Okay. (Reading) Take locator to photo LM; I got it (in the pan). Bob, I'm on (frame count)...If I can get where I can read it...on about 71 on my frame count; and let me give you...Boy, we got to stay out of this area, Jack. We'll pick up these cables (with our feet) just as sure as the devil. (Pause) Oh, that fender. (Pause) Boo. Boo.

123:07:30 Schmitt: Hey, Houston, will you look at your solar panels?

123:07:35 Parker: Rog. We see some solar panels.

123:07:40 Schmitt: You notice how they flop up?

123:07:43 Parker: We noticed that, too.

123:07:44 Schmitt: I think we need some grey tape.

[The panels are not lying flat but, rather, the two outside ones are folded slightly upward.]

123:07:48 Cernan: Okay, (the gravimeter reading is) 670, 010, 101; that's 670, 010, 101.

123:07:59 Parker: Okay, I got that one, Geno.

123:08:01 Schmitt: (Returning to the Rover) The wires have memory.

[Schmitt - "There were some wires on the back of the solar panels which hadn't straightened out but, rather, were causing the panels to flop forward.]

123:08:05 Cernan: Okay, let me...
123:08:06 Schmitt: I need grey tape (to hold them flat).
123:08:07 Cernan: Let me put this in your bag, and I'll get the grey tape.
123:08:09 Schmitt: Okay.
123:08:14 Cernan: We didn't exactly break any records collecting samples, but at least we got an ALSEP deployed. That grey tape, Jack, is not going to stick on anything with dust.
123:08:22 Schmitt: I know; that's what I was thinking.
(Pause)
123:08:28 Cernan: Because I just been there with that fender.
123:08:32 Schmitt: Well...
123:08:33 Cernan: Let's try it.
123:08:34 Schmitt: You have the...
123:08:36 Cernan: I don't need the scissors. I can cut it without it. God. Watch where you...Don't back up in that (antenna) wire. (Pause)

[Fendell is panning the TV and finds both of them at Gene's Rover seat; they leave the field of view before Fendell can stop the camera. With the astronauts out of the way, Fendell gets a good view of the shadowing on the Sculptured Hills.]

[Cernan - "I could tear the tape with my hands. For some reason, this is one of the things I still remember clearly after nearly twenty years."]

123:08:46 Cernan: Just like the cover of the...
123:08:51 Schmitt: Got it? (Pause)
123:08:55 Cernan: (Garbled)?
123:08:58 Schmitt: Yeah, I guess. (Pause) Okay. (Pause)
123:09:05 Cernan: Get this side?
123:09:07 Schmitt: Yep.
123:09:08 Cernan: Keep from falling over? You want to take those solar panels off?
123:09:11 Schmitt: Let me hold on to you.
123:09:12 Cernan: Okay, lean on me. If not, let's take them off and hold them.
123:09:18 Schmitt: No, I think it's going to be easier this way.
123:09:21 Cernan: Okay, try it. I don't think they (the solar panels) are going to be much problem the way they are, anyway.
123:09:28 Schmitt: You holding?
123:09:29 Cernan: Yeah, go ahead and lean if you want.
(Pause)
123:09:42 Schmitt: I don't know how long it (the tape) will stay.
123:09:44 Cernan: No, I don't know. Okay, there's one.
123:09:46 Schmitt: Give me another one.
123:09:49 Parker: It's only going to stay for 2 days, guys.
123:09:50 Cernan: (Garbled) pull the whole thing over.

123:09:54 Schmitt: This will be a test. If it holds until we see it again...(at the start of EVA-2, before they plan to take any SEP data).

123:10:01 Cernan: (Garbled) Don't knock the whole thing over.

123:10:07 Schmitt: Okay, I'm leaning on you.

123:10:08 Cernan: Okay, lean. (Pause) The piece of tape is so dusty it may not work. Try it somewhere. (Pause) Okay, are you happy with the alignment?

123:10:27 Schmitt: I was. Is the (SEP transmitter) gnomon on the zero mark?

123:10:32 Cernan: Gnomon is right up the zero mark.

123:10:34 Schmitt: That's where it's supposed to be.

123:10:35 Parker: Beautiful, guys.

123:10:35 Cernan: Right up the zero mark.

123:10:36 Schmitt: Okay, and the level bubble is just touching the inner circle.

123:10:42 Parker: Okay, copy that. (Pause) And we have that transmitter switch in Standby, right?

123:10:49 Cernan: Bob, there's just a couple little boulders around the transmitter, is that...(Stops to listen to Parker)

123:10:53 Schmitt: It will be...

123:10:57 Cernan: Oh, those are okay. Let's forget those.

[Fendell finishes his pan and returns his attention to the transmitter. The solar panels are now open; the tape seems to be along the top.]

123:11:02 Cernan: Jack, looking where the LM is, if I were you, I'd just walk down.

123:11:04 Schmitt: Come here, Gene.

123:11:05 Cernan: What do you need?

123:11:06 Schmitt: I need some support.

123:11:07 Cernan: Yeah. Boy, that's the key around here.

[Gene holds Jack's hand so that he can do a deep knee bend without quite kneeling.]

123:11:10 Schmitt: Everything on this SEP is coming off harder than it did when we deployed it at the Cape. See that? It just lifted. It may not be harder, but it lifted.

123:11:24 Cernan: Okay.

[Schmitt - "What I think I was trying to say here is that, when I was taking something off the SEP, it lifted the box off the ground."]

123:11:25 Schmitt: Now, I got to reorient it.

123:11:28 Cernan: Now, let me see. You're Standby. Now let me look at it. (Pause)

[Gene helps Jack get up.]

123:11:30 Cernan: The gnomon's right at zero.
 123:11:31 Schmitt: Okay...
 123:11:32 Cernan: Right at zero.
 123:11:33 Schmitt: It's just the same. It settled back just the same. Zero gnomon and inner circle (for the level bubble).
 123:11:38 Parker: Okay; beautiful.
 123:11:39 Schmitt: Let's go.
 123:11:41 Cernan: You want to walk back or ride?
 123:11:43 Schmitt: (Looking at his checklist) Let's see...
 123:11:44 Cernan: (Going to the Rover) It's up to you but...
 123:11:46 Schmitt: Oh, I'll walk back.
 123:11:49 Cernan: Man, I hate this dust. I got to make a new fender tonight.
 123:11:55 Schmitt: Well, let's see, I guess I'm supposed to...
 123:11:58 Parker: Hey, Gene, I presume that the fender that came off is the fender that came off before, right?
 123:12:04 Cernan: Yeah, same one. My tape didn't hold; it was too dusty.
 123:12:08 Parker: All right.
 123:12:11 Cernan: Okay.
 123:12:12 Schmitt: (Joking) Hey, watch out for this antenna line I found out here.
 123:12:15 Cernan: Yeah. Okay. (Reading) "Travel to LM". Okay, Bob, I'm not going to change anything right now except get in and travel. (No answer) All right?
 123:12:27 Parker: That's affirm. Time to go home.
 123:12:33 Schmitt: How's our time, Bob? (Pause)
 123:12:40 Parker: You'll have a nominal closeout, guys, as soon as you get back. We're right about on the time that we've been figuring on for you guys to get back there on. Right now, you are 6 hours and 11 minutes into the EVA.

[Fendell pans to Jack, who is jogging toward the LM.]

123:13:03 Schmitt: Boy, here's a big boulder.
 123:13:07 Cernan: You know, I discovered something. I learned a lot today, let me tell you. (Pause)

[Schmitt - "I put my hands on the boulder and just leaned on it. That let me get my eyes about a foot or a foot and a half from the rock so that I could look at the minerals."]

[Cernan - "Without the scoop or something else to give you leverage, you could still get up from your knees using a 'stand-up kip'. Here, Jack pushed back off the rock to get his PLSS over his knees and then jumped up and kicked his feet forward. It's all center-of-gravity management. And, since you're in one-sixth gravity, you can push yourself up easy enough and sometimes jump to get weight off your feet so you can bring them under you. It would have been a lot harder to do that in one g."]

123:13:20 Cernan: (To Parker) Okay, you're going to lose TV because the high gain is going to be out of whack here in a minute. (Pause)

[TV off.]

123:13:39 Schmitt: Okay, I got a football-size rock of this coarsely vesicular gabbro, Bob. It's off a large 3- to 4-meter buried boulder to the north...Oh, let's say, northeast of the LM about 30 meters. (No answer) Do you read, Bob?

123:14:11 Parker: Roger, Jack. Read you loud and clear on that one.

123:14:17 Schmitt: Okay. It'll be in the big bag.

[The big bag is a long version of the SCB which has been hanging from the MESA.]

123:14:21 Parker: Okay, (garbled)...

123:14:22 Schmitt: Undocumented. It's roughly tabular, 15 by 25 centimeters and about 5 to 7 centimeters thick. One face is very flat; looks like it was off of a parting plane, which were (sic) in that rock.

123:14:47 Parker: Okay, and if it fits in the SRC with all the other samples, you might put it there because the SRC's going to be kind of empty.

[The SRC is the Sample Return Container, a metal rock box which has a high-tech vacuum seal to protect samples from cabin gases and other sources of contamination. Only one rock box will be filled per EVA.]

123:14:57 Cernan: Got any new (Rover) parking angles for your batteries or anything?

14:59 Parker: No, it will be a heading of 013, which is hardly a change at all from the 012 in the checklist.

123:15:10 Cernan: Okay, I'll buy that. (Pause)

[During the drive back to the LM, Gene takes two pictures; AS17-134-20447 and 20448. These are the last pictures taken during this first EVA.]

123:15:27 Parker: Jack, did you copy my comments about putting that thing (the football-sized sample of the boulder) in the SRC perhaps?

123:15:35 Schmitt: Well, it was pretty big. It's in the big bag now. We can do that.

123:15:41 Parker: Well, I'd get the other samples - the small ones and particular(ly the) soils - in the SRC first.

123:15:49 Schmitt: Okay. (Long Pause) (To Gene) Are you through (parking)?

123:16:03 Cernan: No, I'm going right about here. Now I'm done.

123:16:09 Schmitt: Okay.

123:16:10 Cernan: Right there. (Pause)
 123:16:15 Cernan: Okay, Bob, 086 (bearing to SEP), 0.5 (distance driven since resetting, mostly in laying out the antenna pattern), 0.1 (range to SEP), 108, 102 (amp hours). Standby one. Okay. .Amp-hours are at 108, 102; volts are 74 and 75. Batteries are 108 (degrees) and 123. Motors are all off scale low, all four of them.
 123:16:51 Parker: Roger, Gene. Understand 108, 102 on the amp-hours, huh?
 123:16:59 Cernan: That's affirm; 108 and 102.
 123:17:02 Parker: Okay; copy that.
 123:17:07 Cernan: (To himself) I can't read this thing, because it's full of dust, so I've got to get off and dust it.
 123:17:10 Schmitt: (To Parker) Okay, the SEP receiver temp is four-five. Four-five.
 123:17:14 Parker: Copy; four-five. Beautiful.
 123:17:15 Schmitt: (To Gene) You know, I think they left some Velcro off of this thing (the SEP receiver), Gene. There's no Velcro holding those (thermal cover) flaps down.

[During the traverses, the radiator on the top of the SEP is normally covered with thermal blankets held down by pieces of Velcro glued to tabs on the covers and to the thermal bag enclosing the body of the SEP receiver. The glue holding the latter pieces of has failed and the covers are now loose.]

123:17:30 Cernan: Isn't there?
 123:17:31 Schmitt: No. (Pause) Okay.
 123:17:38 Cernan: I've got to get the brush and dust that thing. (I'll be) a minute or two. Okay, let me get the high gain. (Long Pause)
 123:18:06 Schmitt: (Facetiously) I feel I'm gonna take some core tubes tomorrow.
 123:18:09 Parker: I have a feeling you've got a couple left over, don't you?

[Jack was scheduled to use a drive tube at Station 1, but didn't for lack of time.]

123:18:13 Cernan: Bob, you got...
 123:18:16 Schmitt: (Responding to Parker) Yep.
 123:18:17 Cernan: Bob, you got the high gain.
 123:18:18 Parker: Okay, thank you.
 123:18:20 Cernan: Is that my bag (SCB-1), Jack, you got?
 123:18:23 Schmitt: Yes.
 123:18:25 Cernan: (Not having felt Jack take it off) That's pretty good.
 123:18:26 Parker: Okay, let's put all the stuff in that bag (SCB-1), Jack; both the stuff that's in yours (SCB-2) and the stuff that's in Gene's.

[TV on. Gene has parked the Rover roughly between the LM and the U.S. flag.]

123:18:35 Schmitt: Okay. (Pause) Two samples from under the LMP's seat.
 123:18:54 Cernan: Put these unused sample bags) under the seat. Clean you up here while I'm at it. Oh, man, I tell you, it's going to take us half a dozen Sundays to dust. Look at that fender; that's terrible.
 123:19:12 Schmitt: Okay, you want to get my bag off?
 123:19:14 Cernan: Yup. If you're ready.
 123:19:15 Schmitt: Yup. (Pause) I've got to put those samples in the SRC...(correcting himself) in your bag (SCB-1); and we'll save this one (SCB-2), I guess.
 123:19:25 Cernan: Wait a minute. Let me clean you up.
 123:19:26 Schmitt: Okay.
 123:19:27 Cernan: Did you get me cleaned up?
 123:19:29 Schmitt: Yeah, you've lost your...
 123:19:30 Cernan: Wait a minute.
 123:19:31 Schmitt: ...your strap though, here.
 123:19:33 Cernan: Wait a minute, now. (Pause) Okay, (can) you get my hook back up over here?
 123:19:41 Schmitt: Okay, turn around. Your hook's up, but I'm not sure I closed your other one.
 123:19:45 Cernan: Take a look at it.
 123:19:46 Schmitt: Yeah, your Velcro's (garbled). Okay, you're good.
 123:19:55 Cernan: There you go. Okay, you're filling which bag? The...
 123:19:59 Schmitt: Putting them in the bag that goes into the SRC...
 123:20:01 Cernan: That's SCB 1.
 123:20:03 Parker: Roger.

[Fendell pans to Jack, who is at his Rover seat. After all the samples are transferred to SCB-1, Gene will put it in the SRC.]

123:20:05 Cernan: (To himself) Okay; let's see, (scanning checklist pages CDR-34 and CDR-35) offload LM(P) PLSS, core cap dispenser, tools. (To Jack) Okay, as soon as you get that, I'll take that SCB 1 from you, and I'll close SRC-1.
 123:20:19 Parker: Okay; and I gather you didn't have any Rover samples today, did you, Jack?
 123:20:22 Cernan: I've still got my tongs here. I got...
 123:20:25 Schmitt: (Answering Parker) No, I have one sample bag in my pocket that has a rock in it.
 123:20:31 Parker: We'll have to take that out when we get in the Rover (meaning the LM), I assume.

[Gene joins Jack, who is putting samples from under his seat into SCB-1.]

123:20:36 Schmitt: Okay. (Pause) Gene, where's that...You want to put that little rock (in SCB-1)?

123:20:44 Cernan: Yeah, is it there?

[This is the sample Gene collected during the Rover deployment at 117:35:27.]

123:20:45 Schmitt: Well, what did you do with it?

123:20:46 Cernan: It was on the floor on my side.

123:20:47 Schmitt: Your side?

123:20:49 Cernan: There it is; let me get it.

123:20:52 Schmitt: We can put that in one of the core tube slots here. (Pause)

123:21:02 Cernan: Boy, that one fender just is an order of magnitude more of a dust problem.

[That is, dust makes things ten times worse.]

123:21:06 Cernan: Here can you reach this?

[Jack reaches across the Rover to get the sample from Gene, who has now moved to his own side.]

123:21:10 Schmitt: Okay, the rock that Gene picked up early - right at the start - is in a core tube slot in the SRC-1.

[Jack means "SCB-1" rather than SRC-1. Some of the Sample Containment Bags have built-in, interior core-tube sleeves.]

123:21:19 Parker: Okay, I copy that.

123:21:24 Schmitt: Okay. (Pause) Gene, you want this one (SCB-1)?

123:21:30 Cernan: Yep, I want the full one.

123:21:31 Schmitt: Yeah. (Pause) Latched.

123:21:36 Cernan: Okay.

[Gene has come around the front of the Rover; Jack hands him SCB-1, which he takes to the MESA.]

123:21:39 Schmitt: Bob, that's almost full of samples, and I think that big rock probably wouldn't fit in there.

123:21:47 Parker: Okay, then we'll put that in the big bag.

123:21:52 Schmitt: It's in the big bag.

123:21:53 Parker: Good enough. And I gather there's no Rover samples today, right?

123:22:03 Schmitt: Okay... (Hears Parker) No Rover samples. Sorry.

123:22:11 Cernan: (Grunting; Long Pause)

[Jack joins Gene at the MESA. Jack gets a long, white, cloth bag out of the MESA and goes toward the ladder. This is a transport bag for the deep-core stems.]

123:22:38 Cernan: Okay, the (SRC) seal is clear, like I promised I'd make it. Coming over the top. (Pause)

[The SRC seal consists of a knife-edge closure on the rim of the lower section of the box which, when the SRC is closed, digs into a soft, indium strip set in the lid. When the box was packed in Houston, a protective cover made of Teflon cloth was fitted into the box. The cover was fitted on a wire frame that would just barely fit into the box and, therefore, would stay put. The cover had a large opening in the middle to give Gene access to the interior of the box and flaps on all four sides which, at the beginning of the EVA, Gene unfolded and layed on top of the knife edge and the indium strip so that they would stay reasonably clean. Gene is removing that cover and, as well, a Teflon spacer which was installed in Houston to keep the knife edge from cutting into the indium strip prior to this final sealing of the box. Once he has removed the the cover - called the "skirt" on cuff checklist page CDR-31 - and the spacer, Gene makes a final check to make sure that none of the sample bags will catch in the seal when he closes the lid. On some of the prior missions, bags that caught in the seal created leaks and, when the samples were examined in Houston, there were found to be contaminated with cabin and/or terrestrial gases.]

123:22:56 Cernan: Bob, the seal is clear.

123:22:58 Parker: Beautiful.

123:23:02 Cernan: I don't know if it's beautiful, but it's clear.

123:23:06 Parker: It's clearly beautiful.

123:23:11 Cernan: Okay. Okay, that big mamoo (the rock box) is locked. (Turning toward the Sun to get a little light on his oxygen gauge) I got a lot of oxygen! I still got 22 percent.

123:23:24 Schmitt: I expect our (PLSS sublimator) feedwater may be getting a little low.

123:23:30 Cernan: I'm going to leave this (SRC) right here (on the MESA table) until I take it up to you. Okay. (Reading CDR-35) "Close (the SRC) and verify good seal, place (SRC) in plus Z (LM footpad)." Okay, "LRV circuit breakers: LRV LCRU power, Off. Dust." Well, let me get at that dusting first.

[Gene goes to the Rover; Jack is working just beyond the ladder.]

123:23:44 Schmitt: Give me a yell when you need a spell there.

123:23:47 Cernan: What, dusting?

123:23:48 Schmitt: Yeah.

123:23:49 Cernan: Well, I need a fender, that's what I need. Figure out something we can make a fender with.

123:23:56 Schmitt: How about one of the others that's not as critical?

123:23:59 Cernan: Yeah, but I wouldn't ever take one of those off! You know, I had one to put on and it didn't stay, which is what I figured.

123:24:06 Schmitt: I thought you said it was broken, though?

123:24:07 Cernan: Well, it was. But these aren't supposed to come off, either, unless you break them. (Pause) I broke that one. My hammer got caught underneath it. It wasn't the fender's fault.

123:24:19 Schmitt: (At the ladder) Okay, the (deep) core tube is packed. (Long Pause)

[Gene is standing between the TV and the LM while he dusts the battery cover.]

123:24:50 Schmitt: Every time I read "containment bag", it fools me; I can't figure out what it is.

123:24:53 Cernan: Every time what?

123:25:03 Schmitt: I read "containment bag".

123:25:06 Cernan: (Guffaws) You've been thinking of the other kind too long. You've been living in the Command Module too long. (Pause)

[Jack is thinking of fecal containment bags. Upon reflection, Jack and Gene both believe that the containment bags Jack is now stowing in the ETB were later put around the SCB's to help with dust control. According to the Lunar Surface Procedures document, the six "sample containment bags" stowed in the MESA are distinct from the six "sample collection bags (SCB's)" stowed on the geopallet. See the discussion at 171:22:03.]

123:25:25 Schmitt: (Joking) That's a pretty good day's workout, you know. I don't think we need an exercise period.

[When they are in the Command Module, they have regularly scheduled exercise period to help counteract the effects of weightlessness.]

123:25:32 Cernan: (When) we get back in there, I don't think we have to apologize to anybody. I'm sorry we didn't get out to Station 1. One of the main reasons is, I think, we could have got our navigation bearings a little bit better.

123:25:45 Schmitt: Well, I'll tell you.

123:25:47 Cernan: This hole out here...

123:26:49 Schmitt: That new ALSEP had more to it than met the eye.

[Gene leaves the field of view; Fendell examines the top of the LM.]

[Schmitt - "Although we still called it the ALSEP in the checklists, this was really a new piece of equipment which, among other things, had a two-year design life rather than the one-year life of the prior units."]

123:25:54 Cernan: You know, this is just such an easy site to find out and to identify yourself on and to land in. But, I tell you, all of a sudden there is so many local holes that I can't think big enough.

123:26:06 Schmitt: Does that sound familiar?

123:26:09 Cernan: Okay, Jack, I'll wait on the rest of my dusting until...

123:26:12 Schmitt: Am I in your way?

123:26:13 Cernan: Yeah, I'd like to get over there to get this last battery cover. (Pause; the TV camera shakes) That's good enough. I can get over there now. I want to make sure these things stay clean because I don't want to walk.

[That is, he doesn't want the Rover to fail because a battery or some other critical piece of equipment overheats.]

123:26:37 Schmitt: I agree. (Pause) Okay, Bob, containment bags and two cameras are stowed in the ETB (Equipment Transfer Bag).

123:26:51 Parker: Copy that. And don't forget the scissors, guys.

123:26:56 Schmitt: Don't worry. I've got them right here.

123:26:58 Parker: Beautiful. Don't want to go hungry.

123:27:03 Cernan: That's a good call, Bob.

123:27:05 Schmitt: That's right.

[As Fendell moves the TV camera, The SEP receiving antenna is briefly visible above Jack's seat. Jack is starting page LMP-36.]

123:27:06 Parker: And, Jack, give me your consideration - or Gene - on that question of bringing back the big bag into the cabin. The people down here are saying they want to bring it in, and then we'd end up bringing it back out on the second EVA. What do you guys think about that?

123:27:23 Schmitt: That's all right; we can do that.

123:27:24 Cernan: Yeah, we can do that. I guess just because that rock's in there, huh?

123:27:27 Schmitt: I'd like to do that and look at that rock with the hand lens.

123:27:31 Parker: All right; so then we'd be taking it back out in the second EVA, if you guys are agreeable to that.

123:27:38 Cernan: Yeah, we'll do that, Bob.

123:27:40 Parker: And, Jack, do you think it'll go in the SCB?

123:27:46 Schmitt: Say again.

123:27:47 Parker: Do you think it'll go in the SCB number 2?

123:27:54 Schmitt: What would? The rock?
 123:27:56 Parker: Yeah, that's right.
 123:28:02 Schmitt: Well, it'll go in there! It's not that big. I gave you the dimensions.
 123:28:06 Parker: Okay, why don't you put it in SCB-2 and bring that in, instead. Leave SRB (Sample Return Bag, the big bag) out, and then we'll just leave SCB-2 in (the cabin) forever.

[Fendell finds Jack at Gene's side of the Rover. The SRB can be seen in AS17-143-21924, a charge "locator" that Jack will take at the end of EVA 3 at 169:12:57.]

123:28:15 Schmitt: Okay.
 123:28:18 Cernan: Okay. (Reading CDR-350 "Verify (good seal)...SRC (in) plus-Z pad..." What are those things going over? What is that, Jack? Hey, something just hit here!

[Beyond Jack's head, a piece of debris is visible moving north and away from the LM.]

123:28:30 Cernan: What blew? Hey, what is that?
 123:28:33 Schmitt: Oh, your antenna...It's that styrofoam off the high-gain antenna package.
 123:28:41 Cernan: On the LM?
 123:28:42 Schmitt: No, the one you deployed. The Rover high-gain antenna.

[Another piece of foam packing has exploded because of sunlight heating of trapped gas bubbles.]

123:28:47 Cernan: My god, it blew up!
 123:28:49 Schmitt: Yeah.

[Fendell pans to Gene at Jack's seat; he is holding the dust brush.]

123:28:51 Cernan: I thought we'd been hit by a...Look at that stuff just keeps flying over the top of our heads! I thought we were the closest witnesses to a lunar meteor impact. (Pause) I wonder if that's the same glass I picked up?

[Gene is beginning to realize that the piece of "brown glass" he picked up at the SEP site was actually a piece of foam.]

123:29:09 Schmitt: Oh, I don't know, (garbled). Weren't you kidding?
 123:29:10 Parker: John (Young) says it blew up on his mission too, guys.
 123:29:11 Cernan: Well...

123:29:12 Schmitt: (To Gene, not having heard Parker yet)
 Isn't that what you thought it was? Isn't that what you
 thought it was?
 123:29:17 Cernan: Huh?
 123:29:18 Schmitt: I thought you were kidding (about the
 "brown glass").
 123:29:19 Cernan: No! I've never seen that before.
 123:29:21 Schmitt: Oh, I'm sorry. I thought that was...
 123:29:23 Cernan: Well, you saw that stuff coming. I
 didn't see that at all. Holy Smoley!
 123:29:30 Parker: Roger, 17. And John says that it blew up
 on his mission, as well.

[Evidently, some of the interior voids in the styrofoam have remain filled with gas despite many days of exposure to vacuum during the trip out from Earth. Alternatively, the voids may have been filling with gases released from the foam matrix during the six hours or so that it has been lying out in the sunlight. In either case, solar heating has raised the pressure of the trapped gases. The fact that several fragments can be seen - coupled with Gene's use of the word "exploded" and John Young's phrase "blew up" - indicates an explosive disintegration of a piece of foam. Such explosions would propel fragments over considerable distances. For example, if a piece was launched at a 45 degree angle at a speed of 15.6 meters per second, it would come down 150 meters from the LM after a 13.6 second flight. It is also possible that the piece Gene picked up at the SEP site got there in several hops, each the result of a separate explosion or of a non-explosive venting episode.]

123:29:38 Cernan: Okay, Bob, I guess I'm going to take the TV away from you.

[Fendell pans to Jack at Gene's seat, packing maps, cameras, and film magazines into the ETB.]

123:29:45 Parker: Okay. And, Gene, one thing we'd like before you guys leave the
 123:29: Cernan: Okay, I'm going to open the circuit (breakers)... (Stops to listen to Parker)
 123:29: Parker: One thing we'd like before you guys leave the Rover is a fairly good description of what happened to the rear fender when it came off. Is the damage primarily to the piece that you've lost, or are the rails on the pieces remaining fairly bad?
 123:30:08 Cernan: (To Parker) Okay.
 123:30:12 Schmitt: Mag...
 123:30:15 Cernan: The...
 123:30:17 Schmitt: ...Romeo!

[Jack is loading film magazines into the ETB.]

123:30:20 Cernan: Well, a piece of the rail on the aft inboard side here...The rail isn't missing; it's just a piece of the flange, the rail that fits against the fender (that's missing). But that doesn't hold any part of the fender on. I don't remember what I saw on the (missing) fender (when he was taping it back on at the start of the EVA). The rails look pretty good, Bob. And I had one of them completely on, and I just couldn't get the other one on. If I had known what that dust was (going to be like), I would have tried an awful lot harder.

123:30:48 Parker: Okay, do you have any feeling that...

123:30:49 Cernan: I heard John telling me, but...

[Young lost a fender during the second Apollo 16 EVA, in much the same fashion.]

123:30:52 Parker: Do you have any feeling that you could get away with putting a front fender on?

123:31:01 Cernan: Well, I have done it before, but it's not easy.

123:31:07 Parker: Okay, as far as you can tell, so that we can look at it overnight, the rear fender - the part that's remaining - looks in fairly good shape, right?

[In Houston, there is a discussion going on to the effect that re-attaching the fender is difficult enough unsuited, and probably impossible in a suit.]

123:31:20 Cernan: Let me take a good look at it. (Pause) Yeah, the part you need, I think, to hold that fender on...(Pause)

[Jack is packing film magazines and loose rocks in the ETB; he briefly examines one of the rocks or one of the film magazines.]

123:31:39 Schmitt: Let's see. We better take those dustbrushes up there.

123:31:42 Cernan: (To Parker) Yeah, that's all here. There's enough here to hold the fender on, Bob.

123:31:46 Parker: Okay, we'll take a look at it here while you're sleeping.

123:31:53 Cernan: Okay, let me get some (Rover circuit) breakers here. LRV breakers Alpha, Bravo, Charlie, and Delta.

123:31:59 Schmitt: Bob, while you were talking, I got all the mags: Romeo, Alpha, Golf, Charlie.

123:32:09 Parker: Hotel.

[TV off.]

123:32:12 Schmitt: That's on a magazine. (Correcting himself) That's on a camera.

123:32:15 Parker: Okay. Got you on that one; you're right.

123:32:19 Schmitt: Is it not?
123:32:21 Parker: You're right; my fault. You've got the maps, too.
123:32:24 Schmitt: Okay, I need those maps, Gene. Could you hand me the maps?
123:32:30 Cernan: I don't know. (Pause)
123:32:35 Schmitt: Pretty good clip.

[Jack is probably referring to the map clip on the accessory staff. It has held the maps tightly despite the bouncy ride.]

123:32:37 Schmitt: (The maps are) splitting apart a bit, too, aren't they? (Probably from) getting hot!

[The maps are printed on stiff, chronopaque pages with an overhead photograph on one side and, laminated to the back, a contour map. The photos and maps are black and white, generally a fairly dark grey; they probably absorb heat fairly readily and may be delaminating as a result.]

123:32:45 Cernan: This thing (possibly the LRV sampler) keeps falling out of your clip, in case you're interested, or I keep knocking it out.
123:32:55 Schmitt: Put it down, yeah. Okay, I've got the maps, the 500 mag. Yeah. And the two cameras.
123:33:05 Parker: Okay, we'll have to get the contamination bags, too, there.

[Parker means the previously mentioned "containment bags", which is the designation in the checklist.]

123:33:11 Schmitt: Okay, ETB is going to the old LEC hook. (Pause)

[This is a hook on the back of the ladder, the one that Jack hung the scissors on at the start of the EVA.]

123:33:13 Cernan: Huh?
123:33:17 Schmitt: Say that again, Bob.
123:33:18 Parker: Roger. We've got the contamination bags to get, too, out of the MESA.
123:33:26 Schmitt: I got them.
123:33:27 Parker: Okay; copy that.
123:33:28 Schmitt: Mentioned that earlier (at 123:24:53).
123:33:29 Parker: Sorry about that.
123:33:30 Schmitt: They're in there (in the ETB).
123:33:33 Parker: Okay; and Geno, when you're brushing the LCRU, we'd like the blankets (that cover the radiating mirrors left at 100 percent rather than 65 percent. We'd like them all left open; and it's been a little warm, also.
123:33:56 Cernan: Okay, Bob, I've already dusted everything. And it all looks pretty good. The breakers are

Open; the LCRU power is Off. I'm going to...Where do you want the TV camera? Do you want it tilted down and aft?

123:34:14 Parker: Rog. Down and away from the Sun, like we talked about. Think that's what you mean by aft.

123:34:18 Cernan: That's what I thought. Okay, it is down...Yeah, it's there.

123:34:22 Parker: Okay; can you confirm that that's 100 percent on the LCRU blanket rather than 65 percent as per the checklist?

123:34:34 Cernan: Yes, sir; I sure can. (Pause) Okay, I'm opening all the battery covers. The batteries are not dirty. I've been dusting the covers every stop.

123:34:49 Parker: Okay; good.

123:34:52 Schmitt: (To Gene) Are you through with the SRC?

123:34:55 Cernan: Yeah, I just left it there.

123:34:56 Schmitt: I've got to get to the (MESA) table.

[Gene decided to leave the SRC on the MESA table, rather than move it to the plus-Z footpad at the base of the ladder.]

123:34:58 Cernan: Okay. (Pause) Okay, the batteries look pretty good. Bob, the left-hand forward reflector on the batteries is about 10 percent in shade. The others are in the Sun. Is that what you want?

123:35:23 Parker: Stand by. (Pause) Okay; that sounds right, they say.

123:35:33 Cernan: Okay, the LCRU has been dusted; everything is dusted. Our blankets are open 100 percent. But why don't I recheck (the tasks at the bottom of CDR-35). Battery covers, open; LCRU blanket is open 100 percent; samples off. You got them all off, Jack?

123:35:45 Schmitt: Yeah.

123:35:46 Cernan: And anything else? Let me look around. (Turning to CDR-36) I got to get the TGE.

123:35:50 Schmitt: Check it one more time.

123:35:52 Cernan: Samples off; let's look under here. There's nothing under here. This bag is empty. Those are (unused) sample bags.

123:36:04 Schmitt: Okay, we do not bring up the LM ECS canister. Is that correct?

123:36:10 Parker: That's correct, 17.

123:36:14 Schmitt: Okay. (Pause)

[Jack is referring to a replacement lithium hydroxide (LiOH) canister for the cabin Environmental Control System (ECS). The canisters remove carbon dioxide from the cabin air and need to be replaced at intervals through the mission. Replacements are stowed in the MESA. At the moment, Jack is getting EVA Pallet 1 out of the MESA. Jack remembers that the pallet contains their food for the next 24 hours, along with such things as replacement batteries and replacement LiOH canisters for the PLSS's. The ECS LiOH can is not

stowed in the EVA Pallet but, rather, in a separate MESA stowage slot.]

123:36:21 Parker: And, Jack, confirm you have the scissors in the ETB.
 123:36:22 Cernan: Okay, and (garbled)
 123:36:24 Schmitt: (Laughing and responding to Parker) Yes, sir. Thank you, again.
 123:36:32 Cernan: Okay.
 123:36:33 Schmitt: Fighting the old blanket. (Pause)

[Jack is tidying the MESA thermal blankets.]

123:36:39 Schmitt: Okay, that pin's green; that pin's green. Both pins are green.
 123:36:45 Parker: Copy that.

[The pins are indicators on the PLSS replacement batteries. The fact that they are green indicates that the batteries are fresh.]

123:36:48 Schmitt: But dirty. (Pause)
 123:36:53 Cernan: Okay. (Pause)
 123:36:59 Schmitt: Okay, I'll take some stuff up (to the porch). SCB-2, we don't have. Oh, wait a minute. What did we decide to do? ...
 123:37:09 Parker: SCB 2 for the big rock there, Jack.
 123:37:11 Schmitt: Put that big rock in the... (Hearing Parker) Oh, okay.
 123:37:17 Schmitt: How's our time, Bob?
 123:37:20 Parker: No problem on time.
 123:37:23 Schmitt: There's a little (dust) in on those (radiating) mirrors, Geno.

[Gene is dusting the SEP. Jack has noticed some dust that has gotten under the loose cover.]

[Schmitt - "Poor Gene. It was just like when you're doing windows and somebody taps from the other side to point out you missed something."]

123:37:29 Schmitt: Can I sneak in and get a bag?
 123:37:31 Cernan: Yep. (Pause)

[Jack is getting SCB-2 from his seat so that he can take it to the MESA, put the football-sized rock into it, and then carry it and the core-stem bag up to the porch.]

123:37:41 Schmitt: See you later, Rover.
 123:37:51 Cernan: Okay. (Pause) Okay, the SEP blankets are open; it is dusted. Okay, and I verify that the DSEA is Off, and the power's Off.
 123:38:08 Parker: Copy that, Gene; thank you.

[The DSEA is the SEP Data Storage Electronics Assembly, which Gene and Jack will remove at the end of EVA 3 and return to Earth for analysis.]

123:38:13 Cernan: Okay, you want the TGE (put on the ground next to the) right side of the MESA, but in the shade. Okay.
 123:38:19 Parker: That's affirm. (Pause)
 123:38:26 Cernan: Boy, did it (the TGE) get covered with dust (because of the lost fender), too. (Long Pause) Bob, no trouble with the TGE and the TV, huh?

[TGE readings could be taken with the instrument on the ground or mounted on the back of the Rover. In the latter case, there had been some concern that movement of the TV camera would spoil the measurements.]

123:38:55 Parker: None so we can tell. We'll get another reading here when we see it on the ground here. (Long Pause)
 123:39:08 Cernan: Okay, Jack, if I set this here, we'll... (Pause) Jack?
 123:39:15 Schmitt: What?
 123:39:16 Cernan: Okay, I just want to set it here so you don't knock it over.
 123:39:18 Schmitt: What's that?
 123:39:19 Cernan: The TGE, right where you left foot is.
 123:39:21 Schmitt: Oh, well.
 123:39:23 Cernan: I'm afraid we'll knock it over if I set it anywhere else.
 123:39:24 Schmitt: Well, stand by; I've got a lot of stuff here.
 123:39:27 Cernan: Okay.
 123:39:31 Schmitt: We should have volunteered to take the big bag in.
 123:39:33 Cernan: Why? You having trouble getting that thing (the football-sized rock) in?
 123:39:36 Schmitt: Oh, it's just (non)standard. (Pause) Yes, I'm having trouble.
 123:39:45 Cernan: Well, here; let me help you.
 123:39:47 Schmitt: Hold this big bag, please.

[They are trying to transfer the football-sized sample from the big bag to SCB-2. The big bag has the same-sized opening as the SCB but is considerably deeper.]

[Schmitt - "I couldn't get a grip on the rock to get it out, and I needed to have Gene hold the bag still."]

123:39:50 Cernan: Just don't back up if you can help it.
 123:39:52 Schmitt: Hold the bag. This big one, this one. No, the other one, the other one; don't.
 123:39:57 Cernan: I can't (garbled). (Pause) I got it. That's a big rock. (Garbled) fit there is long ways.
 123:40:07 Schmitt: Okay, there should be another one in there. Is there?

123:40:12 Cernan: Feel it, squeeze it...Hit it. On the bottom. See if there's any in there.
 123:40:15 Schmitt: (Thinking that he can feel a rock in the bag) Yeah, there is.
 123:40:16 Cernan: Okay. (Pause) Well, let's get it out. Here, pick it up. We'll get it out. (Pause) Hold the top. (Pause) Shake it.

[They've probably turned the big bag over to see if they can shake anything out.]

123:40:41 Schmitt: Well, I thought there was one in there.

[Jack is looking for the sample he collected near the back of the LM at 118:31:10 and put in the big bag a moment later. Jack makes another reference to the disappearance of this rock at 147:36:11. It seems likely that the sample fell out during their struggle to get the football-sized rock out of the big bag.]

123:40:43 Cernan: I don't think there's anything in there.
 123:40:44 Schmitt: I thought I put one in there.
 123:40:45 Cernan: Okay.
 123:40:46 Schmitt: Well, I guess not. If I did, it's gotten out. Got away.
 123:40:58 Cernan: Okay, I'm going to leave the TGE right here. "Offload TGE (at the) right side of MESA." Okay, I might give them a gravimeter reading, believe it or not. Boy, I'll tell you, the only thing bad about putting this thing on the ground - just like everything else - you have to bend over to get at it. And you need support to get back up. (Pause) Okay. Mark, gravimeter.
 123:41:20 Parker: Mark your Mark
 123:41:22 Cernan: And she's flashing, Bob.
 123:41:24 Parker: Thank you. (Pause)
 123:41:32 Schmitt: Okay, I'm supposed to take this (SCB-2) and the core stem bag up there (to the porch).
 123:41:36 Cernan: I'll get it for you.
 123:41:38 Schmitt: Can you get the core-stem bag?
 123:41:40 Cernan: Yeah, I'll get it for you. (Long Pause)

[Jack probably jumps up to the first ladder rung during this interval and then waits for Gene to hand the two bags up to him.]

123:42:16 Schmitt: Okay, you got a core stem bag?
 123:42:18 Cernan: Yep, let me give it one zap with the brush.
 123:42:22 Schmitt: Okay. (Pause) I didn't mean to drop that, but I did.
 123:42:31 Cernan: Yeah, we got to keep from dropping everything. I'll tell you, the big lesson today...
 123:42:35 Schmitt: (Garbled)
 123:42:36 Cernan: Dust, I guess.

123:42:38 Schmitt: The big lesson is that it's going to get dropped if your hands get tired.

[Cernan - "The longer you work in that suit, the less feeling and dexterity you have in your hands. Your hands try to relax and you tend to drop things. And, if you drop things, they get dusty. If you drop things, you've got to get down and pick them up."]

123:42:41 Cernan: Here you are.

123:42:43 Schmitt: Let me come down. (Pause) Got it.

123:42:54 Cernan: Okay. (Garbled). (Reviewing CDR-36) Okay, the TGE is reading. We got to stow our antennas and...(Pause) Get some dusting done here. I'll make a check of what you've got up there. What have you got up there so far?

[Gene is running down the items on CDR-37.]

123:43:13 Schmitt: Just the SRC-2 (means SCB-2) and the core stems.

123:43:17 Cernan: Okay, SRC-2 and the core stems. Okay. (Consulting his checklist) Where's the EVA pallet?

123:43:26 Schmitt: It's on the MESA table.

123:43:28 Cernan: Okay, that's good; that's ready. Where's ETB? That's ready to go up.

123:43:32 Schmitt: Yep.

[The ETB is probably hanging from the lanyard, which is next to the ladder.]

123:43:33 Cernan: Okay, (reading) core stem bag, SRC-2 - (correcting himself) SCB-1 is in SRC-1. It's there. Big bag is not required. Okay, any more room up there? If not, why don't...

123:43:49 Schmitt: No, I think...

123:43:50 Cernan: Why don't I dust you here.

[Jack is probably on the ground again, having put the core stems and SCB-2 on the porch.]

123:43:51 Schmitt: Okay. This rock you landed on here...

[This is a rock under the west or plus-Z footpad, the one below the ladder.]

123:43:55 Cernan: Watch your foot; you're caught in that thing.

123:43:57 Schmitt: Yeh.

123:43:58 Cernan: Pick up your right foot. (Pause) Jack, you're just going to have to get up on that ladder somewhere so I don't get the dust all over this thing.

[Gene is probably referring to the TGE.]

123:44:04 Schmitt: Well, I've got to dust you, too. (Pause)
 123:44:08 Cernan: Well, okay. Go ahead and get me.
 123:44:11 Schmitt: Yeah, where's your brush?
 123:44:12 Cernan: Right on the hook. (Pause)

[This is a hook on the inside of the ladder strut.]

123:44:15 Cernan: Let me see what I can do. (I'll be able to) kick most of it off, I hope.
 123:44:18 Schmitt: You have to go anywhere else, now?
 123:44:20 Cernan: Just right around here; no place but right around here. (Pause) Man! That (dusting)'s like a super-endless task. (Pause) Get the top of that thing (possibly Gene's RCU) if you can.
 123:44:44 Schmitt: Oop. Oop. Landed on a slope.
 123:44:49 Cernan: Yup.

[They may have dropped the brush.]

123:44:52 Schmitt: Okay. That's good.
 123:44:56 Cernan: How about the arms?
 123:44:58 Schmitt: Can you hold them up and shake them, too, in case there's anything down in them?
 123:45:00 Cernan: Let me just...Yep. Let me get lower so you can get at me. Okay, how's that? (Pause)
 123:45:13 Cernan: But, at best, it is going to be bad but we want to get as much off as we can. (Pause) How about this one?
 123:45:29 Schmitt: Guess I can come around on the other side, if you want.
 123:45:31 Cernan: Yeah, I can hold on (to the ladder) better that way. (Long Pause)

[Schmitt - "You're hands were tired, so it was hard to hold on to the brush; and, in the suit, you couldn't position the brush any old which way you wanted. So you had to keep moving your body to get in position. It was a mess."]

123:45:56 Schmitt: It's taking some of it off.
 123:45:57 Cernan: Yeah.
 123:45:59 Schmitt: Hold still.
 123:46:02 Cernan: I'll get up on that ladder and you get a whack at my legs, best you can. And I'll kick my boots clean. (Pause)
 123:46:16 Schmitt: That fender is really going to be a nuisance. (Pause) (We got) rained on. (Pause) I'm going to have to get you to bend over, too, so I...Not now. Know there's a lot (of dust) on the OPS.
 123:46:45 Cernan: Might just as well stow my antenna if you're up there (working on the OPS).

[Jack doesn't get Gene's antenna at this point.]

123:46:54 Schmitt: Just a second. Oh, boy! That's really putting the finishing touches (of tiredness) on the old arms, isn't it?

123:46:58 Cernan: Yeh. (Long Pause)

123:47:12 Schmitt: How'd you get so dirty?

123:47:15 Cernan: Wait until I show you the picture I took of you.

123:47:20 Schmitt: Didn't. Okay, Gene. Most of what's left is up on your...Get your antenna. Oh, you're going to go up there (on the ladder), first?

123:47:33 Cernan: You want...

123:47:34 Schmitt: Okay.

123:47:36 Cernan: I don't know how you do that.

[This is Gene's first attempt at jumping up to the bottom rung on the ladder.]

123:47:38 Schmitt: Just really spring. You got it!

123:47:46 Cernan: Beautiful!

123:47:47 Parker: Okay, 17, do we copy...

123:47:48 Schmitt: Okay.

123:47:49 Cernan: Better get my legs, and I'll kick (garbled).

123:47:49 Parker: ...both antennas up?

[On Apollo 15, Dave Scott forgot to stow Jim Irwin's antenna at one point, and it broke off when he climbed back in the LM. Fortunately, Scott and Irwin were able to use tape to make an adequate repair.]

123:47:53 Schmitt: No!

123:47:53 Cernan: No, sir, Bob. I'm still getting dusted. We're trying to go over this thing pretty thoroughly.

123:47:56 Parker: Okay. (Pause)

123:48:14 Schmitt: (Your) pocket is probably full of dirt.

123:48:16 Cernan: That brush does pretty good, though. (Pause) Want me to move, or anything now?

123:48:23 Schmitt: No.

123:48:24 Cernan: Okay.

123:48:29 Schmitt: (Garbled) Of course, when I do this, I get dirtier.

[Gene is on the ladder, above Jack. As Jack cleans Gene's legs, the dirt falls on him.]

123:48:31 Cernan: Well...(Pause) Once I get you this far, I'm just going to shove you on up that ladder and not let you get in the dust. Whoo! (Long Pause)

[Schmitt - "The dust issue is one that just has to be addressed. It's going to be the major environmental issue for future missions on both the Moon and Mars. Mars is going to have a different type of dust; but in both cases it's going to require careful thought to design suits that can

handle 100 or 200 or 300 EVA's compared with the three that we did."]

123:49:17 Cernan: Okay?
 123:49:18 Schmitt: No. You're not okay. You're awful dusty. But I don't know that I can...
 123:49:24 Cernan: Okay.
 123:49:25 Schmitt: ...do too much more.
 123:49:26 Cernan: That looks pretty good. I'll walk...
 123:49:27 Schmitt: Hit your boots real hard when you come up.
 123:49:29 Cernan: Yep. (Pause) Okay. I've just got to stay on my feet here for a while.
 123:49:36 Schmitt: Want me to...
 123:49:38 Cernan: Stand in the (foot)pad. Yeah. Stay there and I'll get your back and your PLSS while I'm at it - to start with. Stoop down, if you can. Stand on the bottom of the pad...There you go. (Pause)
 123:49:54 Schmitt: How's the old ALSEP, Bob?
 123:49:58 Parker: It's looking great, guys.

[Schmitt - "Little did we know!"]

123:50:07 Cernan: Don't forget, Jack; you'll have to stow my antenna yet.
 123:50:11 Schmitt: Right.
 123:50:13 Cernan: Okay, while I'm up here let me get the top of your OPS and I'll stow your antenna at the same time.
 123:50:18 Schmitt: Okay.
 123:50:19 Cernan: You're going to have to get further down. I can't reach it. (Pause) That's good.
 123:50:26 Schmitt: (With knees bent so that Gene can reach his OPS) I feel like I'm praying. I guess I am.
 123:50:30 Cernan: Now, maybe I can get some dust off you. Okay, stay there. The antenna will be stowed in half of a jiff. (Pause) Oh, my fingers! They do not have the dexterity that they once had. (Pause)
 123:51:10 Cernan: Okay. (I'll) make sure you don't have anything hanging on you. Wait a minute. (Pause) Okay. You can stand up. I'll work on your arms. (Long Pause)
 123:51:58 Cernan: I'll come around that side and get the other one. No, maybe I won't either. Maybe I'll get it...Hold onto the ladder some. It'll give me stability, too. (Pause) Okay, I'll get the backside of your arm from the other side. Let me get around your waist here now. (Pause)
 123:52:30 Cernan: Getting there. (Garbled; Pause) Ah. (Pause) Okay, let me try your left arm. (Long Pause)
 123:53:04 Cernan: Why don't you go up the step. (Pause) Okay. Stay there. (Pause) Oh, boy. Hallelujah. Yeah, do that. That gets a lot off, Jack. Keep doing that. Keep doing that. Boy, that gets it off your shoes.

[Jack is stomping his boots on a ladder rung.]

123:53:34 Cernan: Okay. Put this foot out here, again.
 (Pause) We're still at it, Bob.
 123:53:56 Parker: Yeah! It seemed to go a lot faster down there in the clean room at the Cape.
 123:54:04 Cernan: Boy, you bet you. And I know why we didn't do it. It was just as tough down there as it is here.

[Cernan - "We practiced dusting each other in training, but never with any dust or dirt; we just went through the motions."]

123:54:11 Schmitt: (Asking Gene if he is finished dusting) Okay?
 123:54:12 Cernan: No, not yet. I want to get the other leg. And then I want you to lean over and get my antenna.
 123:54:27 Schmitt: Oh, that's right. I need to brush off the top, too. I'll stow your antenna first.
 123:54:36 Cernan: Okay, babe. That's about all I can do for you. Okay, get my antenna. Oh, I think all the dust I took off you went on me. (Pause) Can you reach it from there? (Pause)
 123:54:51 Schmitt: Well, yeah; I think I can. (Pause) Oh, whew! (Pause)

[They've been dusting each other for eleven minutes.]

123:55:13 Cernan: I have 7 hours from the time I looked at my watch. That's got to be pretty close.
 123:55:19 Parker: You guys have got 6 hours and 53 minutes and 40 seconds.
 123:55:23 Schmitt: Okay, Gene, you're stowed. Let me... (Stops to listen to Parker) (To Gene) Okay. Let me see your brush.
 123:55:27 Cernan: Okay. Here it is. (Pause)
 123:55:38 Schmitt: Okay. That's the best I can do.
 123:55:39 Cernan: Okay. Let me get the top of this (shin) pocket. (Pause) Okay. Go on up; stay clean.
 123:55:48 Schmitt: Well...You've got...Let's see...
 123:55:52 Cernan: I'll hand you something.
 123:55:53 Schmitt: You've got to bring stuff up I guess, huh?
 123:55:54 Cernan: Yep.
 123:55:55 Schmitt: Okay. I need the EVA pallet.
 123:55:57 Cernan: Okay, I've give you that and then I'll get to work. I've got some work I've got to do for Bob. Ah! Okay, (is) everything on the EVA pallet?

[Schmitt - "I don't think I'd actually loaded anything on the pallet. Gene just wanted to make sure nothing had fallen out."]

123:56:06 Schmitt: Yeah. Just hand it to me and I'll start unstowing it up there.

123:56:09 Cernan: Okay. Man, I forgot I had my visor up. Zowie! See if I can get back in the shade. (Pause)

[Schmitt - "Gene must have put his visor up so he could see to dust me while we were standing in the LM shadow at the ladder; and then he stepped out into the sunlight."]

123:56:30 Cernan: (Handing up the pallet) Got it?

123:56:32 Schmitt: Yeah.

123:56:34 Cernan: Okay. (Pause) Okay, Bob. I'll try giving them to you one at a time (that is, the items at the bottom of CDR-36). LMP's got the EVA pallet. Let me give you a MESA (meaning gravimeter) reading...(correcting himself), or a reading, then I'll tidy the (MESA) blanket.

123:56:49 Parker: Okay. (Pause)

123:56:55 Cernan: Okay. The reading is 000, 133, 201 (a nonsense reading), and I can only assume that one of us hit it. I think I've got time to give you another one.

123:57:07 Parker: Okay. Quickly.

123:57:10 Cernan: Well, that's the way it'll be, because it's already punched. (Pause) Mark it.

123:57:16 Parker: Copy that. (Pause)

123:57:22 Cernan: Okay, I'm tidying up the MESA blankets. I'm pretty tidy!

123:57:27 Schmitt: I did that.

123:57:28 Cernan: Okay, MESA blankets are tidied. Okay. Open TGE. I'll do that (later). Brush to ladder hook. Final transfer (check, on CDR-37), Jack. I'm going to...(Pause) Okay, I'll tell you what I'm going to do. I'm going to inventory here. You got the pallet. ETB is here, and you got the core stem bag. SCB-2 is (up) there; SRC-1 is here; big bag is not required. Bob, I think we got everything. The two things on the surface yet are the ETB and the SRC and me.

123:58:11 Parker: Okay, we copy that. But, of course...

123:58:12 Cernan: Jack, get down (on your belly) a little bit more, and you've got another 2 or 3 inches (to clear at the top of the hatch).

123:58:20 Schmitt: "I can't get any lower, Willie. Me buttons are in the way."

[Schmitt - "This a quote from one of Bill Mauldin's more famous World War II cartoons in the 'Up Front' collection. Willie and Joe are down in the mud with bullets going over them and that's the caption."]

123:58:23 Cernan: Okay. Keep going. Get your pockets over the sill. There you go. There you are. You're in. Kick off your feet if you can; kick them right there. That's good. That got a lot off. Okay, go on in. You're over to the right...Okay, there you are. You've got all the room you want now.

123:58:43 Schmitt: That's not as easy as in the K-bird.

[Cernan - "We could get about 30 seconds of 1/6th gravity flying in the KC-135 aircraft. That was too short for a lot of things and it had been a problem way back in Gemini. Training underwater was not totally realistic either, but at least it gave you a lot longer duration."]

[Schmitt - "We practiced getting in a hatch simulator in the KC-135 but that wasn't a static environment and I think it made it easier. There was just a little bit of motion and I think that helped you get through the hatch. And, of course, our hands weren't tired in the 135 and that also made a significant difference."]

123:58:50 Cernan: Okay. I think I'll give this rock box a quick dusting here.

123:58:57 Schmitt: Your (LM) hoses...We've got to have a better way to store your hoses.

[Jack is crawling into the LM and is getting caught up in Gene's LM hoses. They would be to Jack's right as he goes through the hatch, draped over Gene's hand controller.]

123:59:00 Cernan: Yeah, I don't like them there either. (Pause) I saw that when we went out. (Pause)

123:59:17 Schmitt: (Breathing heavily) Whew, boy.

123:59:15 Cernan: (To Jack) You in?

123:59:17 Schmitt: Yuh.

123:59:19 Cernan: Sounds like it. (Pause) (To himself, possibly having missed the first rung and having to jump again) Oh, come on. Get up there. (Pause) Okay, Jack, coming up with the rockbox.

123:59:35 Schmitt: I'm not ready.

123:59:36 Cernan: Well, I've got to...I've got to...

123:59:39 Schmitt: Can you put it on the porch?

123:59:42 Cernan: Well, I only got one more thing to do and that's just clean up (that is, read) the TGE. Okay. I've got to come up there anyway. (Long Pause)

124:00:08 Cernan: "Godspeed the crew of Apollo 17."

124:00:13 Schmitt: Who signed it? I forgot to read it.

124:00:16 Cernan: I'm not going to tell you, but I like the message. (Pause) Probably shouldn't tell you. (Pause, grunting)

[Gene isn't absolutely certain, but thinks that the message was written on a piece of tape on the strut. He thinks he may have put the message there himself. Gene and Jack took a number of photos of the official plaque mounted on the ladder strut. One of these shows all but the top two rungs and there is no piece of tape discernible in a 16x20 inch enlargement. Because a good deal of detail on the official plaque can be seen in this image, I conclude that there was no taped message in this part of the image. At the start of EVA 3, Jack took a picture of the entire forward face of the LM as part of a color pan taken with Gene's

camera. The LM image is AS17-140-21370, but nothing definitive shows up in an enlargement of that image, either.]

124:00:33 Cernan: Okay, that (rock box) ought to stay up there. (Pause) Okay, I can't hand you anything in anyway. I'm going down and clean up the TGE.

124:00:45 Parker: Rog. It should be ready to read by now.

124:00:47 Cernan: Oh! That last step down again. Okay. Bob, before...Well, let me get this for you. (Long Pause)

124:01:06 Cernan: Okay, Bob, 670, 021, 501; 670, 021, 501.

124:01:14 Parker: Okay. Got that, Gene.

124:01:17 Cernan: And the cover is up. (Breathing into his microphone as he bends down to reach the TGE) Cover is up, if I can keep it up. (Pause) If I can keep it up. (Pause) That'll keep it up. (Pause) It's been dusted. And I'll get it to Standby.

[Gene is opening the top of the TGE to expose a radiator. The TGE is now sitting in the shade of the LM and will be able to cool during the rest period.]

124:01:41 Parker: Okay. Copy that. And did you dust the radiator?

124:01:47 Cernan: Yes, sir; I dusted that a little earlier. Okay, it is Standby, Bob. Radiator is up.

124:01:54 Parker: And dusted.

124:01:58 Cernan: Cover is open.

124:02:00 Cernan: Okay. I'm going up to the porch. All I've got down here is ETB, and it's on the LEC.

[On the early missions, the Lunar Equipment Conveyor (LEC) was a clothesline-like device used to transfer equipment up to the cabin. Using it was a two-man operation. Beginning with Apollo 14, the astronauts carried at least some equipment up the ladder by hand. Finally, the Apollo 16 crew decided that the clothesline LEC was more trouble than it was worth and carried everything but the ETB up by hand. To raise and lower the ETB, they used a simple hook-and-lanyard, but kept the LEC designation. Gene is using the lanyard-type LEC.]

[Schmitt - "We used the lanyard to raise and lower the ETB because it had delicate equipment in it, particularly the cameras. It wasn't a rigid bag and, while I don't remember how or when the decision was made, I think we decided that, rather, than sling the ETB around, we'd just hoist it up."]

124:02:07 Schmitt: I'm ready for you.

[Jack has been emptying the EVA pallet, which he will now push out through the hatch, almost certainly with his foot, so that Gene can discard it.]

124:02:08 Cernan: Have you got anything else?

124:02:10 Parker: Negative.

124:02:11 Schmitt: I'm ready for you up here.

124:02:15 Cernan: Let's see what kind of dusting job I can do on myself. (Long Pause)

[The sound of Gene beating on his suit with the brush is audible, unless we are hearing him hit his microphone on his neckring as he strains to look down at what he is doing.]

124:02:49 Cernan: Okay, Jack, coming up.

124:02:50 Schmitt: Okay.

124:02:51 Cernan: (Pause, as he makes the long jump, this time unencumbered.) Whee! (Pause, as he climbs to the porch) Okay.

[Cernan - "Getting up the ladder was a piece of cake. You pushed up with your legs - just a little spring up - and pulled with your arms."]

124:03:11 Cernan: (I've got to get) a little higher.

124:03:13 Schmitt: I'll get it (the EVA pallet) to you.

124:03:15 Cernan: I got it.

124:03:17 Schmitt: Watch the (hatch) seal.

124:03:24 Cernan: Okay. (Pause) Okay, here's an SRC.

124:03:27 Schmitt: Okay; float her in here.

[Gene probably stands the SRC on end to make it easier to grab; then it falls on its side.]

124:03:30 Cernan: Oh, me. Well, I'll get it up for you.
 124:03:34 Schmitt: No. That's all right.
 124:03:37 Cernan: Ah. I think you got the ticket right there.
 124:03:40 Schmitt: Ah. (Pause)
 124:03:44 Cernan: I'll watch that. No sense making it hard. See if I can't stand this one up. (Pause) Okay.
 (Pause)

[Jack is having to bend over as far as he can to grab the equipment as Gene hands it through the hatch. Jack notes that his voice quality suggests that he has his chin bent down so that he can see.]

[Cernan - "Even with the hatch open, he couldn't have worked kneeling, because he would have had to have his legs toward the hatch and it would have been hard to reach back and pull things in around his body."]

[Schmitt - "As Gene handed the stuff in, I probably put it back on the engine cover, although I may have stowed the SRC right away. There were special compartments for each of the SRC's and the SCB's but we may not have stowed those until after we were repressurized."]

124:04:05 Cernan: Okay, and here come the core tubes.
 (Pause) Boy, let's protect that core tube. Man, that was the turning point today. (Pause)

[Cernan - "Once the deep core was finished it really was a turning point. While we were deploying the ALSEP, we had a fixed set of tasks to do; and removing that core was probably the hardest of them. But after it was finished, then we could settle back into an exploratory mode of operations with a lot more control and choice about what we did."]

124:04:01 Cernan: Got it?
 124:04:22 Schmitt: Got it. (Pause) Yeah, we had a lot of turning points.

[Schmitt - "From my point of view, the big turning point of the mission didn't come until we'd finished the second EVA. From an operational point of view, which was Gene's perspective, getting the core extracted and the rest of the ALSEP deployed was a major accomplishment; drilling those holes and extracting the core was tough work. But I was frustrated that we were still in the position that, if we had to leave the Moon before we had done another EVA, we wouldn't have had much information about the site. We'd gotten the heat flow experiment deployed so we were going to get confirmation of the Apollo 15 measurement. We had a few samples of the basalt, but had done no systematic sampling. We had the soil in the core, so we probably would have found the black beads; but there's not a lot of orange soil in that valley - it's mostly black - so we might not have had enough

orange beads in the core to recognize it's importance. We had put out two seismic charges out which, by themselves wouldn't have given us much. We had a few gravimeter readings but no profile across the valley and not enough information to understand the depth of the basalt fill. And, although we didn't know it at this point, the major experiment on the ALSEP, the long-period gravimeter (LSG), wasn't going to work. So, at the end of the first EVA, we were in the scientifically vulnerable position of having gone all the way to the Moon without having gotten very much out of the mission relative to what the potential was. By the time we finished the second EVA, we had a lot of information about the site and, from a scientific point of view, that was the big turning point of the mission. By the end of the second EVA, we had at least half a gravity profile because we'd gone across one contact up onto the South Massif; we had several more seismic charges deployed; and we had done a lot of systematic sampling of the mare basalts, the massif breccias, and the soils."]

124:04:28 Cernan: Do you want the LEC in there? You don't, do you?

124:04:32 Parker: Negative, you can leave the LEC outside.

124:04:37 Schmitt: (Answering Gene) No, just the bag (ETB).

124:04:39 Cernan: Where are the scissors, by the way?

124:04:40 Schmitt: They're in the bag.

124:04:41 Cernan: Okay. I hope they don't come out this time.

124:04:43 Schmitt: Well, I stuck them down in there. I hope they don't.

124:04:46 Parker: Yeah, Jack...

124:04:47 Schmitt: We'll have to figure out something else if they do.

124:04:48 Parker: ...you guys put the scissors in the ETB.

124:04:53 Schmitt: I think so, Bob.

124:04:55 Cernan: I'll take a peek down there. If they fell out, they'll be right on top (of the ground surface). Okay. (Pause) Mama me. (Pause)

124:05:09 Parker: Okay, Gene. And you got the SCB number 2 in and the pallet out, right?

124:05:17 Schmitt: Right. (Pause)

124:05:25 Cernan: Here it comes, Jack. (Pause) Take that? (Pause) There are no scissors on the ground beneath where the ETB was. So I would say that they're probably in the ETB.

124:05:54 Parker: Well, good enough.

124:05:55 Schmitt: (To Gene) Okay. You got everything, now?

124:05:57 Cernan: Yes, sir.

124:06:00 Schmitt: Okay, let me get out of the way. (Long Pause)

[Jack has been working with the hatch door fully open to his right. He now moves to Gene's station on the left side

of the cabin, closes the door far enough so that he can move across to his station on the right and then swing the door open as far as possible against his legs.]

124:06:23 Cernan: Okay. (Kicking his boots and shaking the spacecraft) Whoops. That's me dusting. Well, I guess I got about (counting the marks on the gage) 25, 20, 15, I guess thirteen percent oxygen (and) 3.8 (psi). Okay, babe.

124:06:47 Parker: I copy that. Fifty (sic) percent oxygen, Geno...That's...

124:06:49 Schmitt: Come on in.

124:06:50 Cernan: Coming through that hole. (Answering Parker) No; thirteen percent, I think.

124:06:56 Parker: One-five (sic). (Pause)

124:07:08 Schmitt: Okay. Put your "buttons" down. You're great. Now your head up. You're right against the top. Right against the Z-27 (that is, the aft bulkhead). Come towards me. Okay, now up. (Pause)

[Cernan - "By this time, I was really tired and it was a lot of trouble to get back in the cabin. It's such a small space; and you've got twist and turn to get in there. You've got to crawl in with that big PLSS on your back until you hit the back bulkhead with your helmet. Then you've got to start arching your back so that you can get your head up so that you can get further in further. But you've got to keep the PLSS clear of the DSKY, so that means really arching your back. Then you push with your feet until you're in and you can stand up and then turn to turn around. And it didn't help that a lot of space, particularly on the engine cover, was taken up by the boxes and bags we'd brought in from the surface. It was really crowded."]

124:07:29 Cernan: Okay.

124:07:30 Schmitt: Tight fit.

124:07:32 Cernan: What am I caught on back there?

124:07:34 Schmitt: You're just scraping against your PLSS.

124:07:36 Cernan: Okay. I'll just bend.

[Schmitt - "While you were arching your back, trying to keep your PLSS from hitting the DSKY, you really had to be careful not to scratch your visor on the back bulkhead any more than absolutely necessary. Gene may have had more trouble getting in than I did, simply because he is a longer person, even though, for the same reason, he didn't have as much trouble getting his back arched. Certainly he was tired - we both were - and it was only prudent for me to help him. You didn't want to bang that DSKY any more than you absolutely had to."]

124:07:37 Schmitt: Watch your pockets. Your leg pockets might be part of the problem.

124:07:42 Cernan: Okay.

124:07:45 Schmitt: Okay. Come on in. Just hug as close as you can. Okay, you're there. (Long Pause) Okay?

124:08:07 Cernan: Yup, let me just get on my feet here. Ohh! Ah. Wait a minute. Got to turn one way or the other. Does this look better?

124:08:18 Schmitt: Yeah. I'd turn towards your right. (Pause)

124:08:24 Cernan: Well, can't do that.

124:08:25 Schmitt: Try the other way. Get your PLSS back in there towards the circuit breakers.

124:08:32 Cernan: Move your right...(correcting himself) your left arm.

124:08:34 Schmitt: (Laughing) Where? Okay.

124:08:39 Cernan: There. Okay. Let me make sure there's nothing in that hatch.

124:08:43 Schmitt: Well, there's dust. That's one thing that's in there.

124:08:44 Cernan: Well...Take one quick peek.

124:08:49 Schmitt: From where I stand, all I can see is dust.

[Cernan - "With two guys standing there, relatively immobile and wearing PLSS's, there wasn't a lot of room to bend over to look at the hatch opening for things that might keep you from getting a good seal. So you leaned back to get a look at it. It was important to get a good seal the first time, because otherwise you'd have to go through the whole procedure again."]

[Schmitt - "You would probably blow the hatch seal clean if you depressed again, but you certainly didn't want to lose all that pressurization oxygen."]

124:08:52 Cernan: Okay, it (the hatch seal)'s clear. Hit it. Is that what do we do next?

124:08:56 Schmitt: Pockets...Your pockets (are catching on the hatch door). Okay?

[Jack may be kicking the hatch partially shut to get it out of the way. They will actually close and latch the hatch at 124:10:44.]

124:09:05 Cernan: Okay.

124:09:07 Cernan: (Reading from the post-EVA cue card, which has the same information as checklist page 3-1) "Primary water, Closed. Forward hatch..." Turn our Water (to) Off. (Pause) Do you have to turn the primaries or just the secondary (Auxiliary), Bob?

124:09:22 Schmitt: Primary.

124:09:23 Parker: Primary only. (Gene is breathing very heavily) That's why you don't turn your Primary Water off when you go to Aux.

[The two feedwater tanks are hooked up in series. The auxiliary tank was added to the PLSS for Apollo 15 and subsequent missions. Apparently, it was easier to add a second tank to the design than to enlarge the existing tank.]

124:09:34 Cernan: Okay. I've got them both Off. Is that all right?
 124:09:36 Parker: That's okay, too.
 124:09:40 Schmitt: Well, wait a minute.
 124:09:42 Cernan: Got yours?
 124:09:43 Schmitt: No, I can't quite reach it.
 124:09:45 Cernan: Well, if you can roll to the left, I'll get it for you.
 124:09:46 Schmitt: Yeah, I can.
 124:09:48 Cernan: (Garbled), let me get back here. I've gotten bigger since I've been out there. (Pause) You got to go (that is, turn) more. You got to go more.
 124:10:03 Schmitt: Yup. There's something keeping me from going more.
 124:10:06 Cernan: Okay. Okay, let me see if I can't...(Pause)
 124:10:18 Schmitt: (Garbled) awfully far inboard for what I (garbled).
 124:10:23 Cernan: Okay. Your Primary Water is Off.
 124:10:25 Schmitt: Okay. LMP's Water is Off.
 124:10:28 Cernan: Now you're going to have to move way over there, so I can get the hatch.

[Closing the hatch is a difficult job in an inflated suit. Gene needs Jack to get back against the rightside circuit breaker panel so that he, Gene, can reach down to close the hatch.]

124:10:31 Schmitt: Yeah, I have to go back the way I was.
 124:10:34 Cernan: Back up against the circuit breakers.
 124:10:35 Schmitt: Yup.
 124:10:36 Cernan: Can you see what I'm catching on, upward?
 124:10:39 Schmitt: Yeah. You're just hitting the rail over there.
 124:10:44 Cernan: Okay. Now. (Pause) See, I can't..."Close and lock forward hatch", huh?
 124:10:54 Schmitt: Yeah. (Pause) Can you do it?
 124:10:59 Cernan: Yup. Can't see it. Okay. (Pause)

[Cernan - "To get the hatch closed and latched, you had to lean forward and sideways and close it by feel. The instrument panel stuck out about a foot into the cabin and you just couldn't see under it while you were closing the hatch. Then, once I got back up, I could lean back and see it was closed, and as Jack could, too. All of this was necessary because we were really constrained by weight; the LM had to be as lightweight as possible and we couldn't afford a lot of volume in the spacecraft. If we'd had more

room and a little bigger hatch, all of this would have been a lot easier and have gone a lot faster."]

124:11:07 Cernan: Forward Hatch is Closed...
 124:11:10 Schmitt: Locked?
 124:11:12 Cernan: ...and Locked. Which one of those dump valves is (open)...That one up on top. I can get that one.
 124:11:17 Schmitt: Okay. (Pause) Take it easy.

[Gene is reaching up and behind to his right to close the overhead dump valve.]

124:11:20 Cernan: Oh, whew! (Pause) It's Auto, and it's locked.
 124:11:38 Schmitt: You're sure? Is that locked there?
 124:11:40 Cernan: Yes, sir.
 124:11:41 Schmitt: Okay.
 124:11:42 Cernan: And it is Auto.
 124:11:44 Schmitt: Okay.
 124:11:45 Cernan: Okay.

[In the Auto position, the dump valve will open if the cabin pressure exceeds 5.4 psi.]

124:11:46 Schmitt: Okay, I got a tone and I got an H2O flag.
 124:11:48 Cernan: Okay.
 124:11:49 Parker: Roger, Jack; we saw it.

[Having turned the PLSS water pump off, they verify that the warning signals are working properly.]

124:11:54 Cernan: Okay, PLSS O2 is not less than 10 percent.
 124:11:57 Schmitt: Yeh. Okay...

[If the PLSS oxygen supply in either suit was less than ten percent, they would have to do a manual cabin repressurization, watching the suit pressure gage to make sure the suit maintained positive pressure.]

124:12:00 Cernan: Okay, let's go.
 124:12:01 Schmitt: "If not less (than 10 percent)...manual control repress." Okay. I've got to turn (so that he can get at the valves and circuit breakers and controlling the Environmental Control System (ECS).
 124:12:06 Cernan: Okay. Let me get out of your way. Okay. About as far as I can go. Okay. I'll read it to you, when you get there. (Pause)
 124:12:17 Schmitt: I think part of our problem is this slope. There's no "purchase"- as my Father used to say - no "purchase".
 124:12:26 Cernan: Okay, are you ready? Are you ready?
 124:12:30 Schmitt: Wait a minute.

124:12:34 Cernan: I need you on Cabin Repress (valve),
Auto; and then on (circuit breaker panel) 16 I need you...
124:12:39 Schmitt: Okay.

[Jack will set the cabin repressurization valve so that,
when he closes the corresponding circuit breaker,
repressurization will begin and, when the cabin is up to 5
psi, the valve will close automatically.]

124:12:41 Cernan: Okay; Cabin Repress, Auto.
124:12:44 Schmitt: Going Auto.
124:12:47 Cernan: Okay. ECS Cabin Repress (circuit
breaker), Closed.
124:12:49 Schmitt: Okay. Stand by for repress.
124:12:50 Cernan: I'll try and get cabin...that master.
Okay, there's the Master Alarm. (Audible sound of
repressurization) Well, I can't (garbled).
124:12:58 Schmitt: Okay.

[Gene is turning to make sure that the Cabin Warning
light has come on.]

124:13:01 Cernan: Cabin is coming up. (Garbled) closed at
1 psi.
124:13:04 Schmitt: Okay.
124:13:05 Cernan: Okay. Verify cabin pressure increasing.
Press(ure) Reg(ulator's) A and B to Cabin.
124:13:17 Schmitt: Now?
124:13:18 Cernan: Now.
124:13:19 Schmitt: A's Cabin; B's Cabin.]

[The pressure regulators are now set to keep the cabin
pressure at 4.8 psi.]

124:13:21 Cernan: Okay, and I want your PLSS O2 Off, when I
give you a call. That's when we get greater than 2.5 (psi
cabin pressure). (Pause)
124:13:33 Cernan: Okay, now. We're at 3. Can you get it?
If you can't, I'll reach it for you.
124:13:39 Schmitt: It's Off.
124:13:40 Cernan: Okay, Cabin Warning Light Off. Verify
cabin pressure stable at 4.6. Okay, it's coming up. It's
3.6. And you use the Purge valve to depress.

[The EVA ends when the cabin pressure reaches 3.5 psi.
Although the PLSS oxygen is off, without intervention, the
suits would deflate relatively slowly. To hasten suit
deflation, once the cabin pressure is significant, they can
open the purge valves.]

124:13:55 Schmitt: What's our pressure?
124:13:57 Cernan: Cabin pressure is 4. Let me just take a
look here at 4.6. Okay. I'm coming down. Suit's coming
down. Cabin's up to...Cabin's up to 5, Jack.

[The sound of repressurization ends abruptly.]

124:14:09 Cernan: Okay, it's 5. It shut off.
124:14:10 Schmitt: Okay.
124:14:11 Cernan: Okay, I'm about depressed.

[That is, he has opened the purge valve and his suit is virtually deflated.]

124:14:13 Schmitt: So am I.
124:14:14 Cernan: Okay. Post-EVA configuration. White dots out and EVA decals.
124:14:20 Schmitt: Okay. Checking.

[Jack is verifying that the circuit breakers and switches marked with white dots and EVA decals are in the same, powerdown configuration they were in prior to the start of the EVA.]

124:14:22 Schmitt: White dot.
124:14:23 Cernan: Okay. Give me a chance to turn around and look. Okay. White dots are out; all the white dots. Okay, they're all out here. Boy, does this feel good to get soft suits. Oh, my hands.

[Cernan - "Your hands just get so tired and sore, both from the work of squeezing your gloves around things all day and from the constant chafing. I wound up with blisters all over my hands, particularly between the thumb and the forefinger."]

124:14:47 Schmitt: Okay, they're all out here.
124:14:48 Cernan: Okay. Okay, on (panel) 16, Suit Fan number 2, Closed.
124:14:54 Schmitt: Suit Fan 2, Closed.
124:14:55 Cernan: And Suit Fan Delta-P, Closed.
124:14:57 Schmitt: Closed.

[They are turning on the fans and a fan sensor in the Environmental Control System (ECS) Suit Circuit.]

124:15:00 Cernan: ECS caution and Water Sep(arator) Component light's on.
124:15:03 Schmitt: Okay, ECS...(Pause) I think it's on. It's hard to see it.

[This indicates, as expected, that the Suit Circuit Water Separator is not yet up to speed.]

124:15:12 Cernan: Okay. (Pause) Doff your gloves. Stow on comm panel. Hallelujah!

[It is a great relief to get the gloves off.]

124:15:16 Cernan: Cabin's stable, Houston. How's it look to you?
 124:15:28 Parker: Looks good to us, 17. And I'd like you to know you had a 7-hour and 12-minute EVA, from 3.5 (psi) to 3.5 (psi) .
 124:15:40 Cernan: Well, until I get out of this suit, I'm still EVA.
 124:15:48 Parker: Roger.

[It is now eight hours and fifteen minutes since they started to get Jack's PLSS on, and it will be another forty-five minutes until they are both out of their suits. Preparations for the next EVA will take even longer, since they will have to start with suit donning.]

124:15:49 Cernan: Oh, doesn't that feel good. Whoo!
 124:15:52 Parker: And I think it's a tremendous job for what we might call a "challenging" EVA.
 124:16:00 Cernan: Bob, that's no pun. It really was. It really was.
 124:16:04 Parker: I know it, men. I know it.
 124:16:11 Cernan: I tell you, I really wish you guys could have been here with us. You worked as hard at it as we did, if not harder.
 124:16:20 Schmitt: Harder, I think. Until today.
 124:16:24 Cernan: Ohh! You don't have a tub of hot water I can soak my hands in, do you? (Pause)

[Schmitt - "I had been aware from the experience of previous crews that you could get rough or damaged finger tips and that your fingernails could lift right off the quick as a result of constantly reaching in the suit and getting a little bit of grabbing from the rubber bladder. Knowing that, I wore some nylon liners and also kept my fingernails clipped down as far as possible to delay the process. But, ultimately, all my nails were lifted off the quick and I can remember seeing blood under Gene's fingernails. There was nothing much else you could do about it; it was just a continuous, traumatic soreness which faded into the background."]

124:16:39 Cernan: Wait until that dust hits the sweat of your hands.
 124:16:43 Schmitt: (Sub-vocally) Oh, shoot. (Pause) I tell you.

[Schmitt - "Other than the times when I was talking to Gene or when Parker had asked a specific question, I don't think I was talking to anyone so much as I was dictating - particularly about the geology, providing a verbal set of field notes that I realized that I or others would be using. So I'm surprised that, even under those circumstances, we had a subconscious avoidance of profanity. Gene would

occasionally use his "Manischewitz" as a substitute and I used "Oh, shoot" here and probably used other things on occasion. And I think it was characteristic of each of the crews. They all pretty much avoided profanity except on Apollo 16 when they accidentally had their mikes keyed when they were talking about the orange juice and on Apollo 10 when they had that startling experience with the jets firing when they weren't expected to."]

124:16:48 Cernan: Man! Okay, my gloves are off. (Reading) "Doff helmets with visors, lower shades, and stow in BRA." Well, I guess the first thing is to get this thing off. Boy, let me tell you.

[The BRA is the helmet bag made out of webbing. It has two cavities, one for each helmet.]

124:17:09 Parker: Okay. And 17 - or Jack and Gene - I'm going to turn you over to Joe (Allen) now. I'll be back in a while.

124:17:19 Cernan: Okay, Bob. Thank you for a job well done.

124:17:22 Parker: Well, job well done on your side, guys. (Pause)

124:17:30 Schmitt: (Sub-vocally) God Damn. (Pause) Oh, I can't do it. How about getting my glove off? (Pause) Can you handle it?

124:17:48 Cernan: (Garbled; pause)

124:17:52 Schmitt: Thank you. (Pause)

124:18:06 Cernan: Jack, the big one's out of the way. The one (EVA) we really had to get out there on. Boy, look at that visor. No wonder I couldn't see. (Long Pause) Jack, do you read?

[They have their visor assemblies (LEVA's) off, but still have their helmets on.]

124:18:35 Schmitt: Yeah.

124:18:36 Cernan: Okay, I thought you knocked your thing (the RCU comm switch) to AR or to A or something. (Pause) There's a lot of noise in the background. That's why I was wondering. Need some help? (Long Pause)

124:19:00 Schmitt: Stow the visors, huh? What is it?

124:19:04 Cernan: Yeah, stow them in the BRA.

124:19:06 Schmitt: No, but I mean...Keep the protective visor down?

124:19:07 Cernan: Keep the protective visor over it, and stow the whole thing in the BRA. (Long Pause) "Verify safety on the dump valve." I guess I can do that now...

124:19:39 Schmitt: Again?

124:19:40 Cernan: That one's still safe. And that one's still safe.

124:19:47 Schmitt: Smells like gunpowder, just like the boys said.

124:19:53 Cernan: Oh, it does, doesn't it? (Pause)

[They have just removed their helmet and, as did previous crews, notice that the dust in the air smells like burnt gunpowder. There is enough dust in the air to smell, but not enough to see.]

124:20:00 Cernan: Okay, "Descent Water valve, Open." Ohh, boy! I ran out of water out there. I mean the drinking kind. (Pause)

[Cernan - "I ran out late in the EVA, so it wasn't a problem."]

124:20:11 Schmitt: Okay, what's next?

124:20:13 Cernan: Okay, "Descent Water Valve, Open."
(Pause)

[They are opening the descent stage water supply, having turned it off prior to the EVA. This will provide cooling and drinking water until they get out of the suits.]

124:20:24 Schmitt: Okay. Coming Open.

124:20:29 Cernan: Okay, and then you get your purge valve out.

124:20:32 Schmitt: Not too hard.

124:20:33 Cernan: Good shot. (Both laugh) If they say anything, just say, "I told you so." (Still laughing) Okay. Remove your purge valve...

124:20:45 Schmitt: (Laughing)

124:20:46 Cernan: ...and disconnect your OPS hose.

124:20:47 Schmitt: Yes, sir. (Laughing) If I can.

[Twenty years after the event, neither Gene nor Jack remembers what this was about.]

124:20:54 Cernan: Okay. I tell you, I haven't seen anything...Drilling those holes was a piece of cake until I couldn't get that core tube out. I thought that whole...

124:21:04 Schmitt: (Garbled), will you?

124:21:05 Cernan: I thought that...

124:21:06 Schmitt: I'm glad there were two of us.

124:21:07 Cernan: I thought that whole thing was going to break. It was bending about...at about a...(Laughs)

124:21:12 Schmitt: Well, next time we have to do it...

124:21:15 Cernan: Yeah.

124:21:16 Schmitt: Let's see, OPS. That must be this one.

124:21:18 Cernan: "Disconnect OPS hose. Connect LM hoses, red to red, blue to blue." I don't want LM (oxygen) hoses yet. I'll just get on water right away. (Pause) Let's put...I'm going to..."Diverter valve, horizontal."

124:21:31 Cernan: "Suit Isol(ation valve), both." I'm going Suit Flow, get some flow in this cabin. Okay.

[They are directing the flow of Suit Circuit oxygen into the cabin via the LM oxygen hoses.]

124:21:38 Schmitt: Here, you want me to get it?
 124:21:41 Cernan: I tell you, my hands, after working at picking up little things.
 124:21:45 Schmitt: I feel the same way. I think you had the worst of it.
 124:21:49 Cernan: Okay, let's keep as much dust out of those connectors as we can. (Jack laughs) Wise guy.
 124:21:55 Schmitt: Okay.
 124:21:57 Cernan: Let's wait on these. Okay, your diverter valve horizontal?
 124:22:03 Schmitt: Yep.

[By setting the suit diverter valve to the horizontal position, they will direct some of the oxygen flow - once they get the LM hoses hooked up - into the torso, which will help dry the suits.]

124:22:05 Cernan: Okay, and if you can get to the Suit Flow, you can go Suit Flow. In the meantime, get your Fan (and) your Pump, Off.
 124:22:13 Schmitt: Fan's Off. Pump's Off.

[These are RCU switches for the PLSS oxygen fan and the PLSS LCG water pump. Astronaut Joe Allen joins the conversation as CapCom.]

124:22:16 Cernan: Joe, are you still reading us down there?
 124:22:21 Allen: Loud and clear, Gene. We're following you close and...
 124:22:22 Cernan: Okay. I just wanted to see whether you were there.
 124:22:24 Allen: Roger. Following you close here.
 124:22:29 Schmitt: Keep us honest.
 124:22:30 Cernan: Okay, we're just looking at 5 psi and all the hatches are battened down, and the safeties are on. You can keep a look at the rest of it for us.
 124:22:38 Allen: Copy that. And we're seeing the same thing.
 124:22:39 Cernan: (To Jack) Okay, disconnect your PLSS water. Now what I do, Jack, is... (Listens to Allen and then continues) I was going to say put your cover on, but we're going to stow those.
 124:22:48 Cernan: (To Allen, having turned to checklist page 3-2) Okay, guess we've got to go off the air for a little while. We're both going 0.
 124:22:54 Allen: Okay.

[They are turning their RCU' switches to the Off position.]

124:22:55 Cernan: And we'll get on our LM comm here, shortly.
124:22:57 Allen: Roger. Check back in.

[Comm Break. Houston is waiting to reacquire the Command Module, now on its 19th orbit. They expect that Evans went to sleep during this Farside pass.]

124:24:49 Schmitt: (Garbled). Okay, we got to do some more switching, yet.
124:24:51 Cernan: Okay. Connect the...Okay. Now in...Audio circuit breakers, Closed. Now, both panels, VHA...(correcting himself) VHF A, Receive; B, Off. Okay. Mode ICS/PTT.

[Comm Break]

124:26:01 Cernan: Hello, Houston. Do you read Challenger on LM comm?
124:26:05 Allen: Okay, Challenger. This is Houston. Reading you 5 by.
124:26:11 Cernan: Okay, we're going to go ahead and charge up the...let's see...the LMP's PLSS with oxygen.
124:26:26 Allen: We copy.

[Cernan - "We wanted to get all of the housekeeping chores out of the way as soon as we could. Charging the PLSS's let us get them stowed - on the walls, I think - so that we'd have more room."]

[Long Comm Break. The LMP PLSS oxygen recharge is at the bottom of the lefthand column of Surface 3-2.]

124:32:56 Schmitt: Hello, Houston. The recharge on the LMP: 95 percent.
124:33:01 Allen: Copy that.

[Long Comm Break as they recharge Gene's PLSS. Jack's PLSS now has 95 percent load of oxygen. They will top off the oxygen in both PLSS's at about 126:20, after their eat period.]

124:39:40 Cernan: Hello, Houston. This is CDR with a recharge of 93 percent.
124:39:44 Allen: Sounds good, Geno.

[There is, of course, only one recharge hose.]

[Long Comm Break. During this period they doff their OPS's and PLSS's and check the OPS pressures.]

124:48:18 Schmitt: Okay, Houston. OPS pressures: LMP, 6100 (psi), and CDR, 5900.
124:48:21 Allen: Thank you, Jack.

[Each of the OPS's contains two spherical oxygen bottles, each about eight inches in diameter. The high pressure in these - about 6000 psi - and in the PLSS bottles is necessary for the storage of significant amounts of oxygen in such small volumes.]

[Long Comm Break. The following exchanges were recorded during a change-of-shift press briefing and times are not available from the Public Affairs tape. During this period, they are changing PLSS batteries and LiOH canisters. The used items are placed in the jettison bag for disposal at the start of the next EVA. They are now on Surface 3-3.]

124:58:01 Cernan: Joe, we're changing a (LiOH) cartridge out in my PLSS. We've got the (PLSS) battery changed.

Allen: Okay, Geno; thank you.

[The lithium hydroxide canister is a 6-inch diameter cylinder which lies horizontally across the two-foot width of the PLSS. The crew has removed the fabric thermal-covering from the PLSS in order to remove the used can and install a new one. The primary purpose of the LiOH can is the removal of carbon dioxide.]

Cernan: (To Allen) You don't have a cold something or other, do you?

[That is, a cold beer.]

Allen: I'm sorry you even mentioned it.

Cernan: We can think about it, can't we?

Allen: Mercy, yes.

Cernan: Hey. Does Captain America know all about this?

Allen: (Making a mis-identification) Roger, Jack. He does. He's been fully advised, and his response is (that) he's sound asleep, now.

Cernan: Yeah. I forgot. He was going to bed before we did today.

Schmitt: Did he have a good day up there?

Allen: He surely did. Fine day. And I want to make the observation as a casual bystander: it was a real pleasure to watch your EVA unfold down here.

124:59:55 Cernan: Thank you, Joe. I think you are more than a casual bystander though.

[Long Comm Break. Now they are changing batteries and the canister on Jack's PLSS.]

125:07:23 Cernan: Hey, Joe. We've got 1 and 3 - or, correction - 1's replacing the 3's and 2's replacing the 4's on the PLSS.

Allen: We copy.

[Comm Break]

Schmitt: Joe, we're in the right-hand column of page 3-3 now.

Allen: Roger.

[Comm Break. They have finished with Jack's PLSS and are now weighing and stowing samples.]

125:15:24 Schmitt: Joe, collection bag (SCB) 2 is 16 (pounds)

125:15:29 Allen: Thank you. (Long Pause)

125:15:50 Cernan: And the SRC is 32 pounds.

125:15:56 Allen: Copy; 32 pounds.

[Comm Break. The crew has a small spring scale which gives them terrestrial weights. That is, on Earth, a two-pound (Earth-weight) rock would register twelve pounds on the scale while, on the Moon, it would register two pounds. The actual weight of rocks collected during this EVA is given in the Mission Report as 31 pounds. The 48-pound total given here includes the weights of the individual sample bags, the two 1.7 lb SCB's, and the 14.7 lb SRC. Weights are measured so that the flight engineers can adjust the stowage for center-of-mass control, if necessary.]

125:17:03 Cernan: Okay, Joe. The Heater is On for the (urine) dump.

125:17:09 Allen: Okay.

[Long Comm Break. They are heating the urine line so that, when they empty the urine out of the bladders in their suits, it won't freeze before reaching the sump in the descent stage.]

125:21:51 Cernan: Okay, Joe. The circuit breakers are verified. On both (panels) 11 and 16, with the exception of the (urine) line heater.

125:22:09 Allen: Okay, copy that. Thank you very much.

[Comm Break. They have finished the last of the tasks on Surface 3-3.]

125:24:06 Schmitt: Okay, Houston, we're going to turn the Biomed, Off.

125:24:12 Allen: Okay.

[Very Long Comm Break. They have completed the urine dump and are getting Gene out of his suit. After they get his suit off, he will clean the hose connections and the neck and wrist rings, and lubricate the zippers. Then they will lay the suit on the ascent engine cover, cover the legs with a jettison bag to keep the dust down, and attach the LM oxygen hose to dry the suit out.]

125:46:44 Schmitt: Houston, Challenger. We'll both be off the air briefly here as we swing into getting our suits and LCG's (Liquid Cooled Garments) off. The Commander presently has his suit off, and I'll start on mine.

125:47:00 Allen: Roger, Jack.

[Very Long Comm Break.]

126:09:43 Cernan: Hello, Joe; you there?

126:09:48 Allen: Waiting patiently.

126:09:54 Cernan: Okay, if you're keeping score, on the bottom of (page) 3-4, we're both out of our suits. And does that feel good.

126:10:02 Allen: Roger, Gene. Thank you.

126:10:07 Cernan: Okay, I'm out of my LCG, if you want to turn the page (to 3-5).

126:10:12 Allen: Okay, Geno, and how are your hands doing?

126:10:18 Cernan: Oh, they're a little tired. On both sides, here.

[Gene's means both sides of the cabin and, therefore, both he and Jack.]

126:10:27 Allen: Can imagine.

126:10:29 Cernan: But I think they'll pull through.

(Pause)

[Gene sounds tired. He and Jack have been awake since 105:47 or nearly 20 1/2 hours.]

126:10:47 Cernan: Do I read this (checklist) that the LMP sleeps on bio tonight? Is that right?

[Jack will wear biomedical sensors through the sleep period.]

126:10:51 Allen: Stand by. (Pause) Rog; that's affirm.

126:11:00 Cernan: Okay, so I can take mine off, huh? My sensors?

126:11:09 Allen: That's affirm, Gene.

126:11:14 Cernan: Okay. (Pause)

[Cernan - "The sensors itched, and it was just generally irritating to have them on. We had learned to put them on ourselves, so that we could take them off when we could."]

126:11:26 Cernan: Well, we'll be up to the EVA debriefing time here very shortly.

126:11:30 Allen: Rog. (Long Pause)

126:11:56 Cernan: Joe, do you know how much time has elapsed since we initially charged our PLSS's with 02?

126:12:04 Allen: Geno, it's time to charge them again, if you want to.

126:12:12 Cernan: Okay, I just might pick that up.
 126:12:14 Allen: All righty.
 126:12:22 Cernan: We'll let you know where we are, though.
 126:12:24 Allen: Okay.

[At the bottom of Surface 3-5, there is a notation to verify that one hour has elapsed since the initial oxygen recharge before starting the top-off. They finished the initial recharges at 124:39, well over an hour ago.

[Schmitt - "My guess is that you did an initial charge and then let things stabilize - let the oxygen cool or the tank relax - and then you topped it off."]

[Comm Break, then Deke Slayton joins the conversation.]

126:13:43 Cernan: Say, Joe, I guess the home front was probably listening in. Any one talked to 'em? (Pause)
 126:13:57 Slayton: Haven't talked to them today, Geno. I haven't at least.
 126:14:06 Cernan: Hello, boss, how are you doing down there?
 126:14:08 Slayton: Just fine. Waiting for you guys to go to sleep so we can do the same. (Pause) Had a great day up there, guys.
 126:14:16 Cernan: Oh, you don't have to wait for that. We're...(Stops to listen to Slayton's second remark) It was super from here. It's quite an experience, Deke, and quite a challenge.
 126:14:26 Slayton: Yeah, it looked beautiful from here.
 126:14:34 Cernan: I tell you, it makes you feel like you had a good day's work behind you, though.
 126:14:42 Slayton: I can believe that.
 126:14:47 Allen: We're about to give you the rest of the day off, Gene.
 126:14:54 Cernan: Thank you, Joe. (Long Pause)
 126:15:20 Allen: Geno, while you troops are...
 126:15:23 Cernan: Hey, it's 3 o'clock in the...
 126:15:24 Allen: Go ahead.
 126:15:26 Cernan: Go ahead, Joe. I was just going to say, it's 3 o'clock in the morning (Central Standard Time) back there.
 126:15:31 Parker: We know it.
 126:15:34 Slayton: It's 3 o'clock in the morning up there, too!
 126:15:41 Cernan: Yeah, (chuckles) and we know that too.
 126:15:46 Allen: Troops, while you're in a listening mood up there, we're going to be coming at you with a number of items here - not too many -, but the first will be some surface block data. Then we're going to read up to you a LEVA (Lunar Extravehicular Visor Assembly) cleaning procedure which is fairly simple; a real short geology debrief; a one-line change in the Lunar Surface Checklist. And then, we've been doing some thinking down here about how to fix the fender. And it's going to involve - we think, although we'll work on it while you guys are getting some rest - it's going

to involve using utility clamps, from inside your LM there, instead of tape, to fasten some sort of stiff material onto the Rover in place of the missing fender. And we'll go with either with one of your cue cards, or possibly with part of insulation that was the flame blanket protecting the Rover during the landing. Or perhaps part of the packing material that was between the Rover wheels and is probably lying on the ground underneath the LM there.

126:17:07 Cernan: Joe, you couldn't be reading our mind more. We were talking about that, and there is a piece of it right outside my window. I saw it after we got in here. Either that or back of a part of a data book or something. I hate like the devil to tear one of those other fenders off. And the reason tape won't stick is that everything's got a fine coating of dust, and the only way I could finally get it to stick was to put tape on it (and then) rip the tape off - or take the tape off - which took some of the dust off and then (another piece of) tape would tend to hold it. But it just won't hack it up here.

126:17:39 Allen: Roger, Gene. That's exactly what we're thinking. And what we're going to do is run through the fix in a pressure suit a few hours from now. And if it looks like we can do it, and it won't cost you many more than say 10 minutes, we're going to have you go through with it. If it takes longer than that, we're going to go back to the drawing board and see what else we can do here.

126:18:08 Cernan: Well, you know John (Young) and Charlie (Duke) can tell you just had had it is. I wouldn't have believed it and I guess I didn't believe it, or I would have worked a little harder to make sure that fender was going to stay on. But, man, just that short trip back from where we lost it, and we were just covered. The whole...I couldn't even read parts of the panel on the Rover, plus (there was a lot of dust on) all the battery covers and everything.

[Cernan - "It was just an unacceptable situation. Imagine, a little thing like knocking a Rover fender off having the potential compromising the rest of our mission. I still have no doubt that we had to find a fix. If we hadn't, then at bare minimum it probably would have taken thirty to forty percent of our time to consciously keep the dust off of the Rover, the tools, and the rest of the equipment. We wouldn't have been able to drive as fast, we would have had to spend a lot more time dusting.

"I was concerned in the sense that I knew that we had to find a fix; but I was also confident that we'd find one. I knew that the ground was going to be working on a fix, but I was also responsible for the mission on our end and I was going think about the problem, too. I'm the guy on the scene; I'm the guy who's got to actually fix the fender. The help we got from the ground was tremendous. They knew exactly what we had in the LM and were able to try out things during the night. But they were a quarter million miles away and I was going to have to do the fixing. So I spent some

time, including while I was lying in the hammock, thinking the problem through.

"Before the mission, probably no one could have believed that losing a fender could have been that serious. But, if that had been an unmanned vehicle, dependent on the radiator for cooling and a clean TV lens for scientific exploration, you might have been out of business. Of course, maybe you could say that if we hadn't been there, it wouldn't have gotten knocked off; but even an unmanned vehicle can lose a fender by going too close to a rock or something."]

[Schmitt - "As I recall, my perspective on the fender was that it wasn't a big deal; primarily because I had worked those kind of problems between EVA's on other missions. As Gene implies here, there are an infinite number of things that you can do to fix a problem; and that was the tradition of the whole ground support effort. You've got a problem? You go work on it and you fix it. And, so, I wasn't going to worry about it. I never imagined that they weren't going to come up with a solution. The only thing that bothered me - and I do remember thinking about this - was that the fix was going to eat up time out of the second EVA. As you may have noticed, Gene talked about the fender frequently but I never even responded to him, being busy with other things. So, obviously, it wasn't a big concern in my mind."]

126:18:35 Allen: Roger, Gene. What we really need, I think, is some white mud flaps up there.

126:18:50 Schmitt: That's a little too old fashioned, Joe.
(Pause)

[Both Jack and Joe grew up in small towns: Jack in Silver City, New Mexico, and Joe in Crawfordsville, Indiana. According to Allen, in the late 40's, it was the height of automotive fashion - at least among teenagers in small-town America, to hang white mudflaps behind the wheels of a Ford or Chevy sedan. It didn't matter, Allen says, what color the car was - the flaps had to be white.]

126:19:06 Allen: I guess we'd know wouldn't we?

126:19:15 Schmitt: I'm afraid so. (Long Pause)

[Schmitt - "This was just a bit of small talk between two people who grew up in small towns, two people who carried on a lot of small talk."]

126:19:56 Cernan: Okay, Joe. Mark. I'm giving my PLSS a second (oxygen) charge right now.

126:20:06 Allen: We're watching.

[Schmitt - "The second charge procedure probably came out of people trying to push as much time into an EVA as possible for the J-missions. Probably somebody did a little experiment and realized that they could get another half-hour's worth or something like that. The whole J-mission or

Block 2 effort was to extend capabilities over what had been possible on Apollo 11 and the other H-missions. Apollo 15 had originally been scheduled as an H-mission and Scott worked very hard to fly a Block 2 LM."]

[In 1967, NASA drew up a list of mission-types which would lead up to the first landing. "A" missions were unmanned, earth-orbital tests of the Saturn V and the Command-and-Service Module. "B" missions were unmanned, orbital tests of the LM. "C" missions were manned, earth-orbital tests of the CSM. Apollo 7 was a C mission. And the added Apollo 8 lunar orbit flight became a C-Prime mission. "D" missions were earth-orbital tests of the CSM/LM combination (Apollo 9). "E" missions were to have been CSM/LM missions to high-earth orbit and none of these were ever flown. "F" missions were full dress rehearsals in lunar orbit (Apollo 10). The "G" mission (Apollo 11) was the initial landing; and "H" missions were follow-on landing missions. By 1969, NASA was hard at work on significant LM upgrades which would allow three-day stays on the Moon supported by a Roving vehicle. These became the "J" missions. "I" missions were lunar-orbit-only science missions, none of which were ever flown.]

126:20:11 Schmitt: You should be getting LMP biomed. (Long Pause)

126:20:31 Cernan: And Joe, give me a hack after about 10 minutes in case I forget on that PLSS recharge.

[Gene is sounding a bit more alert.]

126:20:36 Allen: Rog. (Pause)

126:20:47 Cernan: Can I do...I can do both the water recharge and the 02 recharge at the same time, can't I?

126:20:56 Allen: That's affirm.

126:21:01 Cernan: Okay. (Pause)

126:21:09 Allen: Gene, a caution not to tilt the PLSS while you're doing that (water recharge).

126:21:16 Cernan: Yeah, good idea. Mine's in the station.

126:21:24 Allen: And, Gene, if you want to get the geology debrief out of the way anytime, just give us a whistle on that.

[Comm Break]

[Cernan - "Listening to these conversations (that) we had once we were back in the LM, out of the suits, and relaxed is kind of a nostalgic experience. For me, it's really, really interesting to listen to this and it really brings back a lot of things that passed by so fast at the time. This is the first chance I've had in almost twenty years to go back and think about the details of some of these things, despite the fact that I see Joe Allen and Bob Parker maybe two or three times a month."]

126:22:33 Schmitt: Joe, why don't you give me the block data, and then we can go on that geology (de)brief?
 126:22:44 Allen: Okay, are you ready to copy?
 126:22:51 Schmitt: Go ahead. (Pause)

[This list of lift-off times begins with Command Module orbit 21.]

126:23:03 Allen: (Reading slowly, and carefully enunciating each digit) Okay, Jack. Surface block data; lift-off times: T21, 128 plus 47 plus 12; T22, 130 plus 45 plus 44; T23, 132 plus 44 plus 18; T24, 134 plus 42 plus 50; T25, 136 plus 41 plus 28. Over.
 126:23:58 Schmitt: (Reading faster, but still enunciating each digit) Okay, Joey. 21, reading in order 128:47:12; 130:45:44; 132:44:18; 134:42:50; 136:41:28. And what's the present rev?
 126:24:26 Allen: Present rev is two-zero, and readback's correct.

[Comm Break]

126:25:29 Schmitt: Okay, Joe, you can go ahead and fire away at the LMP.

[Jack is also sounding a bit refreshed.]

126:25:35 Allen: Okay, Jack; and, for the geology questions, I'm going to turn the console over to the well-known geologist of the Seifert Galaxies.

[This is a reference to the fact that Parker began his career as an astronomer, not a geologist.]

126:25:47 Schmitt: Can't hack it, huh? You've all forgotten everything I taught you.
 126:25:53 Allen: I draw my sword.

[Allen is also a scientist-astronaut, trained in physics.]

1126:26:25:56 Parker: Okay, guys, you want me to address first those to Jack, and then address them to Gene later on, or you guys both want to answer them at the same time?

[Parker sounds congested and tired.]

126:26:07 Schmitt: Well, we're both listening. We can answer them.
 126:26:10 Parker: Okay, the way you asked that, I wasn't sure. (Pause) Okay. Question number 1 concerns the Rover mobility rates. The Rover mobility rates over the short span you drove, which is hardly representative, are slower than people had anticipated. Do you think this is due to

visibility, terrain, or what? Do you think you can still hack a 7.3 or 8-kilometer (per hour) average to Station 2 tomorrow?

126:26:39 Cernan: The answer to that is "yes", Bob. I think it's partly familiarization, but it's also the fact that we did a lot of circling. We didn't drive in many straight lines. Trying to find, for the most part, our bearings, and tried to pick some high spots so we could look around. So I think straight-line navigation out in the area we're going (tomorrow) is going to be easily 8 kilometers (per hour).

126:27:05 Parker: Okay, great.

[Cernan - "One of the things I was expecting to hear myself comment on was the fact that any time you traveled east - particularly on that first day when the Sun was so low - you just couldn't see very well and just had to go slower."]

126:27:07 Parker: Okay. Another question here, Gene, that you should be able to answer with a simple yes or no. Was there any spillage of the material in the drill core while you were breaking it down?

126:27:23 Cernan: Simple "no".

126:27:24 Parker: Okay. And...

126:27:25 Cernan: Spillage out of it?

126:27:26 Parker: Yeah, you know, when you broke the sections, did you lose much material out of it?

126:27:33 Cernan: No, sir; I didn't lose any.

126:27:35 Parker: Okay, next simple question. When you were drilling the deep core where the neutron probe was, could you see the RTG over the rock?

126:27:46 Cernan: Yes.

126:27:50 Parker: Okay. You have any feel for how high the rock is or how low...(correcting himself) how deep the thing (the top of the neutron probe) was with respect to the RTG? Were you down in a level that was below (the RTG), even without the rocks being there?

126:28:10 Cernan: Yeah, I think I...Yeah, I was in a slump. There was a ridge between us and the RTG, and I had the rock in a line of sight between it and where I put that core (hole). And I'd say the rock was certainly near the ridge and it was - what, Jack? - I don't know, was it a meter to...(It was a) meter high for the most part. And it sloped off, and I'd say at least a half a meter high in the line of sight from where the neutron probe is to the RTG. Plus, there's a lot of undulations...I think it'll be below the line of sight, anyway.

[That is, there is plenty of material in the way to absorb the flux of neutrons produced by the RTG and, thereby, keep contamination of the measurement of the natural background to a minimum.]

126:28:46 Parker: Okay. And a somewhat more general question, here. It says, and I'll read it, "We're still puzzled as to whether there is a dark mantle. Could you say something more about the dark regolith surface?" There's a lot of discussion, today, about whether or not it could have been a regolith derived from the intermediate gabbro which you were sampling as boulders.

126:29:15 Schmitt: Bob, I think I don't have too much to add to what I said near the end of the EVA. I do not have an intuitive feeling that the regolith has been derived from most of the boulders that we're seeing. Because those boulders are fairly light-colored, they look like they're probably 50 percent plagioclase. It could be that the regolith is derived from some other material that has blanketed the area. I don't think we have that answer, yet.

126:29:49 Parker: Okay. I copy that.

126:29:51 Cernan: Bob, the boulders we were sampling... think Jack and I both feel that it's probably... We feel we sampled the subfloor because we saw, in the sides of the craters, where some of these boulders were exposed almost as if they were bedrock down there. In driving back from what we called Station 1, we could definitely see the light mantle out in the area where the potentials of a slide are.

126:30:19 Parker: Okay, very good. Yeah, I think that the... At least, it's a going bet around here that we're sampling the subfloor when we're sampling - at least the top of the subfloor - when we're sampling the intermediate gabbro there. The rocks and the boulders.

126:30:34 Parker: Okay. We also...

126:30:35 Schmitt: Yeah, the...

126:30:37 Parker: Go ahead.

126:30:39 Schmitt: Bob.

126:30:40 Parker: Go.

126:30:42 Schmitt: It is sort of strange that we don't see a good population of finer-grained rocks. These rocks look very much like igneous rocks, but they're considerably coarser than comparable... Well, they're about the grain size of some of the coarse-grain Mare basalts that tend to differentiate the crystallobalite and tridymite; but we didn't see any of the finer-grain versions. If it's an intermediate crystalline rock, we have not seen any fine-grain equivalents yet. At least not in abundance.

[Grain size is an indicator of cooling rate and the coarse-grain character of the gabbros suggests that they cooled more slowly than most of the mare basalts brought back by the other crews. Because the rate of cooling increases as one goes deeper in a flow, one would normally think of coarse-grained samples as having come from a relatively deep portion of a flow and that one should also find finer-grained rocks derived from the upper parts. During a final review of the manuscript, Jack Schmitt suggested that one possible explanation for the absence of fine-grain rocks is that they

had been pulverized during the process of regolith formation.]

126:31:24 Parker: Okay, I copy that. (Pause) We gather that there's no color change in the dark-mantle material at depth. In other words, the footprints, wheel tracks, and the rake sample, et cetera, were sort of uniform in color.

126:31:43 Schmitt: No, there's no major change, but looking out the window - and I think I commented on it - the disturbed regolith (near the LM) is darker. Oh, I don't know, maybe by 10 percent albedo, something like that, than the undisturbed surface.

126:32:08 Parker: Okay, I remember your commenting that when you were walking to the ALSEP, I think, Jack, in fact. (Pause) Okay, during drilling of the heat flow holes, Gene...

126:32:16 Schmitt: (Responding to the first half of Parker's comment) That's right.

126:32:17 Parker: ...was there change in color of the cuttings as they piled up...as you went down in depth? Do you remember any of that?

126:32:30 Cernan: Yeah, Bob, both in the core and the heat flow holes, it really didn't seem to pile it up like you're accustomed to at the Cape, and I guess maybe that's because I was kicking so much dust around there. But I looked specifically when I cleared flutes and what have you, and I didn't see any difference in terms of color, texture, or anything else coming up.

126:33:00 Parker: Okay, copy that. (Pause) On the outcrops you think you see in the North and South Massifs, do they appear to be linear, horizontal or subhorizontal? Can you see layers, and do you have any feel for the thickness or the attitude or the continuity of them? Can you discuss these outcrops?

[Parker is asking if the outcrops line up - hence his use of the word "linear" - and, if they do line up, whether they make a horizontal layer or a slightly tilted (hence "subhorizontal") layer.]

126:33:25 Schmitt: Bob, going over (the site) yesterday (during a pre-landing orbit), I thought I could see a structure dipping off to the southeast, apparent dip anyway, on the eastern side of the South Massif. Or northeastern side. We haven't examined them in detail because we were in a rush to get out. We'll put the binoculars (means "monocular") on them and try to examine that question. There's nothing very obvious, any more than you can see on the (overhead) photos, that the ledges were concentrated in the upper portion - (coughs) excuse me - in the upper portion of the Massif's units.

126:34:03 Parker: Okay. Copy that. Here's a short one that I'll ask Jack since he did it. Again I guess we'll have to prove this. (With regard to) the shade portion of the

cosmic ray experiment: the question is, and I repeat - I quote - "Are you sure that the detectors, not the decals, were facing out?"

126:34:27 Schmitt: I am, Bob; because I said I was sure, and I called you on it.

126:34:32 Parker: Roger. I was sure, too, but I had to ask the question.

126:34:35 Schmitt: I...I under...I know. I understand why it was asked, because I did it wrong at the Cape. But that's why I mentioned it when I deployed it.

126:34:44 Parker: Roger. (Pause) Okay, and we can go and recharge the other PLSS whenever you're ready there, guys.

126:35:05 Schmitt: Okay.

126:35:09 Parker: Okay, the next question - which calls for a little bit of discussion - is: The layers of lineaments that you remarked on in the Sculptured Hills, can you say anything about them?

[Parker is referring to the lineations Gene had described on Bear Mountain after the landing.]

126:35:30 Cernan: Yeah, Bob, I did. I think I said...and I commented (that) I'm not sure whether it was the Sun angle or not...But see, I was not looking at the Sculptured Hills; I was looking back at Bear Mountain, I believe. And, to me it looked like there was some organization that was dipping back to the east, somewhere between, oh, 20 and 25 degrees maybe. And it was very obvious to me. But I'm a little hesitant (to say it isn't a lighting effect) because of some of this Sun-angle stuff.

[Cernan - "Because of the low Sun on that first day - and it was a lot better on the second and third days - it wasn't at all easy to look at the Sculptured Hills and see any detail. They were about 20 or 30 degrees north of east and the glare was just too strong."]

126:36:05 Parker: Okay, I copy that. I gather we didn't get any 500-millimeters of these lineations, today, right?

126:36:13 Cernan: No, but I think we will. They were on the western side of Bear Mountain back there, and I think I commented that I thought that Bear Mountain is probably what the Sculptured Hills look like.

[Schmitt - "Somebody at the USGS - or maybe it was Jim Head - noticed that, in contrast to some of the other hills, they had a knobby appearance and said 'Hey, they look like somebody sculptured them'. So they became the Sculptured Hills."]

126:36:28 Parker: Okay, I copy that. Is there a scar above the light mantle material? In other words, the slide. Is there a scar above that on the South Massif? Can you see

anything up there to indicate that it might have come off of there?

126:36:43 Schmitt: Nothing obvious yet, Bob.

[They never did see an obvious scar. In the 100 million years since the slide, impacts and downhill movement of debris have erased and covered the source area on the mountain.]

126:36:47 Parker: Okay, copy that. On the way back to Station 1, you described a small crater with light material on the bottom. Can you say anything more about that crater? (Long Pause)

126:37:09 Schmitt: Bob, I don't remember saying that, or...Gene doesn't either.

126:37:15 Parker: Okay. You talked about something that was light. I don't remember; I thought it was a boulder, but the question's about a crater.

126:37:22 Schmitt: You're right. You're right, there was a large zap pit in a boulder that was very white. It must have been...The crater for the zap must have been 2 centimeters diameter anyway. And it had about that, oh, maybe 3-centimeters worth of crushed minerals around it, that gave it a white - very bright white - appearance.

126:37:45 Parker: Okay. Well that was indeed a small crater, so I guess the question was right. (Pause) Let me change the mode here and ask you three or four simple ALSEP questions again, to verify for various people exactly what happened. Just to make sure that they're clear on it. Jack, when you were laying out the geophone leads, you mentioned and asked me if it was all right if the geophone leads crossed one another, if there was EMI (electromagnetic interference) problems. And so that made people wonder whether or not it was possible the geophone positions were reversed; i.e., geophone 1 was laid out in geophone 2s' direction, et cetera.

126:38:35 Schmitt: No, that was just a Geophone 4 problem. The geophones are in the right directions.

126:38:40 Parker: Okay.

[Schmitt - "The instrumentation identified the signals from each of the geophones by number and, in order to interpret the data, the experimenters had to know where I had deployed each one of them."]

126:38:41 Schmitt: Geophone 4 fell out of the module and rolled under one of the other lines, or vice versa, I don't know which, and it's crossing one of the other lines. Geophone 1, I think.

126:38:56 Parker: Okay, no problem. When you went to put the LSPE antenna in the heat-flow socket, you weren't able to do it at first; was it because of there was a lot of dust in there?

126:39:11 Schmitt: No, I think it was the same old problem of that piece of aluminum foil or whatever it is going down in the socket and jamming briefly.

126:39:23 Parker: Okay, I copy that. Did you clear out that foil when you did it, or did you just push it on through?

126:39:29 Schmitt: I forced it.

126:39:31 Parker: Okay. When you taped the SEP solar cells down, how much of them did you cover with tape?

126:39:41 Schmitt: We taped the back.

126:39:44 Parker: Ah, very good thinking. And, Geno, a question for you on the Rover when you parked it. Do you have any feeling for the roll angle it was parked at the LM? The roll angle.

126:40:03 Cernan: Yeh, let me look. (Pause) Bob, it's pretty flat. If I had to guess, I'd say zero. And you can bias that by a degree or so, but basically zero.

126:40:18 Parker: Okay, is the pitch scale still on it, or did it fall off yet?

126:40:24 Cernan: No. I was going to comment on that. It's still there.

[The pitch/roll scale fell off during Apollo 16 but, because a modification of the already-built Apollo 17 indicator would have been difficult and the Apollo 16 crew had had no difficulty in estimating the attitude of their Rover, no change had been made.]

126:40:28 Parker: Okay, very good. Okay, when you went to Station 1A - we're calling the new Station 1 "Station 1A" - were the blocks there as well-filleted as those near the LM and the ALSEP? Do they all look the same?

[Fillets are skirts of soil that pile up at the base of rocks due to small, nearby impacts that splash soil against the sides.]

126:40:45 Schmitt: Bob, all the boulders had filleting to a slight degree, but not an extreme amount. I think it no more than what is being caused by the redistribution of the darker, fine-grained regolith.

126:41:13 Parker: Okay, I copy that.

[People in the Backroom are trying to find evidence to support interpretations of the Apollo 15 photography that suggest that only the northern half of the valley was covered by the hypothesized dark-mantling process. If it was a process that occurred late in the history of the valley, then there might have been a difference in the degree of covering of the pre-existing boulders.]

126:41:16 Cernan: Bob, if I had to answer...

126:41:17 Parker: Go ahead.

126:41:18 Cernan: ...if I had to answer that question, I'd say yes. Yes, that the boulders are filleted over there about like they are over here. That would be my impression.
 126:41:30 Parker: All right. Is there any indication that the fillets are directional, in other words, that the fillets are heavier on one side than the other?
 126:41:43 Schmitt: Bob, haven't noticed that.
 126:41:49 Parker: Okay, I copy that. Do you have the feeling that some boulders are more rounded...
 126:41:54 Schmitt: Well that's a good ...(Hearing Parker) That's a good...
 126:41:59 Parker: Roger. I agree with you.
 126:42:04 Schmitt: That's a good re...(Hearing Parker) That's a good reminder, Bob.

[That is, a good reminder to look for directionality in the filleting.]

126:42:06 Parker: Okay, do have any feeling that some boulders are more rounded than others? Apparently this looked this way in some of the TV pictures.
 126:42:15 Schmitt: Some of the big ones that are just barely exposed above the regolith looked quite well-rounded. Most of those around the craters are subangular. I got the impression that it's just purely a function of how long the same material's been exposed; but some of the big boulders like the one out near the geophones is quite angular in part and quite rounded on other parts. It's quite variable.
 Put Jack's drawing here.

[Schmitt - "Angular boulders have profiles such that you can draw two lines from any point on the rock and the rock will fill the space between them. Subangular is the case where the tip has been rounded off and the rock won't fit between the lines. And "rounded" is the case where you can't draw any fit better than tangents."]

126:42:47 Parker: Okay, do you want to say any more about that boulder (Geophone Rock)? Did it seem to have more or less the same lithology, in addition to the variation in vesicle size that the other rocks in the vicinity of the ALSEP, and the other rocks out at Station 1 had?
 126:43:05 Schmitt: no, it's very comparable to the ones that we saw at Station 1, as a matter of fact.
 126:43:10 Parker: Okay, I copy that.
 126:43:12 Schmitt: Both types of rocks were there, both variations. (Pause)
 126:43:22 Parker: Do you have a feeling for where the big blocks in the LM/ALSEP area came from? Do you think they were from Camelot, like (garbled) been saying?
 126:43:34 Schmitt: Don't have an idea yet; I'm really not sure.
 126:43:40 Parker: Okay, and as you drove along on the traverse from the SEP to Station 1, did the size of the small

craters with blocky rims vary? In other words, what we are looking for here is the variation in the thickness of the dark mantle?

126:43:56 Schmitt: I can't answer that one yet, Bob.

[The diameter and depth of a crater depend on the impact energy. In places where the regolith is thin, impacts forming relatively small craters would penetrate to bedrock (the subfloor) and dig up blocks.]

126:43:57 Parker: Okay. Let me sum up by saying that - I guess as I indicated before - our best guess is that the vesicular crystalline rock - probably gabbro, or I think you've been calling it intermediate basalt or gabbro - forms at least the upper part of the subfloor. I don't think we've been close enough to a large crater rim to say what the deep sections of the subfloor form; but we think that this intermediate gabbro, vesicular rock - at least medium-grained, perhaps coarse-grained rock - forms at least the upper layer of the subfloor. Over. (Pause)

[During crater formation, the ejecta blanket can be described as overturning on the surrounding terrain. Material from near the original surface will be found at the bottom of the ejecta blanket and will be exposed only at relatively great distances from the rim. Material dug out from the greatest depth of penetration will lie on the top on the ejecta blanket, but only at the rim or even on the crater floor.]

126:44:48 Schmitt: Yeah, Bob, I think that's pretty safe, right now. Once again, I'm surprised that it's as coarse as it is, that being the upper portion of a plains unit.

126:45:00 Parker: Roger.

126:45:01 Cernan: Say, Bob, driving back from Station 1, where we did some of our circling and what have you, we didn't have time to get off, but we did see down in - I don't remember whether it was in the slopes of some craters, or down on the slope itself - but I'd say several meters down below the mantle where there was what we almost agreed to might be bedrock (on) at least a deeper portion of the subfloor.

[Gene is beginning to sound tired again.]

126:45:34 Parker: Okay, well, maybe we'll get to it tomorrow. I think I might just give you a clue to our thinking for tomorrow. But, I don't think we've seen, or done anything today that is going to make us change very much from the nominal EVA-2 plan. The fact we didn't get to the large boulders at Emory is probably going to mean that Station 5 might be shifted a little bit to the boulders on Camelot. But certainly Station 5 on the subfloor and also Station 10 have assumed a higher priority than they

originally had. Other than that I, don't think we'll see an awful lot of changes to EVA-2. Over.

[Station 5 (Camelot Crater) and Station 10 (Sherlock Crater) are planned at the rims of large craters sure to have penetrated deep into the bedrock.]

126:46:15 Schmitt: Okay, Bob. I think that's safe. I suppose somebody's thinking about the possibility of going down to Emory. Maybe you just said that. Going down to Emory late in EVA-3.

126:46:27 Parker: I think at the moment they're thinking primarily about going to Station 10, and not going to Station 1. (Pause)

[Station 10 is on the route back to the LM from the more northerly stops planned for EVA-3; Emory Crater, the original Station 1, is well to the south and, therefore, would require a substantial detour.]

126:46:51 Allen: Okay, Jack, I've wrested control...

126:46:53 Schmitt: Some of your experts might...

126:46:56 Allen: Go ahead.

126:47:01 Schmitt: Some of your experts might think about what they might expect to happen to. What the regolith on a fine-grain pyroclastic would look like.

126:47:16 Allen: Okay.

[Schmitt - "I was asking them to think about the situation of a fine-grained pyroclastic laid down on the subfloor. What sort of regolith would develop in that situation and what would you expect to find? Obviously I was thinking about it, and I wanted the bright guys on the ground to think about it, too. We eventually proved at Shorty that this is what had happened, but we hadn't been there yet and I was asking what might be unique about a regolith developed on a pyroclastic versus a regolith developed on a basalt flow. I don't think I ever got an answer to the question."]

126:47:17 Parker: We'll tell them. I'll see you tomorrow, guys.

126:47:22 Schmitt: Sleep well, Bob.

126:47:25 Cernan: Okay, I've just got one question, Bob, before you run off. Did the TGE perform okay with the (TV) camera on?

126:47:39 Parker: As far as I could tell, Geno, it did. As a matter of fact, I didn't see the gravimeter people afterwards to talk to them. But as far as I could tell, it did. We had one funny reading back at the LM very early when it was on the ground, which I'm at a loss to understand right off. But other than that everything seems to have gone very well. The readings were quite uniform in fact, which is what makes me think they went well.

126:48:03 Cernan: Okay, well, I'd like to leave it...You know it's a little change in my thinking (but) I'd like to leave it on the Rover if we can, although it's a piece of cake to take off. It's very difficult to lean over that far without losing your balance and take your readings and what have you. So if we can leave it on (the Rover), it would be far better.

126:48:20 Parker: Roger. I was noticing that. And I also noticed the only three-ball (three-zero) reading we got was when it was on the ground.

126:48:30 Cernan: Yeah. (Pause)

[This is a reference to the disturbed reading at 123:56:55. Parker remembers that a 000 readout was an explicit indication that the instrument had been disturbed while a measurement was in progress.]

126:48:36 Allen: Gene and Jack, if you'll get Lunar Surface Checklist to (page) 3-5, I've got an easy change to read up to you.

126:48:54 Schmitt: Go ahead.

126:49:00 Allen: Okay. After the line: "Empty ETB As Follows," change the first line which reads, "B&W Mag Golf In Forward RHSSC" (righthand side storage compartment) to read, "B&W Mag Hotel In LCG Compartment". And then go into the next column, which begins, "Stow In ETB." Change the second line, which reads: "LMP's Camera With B&W Mag Hotel" to "LMP's Camera With B&W Mag Golf". That's Mag G, ETB. Over.

126:49:59 Schmitt: Got you. Hotel, stow it; and go out with Golf.

126:50:06 Allen: That's got it.

[Gene and Jack had magazines Hotel (or "Helen" as Jack called it when he stowed it under his seat) and Golf ("Gail") out in the ETB at the start of the EVA. During closeout, at 123:31:59 and following, Jack mentioned that he had put Golf in the ETB and Hotel was on the LMP's camera. Hotel is partially used (see below at 126:58:05 and 126:59:20) and will be kept in the cabin for now. Golf is still unused and will be taken out for EVA 2.]

126:50:08 Allen: And I've got a LEVA-cleaning procedure which maybe you could pencil in there. It's an easy three-step procedure. And I'll go ahead and read it step-by-step here. Step number 1 is: "Tap LEVA base to remove loose dust". Step number 2 reads: "If excess dust still remains, use a towel from the LM tissue dispenser, which has been wetted with water, and gently wipe the visor from the top to the bottom; that is, in one direction. And fold this towel after each wipe to keep the contact surface clean". There's a note: "Take care not to wet the inside - that is, the concave surface - of the gold visor." And the last step is: "Allow it to air-dry". And that's it on the LEVA cleaning. (Pause)

[They are using ball point pens, rather than pencils, for note taking. The Gold Visor is a gold-electroplated, ultra-violet shield.]

126:51:20 Cernan: Okay, Joe, we got that. The Commander's PLSS has had its final charge, and we're in the process of working on the LMP's PLSS now. I guess there's no way to verify how much water you've got in there except to go through the procedure.

126:51:44 Allen: That's right, Geno. And we think you fellows have earned a good meal now, and maybe you can take the rest of the day off.

126:52:07 Cernan: Okay, Joe. Thank you.

[Long Comm Break. Details of the final PLSS feedwater recharge are on Surface 3-6.]

126:57:50 Schmitt: Okay, Joe. Just to bring you up to date on (film) magazines. Mag Bravo has seven-seven frames (exposed).

126:57:57 Allen: Okay. (Pause)

126:58:05 Schmitt: Mag Hotel has eight-three frames.

126:58:11 Allen: Roger.

[Comm Break]

126:59:20 Allen: Jack, on your mag Hotel, we'd showed you all the way up to a hundred and eighty three at one time on that. Did you miss the "one", this time?

126:59:38 Schmitt: I may have clipped it out, Joe. One-eight-three, yes.

126:59:43 Allen: Okay, yeah, you did clip it out, clipped it out cleanly. So thanks for verifying that.

[Schmitt - "Joe was just taking a dig at me. I had not clipped the 'one'. He was just sticking one in."]

[Comm Break]

127:02:28 Schmitt: (Sounding very stuffed up) Joe, mag Romeo has two-one frames. And I took a few, random, and probably not very good 500-millimeter (pictures) of the North and South Massifs.

127:02:46 Allen: Okay, Jack. Thank you. (Long Pause)

127:03:00 Schmitt: And, Joe, verify that you want mag Charlie substituted for Mag Bravo on the CDR's camera.

127:03:15 Allen: Stand by.

[Comm Break. These photographs were taken through a lens with a 500mm focal length. We include some samples here and note that they will take better examples when they are outside.]

127:04:40 Schmitt: Don't get me wrong. I think it's a good idea, Joe. Don't let everybody work all night on that one.
 127:04:49 Allen: Jack, I think the answer to that is "yes". Per the checklist, by the way. That's the way we show it in our checklist here.
 127:05:00 Schmitt: Roger. We probably have about 100 frames left on Bravo, so we'll just keep track of that.
 127:05:07 Allen: Jack, it'll go out later on, Bravo will. Apparently, it's kind of your backup magazine there. (Pause)
 127:05:26 Schmitt: Okay.
 127:05:30 Allen: The reason being, we want to start that EVA-2 with a fresh mag.

[Long Comm Break]

127:10:31 Cernan: Hey, Joe. Bob told us earlier (that) the sounder looked like it was working. (Long Pause)
 127:10:58 Allen: Gene and Jack, just a general comment on that. SIM bay's cooking along beautifully. We are getting lunar sounder data. It looks quite interesting. We've only got one or two annoying problems with it, but nothing major...That is, with the SIM bay, not with the sounder. One of them being that we have our usual mapping camera extend problem. And we've just decided to leave it extended and it will serve it right if it gets a little contaminated with an occasional (water/urine) dump. And I guess there's a minor problem with one of the big antennas. It didn't pass its retract check properly, so I guess it may have to be jettisoned when we do a plane change. Otherwise, things are working beautifully. Over. (Pause)
 127:11:55 Cernan: That sounds great; I'm glad to hear that.

[Very Long Comm Break]

[Cernan - "We were probably eating through this thirty-minute period and I remember that it was almost a relief not to have to talk to the ground or answer questions."]

[Schmitt - "I was hoping they would ask more questions during this eat period. It was an opportunity to chat about the geology. I was tired, but I thought it was a waste of time not to talk. We were on 'push-to-talk' so I don't know what Gene and I were talking about at this point. Probably just the mechanics of eating: 'Do you want this? Or, do you want that?' It was all cold; you couldn't put hot water in it."]

127:42:56 Schmitt: Houston, Challenger.
 127:43:02 Allen: Go ahead.

[They have finished eating and have done second oxygen and water recharges on both PLSS's, They are about to configure the LM for the rest period.]

127:43:08 Schmitt: We're sort of around (1)27:30 in the checklist, more or less, and you want the Power Amp and TM (Telemetry) to High? (Pause)

[They are going to a high rate of data transmission.]

127:43:33 Allen: Ready when you are. (Long Pause) And, troops, are you raiding the pantry up there yet?

127:43:52 Schmitt: Yes, sir. We've been hitting it as hard as we can. (Pause) Okay, Power Amp is going to Primary and PCM (Pulse Code Modulator) to High. (Pause) And, while we're waiting for Gene to look at his computer, shall I do the battery management? (Pause)

[Schmitt - "Battery management meant that you were going to check out all the LM batteries and see if they had the right voltages. And, I think, if you found that some had drawn down more than others, you would equalize them."]

[Details of the battery management procedure are given on Surface 3-6.]

127:44:29 Allen: Jack, stand by - until we get the high bit rate - on that battery management. And, a reminder, are you still recharging that PLSS number 2 there, or have you taken that off the line?

127:44:44 Schmitt: No, we're through with that. We caught it with 10 minutes.

127:44:55 Allen: Okay. We've got high bit rate now. Go ahead with battery management.

127:45:07 Schmitt: Okay, we'll play it...Gene'll work the computer, and I'll work the batteries. And the ED volts are 37.2, both batteries.

127:45:17 Allen: Thank you. (Long Pause)

[Jack is also checking the batteries for the Explosive Devices (ED) which will separate the LM Ascent and Descent Stages just prior to liftoff. The voltages are unchanged from the pre-landing values.]

127:45:56 Cernan: Okay, you got POO and Data, Joe. (Pause)

127:46:05 Allen: Thank you. (Long Pause)

["POO", which is pronounced "pooh", as in Winnie-the-Pooh, is shorthand for Program Zero-Zero.]

[Schmitt - "POO was the housekeeping program that allowed the ground to communicate with the computer to not only check out the computer to see how it was doing but also load data."]

127:46:43 Schmitt: Okay, Joe, the battery management's complete. How does the rest of the spacecraft look, what you can see of it (through telemetry checks)? (Pause)

127:47:00 Allen: Okay, Jackie. Copy the battery management complete, and the Challenger's looking beautiful from down here.
 127:47:13 Schmitt: I guess you don't have telemetry on dust yet, huh?
 127:47:21 Allen: Negative on the dust. And the computer's yours. Sounds like you've got hay fever sensors, as far as that dust goes.

[Jack sounds quite congested; Gene much less so. Jack is the only member of an Apollo surface crew to show an allergic reaction to the dust.]

[Schmitt - "After I took my helmet off after the first EVA, I had a significant reaction to the dust; my turbinates became swollen. And that went away by the next morning - except for a little bit of residual - and never came back again. Nobody's ever explained that to me."]

127:47:35 Schmitt: It's come on pretty fast just since I came back. I think as soon as the cabin filters most of this out that is in the air, I'll be all right. But I didn't know I had lunar dust hay fever.

127:47:54 Allen: It's funny they don't check for that. Maybe that's the trouble with the cheap noses, Jack.

127:48:05 Schmitt: Could be. I don't know why we couldn't have gone and smelled some dust in the LRL (Lunar Receiving Lab) just to find out.

127:48:12 Allen: Goodness knows we've tried. (Pause)

[Schmitt - "Before the quarantines were lifted, there were a lot of people in the Lunar Receiving Lab exposed to lunar dust when they shouldn't have been. I'm afraid that the geologists didn't really believe in the quarantines and they honored them only in the breach for the most part."]

127:48:35 Schmitt: Okay, I'll wait for your cue on the rest of it. (Pause)

127:48:48 Allen: Okay, Jack. Telemetry PCM Low, and your Power Amp Off, please.

127:48:58 Schmitt: Roger.

[Comm Break. After returning the telemetry system to low bit rate, they will start on Surface 3-7. They will reverse the direction of air flow through the suits and rig the hammocks.]

127:50:42 Allen: Challenger, this is Houston requesting Downvoice Backup, and then configure your ECS for sleep at your convenience.

127:50:51 Schmitt: Okay, we're working in that direction. Downvoice Backup, now.

127:50:57 Allen: Okay, Jack and Gene. And, unless you've got questions, or we can help you out in some way, we'll say good night to you.

127:51:10 Cernan: (Faint) (Or) good morning. (Long Pause)
The reason I say that, Joe, it's going to be another 30
minutes or so anyway - probably more like an hour - before we
actually close our eyes. (Pause)

127:51:56 Allen: Roger, Gene. You think you'll be able to
use about 30 more minutes of sleep tomorrow morning? What's
your wish on that?

127:52:09 Cernan: Yeah, I'd like to try to get the full
amount (of sleep). As I recall, tomorrow's a little bit
flexible. If we get out 30 minutes late, it doesn't really
hurt us.

127:52:20 Allen: Sounds like a good way to proceed. We'll
give you the full 8 hours tonight, Geno. And you do have a
time pad in there, so it shouldn't hurt a thing.

[There is some unallocated time in the flight plan, some
"padding" in the schedule.]

127:52:33 Cernan: Yeah, the big object tomorrow is to get
out, and get back in, and the same thing with the next day.
I don't think we're really that time critical either day that
we can't go an hour either way. And I think we'd prefer to
have the full 8 (hours of rest) tonight.

127:52:50 Allen: Roger. We couldn't agree with you more.
And if there's any way we can be helping you now, just speak
up.

127:53:02 Cernan: No, you've been doing fine. We just got
a little housecleaning we got to do that's going to take
us...I expect we'll be an hour late, Joe.

[Long Comm Break]

[Cernan - "We still had to set up the hammocks. Our
suits were probably already in the back of the cabin, hooked
up to hoses to dry out; and there were always a few things to
shuffle around: get our foodstuffs stowed, clean the visors,
look at the rocks and pack them away, and so on. We were
busy almost all the time."]

128:01:56 Schmitt: Hey, Joe.

128:02:00 Allen: Go ahead.

128:02:07 Schmitt: (There was) some ambiguity in your
statement. You want us to use a tissue or a towel on that
visor cleaning?

128:02:18 Allen: Jack, they call it...They call it a
"towel", but it comes from the LM tissue dispenser, so I
would interpret that to mean "tissue".

128:02:36 Schmitt: Well, you and I are thinking alike. But
could you ask back there and find out?

[Jack doesn't want to take a chance on scratching the
visors.]

128:02:46 Allen: Asking right now. (Long Pause)

128:03:43 Allen: Jack, our guess was right on the cleaning of the visors there. We're to use a tissue from the LM tissue dispenser. And I've got an unrelated question for you. We're chasing (the cause of some apparent) water usage down here. Could you tell us, please, if you refilled the drink dispensers in the suit already? Over.

128:04:12 Schmitt: That's affirm. We have. (Long Pause)

128:04:34 Allen: Okay. Thank you. (Pause)

128:04:47 Schmitt: We have been drinking quite a bit of water, Joe.

128:04:59 Allen: Okay. Thank you.

[Comm Break. During the EVA, water lost from the body in sweat and breath would have built up in the suit had the PLSS not contained a wick-like device to extract excess moisture. This was then stored in a reservoir, although not one connected to either the Liquid Cooled Garment closed-loop supply or to the sublimator feedwater supply. They have just finished recharging the PLSS's with feedwater and, prior to doing that, drained the wicked water into the descent stage sump.]

[Cernan - "The Liquid Cooled Garment was really important to help keep you cool so that you wouldn't sweat too much. Back in Gemini we had nothing but air cooling; and, during my Gemini IX EVA, the humidity in the suit got to be 100% and I got my helmet all fogged up. The LCG made it a totally different ball game. You still perspired and you had to make sure you drank enough water that you didn't become dehydrated; but you didn't have to worry about overheating and fogging up."]

128:07:50 Schmitt: Houston; Challenger. How do you read?

128:07:56 Allen: You're loud and clear. Go ahead.

128:08:04 Schmitt: Joe, I just took a quick look with the hand lens at that large rock I brought in, and I don't think there's much more than 30 percent plagioclase. I'll go back to it being more of a standard basalt or gabbro. It has a fair proportion of ilmenite in it, I believe. There's some bright platelets - in the vugs or vesicles - of ilmenite. Now it could be that, if the soil is very glassy, that it's developed the darker color from the contribution of the mafic minerals to the glass, particularly the iron and the titanium.

[Schmitt - "This was another alternative to consider for the dark mantle, another hypothesis to work on. Because there were more mafic minerals in the basalt than we originally thought, you might have had a darker impact glass develop and, so, you had to continue to consider the possibility that the dark mantle was a dark regolith derived from basalt with a high concentration of iron/titanium minerals in it. In a sense, because the glass beads we found at Shorty were dark because they were rich in iron and

titanium, this hypothesis is also a step closer to the truth."]

128:09:01 Allen: Roger, Jack. Copy that. Sounds interesting.

128:09:07 Schmitt: All it means is that we don't yet know the origin of the dark mantle.

128:09:17 Allen: Roger. (Pause)

128:09:26 Schmitt: That rock looks like I may have, by accident, sampled one side of one of the parting planes that I mentioned. (The rock is) very, very sharply bounded on one side by a planar surface.

128:09:52 Allen: Roger, Jack. Say again. You may have sampled by accident the side of what?

128:10:07 Schmitt: No, I mentioned when I sampled it. It had one very planar surface, and looking at it more closely, it looks like one of those parting planes that I talked about even earlier in the EVA.

128:10:17 Allen: Ah, Rog. Copy. "Parting planes", thank you.

128:10:24 Schmitt: That's like a parting shot (for the night). (Pause)

128:10:34 Allen: Of which you've been known to have an overabundance, by the way.

128:10:43 Schmitt: Oh, I didn't know that.

128:10:49 Allen: All us fast finishers do. (Pause)

128:10:58 Schmitt: That's right. You got to figure out what race you're in though, first, Joe.

128:11:09 Allen: I'm sure that Sherlock Holmes would have a suitable quotation to answer that, Jack. I just can't come up with it right now. (Pause) Something like "therein, Watson, lies the problem"...

128:11:20 Schmitt: That, in itself, is a singular event. (Long Pause)

128:11:44 Schmitt: But the dog did nothing in the nighttime, Joe. (Long Pause)

128:11:59 Allen: And when you've examined all possibilities and eliminated all but the very improbable ones, then the improbable one must mean the truth.

128:12:16 Schmitt: I told you he (Holmes) was a good geologist (pause), one of the experts on the soils of London. (Pause) Not to mention their relationship to all kinds of brands of tobacco. (Pause)

128:12:58 Allen: Jack, maybe we better get off onto another vein. Surgeon's giving me a puzzled look over here. We may be getting in trouble.

128:13:12 Schmitt: You want to talk about veins. Now that's something an old ore geologist could talk about all night. (Pause)

128:13:26 Allen: Ore geologists and cardiologists alike. (Pause)

128:13:42 Schmitt: Thou strikest for the jugular. (Pause)

128:13:53 Allen: Jack, we running a contest down here to come up with a reply to that.

[Schmitt - "Through the years, Joe and I would occasionally pun together. Still do."]

128:13:58 Allen: We're getting a request, many requests, for a weather report. We've been missing your weather reports and wonder what the weather is on the Moon right now. (Pause)

[If Jack is in his hammock, lying with his head to the north and his feet to the south. He can see Earth out his window, unless they've got window shades up by this time.]

128:14:16 Schmitt: Well, the Moon's weather is clear and sunny. It's only scattered clouds, and all of those seem to be attached to the Earth. (Pause)

128:14:35 Allen: Except for a cloud of dust around the right rear wheel of the Rover, we've noticed.

128:14:46 Schmitt: Yeah, but that dissipates in the morning warmth. (Pause) Believe it or not, Joe, I'm going to be off the air briefly. (Pause)

128:15:15 Allen: So far, I don't believe that.

128:15:23 Schmitt: Well, if you don't get any heart beat for a little while, don't worry. (Pause)

128:15:32 Allen: Okay.

[Very Long Comm Break]

[NASA Public Affairs reports to the media that Gene and Jack turned off the voice sub-carrier at 128:54 but weren't yet asleep. The following message came 8 minutes later.]

129:02:37 Cernan: Joe, we're asleep. There's no need to answer. See you in the morning.

[Cernan - "We'd had a long first day, something like 20 hours. This was PDI (Powered Descent Initiation) and Landing day and the whole thing. And you have to realize that, to me, sleeping on the moon is the greatest waste of time a human being can conceive. I mean, you go all the way to the moon; you go a quarter of a million miles to spend three days on the Moon and you sleep through one of them. But you had to sleep; we were just so tired that first night that we didn't have any choice but sleep or, at least, try to get some rest. I can remember just laying there with my eyes closed and thinking, "Hey, I'm on the moon. Why am I wasting my time trying to sleep or rest?" And yet you'd worked so hard that biologically you just had to get some rest. There had been some discussion of a sleep period before the first EVA, but we decided it wasn't very useful to do that. You'd have to take your suit off, and the next day you'd put it on, and you'd just waste more time. We knew this was going to be a long day, but we had prepared for it. Sure, it was exhausting to some degree because it was a long day, a 20-hour day, and physically demanding. Getting the backpacks

on, getting out, getting the Rover deployed, setting out all the experiments: those were all physically very demanding tasks. So we were tired when we finally got into the rest period and I slept fairly well. I'd get some sleep, dozing off. Then I'd open my eyes for a while and then doze off for another hour. It was certainly acceptable rest."]

[Schmitt - "It's interesting that Gene felt that sleep was a waste of time, because there was really no alternative. On Apollo 12, in particular, we found that when the crew tried to sleep in the suits, the continued discomfort - even depressurized - meant they got very little rest. They basically got out for EVA 2 as tired as they had been when they'd gotten in the LM the night before.

"I never felt that sleep was a waste of time. After the rest period, during which I got about five hours of sleep, I felt well rested and was ready to go again. I can't agree that sleeping was a waste of time, for the simple reason that we couldn't have performed well without it. Even with adequate rest, we were working so hard that, for example, I had a real emotional down time at Station 3, and it took the discovery of the orange soil to rejuvenate me. However, there had never been any question in my mind about trying to sleep the first day in between the landing and the first EVA. That just didn't make much psychological sense, even though it made for a long day. And besides the psychological advantage of getting right out, it also gave us a chance to get the ALSEP deployed and a few samples collected in case something happened that would force us to leave early."

"I slept much better on the lunar surface than I did in orbit. One-sixth gravity is a very pleasant sleeping environment with just enough pressure on your back in those hammocks to feel like you're on something but not enough to ever get uncomfortable. I slept but my impression was that I only needed about five hours sleep to feel rested whereas ordinarily on Earth at that time I usually felt that I could use seven. But I think that's related mainly to the lower gravity environment. You just don't get physically as fatigued as you would on Earth. You get as fatigued mentally - obviously you're working just as hard with your neurons - but physically you don't work as hard."]

[Ron Evans has been off-comm - and/or asleep - since 123:33 and receives his wake-up call from Houston at 131:23. Three hours later, at 134:42, he has the following exchange with Gordon Fullerton.]

[Fullerton: You ever have anything you'd call a visual on the LM?]

[Evans: No, I really haven't looked that much, Gordo. See, my optics are always pointing up in the air; so I can't use the sextant (to look for the LM). The binocs...I'm having a heck of a time holding them still enough to concentrate on anything very small.]

[Fullerton: Roger.]

136:55:05 (Music: "Ride of the Valkyries" by Richard Wagner)

[Jack Schmitt and Gordon Fullerton were both undergraduates at the California Institute of Technology. At 7:00 a.m. on the mornings of Caltech final examinations, it was traditional for students with hi-fi systems to tie them together and wake up everybody in the undergraduate dorms by playing "The Ride" at full volume. For those - including your editor - who have been through the experience, the sound always gets the blood pumping no matter how little sleep they've had the night before.]

136:56:39 Fullerton: Good morning, Challenger.

136:56:43 Schmitt: Sounded like Parker had the duty (of picking the wake-up music). Both monumental and epic.

[Bob Parker was a married graduate student at Caltech and lived off campus. Playing the Ride was strictly an undergraduate phenomenon and, for Parker, the Ride wouldn't have had the same significance as it did for Schmitt. In a February 1992 telephone conversation, Parker said that, if it was he who picked the piece, it was simply because he likes Wagner and can think of few things more stirring than the Ride. He also says that, in the Apollo era, the wake-up music was usually picked the night before and that they sometimes had trouble finding a recording in time.]

136:56:50 Fullerton: Jack, that's supposed to take you back to Caltech final's week.

[In a separate telephone conversation, Fullerton said that he is certain that the idea of playing the Ride was not his. He noted that there were plenty of Caltech people around and that any one of them might have come up with the idea.]

136:57:01 Schmitt: (Humming Beethoven's Funeral March)
(Long Pause) How's everything look, Gordy?

136:57:41 Fullerton: Couldn't look better. How's it look to you?

136:57:49 Schmitt: Well, it's nice to have rested some.

136:57:55 Fullerton: Rog. I'm sure of that. (Long Pause)

[Schmitt - "I wore the ear-piece every night because I was closer to the panel. The usable volume of the cabin is T-shaped. My hammock was stretched across the front, and Gene was stretched out toward the back, over the engine cover, with the suits under him."]

136:58:11 Schmitt: How do our consumables look today?

136:58:16 Fullerton: They look good, as expected. Right on.

[Comm Break. They are on Surface 3-8 According to the checklist, the crew has 25 minutes for "Postsleep" activities. Those that are called out are stowing the hammocks and sleep restraints getting a stay/no stay decision from Houston, reporting on their sleep and meals, and copying liftoff times for the next several hours. Needless to say, they are also taking time to urinate and perform other personal and housekeeping chores before having breakfast and getting into their Liquid Cooled Garments and suits. Because they were on a low residue diet, neither of them had to defecate while they were on the Moon.]

136:59:51 Schmitt: (Unintentionally keying his microphone as he talks to Gene) Be through in a jiffy. (Long Pause)
 137:00:32 Schmitt: (Unintentional key) Stow your sleep restraint up there? (Pause) I mean, your hammock. (Pause) Either way. I'll stuff all mine in this compartment here, if you'll just get yours in there. Otherwise, we can rearrange it. See how it looks first.

[Schmitt - "We were very careful to keep things stowed in the place to which they were assigned. We had many storage training sessions. During the mission, I would have known where everything was stowed but, now, I can't remember anything except that there were a lot of soft fabric bags in the back portion of the usable volume of the ascent stage, along the walls as I recall. Actually, I take it back. I don't think they were soft; there were some soft containers, but I think they all had aluminum latch covers on them. But anyway, we had a place for everything and we made sure it went back into that place. Otherwise, it would have been chaotic. We tried not to have a lot of stuff out at one time."]

[Cernan - "Because of weight restrictions, I don't think we had aluminum covers on all of the storage compartments and, rather, a lot of our stowage areas had net coverings on them. Although we were going to be on the Moon for three days, we always had to keep things well stowed in case we had an emergency liftoff."]

[Comm Break]

137:01:50 Schmitt: Gordy, you guys held comm pretty well last night; I only remember one break.

137:02:02 Fullerton: Roger, Jack. (Long Pause)

[That is, Jack only heard comm noise once during the rest period.]

137:02:33 Schmitt: Take you off biomed for a minute.

[Comm Break.]

137:04:28 Schmitt: (Unintentional key) Preamp light is on, like it's supposed to. (Pause) Well, how about it, Gordy? Are we Stay or No Stay for EVA-2 prep?

137:04:41 Fullerton: You're Stay. Never any doubt.

137:04:46 Schmitt: Thank you, sir. (Long Pause)

137:05:45 Schmitt: (Unintentional key, preparing to give Fullerton a Crew Status report) (Garbled) have any medication? (Pause) (Garbled) report the food. (Pause)

137:06:04 Schmitt: Okay, Gordy. Status report is excellent. No medication for either one of us. CDR slept 6 hours pretty good; I slept 6 hours intermittent, but generally good.

137:06:21 Fullerton: Okay, Jack.

137:06:25 Schmitt: And we've eaten well, I think. The food's a little bit confused since we had our little minor explosion in the cabin, but I think you could say it's good. We've had a lot to drink, a lot of juices. We ate the frankfurters. We're sharing a lot of the stuff because it's not symmetrically packed. If you want more details, it will take time. (Long Pause) And, Gordy, we did not eat the corn chowder.

[The "explosion" was apparently caused by a slight expansion of the food bags which, when Gene and Jack opened the stowage compartment, popped out and got very disorganized. There was a prior mention of corn chowder at 115:50:24 and, in both that instance and this one, they are referring back to some episodes of flatulence on the trip out from Earth which they blamed on the chowder.]

137:07:21 Fullerton: Okay. Roger. You did not eat the corn chowder, but most everything else on the menu. Is that right?

137:07:29 Schmitt: Yeah, we got just about everything else. We go into...maybe mixed up two meals, but essentially meal B and C for yesterday were eaten, except for the corn chowder.

137:07:51 Fullerton: Okay, Jack. (We) copy. (Pause)

137:08:09 Fullerton: We're wondering if you could come up with a quantitative estimate on the water you've each drunk and also your PRD (Personal Radiation Dosimeter) readings.

137:08:30 Schmitt: Stand by, Gordy. That may be difficult. (Pause) Yeah, we'll get the PRD a little bit later when we start suiting up.

[Cernan - "I'm pretty sure that, while we slept, we each kept our PRD's in a pocket in our LCG and then, when we got suited, we'd put it in a pocket in the suit itself."]

[The checklist calls for PRD readings after they've got their LCG's and suits on but before they don the PLSS's. There are no mentions of any PRD transfers in the checklist.]

137:08:45 Fullerton: Yeah; okay. That'll be fine. My mistake.

137:08:50 Cernan: Hey, Gordy, on this water. We saturated ourselves before we went out. I finished my drink bag out in

the suit on the surface. Jack finished about better than three-quarters of his. We've had water and tea and then the juice, and we have been drinking water constantly, post-EVA. And to give you a quantity is almost impossible.

137:09:17 Fullerton: Okay; that's fine.

137:09:24 Schmitt: If the water's down, it's probably because we've been drinking it. And I'm ready for your lift-off pad data.

[These lift-off times will be needed by the computer if they have to launch early. In the following list, the first lift-off time is for Command Module orbit 26. The start of each orbit comes roughly at the point over the middle of the lunar Farside at which the crew did the engine burn that first put them into lunar orbit.]

[Cernan - "The pads were pre-printed forms at appropriate places in the flight plan with labeled boxes where you would write things like these updated liftoff times."]

137:09:30 Fullerton: Okay. For rev 26, lift-off time is 138:40:15; 27 is 140:38:49; (28 is) 142:37:22; 144:35:55; 146:34:29; 148:33:03. And the last one, rev 32, is 150:31:37. Go ahead (with a readback).

[Fullerton carefully pronounced each digit, and using "niner" rather than "nine" in his recitation. Jack does not follow suit.]

137:10:34 Schmitt: Okay; rev 26. Is that the first one, Gordy?

137:10:39 Fullerton: That's affirm.

137:10:46 Schmitt: (Reading quickly) Okay. Rev 26 is 138:40:15; 140:38:49; 142:37:22; 144:35:55; 146:34:29; 148:33:03; 150:31:37. And what's our present rev?

137:11:13 Fullerton: Okay; I'll have to check that myself. (Pause) We're on rev 25. He (Ron Evans)'s about three-quarters of the way across the front side. Coming up back side will start 26.

137:11:40 Schmitt: Okey-doke.

137:11:41 Fullerton: And, for your information, he's running the VHF Sounder, and it's working fine.

137:11:52 Schmitt: That's good to hear.

137:11:54 Cernan: By the way, good morning, Gordy.

137:11:56 Fullerton: Good morning, Commander.

137:12:01 Cernan: How does America itself look?

137:12:03 Fullerton: Just as good as ever. Ahead on the consumables.

[Evans is using less oxygen, water, maneuvering fuel, etc than planned.]

137:12:08 Fullerton: No problem on the spacecraft systems. Only minor funnies in the SIM (Scientific Instrument Module) bay, but even it is almost 100 percent.
137:12:23 Cernan: Okay. And I guess from...I didn't hear your comment, but I assume Challenger's the same way.
137:12:29 Fullerton: That's affirm. That's the way it looks here, anyway. (Long Pause)

[Cernan - "People sometimes ask if I worried about getting home. Well, you're sitting there inside an oil can and you've already bitten the bullet. If something's going to happen there's nothing you can do about it. So why worry about getting back until the end of the three days when it's going to count."]

137:13:15 Fullerton: Challenger, Houston. We've been working, while you've been sleeping, on a fix for the missing fender. John Young has been over working it out in the suit with the mockup Rover, and we have about probably 5 to 10 minutes worth of words on how you (might) want to go about (doing) that. Whenever you have that much time to listen - it'll be mostly listening on your part - let us know.
137:13:43 Cernan: Okay, Gordy. Will do.

[Comm Break]

137:15:33 Schmitt: Gordy, you've implied that we may be a little behind on water. Is that correct? (Pause)
137:15:47 Fullerton: No. That's not the problem, Jack. I think our concern was more that you were taking enough onboard internally. (Long Pause)

[Fullerton is struggling as he tries to say what he means.]

137:16:09 Schmitt: Our water.
137:16:10 Fullerton: That's right. That you were drinking enough. That's what we were worried about.
137:16:20 Schmitt: Okay; we'll keep pushing it!

[Comm Break]

[Schmitt - "There was a tendency to be dehydrated and also a tendency not to be either thirsty or hungry - at least in the first few days - so I made a point to force myself to drink and eat. More so than I think either Gene or Ron. Gene didn't eat much the first few days. And neither did Ron."]

[Cernan - "I lost weight on all three of my missions: thirteen pounds on Gemini IX, eight on Apollo 10, and eleven on Apollo 17. (Evans and Schmitt each lost about five pounds during the mission.) Food was a necessity more than an enjoyment. You just didn't get hungry, the food wasn't that great, and you just didn't eat as much as you normally would. I don't remember whether I ate a lot or not; but, having

flown before, I was certainly very aware of the need to continually drink as much water as we could."]

137:17:58 Schmitt: (Accidental key) And cold scrambled eggs.

[Schmitt - "Some of these accidental keys may have been caused by pushing the talk button out of habit."]

[Comm Break]

137:19:09 Cernan: Gordy, we're going to start to eat here. Why don't you talk to us about that fender?

137:19:15 Fullerton: Okay; let me round up John Young. He stepped out for a second. We'll have him here in a minute. Might as well let the resident expert on fenders talk. (Long Pause)

137:19:55 Fullerton: Okay; I'll now turn the microphone over to Captain Young.

[Schmitt - "John Young was involved in this not only because he was the Back-up Commander but also because he had broken a fender on his Rover on Apollo 16 and knew how important the problem was. Without the fender, you get a forward rooster tail and you end up driving into your own dust."]

137:20:02 Young: Hey, Geno. This is John. We spent...

137:20:08 Cernan: Hello, John. How you doing?

137:20:11 Young: Oh, just fine. You guys are doing a superb job; really beautiful. Hey, we spent some time on this fender problem and worked out a pretty simple-minded procedure, which involves essentially taking four of those chronopaque pages out of your lunar surface maps - ones which are not going to be used for discussing the site - taping them together with grey tape so that you end up with a piece of paper about 15 inches by 10-1/2 inches, and then using the AOT (Alignment Optical Telescope) lamp clamps, preposition them full opened, taking them out (in the ETB), taking that piece of paper out (of the ETB), laying it on top of the fender guide rails, and clamping the edges of it with the AOT lamp clamps. It's simple and straightforward, and the beauty of it is you're only spending about 2 minutes in the clamping operation, and it could save you up to about 12 (minutes of) dusting, I think maybe. (Pause) What do you think?

[Gene and Jack have a set of lunar surface maps which are printed on a stiff, photographic paper called "chronopaque". Each map is about 8 by 10 inches. The front of each sheet is a photographic map while the back is a contour map to aid in crater identification. Gene discusses the AOT lamp clamps below.]

[Schmitt - "We had maps to cover the whole area in case we ended up with an "off nominal" landing, as NASA would say, and had to run traverses different from the ones we planned.

So there were a bunch of spare maps and that's what they decided to have us tape together to form the replacement fender.]

137:21:41 Cernan: Yeah, John. I think we ought to try something; because you told me (about the dust problem after Apollo 16), but I guess you can't appreciate it until you see it happen yourself. That dust - without that fender - is just almost unacceptable. This sounds pretty good. How do you want those things taped together)...

137:22:01 Young: You just take four pages and allow...Well, I've got the detailed procedures here, if you're ready to copy. Over.

137:22:11 Cernan: Well, no. I'm not ready to copy yet, but what do you do? Tape the four squares into a bigger square about 16 by 20.

137:22:18 Young: Yeah. Allow about an inch of overlap, and tape both sides of them.

137:22:24 Cernan: Okay.

137:22:27 Young: And then you get the AOT clamps off the utility lights and open the clamp jaws to max. And you stow the clamps, and you roll up the paper...Roll up the...Roll up your fender shortwise and put a grey (tape) tab over that and stow it in the ETB. You got both the clamps and the paper fender in the ETB.

[Cernan - "We had a couple of auxiliary lights which were little spotlights with clamps on the back that you could fasten anywhere: on a circuit breaker panel, on a rod. They were very useful, and I think we even brought the clamps back in with us after the third EVA to make sure we had them. They were called the AOT lamp clamps because, most of the time, we had them clamped to the bars on the cage surrounding the sextant or Alignment Optical Telescope. As the cabin pictures show, the AOT was between us at about head height, on the front bulkhead between the windows."]

137:22:50 Young: And then when you get out to the Rover, you lay the edge of your fender over the inboard guide rail and clamp it, and then you lay the other edge of the sheet over the outboard rail and clamp it. And the only thing you really have to worry about is making sure that the inboard clamp is right over the shock strut so that you don't get any interference with the LRV structure when you turn the wheels.

[There is a picture of the fender, as installed, at the start of the drive out to Station 2. It is frame AS17-135-20542.]

137:23:36 Cernan: Yeah, that's the type of thing I was going to ask about, some of those subtle points. There really should be quite aways...Well, I'll look at it...But almost vertical over the hub, right?

137:23:48 Young: Yeah, on the inboard one. On the outboard one, if you put it a little further back aft on the wheel, it allows you to give your paper fender a little more rigidity.

137:24:10 Cernan: And you just say lay them over the guide rails (and) sort of...so the clamps are also over the guide rails. And not try and align the makeshift fender in the guide rails itself, huh?

[Schmitt - "The guide rails were about as thick as a pencil and you could use them as something to clamp this new fender on so that it wouldn't move."]

137:24:26 Young: No. Just clamp the thing right to the rails. Just allow a little overlap, and clamp that rascal right down. And I know you can tighten those clamps down so good it'll never get loose! (Chuckling) I know you can do it if I can do it.

[Schmitt - "Gene has a naturally strong grip. He has very big hands and that's what John's referring to."]

137:24:45 Cernan: Okay, John. I think I know what you're talking about, and I'd sure like to give it a stab. The only hooker is I hope that tape holds the fenders together well enough...those pieces well enough.

137:25:01 Young: Roger. One of the things - when you're taping the pages together - that you want to be careful of is that you make sure and get the air bubbles out so when you get in the vacuum, it doesn't open up by itself. And maybe you can put an X across there to make sure that, if you get any separation, it's still held together pretty good. We think the tape will work because back about in (Apollo) 13, we were using it just sort of incidentally in the thermal vacuum chamber, and it worked okay there for some reason.

[Young had been the Back-up Commander on Apollo 13.]

137:25:46 Cernan: It would seem to stick on the surface okay - if I could find a dust-free spot - when I put that other fender on earlier.

137:25:54 Young: Yeah, I agree.

137:25:59 Cernan: As far as how much of the new fender to overlap on the present fender, just make it about symmetrical with the other side (that is, the undamaged, left-rear fender), and that probably ought to give me plenty of overlap, huh?

137:26:10 Young: Well, are you talking about over the dovetail part of it, or are you talking about off the aft end of the vehicle?

137:26:24 Cernan: I'm talking about the present fender that's on there, the aft end of that fender. About how much overlap do you want with this makeshift fender? Just give me

an idea. I think I could figure out when I get there, but I'd rather have your feelings before I do.

[The missing piece is the aft half of the right-rear fender.]

137:26:41 Young: We think if you get it out about 4 inches past that fender...You understand what this looks like when you get it put on the fender. It just looks like sort of a roll, and you end up with a sort of a straight fender right at the back end of the Rover. A sort of a straight...About half a pipe straight out there. And, if you get it out 4 or 5 inches, that will keep the dust from coming back over the vehicle.

137:27:18 Cernan: Yeah, (garbled). That would be about 4 or 5 inches. Great.

137:27:22 Young: Yes, it's just sort of like a horizontal fender, like on an old automobile.

137:27:33 Schmitt: (To Gene) I thought I understood what he was talking about. Pipe. (Pause)

137:27:39 Young: Say again, Geno.

137:27:45 Schmitt: Hey, John. This is Jack. Did you say "pipe" there a minute ago? P-i-p-e?

137:27:56 Young: Yeah, but it doesn't roll up into a circle; it's sort of a...a hemisphere. I mean it's half of one.

[Young is trying to describe a cylinder sliced lengthwise.]

137:28:08 Schmitt: Oh, okay. I thought I was with you until you said "pipe", and then you lost me. Okay. I think I understand, too.

137:28:14 Young: You know the problem I have with communications.

[Andy Chaikin suspects that this is a sly reference to an incident during Apollo 16 when, not realizing that he had an open mike to Houston, Young talked freely and frankly - and with a lot of cursing - about the trouble they were having with orange drink that was getting in their hair and microphones.]

137:28:20 Cernan: Hey, thank you, babe. We'll give it a try. We can get something to work.

[Schmitt - "As I recall, I think I was just standing there, admiring the ingenuity of the support crew. The guys on the ground had gone out and thought about everything we had in the spacecraft, looked at the inventory, and then, as a team, tried to figure out what in the world we could do to solve the problem using what we had. I don't remember ever even thinking about a solution once they said the previous

night that they were going to work on it. I figured they would work something out."]

137:28:27 Young: Okay. And we can watch you on the tube (TV) and make recommendations. I think you've got the idea of it. You know Terry Neal thought of these AOT clamps; and that's a great idea because you can clamp those things on that old dovetail...You can put (such) a force on there that those chronopaque pages will never get loose.

[Schmitt - "Terry Neal was a member of our support team. A real young guy. I introduced him to his wife - something to do with a blind date I couldn't make and he was the substitute and eventually married the girl. He was one of the ones responsible for storage of equipment in the LM and for generating the lunar surface operations plans and stuff like that."]

[In a January 1992 telephone conversation, Neal said that he and Ron Blevins - one of the training instructors - were called in to work on the fender problem. They went through the list of materials available in the LM and, having decided on the maps and the clamps, fashioned a fender, and showed it to Young. Neal remembers that Young then took the fender to the Control Room so that the Flight Director and others could examine it. Neal, himself, then went home to get some sleep. As Fullerton indicated at 137:13:15, Young subsequently got into a suit and put the fender on a training Rover to make sure that there wouldn't be any problems with the installation.]

[As an aside, Neal also says that, in the blind-date story, Jack has mixed together two sets of memories. At some point during Apollo, Jack had a date with the daughter of a friend of Al Shepard's and, when a schedule conflict arose, Neal was a last minute substitute. Separately, Neal's future wife, Mary, worked at the Cape in the Crew Operations area and knew Jack in that context. The Neals' courtship did not begin until after she left Florida for Houston, long after the date switch.]

137:28:59 Cernan: Yeah. Those other clamps I was thinking about - paper clip-type clamps - would never hack it.

137:29:05 Young: We tried that. They just don't have the push.

137:29:13 Cernan: Sounds good, babe; appreciate it.

137:29:20 Young: Okay. We've got a detailed procedure here if you want to copy it; just in case.

137:29:36 Cernan: Yeah. Stand by one, though.

137:29:39 Young: Okay. (Pause)

137:29:44 Cernan: Hey, you know, after thinking and looking at some maps last night, and recalling what I saw during landing and where I was planning on putting it down and everything : I still think, to the best of my knowledge, that we are about 1 or 2 o'clock (relative to the down-Sun

direction}, and I'll increase up to about 200 meters or so west and slightly north of Poppie.

137:30:23 Fullerton: Okay, Geno. (Long Pause)

137:30:56 Cernan: Hey, Gordy, the thing that fooled me yesterday is this depression out at 9 o'clock here, which is greatly undersized for Trident - really isn't Trident - and I said yesterday, I didn't think how we could be that close. Well, we really aren't. Trident is way out there, and I'll still hold to my 200 meters at 1 to 2 o'clock of Poppie.

[They hadn't hit any good landmarks during EVA-1 which, given readouts from the Rover navigation system, would have let the people in the back room get an exact fix on the LM. Gene still doesn't realize that the crater 100 meters south of the spacecraft is Poppie.]

[Schmitt - "Gene was more worried about this than I was. We knew where we were close enough for all of our planned EVA activities, so I quit worrying about where he actually landed."]

[Cernan - "Whether or not you're interested in where you landed is a difference between a pilot and a geologist. For me, as a pilot, I wanted to know exactly where we landed, mostly as a matter of pride. For Jack, what mattered was that we'd landed in a geologist's paradise and, no matter where we were exactly, we couldn't lose."]

137:31:21 Fullerton: Okay. We're thinking you might have - on the way to the geology stops - driven between a couple of the Trident craters then. (Pause)

137:31:42 Cernan: Yeah, we may have coming back. I think I went all the way around to the east of the last one going out, though.

137:31:50 Fullerton: Okay. (Long Pause)

[Gene and Jack were actually well east of the Trident craters on both the outbound and inbound legs of the Station 1 traverse. Following Gene's lead, Houston thinks they are about 100 meters south and 200 meters west of the actual landing spot.]

137:32:07 Cernan: If you had asked me at 3- or 4000 feet where we were going to land, I could have told you exactly. But, once you decide where it's going to be, then you decide where in that "where it's going to be" and you forget everything else around you.

137:32:20 Fullerton: Roger. (Long Pause)

137:33:00 Cernan: Besides, Gordy, when you land on a boat (aircraft carrier), all you're worried about is that the boat's there. You let the captain worry about where it (the carrier) is.

137:33:10 Fullerton: Rog.

[Comm Break. Gene is a former Navy pilot; Fullerton flew for the Air Force.]

137:34:51 Cernan: Gordy, while we're eating, have you got a short synopsis of the news?

[Schmitt - "I was always interested in the news, particularly about Truman. He had gone into the hospital while we were on the way out; and I guess he died on the way back."]

137:34:55 Fullerton: Yeah. Sure do. Stand by one.
(Long Pause) We'd like Biomed, Left, please.

[Gene occupies the left "seat" and Houston is asking to look at his biomedical telemetry.]

137:35:17 Cernan: I don't have any sensors on, Gordy.
(Pause)

137:35:25 Fullerton: Okay.

137:35:30 Cernan: You have to wait until I start putting my suit on. (Long Pause)

137:35:45 Fullerton: Okay. As you might have expected, front pages around the country are headlining last night's EVA with photographs taken from TV monitors showing you and Jack going about your tasks. I might add that the TV camera is really spectacular. It couldn't have been a clearer or more beautiful picture, both for fidelity and color. (Pause)

137:36:08 Fullerton: In other news, South Vietnam's President Thieu has suggested that all prisoners of war be released before Christmas. He has also asked that all Vietnamese parties be included in peace negotiations. South Vietnam and the Viet Cong are now not directly represented in the secret talks now under way in Paris (between North Vietnam and the United States). Meanwhile, (U.S. Secretary of State Henry) Kissinger met for more than 4 hours yesterday with Hanoi representative Le Duc Tho. The two negotiators are expected to meet again this afternoon.

1137:37:36:38 Fullerton: The former President, Harry Truman, is still resting quietly, although his condition remains serious according to his doctors. American poet Mark van Doren died at the age of 78. He was a professor of literature at Columbia and a winner of the 1940 Pulitzer Prize for his poetry. President Nixon announced yesterday that he wants to extend wage/price controls beyond the scheduled April 30 expiration date. He also plans to freeze new hiring, promotions, and pay increases for executives of the Federal Government, which doesn't affect us, I guess.
(Pause) The Republican National Committee has a new chairman...

137:37:29 Schmitt: How about me?

137:37:33 Fullerton: ...George Bush of Houston, who is now Ambassador to the United Nations. He will continue his UN post through the present session of the General Assembly. Both national political parties are now headed by Texans. As you recall, Robert Strauss of Dallas became Chairman of the

Democratic National Committee last Saturday. And Jack, I'm sorry to say that you've been replaced. The Nimbus 5 weather satellite is now operating in orbit after its launch from Vandenberg early Monday morning.

137:38:06 Schmitt: Can it talk? (Pause)

[Jack had spent quite a bit of time on trip outbound to the Moon looking back at Earth and providing weather reports for the people stuck indoors at Mission Control.]

137:38:10 Fullerton: Joe Namath tried mightily to lead the Jets to the play-offs, but the Oakland Raiders grounded the Jets in the fourth quarter, 24 to 16. I think you have already heard that score. Namath passed more than 400 yards, but New York only scored one touchdown. And the last item concerns the Houston weather. There's been two kinds of weather since you all left us: that's cold and light rain and cold and heavy rain, and it's still doing it. Fog and drizzly rain are here now, and we're only supposed to get up to the mid-40's and probably down to 32 tonight. Over.

137:39:10 Cernan: Holy Smoley! That doesn't sound too good on the weather. I'm going to take a look, right here up the overhead window. (Long Pause)

[This is a small window over Cernan's position on the left side of the LM - the "rendezvous port" which he will use to watch his position relative to the Command Module during the final approach as they return to lunar orbit. From their position at the landing site, Earth is also visible out the front windows, but it is high enough in the local sky that Gene probably would have to bend down to see it.]

137:39:55 Cernan: Gordy, you're right. There's a band of clouds that comes right up the coast of Mexico. Looks like it covers most of the Gulf (of Mexico) and then gets very dense as it comes up into the Texas area and southeastern part of the United States with a counterclockwise rotation which gets very dense down over the Atlantic, I believe, off the southern east coast of the (United) States. And, from about, oh, I'm guessing, maybe the center of Texas straight north and straight east, it looks like the whole country's clobbered.

137:40:35 Fullerton: Rog.

[Cernan - "Things like this little weather report still seem unbelievable. It's amazing to think that somebody was actually up there on the Moon, looking back at Earth and telling people in Houston about their weather. And it was me that was doing it. Unbelievable!"]

137:40:44 Cernan: Baja (California) looks nice; west coast of Mexico looks nice.

137:40:48 Fullerton: Roger.

137:40:54 Cernan: And (at) Taurus Littrow, the weather's great.

[Long Comm Break. During a preliminary, unrecorded discussion about the mission, Jack remembered how bright the Australian deserts were when they were sunlit. He said he hadn't been conscious of the Earth as a clock but did notice what was visible.]

[Cernan - "I was very conscious of the rotation of the Earth while we were on the Moon. If you gave yourself enough time, you could watch it rotate. It didn't have any strings holding it up; it didn't have any fulcrum like a globe spinning on your desk; but you could watch it rotate hour after hour. You could slowly watch certain continents disappear; and you'd realize that you were looking at something new and strange, and yet familiar. Even though so much of it was cloud- or snow-covered, you could still pick out enough of where the blues were to know where the continents were and therefore detect a shape, with the naked eye, from the Moon. And you'd realize that new continents were coming into view. You couldn't sit there and watch it; that would have been like watching water boil. But, literally, over a period of hours - say the eight hours between when we got out of the spacecraft and when we got back in - the Earth rotated a third of the way around.]

137:44:05 Schmitt: Hey, Houston; Challenger.

137:44:08 Fullerton: Go ahead.

137:44:14 Schmitt: Roger. Gordy, how's the ALSEP doing? And, in that light, I hope you people will take as close a look as you can at the signal strength and its variation and see if you get some idea whether, when I go after the neutron flux tomorrow, if I ought to work on that antenna alignment again. I'm still a little bit concerned about it.

137:44:40 Fullerton: Okay, Jack. We'll consider that; although, they've been getting good performance out of the Central Station, as I understand. A couple of problems with the experiments. One was the LEAM data isn't syncing up like it should. I'll have to get a further, more complete story on that. And we're thinking that's...

137:45:08 Schmitt: I'm joking!

137:45:09 Fullerton: ...mostly a ground (meaning Houston) software problem. The other one is the LSG isn't leveling up properly. We'll cover this further in the planning briefing for the EVA here; but we're probably going to let you off...I mean, have Geno let Jack off at the Rover at the ALSEP and take another look at the leveling on the LSG. That'll be at the end of the EVA.

[Schmitt - "The Lunar Surface Gravimeter (LSG) was a very-long-period seismometer which was basically a gravimeter. The Principle Investigator was Professor (Joseph) Weber at the University of Maryland, and its basic purpose was to monitor the free oscillation frequencies of

the Moon, hoping that, when a gravity wave went past, it would excite both the Moon and the Earth simultaneously, and therein would lie proof of the existence of gravity waves. If it had worked and if they had indeed seen a gravity wave go by, it clearly would have been a Nobel Prize class experiment - probably the only one that ever flew on Apollo in that weird environment of Nobel Prizes. Unfortunately, if I remember correctly, the balance beam had a one-tenth-gram error in its design - right from the very beginning. And you might ask why wasn't it tested. And the answer is that it wasn't tested - to see if it would uncage in one-sixth gravity - because the subcontractor had claimed that such a test would reveal some kind of proprietary information about their gravimeter. And NASA let them get away with that! I heard about that when we did our last deployment of the flight hardware down in a big hanger in the Air Force launch area near the Kennedy Space Center; and I pushed them after that deployment to do a test - which you clearly could do, just by tilting the gravimeter, and making sure it would uncage - and they insisted that they didn't need to do that. And I didn't push it and I should have; I blame myself more than anybody. Then, when we got to the Moon and I leveled it and did everything I was supposed to, it didn't uncage properly; and, as we go through EVA-2 and, I think, even EVA-3, I will keep going back there to try things they'd thought of to make it uncage. They didn't figured out until much later - post-mission - that a design error was what was wrong. They kept saying that there was something wrong with the deployment. My gut tells me it used up two hours of EVA time."]

[The total extra time spent at the LSG was about a half hour, still a significant amount of time. The important point, of course, is that the instrument didn't work as planned. According to the Apollo Program Summary Report (JSC-09423, April 1975), "review of sensor records revealed that an error in arithmetic resulted in the sensor masses being approximately 2 percent lighter than the proper nominal weight for 1/6-earth-gravity operation of the flight unit. The sensor mechanism allows a (plus or minus) 1.5 percent adjustment by ground command to correct mass inaccuracies." In a November 5, 1991 conversation and in a follow-up letter, Weber stated that the source of the uncaging error was not a design error but an arithmetic error made during the manufacture of the balance beam by the subcontractor, LaCoste and Romberg. Lacking any definitive NASA documentation on the matter, I am inclined take Jack at his word and conclude that there was a design error. However, no matter whether the arithmetic error was made by the designer or the manufacturer, the lesson of the LSG experience is that, to the extent possible, every piece of flight hardware should be thoroughly tested before launch.]

137:45:49 Schmitt: Roger. I may just run out there and let Gene pick me up after we...(correcting himself) well, while

he fixes the fender maybe. We'll work that out, Gordy. I'm joking, but maybe I could go kick the LEAM; that might help it.

137:46:07 Fullerton: Let's make sure we've got all our problems solved down here before you do that.

137:46:14 Schmitt: Okay. Hey, Family Mountain - the northeast facing slope - although lower, has boulders and outcrops...I mean. Belay the "outcrop".

137:46:32 Schmitt: (Starting the thought again) It has boulders. From (the appearance of the various) local block concentrations, (it) looks very much like the South Massif does.

137:46:39 Fullerton: Roger (Long Pause)

[Schmitt - "I got my mouth in motion before my mind. It's not good grammar; but it's the way we talked."]

137:47:34 Schmitt: (Unintentional key; clearing his throat) The old sinuses are (garbled). (Long Pause)

137:48:33 Schmitt: (Unintentional key) I've about had it, I think.

137:48:38 Cernan: (Garbled) chocolate.

137:48:42 Schmitt: No, I've had two.

[Comm Break]

137:49:49 Cernan: (Edited for clarity) Hey, Gordo. We're still eating, but let me give you a few observations. That outcrop I talked about (before the first EVA) that was way at the top of the South Massif at the break of slope - at the very top of the break in slope...It's hard to tell that it's in-place outcrop up there. It's hard to convince myself that it is. It looks like there's some very large, 3- to 4-meter rocks up there. And a lot of smaller fragments. I see that type of thing in a number of places over the South Massif. However, they all seem...They all seem to be sitting on top of the South Massif surface. But I do see one other area that it looks like it is protruding from within some kind of mantle on the South Massif, so conceivably some of that could be "in place". An additional impression I got is that, at least with the monocular, those boulders look much more angular than what we see here (near the LM) and, for the most part, they appear to be covered by very little mantle - if at all - except for the one I just mentioned.

137:51:19 Fullerton: Okay. Copy that.

137:51:24 Schmitt: And, Gordy, through the monocular, in contrast to the tan-grey of the South Massif, those large blocks up there look blue - fairly distinctly blue-grey - not unlike, as Gene mentioned yesterday, anorthosites look in certain terrestrial environments.

137:51:49 Fullerton: Roger, Jack.

[Schmitt - "Anorthosite is a rock made up primarily of a calcium-aluminum silicate mineral called anorthite, a kind of

feldspar. The sixty-kilometer-thick crust of the Moon appears to be largely anorthosite with olivine and pyroxene mixed up with it; and most of the light-colored places of the Moon that you see from Earth are this crust exposed. Although the outcrops on the Massifs look like anorthosites from the LM, it turns out that, after we looked at the rocks that had rolled down, these blue-grey rocks were blue-grey breccias. They were rocks composed of fragments of other rocks, some of those fragments being anorthosite. We weren't expecting to see whole anorthosites on the Massifs because the Massif rocks were almost certainly (shocked) material which had been thrown out of the Serenitatis Basin, so we weren't quite sure what we would see: big breccias or big chunks of anorthosite. It might have been either. The important observation from the LM was that the exposed rocks on the Massif looked fairly distinctly blue-grey and, later on when we got over there, indeed, the rocks were blue-grey. They were breccias but some of the chunks in them were anorthosite and others were dunite. Dunite is a rock composed largely of the mineral olivine, and one of those that we sampled was - and still is, I think - the oldest rock ever dated from the Moon at 4.6 billion, plus or minus 0.1 billion. And all of that happened over at Station 2 on this second EVA."]

137:51:53 Cernan: And, Gordy, now that I get my three-dimensional eyeballs working, I can look up on the Scarp out to 9 and 10 o'clock (means 11 to 12 o'clock). It's practically the same (tan-grey) color as the South Massif. It just looks to be very undulating; I see no outcrops evident from here. I think I can just about see where Hole-in-the-Wall is but it's so subtle that I can't really tell you much about it. And the local terrain - which I think is the southern rim of Camelot - just about blanks out where Hole-in-the-Wall should be. Just about covers it up. But what I can see in a small little saddle through our local horizon here in front of us...I can see out there just about - oh, I'd say - 100 meters or so to the south of Hole-in-the-Wall. And it just looks like a subtle, undulating slope. We can't really tell too much about the steepness from here.
137:52:56 Fullerton: Okay, Geno, we...(Pause) Standby one. (Pause)

[In the pictures that Gene took from his window shortly after the landing (especially AS17-147-22482), the gap in the Camelot rim begins above Geophone Rock and extends about ten percent of the picture width to the left.]

[Schmitt - "We started naming lunar features on Apollo 8. Bill Anders decided that it would be far easier to remember names than numbers or letters or anything like that, particularly for the pilots who were used to call signs. So I suggested that we start naming the craters on the Farside - the ones that didn't already have names - that were going to be useful in the navigation and landmark siting exercises.

And before we were through we had named an awful lot of craters - for people in the space program and God-knows what else. Some of them were rejected by the international commission (a nomenclature commission of the International Astronomical Union) that deals in naming features on other planets and some of them were ultimately accepted. Then I did the same thing for the Apollo 10 crew when they did their lunar orbit activities. And then all the crews started to get into it, and most of them did their own naming after that, I think. For our mission, I came up with most of the names for the landing site features and Gene added a few. Poppie and Punk were two of his. Again, the international commission accepted most of names we picked but, for example, the name 'Jefferson-Lincoln' Scarp was not accepted because of its 'political nature', and, I think, it is now called the J-L Scarp. On the other hand, the committee didn't understand the political nature of some of the other names and accepted them: Victory Crater is shaped somewhat like a letter 'V' and was named for Churchill; and Camelot was named for John Kennedy."]

[For the Apollo Lunar Surface Journal, I have taken the view, as long as all lunar exploration was being done with telescopes, the IAU Nomenclature Committee had the responsibility of approving names. However, once the landing missions were starting, the prerogative of naming local features passed to the astronauts and their colleagues. As with the names bestowed by terrestrial pioneers and explorers, the choices were sometimes quirky and sometimes repeated existing names, but were always very personal. In all instances, I have either used the names the astronauts used during the missions or names - like Geophone Rock - that came into common, post-mission usage by the Apollo community. Note that the formal names of the Scarp - Jefferson-Lincoln, J-L, Lee, etc, are hardly ever used.]

137:53:07 Fullerton: Okay. I had something for you but we just decided to cancel the call. Although when you do get out the prep-and-post card I have one write-in for you. So just holler when it's handy.

137:53:24 Cernan: Okay. (Long Pause)

[Schmitt - "The prep-and-post card was velcroed to the panel in front of us so that we could use it when we really couldn't use the checklists. You get to a certain point when you're pressurized in the suit where you really can't fumble with the book, so you just read a summary on the card."]

137:54:05 Cernan: We're wrapping up our eating and drinking here now, Gordy. We'll be ready to go in a minute.

137:54:12 Fullerton: Okay.

[NASA's Public Affairs mentions that the crew is about one hour behind the timeline, a holdover from EVA-1. Houston anticipates a start of EVA-2 at 140:10, or about 5 p.m.]

1 4 0 2 3 6 1 7

Central Standard Time. The actual start will be about thirty minutes later than this estimate.]

[Long Comm Break

[Now that they have finished eating, Gene and Jack are doffing their longjohns and are starting the EVA preps by donning their diapers, urine condoms, and Liquid Cooled Garments. They are on the righthand column of Surface 3-8.]

137:57:22 Schmitt: Gordy. Challenger. Could you ask somebody there in the FAO (Flight Activity Officer) console where the hygiene kit is stowed?

137:57:34 Fullerton: Okay. Will do.

[Comm Break]

138:00:01 Fullerton: Jack. Take a look on the right-hand-side stowage compartment, there, on the forward lower corner under the LEC kit compartment. (Long Pause)

138:00:30 Schmitt: Gordy. You broke up with a change-over or something. Say again. (Long Pause)

[As the Earth rotates under the Moon, the communications link is transferred from one terrestrial receiving station to another. There is a momentary loss of comm right at the handover, in this case from Madrid to Goldstone.]

138:00:59 Fullerton: Okay, Jack. You're right; I got caught right in the middle of a site handover. Look on the righthand side stowage compartment, forward lower corner, under the LEC kit compartment.

[This compartment is on the lower right bulkhead next to Jack's station.]

138:01:16 Schmitt: Fantastic! You picked the one place I'd never looked.

[Long Comm Break]

[Schmitt - "We probably spent thousands of hours in the LM simulators. Full-up simulations were relatively rare - only a few per mission - but we went through the critical phases over and over again. Depending on how complex each phase was, we would adjust the amount of time we spent. Also, if the console people felt we needed more time, they would recommend it. Even though we didn't run through the EVA preps and cabin configuration checks quite as much as some other phases of the mission, through the years I did an awful lot of them because, before I was assigned to a crew, I would check LM stowage for other crews. These were called Crew Compartment Fit and Function checks - 'C-squared/F-squared' or even 'CF-squared'. Mostly these were done with the LM or a mockup fully configured, but there were times when some of the hardware simply didn't appear until fairly

late and we would be using non-flight mock-ups or non-flight hardware as a substitute. Early on, the crews tried to force everybody to use flight hardware near the end, just to make sure that they never flew with anything they hadn't seen and which hadn't been fitted into the spacecraft and exercised in the ways that they would use it. In the early days the crews had been bitten by things that suddenly appeared and wouldn't work. That's where the whole concept of a C-squared, F-squared came about, I think.

"Grumman would do a C-squared/F-squared before they shipped a flight LM and I often went up to do those. Fred Haise and I did several together. He and I were good friends and he would ask me to come up and do them with him. Some were done in shirtsleeve and some were done in the suits. And then we did vacuum chamber checks where we put the lunar module in a pressure chamber at Houston or the Cape. That was a major test, and both flight crews, Prime and Backup, would do those. The exception might have been Apollo 17 where John Young and Charlie Duke had just come off of Apollo 16. As I recall, they opted not to do those sorts of things."]

138:05:57 Schmitt: Houston. Challenger.

138:05:59 Fullerton: Go ahead.

138:06:03 Schmitt: One quick thought about the gravimeter (the LSG). And I'm sure it's been mentioned, but I'll say it. During the CF-squared, we asked about that bundle of wires that has contact with the gimbal. And when I deployed it, that bundle still had contact with the gimbal and everybody at the CF-squared said that was okay. But, you might think about it. I don't know what I could do to help if that is the problem. But that might be causing the problem here that it wouldn't cause on Earth.

138:06:37 Fullerton: Okay, Jack. I'll make sure the experts hear that. (Long Pause)

138:06:55 Cernan: Gordy, everything okay at home today?

138:07:02 Fullerton: (Misunderstanding the question)

Yeah, everything is fine here.

138:07:09 Cernan: Well, thank you.

138:07:15 Fullerton: I'm not sure I copy your question precisely. Haven't talked to your home today, at all.

138:07:27 Cernan: Okay. Don't worry about it. I just thought you might have heard.

[Comm Break]

138:09:33 Cernan: Well, if you hear, Gordy, just tell them they're missed.

138:09:39 Fullerton: Okay; I'll sure do that. (Pause)

138:09:48 Schmitt: Gordy, has anybody heard from Tucson recently?

138:09:51 Fullerton: Check on that, Jack. Just a minute. (Long Pause)

[Jack's mother was staying with his younger sister in Tucson at the time.]

138:10:36 Schmitt: And, Gordy, if you have any updates to the EVA-2 checklist, give me a yell.

138:10:44 Fullerton: Okay, the update I do have...I think the EVA checklist changes, we'll just call you, real time. But, I do have one for the prep card. (Pause)

138:11:03 Schmitt: Go ahead.

138:11:07 Fullerton: Okay. On the front side there, middle column, lower half at "138:45 OPS Connect", half-way down (also on Surface 4-5), it says "install Purge Valve in PGA, red to red". Mark that LMP serial number 211; CDR, 208. This is to maximize the OPS operation, should you have to use it.

[Schmitt - "This probably means that each purge valve was optimized to a particular suit flow system, and they wanted to be sure that we each had the right one. We had taken the valves out at the end of the first EVA, and part of the EVA 2 prep was to put them back in."]

138:11:44 Schmitt: Okay. Give me the numbers again, please.

138:11:45 Fullerton: LMP, 211; CDR, 208.

138:11:56 Schmitt: I take it those are serial numbers.

138:11:58 Fullerton: That's right, the serial numbers on the purge valves.

[Comm Break. Astronaut Robert Parker takes over as CapCom.]

138:13:07 Parker: Okay, Challenger. This is Houston. Would you like to have a little update on the EVA plans?

138:13:15 Schmitt: Do you want me to take notes?

138:13:18 Parker: No, I don't think there are essentially any notes required. I'll make a few real-time callups to you; but, I don't think there's anything you really have to write down.

138:13:31 Schmitt: Okay, Bob, I realize that things were getting a little hectic yesterday. But, if we end up making any changes where I don't need to get a (seismic) charge in my hands, that's an awfully good thing to call; because not only does it tire your hands out holding it, but it means you don't get as many pictures or Rover samples or anything else.

138:13:54 Parker: Roger. You guys are just ahead of us there. We were trying to get that up to you.

[Parker reads most of the following.]

138:14:00 Parker Okay. No, I don't think there is anything here that really needs to be written down. I'll go through (it) with you first, and we can talk about details and writing in (notes), if you want to, on any of them. But, I don't think there is anything that really needs to be

written in (the checklists). The EVA...It is going to be essentially nominal, with two minor exceptions. One is we've allowed about 5 minutes extra at the LM, before leaving, for the Rover fender fix; and John will be talking to you about that in a minute. And the second big change, is that we're also allowing 5 more minutes at the end of the EVA so that we can have extra time for dusting. And I suspect that, if the Rover fender fix works and we aren't getting as dirty as we did last night, then we may gain back that 5 minutes. We're also allowed...What we've done is we've taken the time here (at the LM) out of some of the tasks at Station 3 and Station 4. And, along with the fact that we think you're a little bit farther east than planned, we're allowing 4 minutes additional driving time. But again, that's all real time, and if we're doing well on time, we can reinstitute all those tasks and get rid of the 5 minutes that we are allowing here, there, or elsewhere. So that's just sort of to keep in your thinking.

[Houston still isn't sure of the exact landing point and is making an allowance for up to a quarter kilometer of driving at a speed of 7-8 kilometers per hour on both the outbound and inbound legs. This estimate is actually quite close to the truth.]

138:15:24 Parker: There is a possibility that we'll have some additional overhead at each stop, depending on what the Rover battery temperatures are when you get out this morning. If they're high again, then we'll have to probably park - at least on some of the stops, if not all - with the up-Sun heading and dusting the battery covers and then opening them to let them cool. But, again, that will depend upon what we find on the Rover batteries when we get out this morning.

[The Rover battery covers are hinged at the front so that, with the Rover facing up-Sun, the open covers shade batteries and let them radiatively cool more quickly.]

138:15:53 Parker: The variations that we found on the surface of the South Massif indicating a possibility of layering - I guess you saw those mostly with the monocular - and the observation of boulder tracks and the size of the Massif emphasizes the importance of sampling boulders that can be traced to sources at various elevations on the Massif. And I guess we should say that's "hopefully". And we'll just have to see what happens when we get down to Station 2 on that. But, if we see boulders with tracks, I'm sure you guys remember that they obviously will have a higher priority. Since we didn't get to Emory, and since we didn't really get to the rim of Steno itself, the question of sampling of the actual subfloor is still somewhat ambiguous although there is a large consensus opinion that says that we sampled the subfloor when we sampled that intermediate gabbro yesterday at both the ALSEP and Station 1. There is a possible

alternative conclusion which says that the subfloor has not been sampled, but that these blocks that we sampled and the surface are both parts of a later flow. And, in that line, we're still looking for specific observations which will help us distinguish whether or not the dark mantle is a separate unit from the intermediate gabbro that we're seeing or, whether it's the...Stand by. (Pause)

138:17:30 Parker: Okay. Or whether it just represents the top of (a) very well churned up layer of a flow that was later than the subfloor, if you see what I'm saying there.

All this says is that we're very interested, of course now...

138:17:51 Cernan: Roger, Bob.

[As mentioned previously, the ejecta blanket surrounding a crater represents an overturned section of the original stratigraphy. Materials which were originally on the surface form the bottom of the blanket and, generally, are exposed only at the outer fringe. Materials dug out from the bottom of the crater form the top of the blanket, at least close in to the rim. Because they didn't actually get to the Steno rim, they weren't able to get samples from the deepest parts of the crater.]

138:17:54 Parker: All this says that we're very much more interested in Station 5 (at the rim of Camelot), as you might expect, than we were before. And I guess, for this reason, we'll be trying to keep to the time line a bit tighter than usual to guarantee that we've got some time left over at Station 5. And, we're also interested in perhaps moving Station 5 from its present location there in the southwest of Camelot over to the southeast or east or some location where we have a feeling that we've got big boulders up on the rim.

[Schmitt - "Camelot is about 600 meters in diameter, which means that it probably penetrated to about 150 meters depth. Because the regolith wasn't going to be more than a few meters deep in most places, Camelot was sure to have dug deep into the subfloor material. As I recall, we saw the boulders as we drove by on our way to Station 2 and that, later on, then influenced the actual choice of the Station 5 location. They hadn't anticipated that we would see boulders when we drove by Camelot because there hadn't been any evident in the pre-mission photos, only some variations in brightness which suggested that we would find boulders on the southeast rim."]

138:18:30 Parker: This would be so we could sample, hopefully, some of the white material and some of the boulders together and get a better confirmation that the material from deep in the subfloor unit is this intermediate gabbro, as opposed to just material from the upper part of the subfloor. It's just a matter of proving to ourselves whether or not the boulders we sampled yesterday are from deep within the subfloor, or only at the surface of the

subfloor; or, perhaps, as I said, the other alternative being that the intermediate gabbro is part of the dark mantle, and we're seeing a churned-up regolith on top of it...sort of being the gaseous upper part of the flow having been broken down rather rapidly into the dark mantle. (Pause) Okay, stand by a minute.

138:19:14 Parker: Okay. To summarize that again...I guess I got ahead of myself here in the little spiel they (the team in the Science Support Room) wrote up. At the present time we have two working hypotheses for the dark mantle and gabbro relationships to each other. One: the crystalline rocks that we found - the gabbros - are an upper unit of the subfloor with their dark mantle cover unrelated to them in time. Key observations that they suggest here are stratigraphy at Camelot - Station 5 - and other deep craters. Especially, perhaps, (dig) a trench in sheltered spots which are ungardened (undisturbed by micrometeorite impacts) - as in "plowed" - (and look) for an older regolith underneath the dark mantle, if such a thing could be found. We don't think we found that yesterday. Or, (take) a look at the superposition relations between dark mantle and boulders. Are there instances of the mantle on the boulders or, inversely, of small boulders on the mantle?

138:20:06 Parker: The second working hypothesis is that the dark mantle is regolith derived from a vitreous, vesicular, (basalt) flow top of the crystalline rock flow beneath. And, it (the write up from the Backroom) again goes (on) to say that perhaps the gabbro we sampled yesterday was indeed the late flow; and the regolith was derived from the vitreous, vesicular flow top, as it were. Again, many of the same observations are called for. In particular, they'd be interested then in looking at the coarser fines as they define as (being) from a millimeter to 20 millimeters (in grain size), for some sort of transitional lithologies and textures. In other words, what do the small, walnut-size rocks look like, if you can, in hand specimens?

[Cernan - "All of this came from the Backroom, where the scientists and geologists had looked over our first EVA. It seems as though they could have shortened what they read up to us, but it was like getting a debriefing from them. And we were eating and doing other things and it didn't hurt to listen. And it gave us an idea of their thinking, which was important."]

[Schmitt - "What Bob was probably reading was a piece of paper that the science room sent in. Lee Silver or Gordon Swann or Bill Muhlberger put together something that was then severely edited. This discussion is another illustration of the literal universal importance of superposition in a gravity field. Most of what we do as geologists on Earth is look for evidence of superposition or cross-cutting relationships. And here we're talking about the same thing on the Moon. Their thinking was almost entirely about 'how

do we find out what units lie on top of what other units'. That is superposition.

"I think that what had been surprising was that we had seen no evidence of the dark mantle. It had been so obvious in the pre-mission photographs - particularly in Lunar Orbiter and Apollo 15 photography of the site and even in photographs taken from Earth - that everybody thought that when we stepped out that we would be stepping onto the dark mantle and it would be obvious that it was dark mantle. Well, it wasn't obvious that there was dark mantle there. So, now, they were thinking about the observations we made the day before and they were trying to come to grips with what we saw - the regolith and this intermediate gabbro - and they were trying to summarize their hypotheses. As I've mentioned, the dark mantle question was not really answered until we got to Shorty and put the core tube down into the orange soil. When we pulled it up, the lower 50 centimeters or so of the 70-centimeter tube were dark - (almost) black. And right then it appeared that maybe that - whatever that black soil was - was a contributor to the dark mantle. And later on, it turned out to be devitrified orange soil - glassy, pyroclastic debris, volcanic material that is liquid when it is erupted and which hardened and/or crystallized as it fell back to the surface, a process similar to fire-fountaining that we see in Hawaii. Throughout the region, there was enough of this pyroclastic debris mixed in the regolith to give it - from a distance at least - the appearance of a dark mantle. And, in reality, it is a dark mantle! It has just been mixed up so much with ground-up subfloor material that there wasn't much of it left that you could see as a unit.

"The dark mantle isn't localized in Taurus-Littrow but is found all along the east, southeast, and southern rim of Serenitatis where there are a lot of grabens and graben faulting along which you apparently had volcanic eruptions of this material. And then as you get into the south and southwest portion of Serenitatis, it changes to large area-deposits of orange and red glass, similar to the orange pyroclastic material we saw at Shorty. The large areas of orange were noticed by Ron after I saw the orange soil in the valley of Taurus-Littrow; and then I spent a lot of time defining it and checking it out once I got back into orbit."]

138:20:52 Parker: If I can get more specific in terms of EVA mechanics, let me say that we'll call out - in real time - the deletion of the tasks at Stations 3 and 4, if they become necessary. And what we're planning on doing is: deleting the trench in the base of the scarp at Station 3, and also deleting the radial sample on Shorty (Crater) at Station 4. That's provisionally what we're planning on. And depending on how the time is going, we'll call that out real time. We also have...The (EVA) experiments remain pretty much the same. We'll deploy the charges at the same

locations as we're planning in the checklist at the present time.

138:21:35 Parker: For your planning further ahead, we don't anticipate any significant changes in EVA 3. The charge number 5, which we were going to deploy at Emory but didn't, will not be deployed during EVA 2, but we'll deploy it on EVA 3 out at station 10. And, what we're going to do there is, when you take the eighth (that is, 1/8) pounder and put it between the seats, we'll then have the 3 pounder (charge number 5) left over, and we'd like to put that on one of the footpads in the Sun; that's probably either the minus-Z (east) or minus-Y (south) footpad. And, we'll leave it there in the Sun until the start of EVA 3, in which case we'll put in the Rover underneath the LMP's seat. And, thermally, that looks okay.

[At the start of EVA 1, they loaded a pallet containing four charges - numbers 4,5,6, and 7 - on the back of the Rover. They planned to deploy all but number 4 on the trip out to Emory but, because of the shortened traverse, also did not deploy number 5. Now, they will put number 4 between the seats - as planned - for deployment early in the EVA 2 traverse and will save number 5 for EVA 3.]

138:22:17 Parker: There is a probability that we're going to play the "return to the ALSEP game," and we're going to do this for a couple of reasons. One, we're going to go back and look at getting some more ALSEP photos. I guess Gordy says you've got that. And, that will probably be - in fact, it will certainly be, if it happens - at the end of EVA 3 when you go back to get the neutron flux probe. I might also say with regard to EVA 3 that, obviously, we're more interested in Station 10 than we were before.

[Station 10, Sherlock Crater, will be a chance to sample the subfloor if, for some reason, good samples aren't found at Camelot.]

138:22:48 Parker: Another "return to the ALSEP" goodie that we're looking at - if we have the consumables today when you get back from finishing Station 5 - is that the Lunar Surface Gravimeter has been unable to level itself over the night; and they sent some, you know, some thousand commands trying to get it straightened out, and they say it looks as though it's not level. And, so, we'd like Jack to go back with his practiced hand-on-bubble-levels and recheck that after Station 5 today, if there's sufficient consumables. And, we've planned for Gene to just let Jack off and let him walk back to the LM, after he gets off and looks at that.

138:23:26 Parker: And, that's (pause) about everything we have. As I say, in summary, the big changes are going to be extra time at the beginning, taking care of the fender extension, and the probability of extra time at the end. Although we'll have to see how well the fender works and how

things go. The probability of extra time at the end (is) to allow for dusting. And the time spent on those particular activities we'll probably end up taken out of the task at Station 3 and Station 4. Over. Comments?

[By now, Gene may have begun to attach his biomedical sensors.]

[Cernan - "We almost never had time to just listen to somebody talking; we were always busy. We ate, we cleaned visors, we put on the biomed stuff. We didn't always have to tell Houston exactly what we were doing; they knew that from the checklists. We were always, always busy in that cockpit."]

138:24:12 Schmitt: Okay, Bob. We copy all that. Obviously, you're going to have to catch us in real time on some of the details there...on the charges and the task deletions. One question: did you say we were going to delete the trench at Station 3?

138:24:30 Parker: Roger. The trench at the base of the Scarp, in other words, some of the stuff that you would be doing while Gene was taking the double core.

138:24:39 Schmitt: What do you gain by that?

138:24:42 Parker: Well. No comment on that, Jack.

138:24:51 Schmitt: If you haven't deleted Gene's tasks, then what am I supposed to do?

138:24:56 Parker: You're supposed to help Gene, I guess.

138:25:01 Schmitt: Well, but that's not the way we worked it, Bob. Let's play that one in real time.

[This is the seed of Jack's Station 3 frustrations.]

138:25:05 Parker: Roger. That's why I said there's no point in marking up the checklist on that, Jack. Let me hit you with one more thing concerning the battery temps. An initial reaction down here is that the battery temps were high on deployment because of particularly unfavorable heat soaking on the way out. And the Marshall people are hopeful that they'll be back to normal this morning. However, we're obviously anxious, as I'm sure you are, to get an early reading on the battery temps...that's number 1. And number 2, just for the off chance that the meter's not working, (although) I think we've pretty much discounted that, because of the way the meter worked yesterday...But, on the off chance that the meter's not working, you might just lean over and see if the meter is reading zero before you punch in the circuit breakers, because that would give us at least a partial confirmation in that direction, that there's not something wrong with the offset. If they're sitting there reading 30 to 40 degrees, then that probably says something about the offset. And, beyond that...

138:26:02 Cernan: Yeah, that's...

138:26:03 Parker: Go ahead.

138:26:08 Cernan: I'll look at that, Bob, what the meter has indicated in terms of a temperature change. I'll look and see if there's a bias on them at all.

[In general, although not exclusively, it is Gene who takes responsibility for spacecraft and Rover matters and Jack who takes responsible for geology.]

[Schmitt - "I don't think it was anything more than the way things worked out. As I recall, we didn't sit around and establish that protocol. But it seemed to work pretty well."]

[Cernan - "Jack might have spent more time than I did on the EVA planning, but we were all involved. I involved myself mostly in the operational side - where we could go, what we could do - and left the geological side to the people who knew a lot more about it than I did. During planning and training, the CapComs worked with us as though they were going to make the traverses themselves."]

138:26:15 Parker: Rog. We again also think that that's probably not too likely. (Pause)

138:26:26 Schmitt: Bob, I think, based on what I saw yesterday, that the chances are pretty good that all the big blocks out here in the dark mantle area will be pretty much the gabbro. By the way, I looked at that with a hand lens last night, and I don't know that you got the report, and I'm back to saying that it's probably closer to 30 to 40 percent plagioclase. It's probably just a good gabbro, a clinopyroxene gabbro, and it apparently has a fair amount of ilmenite in it. There's some bright, shiny flakes within the vugs and some dark minerals in the matrix that are probably ilmenite.

[Cernan - "Although we were all exposed to these geologic terms and trained pretty hard - particularly if you'd trained as part of a backup crew or a prime crew as I had on Apollo 10, 14, and 17 - you wouldn't find anyone but Jack who would make a statement that would include words like 'clinopyroxene gabbro with a fair amount of ilmenite'. Now, you'd find people who would know enough about what they were seeing to say 'there's bright, shiny flakes and dark minerals in the matrix; but the precision is going to come from somebody like Jack who has used the terms all his professional life and who, therefore, uses them with a great deal of confidence. That's the advantage of having a geologist on the surface; in real time, Jack could give the people in the Backroom a much clearer picture of what he was seeing than the rest of us usually could."]

138:27:09 Schmitt: And one other additional possibility then, is that the mantling we're seeing here is just dark, fine glass - darker than usual, because of the iron and the titanium in the rocks themselves.

[Schmitt - "I'm getting closer to the truth than they were with this statement. This is exactly what the little beads of glass happened to be. They had a very high titanium content and were dark because of it. A lucky call."]

138:27:28 Schmitt: Also, the probability, I think, still has to be considered that you're dealing with a true mantle that has been gardened enough that, at least where we're seeing it now - in the first few tens of centimeters (of the soil layer) - that it is unrecognizable as a mantling unit yet. The relationship to the large boulders is, I think, one right now of just filleting and a small amount of covering because of the local gardening process. We haven't seen any clearly mantling relationships between the dark mantle or the surface materials here and the large boulders.

138:28:18 Parker: Okay. Copy that. And, we'll be anxious to see what else you find out today. And one last word for your interest: the Marshall people have decided to allow us to go to 140 degrees on this EVA with the batteries, if necessary.

138:28:35 Cernan: Okay.

138:28:40 Parker: Okay; now John (Young) would like to talk to you about the fender fix.

138:28:43 Cernan: Okay. Hold on for 30 seconds. (Long Pause)

138:29:22 Cernan: Hey, while John's talking to me, why don't you check my biomed out. We're going "left".

[Houston can only look at biomedical sensors on one of them at a time. Gene is setting a telemetry control switch so that they can look at his sensors. Gordon Fullerton rejoins the conversation.]

138:29:28 Fullerton: Okay, fine. We'll take a check, Geno. Let me ask you one question here on Jack's PLSS water fill. We're showing about 3 pounds too much water in the LM system, and we're wondering if you got the Aux tanks filled up in Jack's PLSS. Two questions. Were you sure to have the Aux valve open and did you see good clear water in the sight gage with no bubbles after the fill? Over. (Pause)

[Schmitt - "There was no active sensor to show you whether the PLSS was filled or not; there was just a little bulb that you looked at to see if bubbles were coming out as you filled it; and when the PLSS was full there should have been clear water in there."]

138:30:09 Schmitt: I guess we'd have to say "yes" to those questions; but if you've got a question on it we can go through it again. I'd rather do that than take a chance (on running out of cooling water during the EVA).

138:30:21 Fullerton: Let me make sure we want to do that. While we're making sure, I checked with both homefronts. Nassau Bay and Tucson are both in good shape. Geno, Tracy

upstaged you for about 30 minutes last night on local TV during her own interview there, and drew everybody away from watching EVA during that time. She did very well.
138:30:48 Cernan: Yeah, that sort of figures.

[Cernan - "My daughter Tracy was nine years old at the time of the flight and she was interviewed by Jim Hartz of NBC who was covering the flight for the Today Show. She was on for about ten minutes and I have a tape of it. She had been three at the time of my first flight (Gemini IX) and was much too young to understand what was going on. She was six for my second flight (Apollo 10) and has a few memories of it. But, for this one, she was old enough to be very involved. It's heartwarming to watch the tape; there she was and there we were on a TV monitor in the background, walking on the Moon."]

138:30:50 Cernan: Hey, Gordo, why do you say "Jack's PLSS"? Did you see the water drop in the LM when we charged mine?

138:30:58 Fullerton: It was the profile of the water quantity as you were filling both PLSS's, and it was the fill during Jack's fill that looked suspicious...like just maybe 3 pounds less than there should have been (of) flow when you were filling Jack's.

138:31:19 Cernan: Yeah, well, you know it's only (a) passive (means) to know whether or not you've got it filled. I sure don't want to go out there and have him just have some partial water. So let's do the conservative thing.

138:31:29 Fullerton: Okay. I'll verify that. There was some drinking water going out at that time, too, which muddles up the data a little bit, so we're not absolutely certain on that.

138:31:45 Cernan: Okay. We weren't drinking water while we were filling the PLSS, however. (Pause) Okay. You come up with what you think's best on that, and I'm ready to copy John.

138:32:00 Young: Okay, Geno, I don't think you need to copy this. Sort of just ad-lib it. With your four chronopaque maps, tape two maps and allow about a 1-inch overlap to a 15-inch by 10-1/2-inch configuration.

[Two 10 1/2 x 8 inch pages will become one 15 x 10 1/2 piece.]

138:32:20 Young: That's an estimate. And then repeat with two other maps, and then tape the two maps - now four maps - tape them together, and you'll end up with a sheet that's about 15 inches by 19 inches, a sheet of chronopaque. And then tape both sides of it - the overlapping edges - to strengthen it. And you can further strengthen it if you tape an "X" of tape across both sides of it.

138:32:55 Young: And then, on the roll up, on the long axis, secure it with a strip of tape and put it in the ETB. And, on that strip of tape you secure it with, be sure and

leave a tab on the end of it so you can get it off with your gloves. And then remove clamps from both the utility light units, and open the clamp jaws to max. And then tighten the mounting bracket that you've got on it so (that) it will be swinging around; and stow the clamps in the ETB. You got that, Gene?

138:33:39 Cernan: Yes, sir.

138:33:43 Young: Okay. Now you've got everything you need. And it's all put together and all ready to be fastened to the Rover. And then when you get the ETB in the (Rover) seat, you unroll the chronopaque sheet and you locate the front edge - with the long axis fore and aft - even with the axle. And you lay the edge of the sheet over the inboard guide rail and you clamp it. And you lay the other edge of the sheet over the outboard guide rail and clamp it. And, as I said, the inboard clamp must be directly over the axle to avoid interference while steering. And tighten the clamps securely, both of them. And then while you're driving around out there by yourself, it would be good if Jack could take a look at it and see if you're getting any unusual dynamics. And at Station 2, you should inspect the fender for any unusual wear that might have been caused by this mass out there on the fender, of those clamps bouncing up and down.

138:34:50 Young: One thing about it, doing it in a suit, Gene, you have to push in with your leg and hold; and it's sort of a two-handed job. And I'm not sure in 1/6 g if you can position the fender, the pseudofender, on there without Jack, say, holding on to the long end behind the Rover so that won't fall off. It works okay in one g for one man. But I'm not sure it's not a two-man proposition in 1/6. Over.

138:35:27 Cernan: Okay. We'll take a look at it, babe.

138:35:30 Young: Okay, and you really have to bear down to get those things (the clamps) on the dovetail (guide rail) there.

138:35:38 Cernan: I just want to make sure of the geometry now. We want to take two of those pages and put the 10-inch sides together overlapping, right?

138:35:50 Young: Yes, sir.

138:35:53 Cernan: Then take two more and put the 10-inch sides together overlapping, right?

138:35:57 Young: That's true.

138:36:02 Cernan: And then take those two pieces you've got now and put them end to end, so you've got a long fender. Sounds right to me. Sound right to you?

138:36:13 Young: Well, you end up with all four pieces in a big rectangle. You see what I'm saying? You've got a 15-inch by 19-inch sheet of paper.

138:36:37 Cernan: Yeah, we got it. We got it, John. And I copy the overlap and everything. If you had no overlap, I guess you'd have about 16 by 20.

138:36:44 Young: That's correct. But you need to overlap, and taping both sides of it gives it more strength, which you need in that situation. (Pause) You just want to make sure

it's not more than an inch, or you won't have enough to cover up those dovetails. (Pause)

138:37:11 Cernan: Okay, babe, we're going to work on it right now. (Long Pause)

138:37:25 Fullerton: Jack and Gene, this is Gordo again. On the PLSS charge, we're recommending you hook up Jack's according to the decal. Go right ahead and...Stand by one. (Pause)

118:37:43 Fullerton: Okay. Go by the decal and do the full 5-minute fill on Jack's PLSS. It'll take that long to get the Aux tanks filled up, if it was indeed empty. And maybe that's something you can start and (also) work on the paper (chronopaque) taping. Over.

138:38:05 Cernan: Okay.

[There are decals stuck on important pieces of equipment with summaries of procedures. They are going to assume that the PLSS AUX tank is empty and attempt to fill it for the full five minutes that it would take to fill were it empty. This was the most conservative procedure to follow; and there is no danger of overflow if it is already full or nearly so.]

[Comm Break]

138:40:30 Schmitt: Okay, Gordy. I'm on step 4 on the decal...(Correcting himself) Step 5 on the decal.

138:40:37 Fullerton: Okay, Jack. John Covington advises that the sight gage is not a certain indicator that you're filled; and so we're just going to go by time to be sure, and kind of disregard the sight gage readings - as a positive indication anyway.

[Cernan - "John Covington was a member of the support team, a PLSS specialist. A good man; he's still at Johnson. All the people on the support team were invaluable: the suit techs, the guys who helped stow the LM, the guys who helped devise the procedures, the guys who helped us train on those procedures. You couldn't do a mission like this without them."]

138:41:00 Schmitt: Okay, understand that from the past, and we went exactly by time before. We'll try it again here.

138:41:06 Fullerton: Okay.

[Long Comm Break]

138:45:41 Schmitt: Okay, Gordy. Is that about 5 minutes?

138:45:46 Fullerton: Stand by. I'll see if anybody timed you here. That's affirm; 5 minutes now. (Long Pause)

138:46:39 Schmitt: Okay. Step 7 is complete.

138:46:46 Fullerton: Okay. And we did not see any water flow to speak of, so it probably was full.

138:46:58 Schmitt: Yeah, the condensate indications here were that it was full.

138:47:07 Fullerton: Okay. It's better to be sure.
138:47:11 Schmitt: No question.

[Comm Break]

138:49:38 Fullerton: Geno, this is Houston. We want to be sure to have one look at your Biomed before you get into the suit in case something's wrong with it. And if you go right by the checklist, we'll miss that look. So when you get to a convenient place, if you can go to Left and have us take a look at it, we'd appreciate it.

138:49:59 Cernan: Gordy, apparently you...Okay. Stand by. (Pause) I called it out, (but) I didn't give it to you. Stand by one. (Pause) Okay. Now it's yours.

138:50:30 Fullerton: Okay. (Pause)

[Schmitt - "Any time we gave Houston the ability to read a sub-system or, in the case of the computers, to update the memory, we'd say 'it's yours'. It was a sort of gratuitous thing: 'through our generosity we have given you access; and just remember, we can cut you off.' And that was true. Ours was a manned spaceflight program. The fail safe was always to the man. Up until recently, Soviet program has been just the opposite. They relied primarily on the automatic system or on ground control and it cost them on several occasions, cost them some people."]

[Cernan - "A lot of people get fooled by the words 'Mission Control' and think that the ground controlled our spacecraft. Really, it was our 'management advisory office' back here on Earth. With telemetry they could read all kinds of information that we didn't have in the cockpit, largely because of weight constraints and the complexity of the spacecraft; but we were the ones who were flying the spacecraft. We had computers to do a lot of things for us, and we got a lot of information from the ground; but, ultimately, it was the crew that had to tell the spacecraft what to do. In the U.S, the battle for crew control of the spacecraft had been won in the early days of Mercury. Now, I could have put the spacecraft in a configuration where the computer could have done the landing, but it wouldn't have known if it was going to land on a rock or in a hole. And there's no pilot in the world who would have traveled a quarter million miles only to let a computer do the landing."]

138:50:41 Fullerton: That (biomed telemetry) looks good, Geno. You can press on with the suiting operation, there.

138:50:53 Cernan: Okay. (Pause) Call me the little old fender maker.

138:51:07 Fullerton: Roger.

[Comm Break. Gene is now making the replacement fender.]

138:52:06 Schmitt: S-Band Voice going to Voice.

138:52:08 Fullerton: Roger.

[Long Comm Break. When they go to Voice, the comm quality improves dramatically.]

138:58:47 Fullerton: Jack, Houston. With respect to the PLSS water fill, last thing we heard you say was "doing step 7". We just want to verify that you did go ahead and do step 8, which is connect the waste management system to the PLSS Aux vent for 10 seconds. Over.

138:59:03 Schmitt: Yes, that was all done, Gordy. We just got side-tracked, and I didn't call you.

138:59:08 Fullerton: Okay. Thank you.

[Very Long Comm Break as they don the suits. Procedure details are on Surface 3-9.]

[Schmitt - "Thinking back to what's interesting about the old exploration reports, it's a lot of this stuff. It's the whole environment in which the exploration is taking place, all the distractions. The one thing that people forget is that the EVA's were not seven and a half hours. On either side of that was significant pressurized time. We were still in the suits before and after depress and repress and working in that suit was work."]

139:20:09 Cernan: Okay, Gordo. Jack's coming up (on comm), and I'm going off the air. (Pause)

139:20:17 Schmitt: Okay, Gordy. LMP is suited, and...Stand by. (Reading the Personal Radiation Dosimeter numbers slowly, one at a time) 24128. PRD is 24128. (Long Pause)

139:20:44 Schmitt: Hello, Houston. Did you copy the LMP?

139:20:50 Parker: Roger. Copy. 24128. (Pause) How come you guys are not on "Flight Director" like I am? (Long Pause)

[Parker had switched to the wrong communications channel.]

139:21:23 Cernan: And, Bob, 17040 is Commander.

139:21:25 Parker: Say that again please, Geno.

139:21:31 Cernan: The last two digits are 40.

139:21:34 Parker: Copy that.

139:21:39 Cernan: 17040.

139:21:41 Parker: Thank you.

[Long Comm Break. Houston estimates that they are about one hour and twenty minutes behind the flight plan timeline. Astronauts Tom Stafford and Charlie Duke have joined Parker, Young, and Fullerton at the CapCom console.]

139:31:40 Schmitt: Bob, how do you read the Biomed on the LMP?

139:31:44 Parker: Stand by, Jack. (Pause) It looks beautiful, Jack. I think that means "loud and clear".
 (Pause) And, Challenger, have you changed your ECS
 (Environmental Control System) LiOH can? (Pause)

[The lithium hydroxide canister removes carbon dioxide from the cabin air and must be replaced after about 40 person-hours of use. The current canister has been in use since Gene and Jack first entered the LM in orbit at about 107:40 - about 22 hours ago. Subtracting off the EVA time when the ECS was not in use, the canister has been in use for about 30 person hours.]

139:32:20 Schmitt: Bob, we did not. I guess we missed that in the checklist.

139:32:25 Parker: Okay. That's sort of towards the end of (page) 3-9. (Long Pause)

139:32:58 Schmitt: Bob, I guess we're not quite there yet.

139:33:03 Parker: Okay. Copy that.

[Long Comm Break]

139:39:14 Schmitt: Okay, Bob. The canister's changed.

139:39:16 Parker: Roger. We saw that. Thank you.

[Comm Break]

139:40:24 Schmitt: Okay. Biomed's Left.

139:40:26 Parker: Okay. Copy that.

139:40:29 Cernan: Bob, how do you read me?

139:40:30 Parker: Loud and clear, Geno.

139:40:35 Cernan: Okay.

139:40:36 Schmitt: Battery management's going.

139:40:37 Parker: Roger. (Pause)

[Gene is now in his suit. The battery management procedures are on Surface 3-10. There are five batteries in the Descent Stage and, at intervals during the mission, Jack checks their health and switches them on in various combinations to even the power consumption. During the rest period, batteries 1 and 2 had been on line and batteries 3, 4, and L were off line. Here, he will check the voltages of the separate pair of batteries used to power the explosive devices used to separate the LM stages just prior to lift off; and then, with Houston watching, he will bring batteries 3 and 4 back on line.]

139:40:44 Schmitt: 37.2; both batteries.

139:40:47 Parker: Okay, Jack. Just like always.

139:40:50 Schmitt: PCM is High (bit rate). (Pause) You ready for the batteries?

139:41:05 Parker: Stand by. We're still trying to acquire the High Bit Rate. (Long Pause)

139:41:40 Parker: Okay. And, Geno, we have good data from you on the Surgeon. (Pause) And we have High Bit Rate.
 139:41:47 Cernan: Well, that's good to hear. I got good data up here. (Long Pause)
 139:42:15 Parker: Yeah, we're Go to do the battery management now, Jack. We've got the High Bit Rate.
 139:42:24 Schmitt: Roger. (Pause)
 139:42:30 Parker: And a thought for the day. We're not sure that there is going to be any need for the scissors outside today. And if you guys wanted to keep from picking them up off the ground and worrying about them, you might just leave them inside if you haven't packed them already.
 139:42:45 Cernan: Bob, you never know! We're going to take them out with us. So just make a note that we bring them back in, would you?
 139:42:50 Parker: Okay. I'll make a little note again.
 139:42:57 Schmitt: Okay. Battery's complete, and (I'm waiting for) your cue on (going to) the Low Bit Rate.
 139:43:02 Parker: Okay. You can go Low Bit Rate again. And it looked good to us, too.

[Comm Break. They will now spend a few minutes making sure that all loose items in the cabin are stowed. Then they will get out the EVA Prep cue card and begin the tasks on Surface 4-2.]

139:44:48 Schmitt: LMP is (pause) sixty-one hundred (6100 psi) on the OPS.
 139:44:55 Parker: Copy that, Jack.
 139:45:00 Cernan: And about fifty-eight fifty (5850) on CDR.
 139:45:04 Parker: Okay. Copy that, Geno. (Pause)

[Cernan - "In addition to giving us an emergency oxygen supply in case we'd lost integrity on one of the suits, the Oxygen Purge System also gave us another emergency capability. After the third EVA, we threw the PLSS's out of the LM but kept the OPS's so that, at rendezvous, in case we couldn't dock, we could use the OPS's to do an emergency transfer-EVA into the Command Module. We could plug the OPS in directly to the belly of the suit and stay pressurized for 30 minutes, long enough to get into the Command Module had we had a docking problem."]

139:45:14 Parker: And you guys got the word about which purge valves to use?
 139:45:18 Schmitt: That's affirm. (Long Pause)
 139:45:45 Cernan: CDR's OPS is Go.
 139:45:48 Schmitt: LMP's Go.
 139:45:50 Parker: Okay. Copy that. Good.

[Long Comm Break. They are working their way down the lefthand column of Surface 4-2. The last step before donning the PLSS's is to unlock the forward hatch.]

139:52:40 Cernan: Okay. Bob, the forward hatch is unlocked.

139:52:43 Parker: Okay. Copy that.

[Cernan - "The lock was a simple one, rather like what you'd have on a front gate. You unlocked it by turning the handle through about ninety degrees."]

[Schmitt - "We unlocked the hatch before pressurizing the suits because you couldn't really get at the lock mechanism in the pressurized suits. The hatch had enough surface area that it couldn't be opened if there were any appreciable pressure (more than about 0.2 psi) in the spacecraft, so there was no extra risk in unlocking it now. And then, once you were depressurized, all you had to do was pull the handle and open it. There was a valve in the hatch which we opened during depressurization and, if by some extraordinary circumstance, the hatch was fully closed and some gas were released, the cabin couldn't repressurize and seal the door."]

[Long Comm Break]

139:57:47 Schmitt: Bob, the LMP has his OPS on. (Correcting himself) Would you believe the PLSS?

139:57:54 Parker: Say again there, Jack.

139:58:01 Schmitt: The LMP's PLSS is on.

139:58:03 Parker: Okay. Good enough. And I bet the CDR's doing his now.

139:58:11 Schmitt: You're right.

[Long Comm Break. Houston estimates they are about 35 minutes from depressurization at about 5:30 p.m. Central Standard Time.]

140:04:23 Cernan: Okay, Bob. We're in the top of the right-hand column (on the EVA cue card).

140:04:26 Parker: Okay. Copy that.

[Comm Break. They have begun the section titled "PLSS Comm Check" which begins with a check of the circuit breaker panels. They are in the middle of the lefthand column of Surface 4-3.]

[Cernan - "The ground had copies of the cue cards and checklists that we were using and could follow along. When we told them where we were, they could tell exactly what we'd done up to that point and we wouldn't have to call out all the details. Some of the critical things we would verify with them; but in this fairly regimented part of the protocol - getting in the suits, getting the PLSS's on, and checking them out - we'd just let them know from time to time where we were."]

140:06:19 Cernan: ...Max. Okay. I'm in VOX. (Garbled).
Going to T/R. B is Receive. A, T/R; B, Receive. Bob, how
do you read Commander on VOX?

[Here, they have nearly finished the communications
checks on Surface 4-3.]

140:06:33 Parker: Loud and clear, Geno.
140:06:37 Cernan: (Now on Surface 4-4) Okay, Jack.
(Responding to an unheard comment of Jack's) Won't be able
to hear you. (To Jack) And (on circuit breaker panel) 16, SE
Audio (circuit breaker), Open. Okay. Connect to your PLSS
comm. And when you get done with that, we'll go right into
the comm. (Pause) Yeah, zap me. (Long Pause)

[Jack is giving Gene a drink from the water gun. They
do not have their helmets on at this time.]

140:07:36 Cernan: Okay. Your audio (circuit breaker)
closed. Okay. Your PLSS PTT (Push-to-Talk) to main, right,
verify? PLSS Mode A?
140:07:44 Schmitt: Okay.
140:07:45 Cernan: Okay. You'll get a tone, a vent flag, a
press flag, and an 02 (oxygen) flag.
140:07:49 Schmitt: (Slightly garbled) Press flag, tone,
vent flag.
140:07:51 Cernan: Okay. Give Houston a call, and give them
your oxygen reading.
140:07:59 Schmitt: Okay, Houston. This is the LMP with
ninety-three percent. Ninety-three percent (oxygen).
140:08:03 Parker: Okay, Jack. We read you loud and garbled
just like last night when the (PLSS) antenna was stowed.
140:08:12 Schmitt: Okay. And nine-three (93) percent.
140:08:14 Parker: Copy the nine-three percent.
140:08:16 Cernan: Okay, Houston. You got 93...(Hearing
Parker) Okay. He got that, Jack. Okay. We'll leave the
antenna in.

[They could improve the quality of Jack's communications
by raising the whip antenna on his OPS but, since he is
readable, there is no point in risking antenna damage. They
will leave both antennas stowed until they are outside on the
surface.]

140:08:22 Cernan: Okay. On mine (that is, on circuit
breaker panel 11), I'm going to Open my Audio (circuit
breaker), and connect to the comm, Jack.
140:08:28 Schmitt: Okay. (Long Pause)
140:09:28 Schmitt: Okay, Houston, we had a Master Alarm,
ECS. Cabin pressure may be high. (Pause) Could be we've
got a little pumping in the ECS system...in the hoses.
140:09:43 Parker: Roger. Stand by on that. (Pause) Okay,
Challenger. We're seeing it as the Water Separator.
140:09:53 Cernan: Jack, we can...See that.

140:09:55 Parker: You can pull the Water Separator circuit breaker...
 140:09:56 Cernan: (To Jack) You don't have a bleed on yours. (Pause) It's your disconnect.
 140:10:02 Schmitt: Okay.
 140:10:05 Cernan: Okay. That's better.
 140:10:06 Schmitt: That should do her. (To Parker) I think we've fixed it. I had the hoses in my storage slot.
 140:10:16 Parker: Okay. Copy that.
 140:10:18 Schmitt: (Garbled).
 140:10:20 Cernan: Let me give them. Houston, CDR is reading ninety... (Refining his reading) ninety-one percent.
 140:10:29 Parker: Okay. Copy 91.
 140:10:37 Cernan: Did they get that, Jack?
 140:10:38 Schmitt: Yeah, they got it.
 140:10:39 Cernan: Okay. LMP comm check...Okay. You did with them?
 140:10:44 Schmitt: (Garbled)
 140:10:45 Cernan: Okay. You go B, and I'll go A.
 140:10:49 Schmitt: Okay. Going B, Houston. LMP on B.
 140:10:54 Cernan: Okay. And the CDR is B. I'm reading loud and clear. Houston, how do you read CDR?
 140:10:57 Parker: I read you loud and clear.
 140:11:03 Cernan: Okay. Let's go to AR, Jack. You'll get a tone.
 140:11:05 Schmitt: Okay. You're loud and clear. AR.
 140:11:09 Cernan: Okay. I'm AR. How do you read?
 140:11:11 Schmitt: You're loud and clear. How me?
 140:11:12 Cernan: And so are you.
 140:11:13 Schmitt: Got my tones.
 140:11:15 Cernan: And I got mine, too. You got an 0 flag and a vent flag, press flag and...?
 140:11:20 Schmitt: That's affirm.
 140:11:21 Cernan: Okay. Houston, how do you read CDR?
 140:11:24 Parker: Loud and clear, CDR.
 140:11:28 Schmitt: And how do you read the LMP?
 140:11:30 Parker: Loud and clear. (Pause) Okay. And we have...
 140:11:32 Cernan: Okay, Jack, VHF B...
 140:11:33 Parker: ...good PLSS data for both of you.
 140:11:36 Cernan: ...full decrease. Squelch.
 140:11:39 Schmitt: Full decrease.
 140:11:41 Cernan: Yeah, that's Squelch. VHF B to Squelch.
 140:11:42 Schmitt: Okay.

[They have completed the communications checks on Surface 4-4 and will now prepare the spacecraft environmental systems for depressurization, install the purge valves, and connect their OPS hoses. These procedures are on Surface 4-5.]

140:11:43 Cernan: "On (circuit breaker panel) 16, ECS LGC (sic; means LCG) Pump (circuit breaker), Closed." Why don't you close it again.

140:11:46 Schmitt: Okay, it's closed.

[They will now circulate LM water through the Liquid Cooled Garments (LCG's) to get some cooling without having to use PLSS water.]

140:11:48 Cernan: Okay. "On 16, Cabin Repress (circuit breaker), Closed."

140:11:51 Schmitt: Repress is closed.

140:11:54 Cernan: Let's get this too, huh?

140:11:56 Schmitt: Okay. (Pause)

140:12:02 Cernan: Okay. "Cabin Repress, closed. Suit Fan Delta-P, Open?"

140:12:09 Schmitt: Delta-P is Open.

140:12:11 Cernan: "Suit Fan 2, Open?"

140:12:12 Schmitt: 2's Open.

[They are turning off the flow of oxygen in the ECS Suit Circuit and are also turning off a sensor which detects a pressure difference across the fans.]

140:12:13 Cernan: "Verify ECS Caution and O2 and Water Sep lights come on in about a minute." Okay. We'll watch for it.

140:12:16 Schmitt: Okay.

[The warning lights will provide confirmation that the fans and sensor are off. Having finished reconfiguring the circuit breakers, next they will reconfigure the ECS valves on the panel behind Jack.]

140:12:18 Cernan: "Suit Gas Diverter, Pull/Egress." These are verify.

140:12:21 Schmitt: Okay. That's Egress.

140:12:23 Cernan: "Cabin Gas Return, Egress?"

140:12:25 Schmitt: Okay. Egress, yeah.

[They are verifying that the Suit Circuit is isolated from the cabin and, in the following step, that the Relief Valve is in open and, therefore, would open only if the Suit Circuit pressure exceeds 4.3 psi.]

140:12:26 Cernan: "Suit Circuit Relief, Auto."

140:12:27 Schmitt: Auto.

140:12:28 Cernan: Okay. You're OPS connect. "Suit Isol(ation Valve), Actuate Override, Suit Disconnect. Disconnect your hoses. Secure about PGA." They're stowed.

140:12:35 Schmitt: That's done.

[They are verifying that Jack's suit is isolated from the ECS oxygen supply by closing the disconnect valve and unplugging the hoses.]

140:12:37 Cernan: "Connect your OPS hose PGA blue to blue."

140:12:39 Schmitt: OBS (sic) going to PGA, and I'll turn around and let you...
140:12:42 Cernan: Okay.
140:12:43 Schmitt: ...make sure I get that, because it's under (garbled) connector.
140:12:49 Cernan: Okay. Did you already get...Let's see, where are we here?
140:12:51 Schmitt: Right here.
140:12:54 Cernan: Oh, here it is down...
140:12:55 Schmitt: Master Alarm and ECS light; Water Sep light. (Pause)

[The ECS oxygen flow system and the water separator are now completely powered down.]

140:13:10 Cernan: Okay. It is locked, (dust) cover is on.
140:13:13 Schmitt: Okay.
140:13:15 Cernan: Now, you want (purge valve) 211, right?
140:13:17 Schmitt: Roger. 211.
140:13:20 Cernan: Okay. Bob, LMP is getting purge 211.
140:13:23 Schmitt: And out to the side. There you go.
140:13:27 Parker: Okay. We copy that. Thank you. (Pause)
140:13:35 Schmitt: (Garbled), I'll lock it.
140:13:38 Cernan: Okay. And you are Low (flow) and you are in and you are locked.
140:13:42 Schmitt: Okay. Purge valve is in.
140:13:43 Cernan: And you's vertical.
140:13:44 Schmitt: Okay. You get to do the same.
140:13:45 Cernan: Okay, get my hose. (Pause)
140:13:46 Schmitt: Your water hose.
140:13:49 Cernan: Come around behind my shoulder.
140:13:53 Schmitt: Won't fit in there. (Pause) Okay, it's in there (that is, the OPS hose is connected) and it's locked, (garbled), and the dust cover is on.
140:14:10 Cernan: Okay.
140:14:12 Schmitt: And now, we get to put your Purge (valve) in: 208.
140:14:15 Cernan: Make sure it's in Low.
140:14:17 Schmitt: It is, and Low, and the pin is in. (Pause) Okay. (Pause) And you like it where? Down a little bit?
140:14:31 Cernan: No. Same place just... No, let me show you.
140:14:34 Schmitt: Right there?
140:14:35 Cernan: Yeah.
140:14:38 Schmitt: Okay; there. In.
140:14:41 Cernan: Verify it's still in Low. Locked.
140:14:46 Schmitt: And locked.
140:14:47 Cernan: Okay.
140:14:48 Schmitt: Okay. That's good.
140:14:50 Cernan: Let's get another zap of (drinking) water here. (Long Pause) If I have any more water I'll float out there.
140:15:14 Schmitt: (Laughs) Good Navy man.

140:15:19 Cernan: Be a good place to fill with water, you'd make a nice rec(reation) site out of this valley. You could put some cabins up on the side of the massifs. Nice flat bottom, no trees.

140:15:34 Schmitt: No snags.

[That is, there would be no submerged stumps to catch a fishing line.]

140:15:37 Cernan: The fishing ought to be pretty good if you stocked it.

140:15:40 Schmitt: Have a Bear Island and a Family Island.

[Jack named Bear Mountain for a peak near his boyhood home in Silver City, New Mexico. And he picked the name Family Mountain to honor all of the NASA families. Neither is as tall as either of the massifs and, if Taurus-Littrow could be flooded, then both would become islands.]

140:15:45 Cernan: (Laughs) We're going to (have to) fill up the other end though, so it doesn't drain out.

140:15:49 Schmitt: Looks funny like that.

140:15:51 Cernan: Lock it and turn your Descent Water, Off.
(Long Pause)

[They are turning off the flow of water from the supply tank in the Descent stage. Next, they will don their helmets and gloves.]

140:16:05 Schmitt: Snaps, snaps, snaps; the whole world is held together with snaps!

140:16:11 Cernan: Okay, I've got my hand lubed. You can position your mike.

[Although they have a lubricant that they applied to the glove-locking mechanism, the so-called quick disconnects, at the wrist, they had taken care of that before the rest period. Here, Gene is literally greasing his hand to try to prevent skin abrasion as he works in the glove.]

140:16:14 Schmitt: (Descent) water is going off.

140:16:15 Cernan: Okay.

[Gene will now help Jack don his helmet.]

140:16:19 Cernan: Position your mikes. Now, before we turn the (PLSS) fans on and use (PLSS) battery power...Let's just look ahead; we got helmets ready to go...Drink bag position you're happy with.

140:16:27 Schmitt: Yeah, more or less a little far out, but I think...

140:16:29 Cernan: Make sure you've got the plug out.

140:16:30 Schmitt: Okay. Plug is out. (Pause)

140:16:34 Cernan: My end's right, now, but (garbled) even get it out.
 140:16:37 Schmitt: Feel a little pressure in there. You might let out.
 140:16:44 Cernan: Okay. And then we'll lower our protective visor and secure tool harness and self-doff straps.

[The self-doff straps are attached to the sides of the visor assembly and can be used to release the tool harness.]

140:16:50 Schmitt: Okay, and that's...
 140:16:51 Cernan: That's already stowed. Okay. Let's start with you first. You can turn your...Let me get your LEVA then you can get it over your head and turn your 02...(correcting himself) your fan on, rather.
 140:17:02 Schmitt: Okay. (Pause)
 140:17:10 Cernan: Okay, you ready (for your helmet and LEVA)? (Pause) Okay, check all that...Wait. What is this right here? (Pause) Okay, now let me make sure it's in front of everything.
 140:17:26 Schmitt: Okay.
 140:17:30 Cernan: The alignment is way over here. Let me...
 140:17:33 Schmitt: That's good.
 140:17:34 Cernan: Okay. That's aligned right there. Oh, boy. That will never do. With that down in there.
 140:17:44 Schmitt: Okay, it's still clear.
 140:17:47 Cernan: Starting. (Pause) Manischewitz.
 (Pause)
 140:18:06 Schmitt: I think it's caught on the food stick. You ought to open it up.
 140:18:10 Cernan: I think you're right.
 140:18:12 Schmitt: Okay. Get it all the way off.
 140:18:13 Cernan: Okay. Now let's try it. (Pause) Looks like it's going to be much better. Get it in back. (Pause)
 140:18:33 Cernan: Want to make sure that thing is on! Nope, not happy yet. (Pause) Not happy yet.
 140:18:52 Schmitt: Well, (do you) want me to squat down?
 140:18:58 Cernan: I tell you, I got my fingers on it all the way around. Okay. It's locked. It's aligned. Better put your (PLSS) fan on here pretty quick. Okay.
 140:19:13 Schmitt: Fan's on.
 140:19:14 Cernan: Okay, let me get you dressed up back here. (Garbled) center doesn't work, you're going to keep this thing...
 140:19:22 Schmitt: And I'm vertical.

[Oxygen enters the suit from the PLSS through vents at the neck ring and in the suit chest. There is a chest-mounted diverter valve which allows the astronaut to select the relative amount of flow through the vents and, in the vertical position, all of the flow is into the helmet through a vent at the back of the neck.]

140:19:24 Cernan: You are vertical all right. Aghhh.
 Okay. You're covered down there. You are locked.
 Okay...Whoo! Okay? Guess it's my turn. (Pause)

[Jack will now check Gene's suit and help him don his helmet.]

140:19:53 Schmitt: Yup. Let's verify all these things.
 140:19:55 Cernan: Okay. Go ahead.
 140:19:57 Schmitt: Okay. Got your comm. That's you OPS;
 that's your inlet; that's your oxygen or your exhaust; and
 (that's) your purge valve.
 140:20:09 Cernan: Okay.
 140:20:10 Schmitt: And your water
 140:20:11 Cernan: Okay, let me take a look at all yours.
 Okay. That's locked. (Pause) Locked. That's locked;
 you're vertical. That's locked. That's locked. That's
 locked. Okay. Get my helmet on. The main thing is to get
 this stuff back over here.
 140:20:39 Schmitt: Yeah.
 140:20:41 Cernan: Way out. (Pause)
 140:20:54 Schmitt: Okay. Can you grab your food stick,
 cause that hung up on mine. (Pause)
 140:21:03 Cernan: Okay. (Long Pause)
 140:21:19 Schmitt: Got it. You're locked.
 140:21:20 Cernan: Feels good in the back?

[Gene is asking Jack about the fit of the helmet in the neck ring at the back. Jack is using his fingers to feel for any misalignment.]

140:21:21 Schmitt: Yup. And it's locked. (Pause)
 140:21:31 Cernan: It's hard to see with that visor on
 there. (Pause)
 140:21:38 Schmitt: Okay. That's latched down. You're
 locked again.
 140:21:43 Cernan: And, she's in the engaged position here,
 huh?
 140:21:45 Schmitt: That's affirm. (Garbled) engaged. Okay.
 (Pause)

[Cernan - "It's a long, arduous, time-consuming, difficult, energy-consuming process getting ready to get out. You've got to get in the suits and get everything checked out. You're big and bulky and can't move around very well; just a couple of apes in there. I remember vividly what tough, physical labor it was to reach things. And it got even worse when you got pressurized. A difficult job, but absolutely necessary. You had to make sure that everything was on right and that everything was locked because that suit and that PLSS were your life-support system. It all would have been a lot easier if only we'd had a little more room. In the Shuttle they have a big airlock and it's a piece of

cake; and, sometimes, I wonder how we got away with it, particularly in Gemini with that tiny, tiny cockpit. It was a tight fit with a pressurized suit and that chest pack; it's a wonder we didn't lose somebody."]

140:21:53 Cernan: Okay. Verify, verify, verified. Circuit breaker; white dots plus EVA decals. Whoo!

[They are on Surface 4-6 and will now configure circuit breakers and switches for depressurization, opening all the breakers marked with white dots and putting all the switches marked with EVA decals in the indicated position.]

140:22:08 Schmitt: Can you give me a little room to turn?

140:22:09 Cernan: Yep. Go ahead. (Pause)

140:22:10 Schmitt: Okay. White; white. Leave the (ECS LCG) pump on for a minute. You want?

140:22:25 Cernan: Yeah. (Pause)

140:22:30 Schmitt: Okay; and EVA decals, all right?

140:22:32 Cernan: Okay.

140:22:33 Schmitt: You want me over here?

140:22:35 Cernan: Let me turn the page. Don our EV gloves.

140:22:39 Schmitt: Okay. In work. (Long Pause)

[Schmitt - "The most significant physical discomfort we experienced was the fatigue in the forearm muscles that came from squeezing the glove against the pressure in the suit. It was like squeezing a tennis ball repetitively. And within a half hour or so, the forearm muscles were sufficiently fatigued to ache. And you reached a much lower productivity using your hands than when you started and then you stay at a constant level of whatever you can tolerate and still do the job and not drop things and still apply sufficient force to work, and that then went on for the rest of the EVA. However, after a night's rest and sleep, that soreness went away. There was no residual soreness. I think that's related to the lower gravity environment. Your heart and cardiovascular system are so much more efficient in removing the products of metabolism such as lactic acid that you never damage any muscle fiber. You fatigue it, but you don't damage it. And the important thing was that, with rest, it went away. It came back when you went out again and started work, but it wasn't compounded."]

140:22:53 Parker: Geno, we don't see your (PLSS) fan on. If you've got your helmet on, you ought to have your fan on.

140:23:00 Cernan: Thank you, Bob. Good call.

140:23:05 Schmitt: The royal MOCR "we".

140:23:07 Cernan: Boy, grease and lunar dust really make a nice mobile graphite material. (Long Pause)

[Gene is applying grease to either his hands or to his wrist rings - or both. The fact that there is no hint of Jack lubricating his wrist rings during any of the EVA preps

suggests that Gene is greasing his hands. Nonetheless, Gene and Jack did lubricate the seals after each of the EVA's and the following applies.]

[Cernan - "Once we'd been outside, there was always a lot of dust on the suits. You could just scrap the dust off with your hand. You couldn't help mixing at least a little dust in with the seal lubricant. It didn't give us any particular problem; but, unlike graphite, lunar dust is not a lubricant and probably caused some wear in the seals."]

140:23:52 Schmitt: Okay. I'm locked on the right, verified. The old gauntlet's coming on.

140:24:06 Cernan: Okay, and I've got my cover (glove) on over here. Get yours?

[The cover glove resembles a fingerless gold glove and is worn over the suit glove for abrasion protection.]

140:24:10 Schmitt: Well, I'm getting one of them anyway.

140:24:13 Cernan: I can get the other one for you. (Long Pause)

140:24:34 Schmitt: Okay. Number 2. (Pause) (Garbled) And it's on, and locked and locked. Verified. (Long Pause)

140:25:07 Schmitt: I may be learning how on these, finally.

[Cernan - "I think that most of the time I had to help Jack with his gloves. Partly, perhaps, because of the size of my hands and also because I'd put gloves on so many times going back to Gemini. It was pretty easy for me. Jack could get one on with the other hand bare; but it was tough for him to get the second glove on. So I usually helped him; it was part of the buddy system that was so important."]

140:25:14 Cernan: Okay. Mine's on and locked. If I can get my black band on here.

[Schmitt - "This was a band that we put on our arms, over the suit, I think for our watches."]

140:25:21 Schmitt: I think I'm learning how, Geno. Crazy. (Pause) Like a trained "band putter-onner". Okay. I feel pretty good. Need some help?

140:25:41 Cernan: No, mine's all on.

140:25:43 Schmitt: I can't figure that out. Must be easier in 1/6 g.

140:25:47 Cernan: (Laughs) Get my gauntlet donned. And that's dirt protecting dirt.

[Schmitt - "The gauntlets went about halfway up the forearm, protecting the bearing areas of the gloves."]

140:25:59 Schmitt: (Punning) Don't throw down a gauntlet, Gene.

140:26:03 Cernan: That's dirt protecting dirt. Okay. It's all on, Jack.

140:26:08 Schmitt: Okay. Where did we leave off?

140:26:11 Cernan: Right up here (on Surface 4-6, lefthand column). PGA is not biting, LCG's cold; let's leave it cold. Well, I guess you've got to open it (the ECS LCG pump circuit breaker) now. We've got to disconnect the (LM) water.

[PGA is the Pressure Garment Assembly, the suit. They are still connected to the LM water supply and have been cooling down as much as possible before disconnecting. They will not turn on the PLSS cooling until they have the hatch open. In this case, they will be off cooling for about 12 minutes.]

140:26:18 Schmitt: You ready?

140:26:21 Cernan: Jack...

140:26:21 Schmitt: Shall we do it?

140:26:22 Cernan: ...I'm ready.

140:26:22 Schmitt: Let's do it.

140:26:23 Cernan: Disconnect it.

140:26:24 Schmitt: (Laughing) It's disconnected.

140:26:28 Cernan: Okay, and did you disconnect your (water hose)...

140:26:30 Schmitt: Let me come around...

140:26:31 Cernan: Okay, let's turn around and let's help each other. Let's get the...

140:26:35 Schmitt: It's still...(Kidding Gene) This 3 degrees pitch up - 5 degrees pitch up - of yours, its an awful nuisance, Cernan.

140:26:41 Cernan: Hold that for a minute.

[Gene is connecting Jack's PLSS water hose and is asking Jack to hold the LMP LM water hose that he has just disconnected.]

140:26:42 Schmitt: I don't know why you don't learn how to land one of these things.

140:26:45 Cernan: Hold that for a minute...It was a pitching deck. (Straining) Okay, that is in. Boy, it's in. Locked...(although it) took a lot to "in"-ing, though. Okay. Dust cover is covering it.

[Schmitt - "There was a cloth dust cover that protected the connection between the PLSS water hose and the suit."]

140:27:04 Schmitt: Okay. (Pause) You know those chamber runs we had were probably some of the best training we ever did. I hate to say that, because it was some work. Push that...Hang on. There you go.

[Jack is referring to training exercises conducted in a LM that was inside a vacuum chamber. He is now connecting Gene's PLSS water.]

140:27:28 Cernan: Okay. Keep trying.
 140:27:31 Schmitt: It was just a little sluggish. Let me verify it.
 140:27:34 Cernan: (Is it) locked?
 140:27:35 Schmitt: Yeah, (it) won't turn. (Pause)
 140:27:44 Cernan: Oh, every time you do that, my stomach gurgles. (Laughs)

[This one of the few places in the transcript where Gene, Jack, and I cannot agree on the speaker identification. To me and to Gene, the speaker at 27:44 sounds unmistakably like Gene. Jack disagrees and points out that the remark is more characteristic of things he, Jack, would say. However, the context indicates that Jack is still checking Gene's water hose and, therefore, I have decided to believe my own ears. No matter who is right, the following comment still applies.]

[Schmitt - "The hose connections were over my stomach and, with the suit not yet pressurized, when Gene pushed in, he pushed against my stomach."]

140:27:47 Schmitt: Okay...Let me turn around to stow.
 (Pause)
 140:27:51 Cernan: You can stow that, and mine's over here.
 (Pause) Okay. (Reading) "Attach our PLSS water hoses. PLSS diverter valve, Min." Want to verify that? (Pause)
 And, "connect PLSS water hose, verify lock, PLSS diverter valve Min, and PLSS pump (on)." Okay?
 140:28:26 Schmitt: Wait a minute. I want to make sure this (hose) is out of the way when I come in (at the end of the EVA). (Long Pause)
 140:28:51 Schmitt: Okay. Now, you want my diverter Min?
 140:28:56 Cernan: Want your diverter...
 140:28:57 Schmitt: It's Min.
 140:28:58 Cernan: To Min. Your (PLSS LCG) pump on and Press Reg's A and B, Egress. (Pause)

[Cernan - "In the normal configuration, if the cabin had started depressurizing, the O2 regulators would have started pouring oxygen into the cabin to make up the difference. But, in the Egress configuration you were telling the regulators that you were depressurizing on purpose."]

140:29:05 Schmitt: Okay. Pump's on.
 140:29:07 Cernan: Okay.

[The PLSS pump circulates water through the Liquid Cooled Garment. They will leave their sublimators off until the hatch is open.]

140:29:08 Schmitt: And I'm getting a little bite (in his PGA).

140:29:10 Cernan: And mine's on (that is, his PLSS pump).
Okay, the next thing is to turn your PLSS 02 On, anyway.
140:29:13 Schmitt: Oh, okay. Let me go to Egress. Egress.
140:29:16 Cernan: Egress on the Reg's.
140:29:18 Schmitt: The Reg's are Egress.
140:29:19 Cernan: Okay. You ready on my mark.

[They will do a suit pressure integrity check for one minute. The cabin is kept at its normal 4.8 psi pressure and the suits are pressurized an additional 3.85 psi as a safety check. Then, as the cabin is depressurized, the regulators bring the suits down in parallel so that they lock up at 3.85 absolute for surface operations. The cabin/suit air is pure oxygen, and there is no danger of the bends.]

140:29:21 Schmitt: Wait a minute.
140:29:22 Cernan: Tell me when you're ready.
140:29:23 Schmitt: (If I can) find it.

[Jack may be trying to reach the oxygen control on the right-front-bottom corner of his PLSS.]

140:29:31 Cernan: Say when.
140:29:33 Schmitt: Well, where is it? That's that. (Pause)
Okay, let's go ahead.
140:29:42 Cernan: Okay mark it. Get it? If not, I'll get it for you.
140:29:48 Schmitt: No.
140:29:50 Cernan: Here. Let me get it for you.
140:29:51 Schmitt: Wait a minute. I didn't get it. No, there it is. Okay, I've got it.
140:29:54 Cernan: Okay. We going at the same time. I've got us marked. Okay. "PLSS 02, tone on; 02 flag. Press(ure) flag clear 3.1 to 3.4. Cuff Gauge 3.7 to 4.0."
140:30:08 Schmitt: Do you need me to watch the panel or you got it?
140:30:10 Cernan: No, no sweat I've got that.
140:30:12 Schmitt: Okay.
140:30:13 Cernan: We'll have to get the PLSS 02, Off (to start the integrity check). I'll get mine; I can reach yours real easy. I can get it at a minute. As soon as we get up, I'll get it.
140:30:23 Schmitt: Yeah, I can reach it, I think, now.

[After they get the suits pressurized, they will turn off the PLSS oxygen and watch the suit pressure decay. There will be a small decrease due to breathe-down and to slow migration of oxygen into various nooks and crannies in the suit. A decrease of significantly more than 0.1 or 0.2 psi in one minute would indicate a suit leak.]

140:30:24 Cernan: And we're going up to high pressure here when we start dumping the cabin. (Long Pause)

[Once they start depressurizing the cabin, the suit regulators will not be able to keep pace and, for a short while, the relative pressure will be more than 3.85 psi and the suits will be extraordinarily stiff.]

140:30:55 Cernan: I'm coming through 3.5 (psi) now...3.4 really.

140:31:00 Schmitt: Just off the peg here.

140:31:03 Cernan: My press flag did clear.

140:31:09 Schmitt: There's mine. (Pause)

140:31:15 Cernan: Turn mine off. (Pause) Okay. Mark it. It (Gene's oxygen)'s off.

140:31:24 Schmitt: Where are you?

140:31:25 Cernan: About 3.85 (psi). Okay, when you get up, you can turn yours off. Give me a hack, and I'll check the time.

140:31:30 Schmitt: Okay. Mine's off.

140:31:32 Cernan: Okay. Check your pressure.

140:31:34 Schmitt: 3.8.

140:31:36 Cernan: I went at 20 (seconds), you went at 30 (on the second hand of Gene's watch). (Long Pause)

140:31:49 Schmitt: It looks like it's a little tighter.

140:31:52 Cernan: That was the suit loop we were checking yesterday up in orbit, though.

140:31:55 Schmitt: Yeah, but you know we got two tenths (of a psi pressure decrease). Yesterday, too. (Pause) I did.

140:32:02 Cernan: Okay, I'm coming down to 20 more seconds, you got 30 more seconds (to watch the suit pressure decrease).

140:32:07 Schmitt: I'm only about a tenth (of a psi), I guess. (Pause)

140:32:20 Cernan: Okay; 1 minute for me Houston; (3).85 (down) to about (3.)72.

140:32:28 Parker: Copy that, Geno.

140:32:29 Schmitt: Okay. That it?

140:32:30 Cernan: Okay. Mark yours.

140:32:32 Schmitt: Okay. And the LMP was (3).8 to (3).7.

140:32:39 Parker: Okay. Copy that.

140:32:41 Schmitt: And I'm back on.

140:32:45 Cernan: Okay, and we'd like your Go, Robert.

140:32:49 Parker: You're Go for Depress.

[They will now bring the cabin pressure down from 5 psi to 3.5 psi and will watch the response of the suit regulators. They are in the middle of the righthand column of Surface 4-6.]

140:32:55 Cernan: Okay. Jack, (on circuit breaker panel) "16, Cabin Repress, Open; and Cabin Repress valve, Closed."

[By opening the circuit breaker and closing the valve, Jack will make it doubly impossible for the ECS to repressurize the cabin when Gene opens the dump valve.]

140:33:00 Schmitt: Okay, Cabin Repress. Circuit breaker first, right?.

140:33:05 Cernan: Circuit breaker first. "Cabin Repress, Open."

140:33:07 Schmitt: Okay. Let me turn around here. Okay, it's open.

140:33:10 Cernan: Okay. And "Repress valve, closed."

140:33:14 Schmitt: Okay. It's going closed.

140:33:16 Cernan: And then stay over there (on the right side of the cabin) as far as you can, 'cause I got to get the overhead dump valve.

[Schmitt - "There were two valves we could use to dump the cabin oxygen for depressurization. There was one in the forward hatch, but the one we used was overhead on the docking hatch and was easier to reach. And that wasn't closed until we came back in."]

[Cernan - "These were just little accordion valves, each with a small lever that we used to break the seal. Air pressure in the cabin was enough to keep them shut, but the surface area was small enough that you could open it easy enough with the lever. As Jack says, the overhead was just easier to get to in the pressurized suit. Here, he was probably standing facing away from me, so if he leaned toward me, his PLSS would be on my side of the cabin, and I was probably having to turn a little to get my right arm up and back to get at the valve."]

140:33:19 Schmitt: Okay, I'm over as far as I can get. I can turn around and give you more room.

140:33:22 Cernan: Yeah, turn around and you'll have to look at the Cabin (pressure gage).

140:33:25 Schmitt: Watch yourself there.

140:33:28 Cernan: You went awful weak all of a sudden. Are you...

[There is no change in Jack's volume as recorded in Houston.]

140:33:30 Schmitt: Hello. How do you read?

140:33:31 Cernan: Very weak. Give me a call again.

140:33:33 Schmitt: Very weak?

140:33:34 Cernan: Okay. My volume (control on the RCU) got...

140:33:35 Schmitt: You got to hit your volume.

140:33:36 Cernan: Okay, now.

140:33:38 Schmitt: Let me get over here...

140:33:40 Cernan: Wait a minute.

140:33:42 Schmitt: Is that enough?

140:33:44 Cernan: No, your arm's in the way. (Pause) Okay. I can get at it now.

140:33:47 Schmitt: You want to go to...Let me get that..."Open, then Auto at 3.5." Okay, go ahead.

140:33:56 Cernan: Okay. Coming down. I can see it (the valve) open.
140:34:00 Schmitt: There it is. That's 5 (psi). 4 and a half. 4. Stand by. Mark it (3.5 psi).
140:34:09 Cernan: Okay, it (the dump valve)'s Auto.
140:34:11 Schmitt: Okay, about 3.4. And, I (garbled).
Watch; looking at a watch.
140:34:17 Cernan: Okay.
140:34:20 Schmitt: And my cuff gage went up to 5.0. Good.
(Pause) Suit circuit's at 4.6. That's okay. And I'm decaying. Are you decaying?
140:34:42 Cernan: I'm decaying.

[They have bled the cabin pressure down to 3.5 psi and are holding there while they watch the suits react. The EVA clock starts once they are satisfied with the suit integrity and then begin the final depressurization.]

140:34:43 Schmitt: Okay. We can start our watch. (Pause)
140:34:50 Cernan: Okay.
140:34:52 Schmitt: My watch is started. At 5:30, more or less (Central Standard Time on Tuesday, December 11).
140:34:57 Cernan: At 5:30. Yes, sir.
140:34:59 Schmitt: Okay.
140:35:00 Cernan: Press on.

[They are now on Surface 4-7 and will start the final depressurization.]

140:35:01 Schmitt: Okay. Overhead (or) Forward Dump valve, Open.
140:35:04 Cernan: (Straining) Okay, baby! It's open all the way.

[Cernan - "I'm really stretching to reach back up to get the valve because now the suits are even harder then they were when I first opened the valve."]

140:35:07 Schmitt: Okay, and pressure's coming down.
140:35:10 Cernan: Okay. I believe it.
140:35:11 Schmitt: I get a tone and an H2O flag, and you should pop your Relief (valve on the suit), I think.
140:35:13 Cernan: Yeah, I'm at my relief pressure now.
(Pause)

[At this point, the pressure difference between the suit and cabin is high enough that a pressure relief valve opens. Sensors in Jack's PLSS are responding to the fact that the sublimator is off when the external pressure low.]

140:35:29 Cernan: What's Cabin (pressure) now?
140:35:31 Schmitt: Cabin is one point two (psi). (Pause)
One (psi). (Pause)

140:35:50 Cernan: Well, let's see if I can partially get this hatch open.
140:35:52 Schmitt: It's point seven (0.7 psi cabin pressure) still.
140:35:53 Cernan: Okay. (Pause)
140:36:00 Schmitt: Point five. (Long Pause)
140:36:15 Schmitt: Point three. You got it (open) at what...About point two yesterday?
140:36:21 Cernan: Why don't you move over as far to the right as you can...
140:36:21 Schmitt: Okay.
140:36:22 Cernan: ...so I can bend down (to reach the handle on the forward hatch).

[“Lean” would be more accurate than “bend”.]

140:36:25 Schmitt: Well, I think that's as good as I can do.
140:36:26 Cernan: Okay. That's good. I can reach it. No; too much pressure on it yet.
140:36:34 Schmitt: Okay. About point three. (Long Pause)
140:36:52 Schmitt: Okay. There's my H2O flag.

[The cabin pressure has dropped low enough for sublimator operation and the flag is telling Jack that there is no feedwater flow into the sublimator. The flag is, therefore, telling Jack three things: that he has no feedwater flow, that the cabin pressure is quite low, and that the PLSS warning system is working.]

140:36:55 Cernan: Well, in that case, let me see if I can't get this. Oh, man!
140:37:00 Schmitt: Get it opened?
140:37:01 Cernan: No.
140:37:03 Schmitt: It's unlocked, isn't it?
140:37:05 Cernan: Yeah, I unlocked it earlier.
140:37:09 Schmitt: Still point two. (Pause)
140:37:14 Cernan: Yeah, it's unlocked. (Long Pause) Here it comes.
140:37:34 Schmitt: There goes all the junk out there again. Guess that's ice.

[Cernan - “This was one of the reasons that it was a good idea not to leave things lying around in the cabin. Once the pressure got down low enough - 0.1 or 0.2 psi - you could lean down and use the handle to open the hatch. Then the rest of the air rushed out and anything lying around just zapped out the hatch with it.”]

140:37:41 Cernan: Okay.
140:37:43 Schmitt: Probably cleaned some of the dust out, I hope.

[Schmitt - "Anything that wasn't tied down flew out. I don't remember any of the dust going out; it was down below the floor so it was a little harder for it to flow out."]

140:37:45 Cernan: Yeah, there goes a lot of junk. Sure wish it would clean the dust out. But it isn't. It's cleaning everything else out.

[Cernan - "The floor we stood on wasn't the pressure hull of the spacecraft but, rather, was a fitted floor made up of panels with cracks between them. The dust got down in there and it was impossible to clean it out."]

140:37:51 Schmitt: Okay, Geno. We turn our PLSS (sublimator) water on.

140:37:53 Cernan: Okay.

140:37:54 Schmitt: If we can get to it. (Pause) (That) feels like a water valve.

140:38:09 Cernan: Okay. Mine's on.

140:38:11 Schmitt: LMP's water's on.

140:38:15 Cernan: Okay. (Pause) Okay? (Pause)

140:38:21 Schmitt: Open...

140:38:23 Cernan: We're right there.

140:38:25 Schmitt: What?

140:38:26 Cernan: My water flag is clear!

140:38:31 Schmitt: That just means you've got feedwater pressure.

140:38:33 Cernan: Okay. (Reading) "Open hatch. Rest until cooling sufficient; verify PGA 3.7 - 4.6." Now mine's coming through 4.8; let me stand there a second.

[Cernan - "It took the suit regulator a while to get itself down to 3.85 psi and, until then, you were working with an extra stiff suit and there wasn't much point in trying to get down on your knees to get out."]

140:38:42 Cernan: "CWEA status, PREAMPS and ECS."

140:38:44 Schmitt: Rog.

[The warning lights are telling them that the ECS is off and that the cabin is depressurized. This is primarily a confirmation that the warning system is functioning.]

140:38:45 Cernan: (Is the) Water Sep Component Light on?

140:38:47 Schmitt: Rog.

140:38:48 Cernan: Okay.

140:38:49 Schmitt: I mean "affirm". Get my terminology straight here.

[Schmitt - "The actual meaning of 'Roger' is 'Understood', but it tends to be used as a substitute for 'Affirmative'; most of the pilots tended to use 'Roger' wrong and this was just me, trying to get it right."]

140:38:52 Cernan: Okay, Jack. I'm going to start doing about a 90 here.

[Gene will turn ninety degree so that he can get his feet through the hatch.]

140:39:01 Schmitt: Okay. Let me...I need to turn around (and face inboard) as soon as you do so I can help you get under that (DSKY housing). (Pause) That's better.

140:39:24 Cernan: Okay; it knocked it off. Okay. I'm out of the way now, if you can move your left leg.

[Jack needs to get as far to the right side of the spacecraft as possible so that Gene can open the hatch with Jack standing behind it.]

140:39:31 Cernan: Okay. I got an 02 Flag. And it's cleared. The pressure is 4.6. (Pause) Okay, Houston. If you're happy, CDR is going to get out.

140:39:47 Parker: Roger. We're happy, Geno.

140:39:52 Cernan: Okay.

140:39:56 Schmitt: (Sub vocal) Okay, I'm going to get back out of your way. (Pause) Okay. Hatch is full open.

140:40:06 Cernan: Okay.

[Jack means that the hatch is open against his legs as far as it will go.]

140:40:09 Schmitt: And you're still...Your scraping your (PLSS)...just a little bit. Just get your buttons down there. That's good. Okay. Oh, hey, remind me to fix your...

140:40:34 Cernan: PLSS straps.

140:40:34 Schmitt: ...your donning straps.

[At 40:09, Jack's "get your buttons down" is another reference to the Bill Mauldin cartoon discussed at 123:58:20.]

140:40:37 Cernan: Okay. (Pause) That is ice, by the way, Jack. (Pause)

[The cabin air cools rapidly as it escapes through the open hatch and some of the moisture condenses on the hatch opening and other surfaces. This ice will soon sublime.]

140:40:50 Cernan: Oh, man! I tell you, with a stiff suit...I'm still at 4.5 (psi). But, I am out here on the porch.

140:40:56 Schmitt: Okay.

140:40:57 Cernan: Oh, man. Okay, I'm out here.

140:41:00 Schmitt: (Reading cuff checklist page LMP-4) I've assisted you. (Pause) Here comes the jett(ison) bag whenever you're ready.

140:41:03 Cernan: Well, let me get...Okay. I'm all set. Man, I wish this suit would come down to 3.8. Here it comes. Okay, any time. (Pause) Give it (the jett bag) a swat; there you go.

[Once Gene gets out on the porch, Jack can swing the hatch partially closed, move to the other side of the cabin, and then swing the hatch fully open. He has just put the jettison bag in the hatch opening and pushes it farther out with his boot.]

140:41:30 Schmitt: Oh, the beauty of (garbled)...

140:41:33 Cernan: Okay; let me look at something here. (Pause; Gene chuckles as he looks in his checklist)

[Schmitt - "There was probably some kind of humorous picture that the support crew had inserted into the checklist at this point. Heaven knows what it was. I don't know where those checklists went. But the support crew kept sticking things in there, particularly Bob Parker. At the end of every section we could count on finding 'This is the end and not the beginning', because Gene had come up with a slogan for our mission 'This is the beginning and not the end' and Parker turned it around every chance he had. The typical weird humor of the Caltech graduate."]

140:41:42 Schmitt: What's that?

140:41:44 Cernan: I was just turning my checklist pages.

140:41:46 Schmitt: Oh. Here you go.

140:41:48 Cernan: Okay. Jett bag. I need...What you got next; ETB?

140:41:51 Schmitt: ETB.

140:41:52 Cernan: Okay.

140:41:53 Schmitt: Can you reach it?

140:41:54 Cernan: Yeah. (Now, I'll) get it hooked up here. (Pause)

[Gene is attaching the Equipment Transfer Bag (ETB) to the lanyard - called the LEC or Lunar Equipment Conveyor - with which he will lower the ETB to the surface, in part to protect the cameras in the bag and, in part, to free Gene's hands as he goes down the ladder.]

[Schmitt - "It was a lot easier using two hands going down the ladder. It wouldn't have hurt if you fell; or, I don't think it would have except it might have damaged the PLSS."]

140:42:00 Schmitt: Okay. Turn the tape recorder off.

(Pause) Tape recorder's off.

[This is an engineering data recorder, not a voice recorder.]

140:42:13 Cernan: Big hook. That's a legacy of Gemini IX.

[Cernan - "This was probably a hook on the lanyard that I was hooking onto the ETB or that I was using to attach the lanyard to the ladder. We learned on Gemini IX that, with the pressurized gloves and the lack of dexterity, we needed big things that we could get a hold on, not little things that you had to open with your finger tips. We learned a lot in the early days about the kind of equipment you needed to work with in the pressurized suits."]

140:42:17 Schmitt: "Max (sensitivity on the comm circuit). (Pause) EVA decals." (Long Pause)

[Jack is making a final check of the circuit breakers and switches.]

140:42:44 Cernan: ETB is hanging. (Is) that all I need?

140:42:50 Schmitt: I think so. You hit your comm again.

140:42:56 Cernan: No, I didn't; I'm okay.

140:42:57 Schmitt: What happened to the static? Did we lose Houston?

140:42:59 Parker: We read you loud and clear.

140:43:02 Schmitt: Hello, Houston. (Hearing Parker) Oh, you must have switched to...Oh, I don't know.

140:43:08 Cernan: Okay. I'm going down the ladder.

140:43:10 Schmitt: All of a sudden, all the noise is gone; that's very good. (Pause)

140:43:21 Cernan: "Godspeed the crew of Apollo 17." I think I'll read that every time I come down the ladder.

140:43:28 Schmitt: Okay. All the circuit breakers are verified. Noise is back.

140:43:34 Cernan: Okay. My visor's coming down.

140:43:37 Schmitt: Utility lights are off. We're not going to use the (16 mm) camera. (Pause)

[Here, Jack is referring to the sequence camera, which is mounted in his window primarily for taking one-frame-per-second movies of landing and take-off.]

140:43:43 Schmitt: Okay, I get to get out.

140:43:47 Cernan: Okay, Houston. On this fine Tuesday evening, as I step out on the plains of Taurus-Littrow, Apollo 17 is ready to go to work.

140:44:02 Parker: Roger, Geno. Good deal.

140:44:08 Cernan: And the first thing I'll do is give you a TGE (Traverse Gravimeter reading). Let me turn it on. And you want a reading. Okay. It's on. Bob, and the reading is 222, 262, 207; that's 222, 262, 207.

[The gravimeter is on the ground, in the shade of the LM, near the ladder. Gene had made a reading just before climbing the ladder at the end of EVA 1, and then put the instrument in the Standby mode. This reading is an instrument check.]

140:44:36 Parker: Roger. We copy that, Gene.
140:44:44 Cernan: Looks good from here, Jack. Keep coming.

[Jack is getting out of the LM.]

140:44:50 Schmitt: Come on, hatch!
140:44:53 Cernan: Oh, what a nice day. (Somebody burps)
140:44:57 Schmitt: (Both laughing) Funny, there's not a cloud in the sky. Except in the Earth
140:45:02 Cernan: (To himself) Take it nice and easy today and get accustomed. Whee!
140:45:08 Schmitt: (Probably on the porch and closing the hatch) Okay.

[Schmitt - "Getting out the second day was actually more exciting for me than the first was because it looked like we were actually going to have a chance to do something useful (laughing) rather than just deploy the ALSEP. I don't think getting out was an 'adrenaline pumping' type of excitement because your checklist kept you organized and moving from one thing to another. I think the real adrenaline was Launch, Translunar Insertion, Lunar Orbit Insertion, Powered Descent Initiation, Landing, Liftoff from the Moon, and Trans-Earth injection. Although, again, it's amazing how training and procedures suppress those kinds of things because everybody has things they have to do; and so you have to keep doing them. If you got into an adrenaline high you'd increase the chance of missing a step. Training is a great suppresser of adrenaline. It's like being prepared to take an exam in college. The more prepared you are, the less exciting it is."]

[Cernan - "I don't know that the adrenaline wasn't pumping the first time we got out on the surface. The second time I was a little more calm and collected, but there was still the realization that I was back out on the surface and that the first time around wasn't just a figment of my imagination. I agree with Jack that where the heart really started pounding and beating wasn't when you were crawling down the ladder. It was things like the landing. It wasn't like you were crawling down the ladder into a pit full of rattlesnakes. You were crawling down the ladder to do something you were looking forward to, something you knew you were going to enjoy, something that, within reason, you had control over. It wasn't one of those heart-pounding things, but it was still a little unbelievable that I was really there. The first day was almost literally like walking in a dream the whole time; the second day, you could look around and begin to appreciate a little more where you were and prepare to be a little more productive. Everything on the first EVA had been checkout, checkout, checkout, checkout. This time we had the Lunar Rover out, we had the ALSEP deployed, and we could begin enjoying ourselves."]

140:45:11 Cernan: I'll be right there, Jack, to get the (PLSS) antenna - as soon as I turn the LCRU on.

[The LCRU is the Lunar Communications Relay Unit, hanging on the front of the Rover.]

140:45:16 Schmitt: Okay. I'm on the ladder. Door is closed. (Pause)

[There is a dump-valve handle on the outside of the hatch.]

140:45:27 Cernan: Okay, (TV) Power switch is Internal. I'm in Mode 3. LCRU blankets are open 100 percent. AGC is 4.0 plus, and power is about 1.8. Temps are about 1.6 or 1.4.

[The TV comes on, showing Gene's footpan. As usual, Ed Fendell - who is operating the camera from Houston - starts with a counterclockwise pan.]

140:45:48 Parker: Okay. And we have a good picture there, Geno. Thank you.

140:45:56 Cernan: Already, huh?

140:45:57 Parker: Already.

140:45:59 Cernan: Well, let me just tweak you up a little bit. Okay, I've got you tweaked, right in the middle.

[Gene has centered Earth in the high-gain antenna boresight.]

140:46:07 Parker: Thank you. And, Gene, after you finish closing up both those battery covers up front there, why don't you go back and give us that (Rover battery) temperature reading and then put the breakers in and then give us another temperature reading on the batteries.

[Fendell now finds both Gene and Jack at the back of the Rover.]

140:46:21 Cernan: Yes, sir; I'll do that. Jack, here, let's get the (PLSS) antennas.

140:46:35 Schmitt: You want to get...You want to hang on (to) the Rover?

[Jack is asking Gene to lean on the Rover so that he can reach his antenna.]

140:46:37 Cernan: I guess...Well, okay.

140:46:39 Schmitt: I think it's easier.

140:46:42 Cernan: Now, I'm low, so get mine, now. I'm (standing) in a hole. (Long Pause)

140:47:00 Schmitt: Okay; you're up.

140:47:02 Cernan: Okay. (Long Pause) Standby...get down there yet. Got to secure the flaps. Okay, you're all right.

[Jack now bends his knees so that Gene can free his antenna.]

[Cernan - "Getting those antennas free was no easy task in the gloves."]

140:47:35 Cernan: Okay, you're up.

140:47:39 Schmitt: Okay.

[Jack moves to the SEP receiver, mounted on the geopost at the right rear of the Rover, behind his seat. He is now on LMP-5]

140:47:41 Schmitt: Okay, (SEP) Power switch is going to Standby. And the temperature is 80 (degrees Fahrenheit). And I'll close the blankets.

140:47:51 Parker: Copy 80 on the SEP.

140:47:54 Schmitt: That's affirm. (Pause) You know what happened? The Velcro came unbonded. That's why those (dust covers) don't hold down. We probably ought to get a piece of tape on those. Because they've got a set and it's going to get dusty. The blankets...There's no Velcro left to hold the SEP blankets down, Bob.

[The top of the SEP is at about chest height. The glue holding Velcro fasteners onto the SEP dust covers failed sometime during the first EVA. The unit has an internal temperature sensor which will shut it down if it gets too hot - greater than about 108F - and that limit is being approached. They will get data during the traverse to Station 2 and some on the drive back from Station 4 to the LM. Thereafter, the unit will be too hot to work.]

140:48:22 Parker: Okay, I copy that, Jack.

[Jack goes to the LM ladder to get the ETB.]

140:48:27 Schmitt: Do you have a reading on the gravimeter?

140:48:30 Cernan: Yeah, I took a reading, Jack.

140:48:31 Schmitt: Okay.

140:48:32 Parker: It's measuring right now, Jack, we'll get it later.

140:48:34 Cernan: All right.

140:48:35 Schmitt: Okay. I hope I didn't hit it with some dust.

140:48:37 Cernan: Hey, it is not measuring, Bob...

140:48:41 Parker: Oh, that's right. Sorry about that.

140:48:42 Cernan: ...All I did was take a reading. I turned it on and took a reading.

140:48:44 Parker: You're right, you're right, and I'm wrong.

140:48:49 Cernan: Okay, Bob...

140:48:50 Schmitt: Hey, Bob.

140:48:51 Cernan: ...the (Rover) battery temperatures are 0 and 0.

140:48:55 Parker: Copy that. Okay.

[There had been some concern about the battery temperature indicators and this is a check to see if they are giving proper zero readings with the batteries off.]

140:48:59 Schmitt: Bob, there's your pendulum.

[Schmitt - "Bob Parker and I had talked about getting a TV picture of a pendulum motion in 1/6th gravity. The lanyard was hanging down and so I just gave it a little push so that he could he could have his pendulum."]

140:49:03 Parker: Okay.

[Because nothing is hanging from the lanyard to make it a classical pendulum, Jack's push excites multiple modes of oscillation.]

140:49:05 Schmitt: It's not a very good one. I'll work on that. (Pause) Are you going to be there for a minute, Gene?

140:49:16 Cernan: Just putting these batteries in. I'm done on this.

[Gene leans across his seat to close the battery circuit breakers and read the battery temperatures.]

140:49:19 Cernan: (To Parker) Oh, you'll be glad to hear this. We got 70 (degrees) on battery 1 and about 92 on battery 2.

140:49:24 Parker: Beautiful! Beautiful. 70 and 92. I copy.

[At the end of the first EVA, the temperatures were 108 and 123 degrees, respectively. Clearly, the combination of Gene's dusting and the wax cooling system has been effective.]

140:49:29 Cernan: Yes, sir! Let me just verify this (navigation circuit breaker) is in, Jack, and I'll be all done. Okay. You've got it. I'm all done.

140:49:39 Schmitt: Okay. (Pause) Okay, here's your old fender.

[Gene has gone toward the LM to open Sample Return Container (SRC) 2; Jack removes the replacement fender from the ETB and lays it in Gene's footpan. Gene is now on CDR-5.]

140:49:50 Cernan: Yeah, I'll work on that. Shortly. (Pause) Well, I think I'm going to Intermediate (suit) cooling to start with here.

140:50:04 Schmitt: Okay. I think I will, too. That's a good idea.

140:50:07 Cernan: One zap of cold (that is, maximum cooling) to see if it's working. (Pause) It's working. And back to Intermediate. (Long Pause)

[Schmitt - "By putting the valve all the way up to full cold, you could very quickly feel a pulse of cold water in the Liquid Cooled Garment. This was done just to make sure the valve was working."]

[Jack is removing film magazines from the ETB.]

140:50:48 Schmitt: Okay. Lots of (film) mags. (Pause) Okay; mag...

140:51:11 Cernan: I have the same problem with this SRC, I'll bet.

[Fendell pans to watch Gene at the MESA. He is sealing the organic sample - a roll of aluminum metal - in a sample bag and will put it in the SRC to provide experimenters with a measure of contamination of lunar samples by gases released by the spacecraft and the suits. Once the sample is sealed, Gene will close the SRC lid to prevent excessive heating. At the start of the first EVA, he'd had trouble getting the lid of SRC 1 to stay closed and eventually had to put the "big bag" on the top of the lid to hold it down.]

140:51:14 Schmitt: Mag Romeo is going to go on the old 500 (-mm camera) in a minute. Mag India is in there. Mag Kilo (Pause) Mag Juliet (Pause) Mag Bravo, Mag Delta.

[Jack is taking film magazines from the ETB and is putting them under Gene's Rover seat. Gene closes the SRC lid. Some readers may want to note that Jack is not trying to come up with women's names for the film magazines as he did during EVA 1 and will later in the mission. Through this section, he seems too intent on getting ready for the traverse - his first chance to really get out and do geology - to be quite as playful as he is at other times.]

140:52:05 Cernan: Okay, Bob, the SRC organic sample has been sealed. And the SRC lid is staying almost closed, about 2 or 3 inches open; if that's fine, I'd like to leave that.

140:52:20 Parker: Okay. Go ahead and leave it, Gene. If it's not (okay), we'll get back with you on it.

140:52:26 Cernan: Okay. I'm going to hit your gravimeter here.

[The gravimeter is on the ground, between the MESA and the ladder. Gene bends his knees, holding on to the MESA to reach the Grav button to start a new reading.]

140:52:31 Schmitt: Polarizing filter,...

140:52:35 Cernan: Mark it;...

140:52:36 Schmitt: ...utility light clamps.
140:52:37 Cernan: ...and the light is flashing.
140:52:38 Parker: Copy that. (Pause)
140:52:42 Schmitt: Scissors. (Long Pause)

[The flashing light indicates that the gravimeter is leveling itself in preparation for making a measurement. In three minutes or less, it will be leveled, the measurement will be done, and Gene can push the Read button. Jack is about to start the tasks on LMP-6.]

140:53:04 Parker: Okay. And, Jack, you're getting ready to take care of the charge; remember EP-4 goes between the Rover seats, and EP-5 we're going to put on one of the footpads in the Sun. Probably either the minus-Z (east) or the minus-Y (south) footpad, whichever is more convenient. Probably the minus-Z is. Just as long as it is sitting in the Sun is the important thing on the (choice of) footpad.
140:53:26 Schmitt: Okay. (Long Pause)

[As was discussed at 138:21:35, there are two charges in a transporter that Gene mounted on the Rover before driving out to the ALSEP site. EP-4 is a 1/8th pound charge which Jack will now put between the seats for deployment early in the upcoming traverse. EP-5 is a three pound charge which they will save until EVA 3 and, for now, Jack is getting it and the first transporter out of the way so that he can mount a second transporter - containing charges 1, 2, 3, and 8 - on the Rover.]

140:53:57 Cernan: Boy, oh boy! Going to be a...(Pause)
Why won't that come out? (Pause) Well, Bob, I'm having a little trouble getting the LCRU (replacement) battery out (of the MESA). I'll have to go back and use two hands.

[The MESA bounces as Gene pulls on the battery, one handed. He has an SCB in his other hand which he now takes to the Rover.]

[Schmitt - "The LCRU batteries were stored in the MESA section of the descent stage, and we had to put in new ones for every EVA."]

140:54:30 Parker: Okay. That sounds like a familiar problem.
140:54:36 Cernan: Well, you got any familiar answers?
140:54:42 Parker: Someone who's been there before (John Young) says you just got to work it back and forth until it comes loose.

[Jack goes to the MESA with the ETB, followed shortly by Gene.]

140:54:49 Cernan: Okay. (Pause) I can get that, Jack. I've got to...

140:55:05 Schmitt: Want to hang it up?
140:55:07 Cernan: Yeah. I've got to work here anyway.
(Long Pause)

[Jack takes the EP transporter - containing EP-5 - to the east LM footpad. Gene is still struggling with the LCRU battery. It is too far inboard for him to get a good grip with two hands.]

140:55:48 Schmitt: Okay, Bob, it's on the minus-Z and the...One corner is facing directly into the Sun.
140:55:57 Parker: Okay; copy that.
140:56:03 Schmitt: That's EP-5.
140:56:05 Parker: Roger that. And I copy (charge) number 4 was put between the seat.
140:56:12 Schmitt: Yeah, it's between the seat, or will be very soon.
140:56:17 Cernan: Boy, this is ridiculous. Ridiculous.

[Gene is puffing audibly.]

140:56:23 Schmitt: Whoops, I need that other (EP) transporter.

[The charge transporter is stowed in the equipment bay on the northeast face of the LM Descent Stage.]

140:56:35 Cernan: (To himself and the world in general) Well, it's nothing worth getting upset about it, but it sure makes you start out...When you shouldn't have to this way.
140:56:41 Schmitt: Come on, just don't wear your hands out now.
140:56:43 Cernan: Yeah.

[Cernan - "In listening to this part, I can still feel the frustration of trying to get that damn little LCRU battery out of a storage area in the MESA. The problems you want to deal with are the ones that are worth solving, not something little that's avoidable. Of course, the real world is always a little different than the training. The training is good because you can try to look at every possible aspect of what you're going to be doing. You anticipate problems, you get proficient, and you get productive; but you're always going to run into new and different situations and, when you do, it's the little, avoidable things that are frustrating. Like having to tie a shoelace that comes undone all the time. If you have the right shoelace to start with, you wouldn't have the problem. Same thing with these LCRU batteries: we had just started the damn EVA and all of a sudden I had to wrestle with a little battery that I should have been able to just pick up and put in place."]

140:56:44 Parker: Hey, Geno...
140:56:45 Schmitt: Need a little help?

140:56:46 Cernan: No, I think I can do it, just got to wiggle...
140:56:48 Parker: ...jiggle it gently and sort of let it come free there. It's a matter of it wedging itself in, of course, on the parallel rails.
140:56:55 Cernan: Yeah. I...I see what's happening, Bob. (Pause) It's still ridiculous. (Long Pause)

[Jack comes to the Rover from the east; Gene is still struggling with the battery.]

140:57:37 Schmitt: Bob, did you hear my comment about the...about the SEP receiver?
140:57:44 Parker: Roger. That the blankets won't stay closed. We're talking about that down here.
140:58:04 Cernan: Boy; a bag of peanuts! Whew!! Man in space. Without them we'd be lost.

[Gene turns into the Sun, now holding the 8x4x2 inch battery by a loop handle.]

140:58:18 Schmitt: Without them we wouldn't have the LCRU and the MESA probably. (Chuckles)
140:58:22 Cernan: Manischewitz. Okay. Let me see what I can do for you while I'm here. Okay. (Consults checklist) "LCRU battery under seat, dustbrush to LCRU. Okay. I'll go get that; then I'll get to work." (Long Pause)

[Gene gets the big brush off the ladder hook where he had left it at the end of the first EVA. Jack goes around the south side of the LM to take a color pan with Gene's camera.]

140:58:51 Schmitt: Hey, Bob, what's my shadow length right now? (Pause)

[Schmitt - "My shadow was the only long ruler that I regularly carried around with me. And, knowing that everybody underestimates distance on the Moon, I asked them to be ready to give me my shadow length so that I could see what it looked like and know what it really was. And it always looked a lot less long than it really was."]

140:58:54 Parker: Stand by. I'll ask. (Pause) We'll get it for you momentarily. (Pause)

[Gene goes to his Rover seat with the battery.]

140:59:14 Parker: Okay, Jack. We've got four-point-five meters or one-five feet.
140:59:25 Schmitt: 4.5 meters, huh? Hmmm.
140:59:28 Cernan: 15 feet!? Is that how long I am on the ground? No wonder I've misjudged distance! Zap!

[Gene waves into the TV.]

140:59:42 Cernan: Hello there, Houston.

140:59:44 Parker: Hello there. (Pause) Okay, Jack. And do we have the new charge transporter on the pallet?

[Fendell pans away counterclockwise.]

140:59:52 Schmitt: I'll say yes, but you could have looked for yourself (with the TV).

140:59:55 Parker: Well, we just looked away.

140:59:58 Cernan: Yeah, it's here. It's here, Bob.

141:00:00 Parker: Copy that. I won't ask if we got the L.C.R.U. battery. That one, I did see.

141:00:11 Cernan: Yeah, we got it. You don't think I'd leave it here.

[Gene will stow the replacement LCRU battery under his seat as a backup for this EVA. If all goes according to plan, he will actually make the replacement at the start of EVA3.]

141:00:14 Cernan: Okay, (Sample Collection Bag) 7. (Pause) Boy, this (tool storage) gate's working like a charm. (Long Pause)

[While Fendell is panning counterclockwise, Gene is taking SCB 7 to the tool gate at the back of the Rover. He will then transfer a core cap dispenser, two packs of sample bags, and three core tubes from SCB 5 into SCB 7 and then stow SCB 7 as a spare under Jack's seat. The checklist then calls for Jack to put SCB 5 on Gene's PLSS, Gene to put SCB 4 on Jack's PLSS, and SCB 6 to be hung on the gate. They will actually wind up with a different pair of SCB's on the PLSS's because of the break in procedure caused by the fender replacement.]

141:01:12 Cernan: Okay. (Reading at the bottom of CDR-5) "Transfer from (SCB) 5 to 7." Okay?

141:01:17 Parker: Okay and...

141:01:22 Schmitt: Okay. The (photographic) pan's complete.

141:01:23 Parker: Okay, Jack. Copy that.

[Jack is southeast of the LM, taking a pan to complement the one he took at the start of the first EVA. These photos are AS17-137-20866 to 20893. AS17-137-20894 is a photo of the front of the Rover that Jack may take when he gets back there.]

141:01:24 Schmitt: And, Bob, those pans around here have more pictures (than normal 12-photo pans) because I'm having...To be sure I get the massifs, I'm having to take extra pictures.

141:01:37 Parker: Okay. Copy that. And I guess we'd suggest that, if you haven't talked about it already, that you work on the fender before you do the Geo Prep. You don't have your cameras and bags to worry about at that point.

141:01:52 Cernan: Okay. Would that be a good time for Jack to go to the ALSEP, do you think? Or do you think we both have to do this fender?

141:01:57 Parker: No. The ALSEP work we're not going to do until the end of the EVA.

[Fendell finishes the counterclockwise pan and reverses direction.]

141:02:02 Cernan: I heard John's words. (Responding to Parker) Okay.

141:02:06 Parker: And, Jack, if Gene's working there on unstowing SCB whatever-it-is - 5, yeah, 5 - maybe when you put the camera down, you might want to shoot off a few 500-millimeter frames of the North and South Massifs, if they look interesting. I can't tell from the TV. That might be an opportune time to grab a couple.

141:02:27 Schmitt: (Incredulous) If they look interesting!? If they look interesting!? Now what kind of thing is that to say? (Pause)

[Schmitt - "The first Apollo TV camera was just ludicrous. NASA just totally screwed up the specs in buying the thing and there was no excuse for it. Finally, we got a good, high resolution camera for 15,16, and 17. Actually, Tom Stafford flew it on 10. But the so-called Apollo Television Camera that flew on Apollo 11 was terrible : low resolution, black-and-white. Just not any good at all. It couldn't take any kind of bright scene at all. On Apollo 8, we had to put every filter in the spacecraft in front of it just to take a picture of the Earth."]

[Apollos 12 and 14 flew a low resolution color television camera which was still too light sensitive. The Apollo 12 crew accidentally burned out the vidicon tube in their camera by pointing it at a patch of reflected sunlight on the LM and, throughout the Apollo 14 ALSEP deployment - at a site down-Sun of the camera - all that could be seen of Shepard and Mitchell was a pair of overexposed, white blobs.]

[Cernan - "Getting color television on Apollo 10 was a personal crusade of Tom Stafford's. It was the first flight to carry color TV, and Tom had to lobby and push awfully, awfully hard to get it qualified and get it on board. It didn't make any difference who you were dealing with, every time you wanted to do something like that - whether it was for scientific purposes or whether it was for PR purposes - there was always an element that thought you were doing those kind of things from a self-promotional point of view. What I don't remember was why the color camera wasn't lunar surface qualified for the first three missions. Television, and particularly high definition color television let people

understand what you were doing or seeing from a scientific point of view - or from an operational point of view or in terms of sharing the experience. Television had a major impact of the space program and we should have started using it a lot earlier. On Gemini 9, the ground had little or no idea what I was going through up there. If they had been able to see, they could have been a part of it; they could have helped. We might have solved some of the problems right then and there in real time."]

141:02:45 Parker: Then, when Gene gets done configuring that SCB-5, we'd like to get on with the fender fix. Then, we'll do the Geo Prep after that.

141:02:55 Cernan: We'll get on with it, Bob. (Long Pause)

[Fendell finds Gene at the gate and Jack at Gene's seat.]

141:03:27 Cernan: My God, we got a lot of loose stuff in SCB 7. (Pause) Okay, Bob. I got three core tubes...Well, wait a minute. (I've) only got one core cap dispenser. Let me get the other one. (Pause as he double-checks his checklist) Well, that's all I wanted. (Reading) Okay; "three core tubes, two 20-bag dispensers, one core cap dispenser, and the short can."

141:04:03 Parker: Okay. Copy that, Geno.

141:04:07 Cernan: Jack,...

141:04:08 Schmitt: Yeah. Are you ready to work?

141:04:09 Cernan: ...see this right here?

141:04:10 Schmitt: Yeah.

[The identity of "this" remains a mystery.]

141:04:11 Cernan: I'm going to put that right there.

141:04:13 Schmitt: Okay. (Pause) Are you ready to work?

[Jack has the 500 millimeter camera.]

141:04:18 Cernan: Just let me turn my (checklist) page here. (Long Pause)

141:04:31 Cernan: Almost (ready); stand by. (To himself, looking at CDR-6) Okay; I already got one (SCB) on the gate. (Pause) That didn't count. (Pause) Okay. (To Jack) Want a couple 20-bag dispensers?

[Fendell looks at the maps on Jack's seat, then returns to Jack at Gene's seat. Gene is getting two more packs of sample bags out of SCB 5 to hang on the 70-mm cameras.]

141:04:58 Schmitt Well, I'm waiting for you to...

141:05:00 Cernan Well, let's get this done.

141:05:02 Schmitt: You want to...

141:05:03 Cernan: Here.

141:05:04 Schmitt: Well, what are you doing now?

141:05:05 Cernan: I was just getting this gear out now to work on the fender.

141:05:08 Schmitt: Okay.

[Jack puts the 500 on Gene's seat.]

141:05:09 Cernan: I'm not to Geo Prep yet.

141:05:10 Schmitt: Okay.

141:05:12 Cernan: Here you are.

141:05:13 Schmitt: Wait a minute.

141:05:15 Cernan: We'll just set these here.

[Gene brings Jack a packet of sample bags to put on the seat, and then goes back to the gate.]

141:05:18 Cernan: And there's another one. Okay; SCB-7 goes under your seat.

141:05:30 Schmitt: Okay. I'll get that. Your camera has the (sample) bags on it.

[Gene goes to Jack's seat.]

141:05:43 Schmitt: You might just put it there, and I'll come over and get those maps and everything.

141:05:46 Cernan: Okay. That goes under your seat. Let me get 4. Okay, we got 4 and 6. I'm going to start on the...We got SCB-4, goes to you, and SCB-6 goes on the gate yet, Jack, but let's pick that up with Geo Prep, and let me get that fender gear. Where's the (new fender)...

141:06:04 Schmitt: It's in your seat pan.

141:06:05 Cernan: In my seat pan? Okay.

[Jack goes around the rear of the Rover to his own seat, passing Gene who is going to his own seat.]

141:06:09 Schmitt: I should have put it over here. That was just where it ended up.

141:06:15 Cernan: You already use the 500?

[Jack arranges the maps.]

141:06:17 Schmitt: No, I didn't get a chance to.

141:06:18 Cernan: Okay. You might do it while I try the fender, and then you're here to help me in case I need it.

141:06:21 Schmitt: (Pointing with the maps) All your (fender) stuff's right there, Gene.

141:06:25 Cernan: Oh, okay. I see it. Well, let's hope it does the job. (Long Pause)

[Jack clips the maps to the accessory staff, puts the extra maps under his seat, and moves a 70-millimeter camera off of his seat. Gene is at the gate. Jack raises his seat and puts the SCB 7 in the seat pan.]

141:07:19 Schmitt: Okay, SCB 7's in my seat. And I put the return-to-LM map in there, too; it's just going to be in the way anywhere else.
141:07:30 Parker: Okay. Copy that. (Pause)
141:07:39 Schmitt: Let me check something, though. (Takes out map) On the way to Hole-in-the-Wall, we want to drive...
141:07:50 Parker: (Garbled under Jack) top of the notch.
141:07:55 Schmitt: (Replacing the map) Okay.
141:08:02 Cernan: Hope this thing gets stiff. It's just a flapper. Sure isn't stiff like I want it to be.

[The front half of the original fender is still in place. Gene, at the back of the wheel, positions the new fender over the top of the wheel and overlaps it with the remaining section of original fender.]

141:08:09 Schmitt: You want me to hold it there?

[Jack, standing to the side and slightly in front of the wheel, takes hold of the new fender.]

141:08:11 Cernan: Yeah, you're going to have to, I reckon. But, that may do the job. Let's see, does it come over the...I want it about right above the axle...Let me...Move your hand a minute. Let me align it. Okay. Hold it right there. Let me get the...
141:08:25 Schmitt: Okay.
141:08:26 Cernan: Let me move it up just a little bit. Right there. Okay. Hold it right there. Let me see how much room I've got coming out.

[He raises the rear of the paper fender to see how much coverage he's got, and then rotates the new fender 90 degrees.]

141:08:39 Cernan: I want to turn this around. We can tape that other end, Jack. There you go.
141:08:42 Schmitt: It's tending to fold a little bit...
141:08:44 Cernan: I think...Yeah, but the dust will be coming up from under it. Let's see.
141:08:49 Schmitt: Temperature, I think, is making it fold.

[Gene lifts the rear edge again to check coverage.]

141:08:51 Cernan: Now, that'll give us plenty of room down there. Yeah, I just don't want to interfere with the steering.
141:08:57 Schmitt: You think that'll stop the dust that way?
141:09:00 Cernan: Well, it'll stop some of it, if it stays on.

[Gene opens one of the clamps. It has a screw mechanism requiring finger work. Young had recommended opening the clamps before they were placed in the ETB. However, Gene

doesn't seem to be having much trouble, despite the stiffness of the gloves.]

141:09:03 Schmitt: Well, what I mean, it's not projecting outward at all. It's curling back under.

141:09:07 Cernan: Well, when I put a clamp here, and a clamp here, see what will happen?

[He pushes down at the clamp locations to demonstrate that the fender becomes a fairly rigid half-tube.]

141:09:10 Schmitt: Oh, okay. (Pause) Is that about where you want it? (Pause) Lean against me, if you need to. (Pause)

[Gene is having trouble reaching the inboard clamp position.]

141:09:37 Cernan: Trying to figure out...No, I've got to clamp it right in that rail; it's not much to clamp it on the inside.

141:09:43 Schmitt: No. Keep the knob up. There, you got it.

141:09:47 Cernan: Hold it right there. We got it all folded up on this side?

141:09:48 Schmitt: Why don't you try the outside.

141:09:49 Cernan: Let it go a minute. Okay.

141:09:51 Schmitt: Why don't you try the outside, first? Fix it...

141:09:56 Parker: Inside first; probably be better, guys. (Pause)

141:10:06 Schmitt: Got enough overlap there?

141:10:08 Cernan: Nope, I want a little more.

[Gene gives up on his second attempt to fasten the inboard clamp.]

141:10:09 Schmitt: Okay.

141:10:10 Cernan: And I am going to try this side because I can get my overlap over here. (Pause)

[He gets the outboard clamp positioned and starts to screw it tight with his left hand.]

141:10:26 Cernan: Okay. Now, hold it right there while I clamp it down. (Pause)

[Gene switches hands after a dozen or so turns of the screw. In Houston, the Public Affairs commentator offers "It's only a paper fender, but the Moon is real" which is a pun on the song lyric, "It's only a paper Moon..."]

141:10:39 Cernan: Well, that paper isn't going to come off, and the clamp's not going to come off, I'll say that. I

don't know how much we're going to get out of the fender but...

141:10:49 Schmitt: Okay, that's fixed?

141:10:51 Cernan: Yeah.

141:10:53 Schmitt: Can you fix that at all?

141:10:56 Cernan: Yep. That ought to give us a little strengthening, stiffening. Yeah.

141:11:02 Schmitt: Pretty tight.

141:11:05 Cernan: Yep. (Grunting) Tighter for the road. I don't want to lose that. (Grunting) Man, that's tight. Now, let's see if I can get this one. (He gets the second clamp open) Jack, why don't you come on this side and hold the fender down right there. (Pause)[

[They trade places; Jack to the rear, Gene to the front.]

141:11:37 Cernan: Hold it right about there.

141:11:43 Schmitt: Okay. You want to get it (the clamp) outboard a little more...I mean aft?

141:11:47 Cernan: No, I want to keep it above this center...the hub here...

141:11:53 Schmitt: Yeah, Okay.

141:11:54 Cernan: ...for steering purposes. See this...

141:11:55 Schmitt: Is that fixed for the...Well...

141:11:57 Cernan: I'll take a look at it. I'm going to tighten it down so it stays, then I'm going to take a look at it. I might turn this thing down, too.

141:12:04 Schmitt: Yeah; I was just going to suggest that. (Pause)

[Gene has the inboard clamp positioned.]

141:12:15 Cernan: Let me take a look before I get it too tight. Well, I'll tell you, that's going to help some.

[Gene gets his arm out of the way and leans in for a close look.]

141:12:20 Schmitt: Yup. It may do the trick.

141:12:22 Cernan: I can't see what's under this rail too well, but I know that clamp is on. It's on tight.

141:12:27 Schmitt: Gene, it looks...

141:12:30 Cernan: (Reaching in) Let me move this...

141:12:31 Schmitt: Move your left hand a little. Okay. Tighten that now.

141:12:34 Cernan: Get this out of the way.

141:12:39 Schmitt: Looks as if...

141:12:43 Cernan: Let me loosen it, and get it a little straighter.

141:12:44 Schmitt: Yeah, I think you need to straighten it.

141:12:47 Cernan: Boy, I had it tight.

141:12:48 Schmitt: Yeah, but you know you've got another piece in there so...

141:12:51 Cernan: Yeah, that's why it's crooked, it's over those pieces.

141:12:53 Schmitt: Yeah. Well, you might want to move it...If you could move it this way about a...(about) an inch, you'd be past the ridge you got.

141:13:00 Cernan: Well, I'm just taking John's word on the steering.

141:13:02 Schmitt: Okay.

141:13:03 Cernan: I'm keeping above the hub here.

141:13:04 Schmitt: Okay; tighten her down then. (Pause)

[Gene starts tightening with his left hand.]

141:13:20 Schmitt: I think that'll stay.

141:13:21 Cernan: I think it'll stay!

[Grunting, Gene tightens it a last little bit.]

141:13:26 Schmitt: Why don't I turn this one...

141:13:27 Cernan: Okay. You won't get that any tighter.

141:13:28 Schmitt: No, I mean, why don't I turn that down because it'll keep...(It will be) that much less to run into (as they work around the Rover). There you go.

[Gene adjusts the outside clamp.]

141:13:37 Cernan: Well, not too close to that wheel. Okay?

141:13:41 Schmitt: I think that's good.

141:13:45 Cernan: Too bad we don't have one more clamp...Well, one more clamp would probably interfere with the steering.

141:13:50 Schmitt: I think that'll stop the rooster tail, because that's...

141:13:53 Cernan: I think that'll stop a lot of it, Houston.

141:13:54 Schmitt: ...that's swinging forward. Okay. Let's go.

[The repair job took about 5 minutes.]

[Cernan - "It seemed like it was a lot longer than five minutes."]

141:13:59 Schmitt: The maps are configured.

141:14:00 Parker: Okay. That sounds like a good attempt, men. We'll hope it works.

141:14:03 Cernan: Does that look...Does that look good to John, from what he did?

141:14:09 Parker: It looks exactly what his did, he says.

[Young has, of course, been watching the proceedings.]

141:14:12 Cernan: That tape will keep it...(Stops to listen to Parker)

[Jack goes to the gate.]

141:14:15 Cernan: Yeah, but he didn't run in the dust, so I guess we'll have to give it a trial run. That'll help some.

[Gene straightens up, the job done to his satisfaction.]

141:14:19 Parker: Roger on that. We're anxiously waiting.

141:14:20 Cernan: Okay, Jack. I'm going to High (cooling) for a little bit. Okay. I need...

141:14:29 Schmitt: Oh, shoot.

141:14:31 Cernan: No, I want (SCB) 4.

141:14:32 Schmitt: I took 8 off (the MESA).

[Gene was supposed to have gotten SCB's 4 and 6 off of the MESA. Jack was trying to get them back on schedule by getting the bags, but got the wrong one. Jack in on LMP-6 and Gene is on CDR-6. They are starting the Geo Prep activities.]

[Schmitt - "The empty bags were stowed in the MESA and you would think that an intelligent human being would be able to grab the right one."]

141:14:33 Cernan: (Consulting his checklist) No, sir. I want 4 and 6. Why don't you just substitute...

141:14:38 Schmitt: (To Parker) Hey, I just took 8 off. Can we use 8 instead of 6?

141:14:42 Cernan: Yeah, we can.

141:14:44 Parker: Yeah, I don't see there's any reason why you shouldn't be able to use that, Jack. Go ahead. We'll just mark it down.

141:14:49 Cernan: Okay. Turn around, Jack. Hey, Bob, we'll use 8 instead of 4.

[Gene starts mounting the SCB on the right side of Jack's PLSS.]

141:14:53 Parker: Okay. Understand 8 will be on the LMP.

141:14:59 Cernan: That's affirm; 8 will be on the LMP.

[Schmitt - "Once the samples were in the SCB's, that's where they were going to stay until recovery. In that way, if they wanted a particular set of samples, they would know which bag to get. Some of the samples would in the boxes (the SRC's) but a lot of them just stay in the bags until they got to the Lunar Receiving Laboratory."]

141:15:10 Parker: Geno, you went to Min (cooling) instead of Max.

141:15:14 Cernan: I think you're right. I just realized that. (Pause)

141:15:23 Schmitt: (To Gene) Got it?

[Gene has SCB-8 mounted on Jack's PLSS; he reaches for his cooling control.]

141:15:26 Cernan: Yep, let me go to Max here for a minute. We need (SCB) 6 off of there, Jack.

[Cernan - "This is a good example of how I had to move my arm forward and then back to loosen the arm bearing and get some momentum so that I could reach the diverter valve. If you tried to just sneak back there slowly, it was hard to do. It was one of the little things you did to adapt to the suit and the environment."]

[Jack opens the gate.]

141:15:32 Schmitt: Oh, 5 stays back here, huh?
 141:15:33 Cernan: We need 6 to the gate. It's probably behind 4, isn't it.
 141:15:41 Parker: Well, put 4 on the gate, guys,...
 141:15:43 Schmitt: Yeah, probably.
 141:15:46 Parker: ...and put 5 on the commander.
 141:15:47 Schmitt: Yeah. Okay; 4 is going on the gate and 5 on the Commander.
 141:15:53 Cernan: (To Parker) Okay, Bob, a little paperwork for you, but that's all right. Okay. (Pause)
 141:16:00 Cernan: (Consulting his checklist) Now, I got to do some more stowing on you when you get that on. (Pause)
 141:16:13 Schmitt: Okay. They're in the...(Pause) Where do you want me?
 141:16:21 Cernan: Your left side.
 141:16:24 Schmitt: I mean...Which way are you going to turn?

[They are mostly hidden by the gate. Jack is facing southeast; Gene is northeast of him, mounting equipment on the left side of his PLSS.]

141:16:33 Cernan: Oh, man, does that Velcro get tough. (Long Pause)
 141:16:50 Cernan: Okay, you've got a core cap dispenser. Stand by; let me fix these for you while I'm here. Okay. Here's your doffing harness on this side. Don't move yet, I've got something I've got to do to you.
 141:17:04 Schmitt: Okay.

[Gene gets something from the gate, probably the drive-tube rammer.]

141:17:07 Cernan: Okay; turn around, I'll get your harness on the other side.

[By getting Jack to turn around, Gene will have sunlight on the rightside straps he's trying to adjust.]

141:17:16 Schmitt: Let me get yours too.

141:17:17 Cernan: Okay. (Pause) Okay, there you go.

[Jack starts adjusting Gene's straps, working in shadow.]

141:17:23 Cernan: Okay, you've got a cap dispenser, you've got a (drive tube) rammer, and you've got...Well, I guess SCB-8, if I'm not mistaken.

141:17:28 Schmitt: Yeah, that's all right, they got it. (Pause) Okay. That's one.

[Jack goes around Gene to the other side.]

141:17:35 Cernan: Okay. You can give me SCB-5 then, and...

141:17:41 Schmitt: Yeah. (Pause) Can you move...Move a little bit. There you go. (Pause)

[Jack pushes Gene away from the Rover a little so that he can get at the gate.]

141:17:57 Schmitt: Okay. There you are. (Pause)

141:18:12 Cernan: You got it?

[Gene starts to move away.]

141:18:13 Schmitt: No.

141:18:14 Cernan: I'm sorry.

141:18:16 Schmitt: In fact, I've got to tighten up your (straps)...

141:18:21 Cernan: We've got to take a picture of that fender if it works.

[Fendell pans the TV upward.]

141:18:23 Schmitt: Wait a minute. No...If you weren't so tall. You just invariably stand so I have to get in a hole! Okay. Now let me tighten up your whole shooting match here. It's loose again. Hang on. (Pause)

141:18:47 Cernan: Okay.

[Fendell returns to them.]

141:18:53 Schmitt: Between Velcro and snaps, the world could never fall apart. Okay, (it's on).

141:18:58 Cernan: All set?

141:19:00 Schmitt: You're set.

141:19:01 Cernan: Okay. I'm going to get a hammer, and then I'll get the TGE.

141:19:04 Schmitt: I'm going to get my camera, and I'll go to the SEP site (140 meters east of the LM).

[Gene gets the hammer from the gate, puts it in his shin pocket.]

141:19:07 Parker: Okay. Why don't you start to the SEP site, Jack...
141:19 Cernan: Hey, Jack, when I start running...(Stops to listen to Parker)
141:19 Parker:...And, also, I presume that the dustbrush is on the Rover now.

[Jack gets a 70-mm camera from his seat and leaves. He is now on LMP-7.]

141:19:15 Cernan: It is.
141:19:17 Parker: Okay. Copy that.
141:19:21 Cernan: Jack, when I drive out there why don't you watch the rear wheel.
141:19:23 Schmitt: I will. Give me a yell when you start to drive.
141:19:25 Cernan: Okay. (Watch) both the steering and the rooster tail.

[Gene goes to read the gravimeter.]

141:19:32 Cernan: Oh, I hope it (the TGE reading he's about to take) is not all zeros. Okay, Bob. 670, 017, 701; 670, 017, 701.
141:19:45 Parker: Okay. Copy that. (Pause)

[Fendell pans away.]

141:19:53 Cernan: Okay; and the SCB is good. It's closed. It's in the shade. (Correcting himself) Or "SRC", I guess.

[Fendell finds Jack jogging to the SEP site.]

141:20:03 Parker: Okay. And, Jack, when you get out to the SEP site, you might give us a reading on what the solar panels look like...How they survived the night with the tape on them.
141:20:17 Schmitt: I wouldn't think of not doing that. I'm curious myself. (Pause)

[The SEP gets its electric power from three small solar panels which Jack and Gene taped open at the end of the first EVA.]

141:20:32 Cernan: Okay. The TGE is on the LRV.
141:20:34 Parker: Okay. Copy that.

[Cernan - "I don't think we had nearly as many acronyms in the Navy as we had in NASA. NASA won the prize. The Navy used them for the names of commands, like 'ComNavAirPac' which means 'Commander, Naval Air-forces, Pacific'. But I tell you, going down to NASA meant learning a whole new language: an acronym for everything. And for the longer ones, like LCRU, you just turned them into words and said 'Lacru'.

It's funny, but a lot of acronyms became so much a part of the NASA lingo that if you stopped somebody and ask them 'What does LCRU stand for?', they couldn't tell you. People would know which box the LCRU was and what it did, but they couldn't tell you what the letters stood for."]

141:20:35 Cernan: (Turning to CDR-7) Okay. I'm making an inventory. I've got the LCRU battery. Okay. We('ve) got (seismic charges number) 1, 3 and 2 and 8; LCRU blankets are open 100 percent. Battery covers are Closed. Dustbrush is on the LCRU. TGE is on the Rover. Jack, can you verify we got the right mags and a polar filter? Polarization (filter).

141:20:57 Schmitt: Yes, sir. I verified that.

141:20:58 Cernan: Okay. Very good.

141:21:00 Schmitt: You better put that 500 back under the seat.

141:21:02 Cernan: Yep. That's where it's going.

[Jack reaches the SEP. Once again, it looks as though he is below the Rover, even though there is really no appreciable elevation difference. He has covered the 140 meters in a bit less than 2 minutes; his average speed, then, is a modest 4.5 kilometers per hour.]

141:21:05 Schmitt: Well, Bob, it looks like (the SEP) tape survived. As I stand behind the panels, the left-hand panel may be tilted at about...well, less than 5 degrees. Probably about 2 or 3, but that's all. Looks pretty good right now.

141:21:24 Parker: Okay; beautiful. Thank you. Good fix.

141:21:29 Schmitt: Okay.

141:21:30 Cernan: Okay, Bob, I'm going to take the TV from you.

141:21:33 Parker: Okay. Copy that, Geno.

141:21:36 Schmitt: And the (SEP) transmitter's going on.

141:21:37 Parker: Copy that, Jack.

141:21:39 Schmitt: (Laughing) If I can do it without destroying it.

[Gene moves the TV camera just as Jack bends his knees.]

141:21:44 Cernan: Yeah. That's hard to do out there, Jack. (To Parker) Okay. TV camera going Position 1.

[TV off.]

141:21:51 Schmitt: Transmitter's on. (I'll) fix the level there. Okay. The level is on the inner ring again. The gnomon has moved a little bit, but not much. But you would expect that, I guess (because the Sun has moved about 9 degrees in the eighteen hours since they deployed the SEP).

[This gnomon is a small post on the top of the SEP transmitter which casts a short shadow on a scale for alignment purposes.]

141:22:09 Parker: Yeah. Seeing the other end of the gnomon up there in the sky (the Sun) has moved a little bit.

141:22:15 Schmitt: Yeah. That's what I said.

141:22:17 Cernan: Okay. (70 mm) camera, tongs, and I'll drive. West leg, heading 270. (Pause) Camera is on. Bob, I'm on...I guess (frame) 26. Yes sir, frame 27, mag Charlie.

[Mag C, or Charlie, is Apollo magazine 137. Jack is using Mag Golf, which is Apollo mag 135.]

141:22:54 Parker: Copy that. Charlie 26...27.

[Here, Gene is referring to the 70-mm camera which he has mounted on a bracket on his chest.]

141:23:00 Schmitt: I had to relearn how to document samples, Bob. I just have. The first part of my roll will have a lot of random exposures and focuses. (Pause) Okay, we're back in business. And while I'm waiting for Gene, (I'm) getting a rock. It looks a little finer grained than the others we've seen. (It's) in the LRV sampler, along with some soil. And that's done. (Gene's heaving breathing can be heard as he mounts the Rover.) Hey, that's a neat sampler. Only way to fly. Okay. and that's in bag 22E. It has the stereo documentation and a locator to the LM, and it's about 2 meters from the SEP.

[Jack's "random exposures and focuses are frames AS17-135-20533 to 20537. 20538 is the locator to the LM, and 20539 and 20540 show the sample location and the raindrop pattern on the soil.]

[Schmitt - "This was the 'dixie cup' sampler which I must have just grabbed and carried out to the SEP site without telling anyone. It held a stack of dixie-cup-like bags on a long handle; and when you filled one and pulled it off, another one was ready to use. Again, the bags each had a metal ring and you clamped it down and twisted it and stowed it. Each of the bags already had a number on it."]

141:24:00 Parker: Okay, Jack.

141:24:02 Schmitt: 22 Echo.

141:24:03 Parker: Roger. Copy that. Did you ever find any sign of that brown, fine-grained rock you saw on the way out to the SEP yesterday?

[Parker is subtly ribbing Gene about a piece of packing material he found at the SEP site at the end of the first EVA and mistook for a piece of brown glass. See comments at 123:03:34 and 123:28:18.]

141:24:10 Cernan: Bob, let me give you some readings, so I can get going.
 141:24:11 Parker: Okay. Go ahead, Geno.
 141:24:13 Cernan: Okay. Amp hours, 108, 100; volts are 68, 68; batteries are 80 and 102; and motors are all off-scale low. I'm on the way. (Pause) On the way, Jack.
 141:24:38 Schmitt: I'm waiting.
 141:24:40 Cernan: Oh, there you are over there, huh? (Long Pause)
 141:24:54 Parker: And, Jack, how's the rooster tail look on that fender?
 141:25:02 Schmitt: Looks like it's going backwards.

[Jack's photo of Gene driving out from the LM is AS17-135-20541.]

141:25:04 Cernan: I don't see anything coming up over the top.
 141:25:05 Schmitt: Looks like a good fix.
 141:25:08 Parker: Beautiful. (Pause)
 141:25:16 Cernan: Okay, Jack; I got to come around...I'm going to come on this side and head west.
 141:25:21 Schmitt: Okay. Watch those...You got the (SEP) antennas?
 141:25:24 Cernan: I've got one over here.

[These are the four 35-meter long wires that form the SEP transmitter antenna.]

141:25:26 Schmitt: Okay. I'll give you a line on the other one. (Long Pause)
 141:25:47 Cernan: Okay. I'm getting close.
 141:25:50 Schmitt: Okay. Turn.
 141:25:53 Cernan: Where is it?
 141:25:54 Schmitt: Right here. I'm on it.
 141:25:55 Cernan: Okay. (Pause) Okay. And I see the other one...Let me (align the Rover) parallel that line.

[There is a burst of static as Gene turns the Rover to head west.]

141:26:13 Parker: Low gain (pointing), Gene, please; after you get stopped.
 141:26:24 Cernan: I guess that's about 2 or 3 meters (from the west antenna wire), huh, Jack? You can better see where it is at.
 141:26:29 Schmitt: Yeah, that's good, Geno. Okay,...
 141:26:34 Cernan: Heading 270.
 141:26:35 Schmitt: You want to...
 141:26:36 Cernan: Am I ten meters from the transmitter? Probably not, huh?
 141:26:39 Schmitt: You're pretty...No, you need to go about 5 meters.
 141:26:45 Cernan: How far am I? See if it's okay.

141:26:48 Schmitt: You're about 3 meters...4 meters.
 141:26:51 Cernan: Hey, Bob, I'm 3 meters to the west of the transmitter and about 2-1/2 meters south of the line going west Is that okay?
 141:26:57 Parker: There's no problem there, Gene. Don't move. It's just they had to be less than those numbers.
 141:27:05 Cernan: Okay. That's where I am.

[Gene needed to park the Rover within ten meters of the transmitter and within 5 meters of the west antenna arm. Once Jack climbs on board, they will drive along the west arm to give the experimenters a calibration reading. At this moment, Jack is taking pictures of the relative positions of the transmitter, the Rover, and the antenna arms at the start of the drive.]

[Schmitt - "The intent here was to drive along the antenna on a constant heading so that the SEP experimenters could have a bit of calibration data that would have been easy to analyze - had the experiment been working. I don't know if it was still working at this point, and we certainly didn't know that until we got the data back to Earth. As I recall, they got a little bit of information on the this EVA and, after that, it just got too hot."]

141:27:08 Schmitt: (To Parker) I'm getting your photos.

[AS17-135-20542 to 20546 document Gene's parking at the SEP transmitter.]

141:27:10 Cernan: Okay; and let me give them a voltage reading, and I'm still reading 68 and 68.
 141:27:14 Parker: Okay; copy that. We don't need those, we just got them.
 141:27:21 Cernan: I know, I just wanted to keep you honest.
 141:27:23 Parker: And give us the nav numbers.
 141:27:27 Cernan: Okay. 265 (bearing), 0.2 (distance), and 0.1 (range).
 141:27:34 Parker: We want heading, pitch, roll, and sun dial there, Gene.
 141:27:42 Cernan: Okay. I'm sorry, Bob. (Pause) Okay; you want a nav update here?
 141:27:49 Parker: Nav initialize, Geno.
 141:27:50 Cernan: (Turning to CDR-9) Yes, sir; you do.
 141:27:51 Parker: Roger.
 141:27:53 Cernan: Yes, sir; I'm sorry.
 141:27:54 Parker: Go to the next (checklist) page.
 141:27:56 Cernan: Let me change my (Rover) position here, just a skosh. (Pause) I knew you'd...

[Gene will do the navigation system initialization by pointing the Rover directly away from the Sun. He had parked heading due west and since, the Sun is 12 degrees south of east at this point in the mission, he'll have to turn the

Rover to a heading of 282 in order to zero the sun-shadow device.]

141:28:15 Schmitt Bob, what was that last LRV sample number I gave you?

141:28:18 Parker: Twenty-two Echo, two-two Echo.

141:28:24 Schmitt: 23 Echo, if that followed in sequence, is another rock near the SEP, documented in the same way.

141:28:31 Parker: Okay; copy that.

[These photos are AS17-135-20547 to 20549.]

141:28:34 Cernan: Okay, Bob. 265, 0.3, 0.1; roll is 1 right, pitch is 0, and the sun-shaft device is 0. I'm heading 281 degrees.

141:28:47 Parker: Okay; copy that. Stand by. (Pause)

141:28:56 Schmitt: Okay. The (SEP) recorder is On and the Receive Power switch is on.

141:29:08 Parker: Copy that.

141:29:09 Schmitt: (To Gene) And, I guess you're going to hand me EP-4. (I'll) get rid of this (LRV sampler).

[Jack will keep the LRV Sampler within reach, attaching it to the accessory staff. He probably would not be laying it in his seat pan since it would be hard to reach while seated.]

141:29:16 Parker: Okay. 282 is the preferred (meaning "the proper heading") but that's too small (a difference) to bother torquing, Gene; you're good as is. We're ready for you guys to go.

[This difference in heading has the potential of contributing up to a 100 meter southward bias to estimates of the LM location made from Rover readouts at the more distant stations visited during this EVA. This point is discussed in full at 164:48. If Gene did not do the correction - and that point is not crystal clear in the following dialog - all LM bearing readouts given during this EVA should be decreased by one degree.]

141:29:24 Cernan: Okay. That looks good because I have to come left just a skosh there to proceed parallel down the west line.

141:29:30 Parker: Okay. We're ready for you guys to go. We presume you have the SEP photos, Jack.

141:29:39 Schmitt: Yes, I do.

141:29:40 Parker: Okay. And you can give us a frame count, if you want. Remember to pick up EP-4 when you get in the Rover.

141:29:50 Schmitt: Okay. We got it, and the frame count is 17.

141:29:54 Parker: Copy 17 for the LMP, and we need a nav reset to verify there, Gene.

141:30:03 Cernan: I did nav reset; I'm reading all balls. And it is back off.
 141:30:06 Parker: Okay. And did you happen to check the SEP temperature when you turned it on, Gene? (Correcting himself) Jack? The receiver?
 141:30:15 Schmitt: No. I didn't; I didn't. Doubt if it changed much since I called you.
 141:30:20 Parker: Okay. We'll catch it at Station 2.
 141:30:25 Cernan: Okay, Jack, we got transmitter and receiver both on, huh?
 141:30:25 Parker: Okay. Low gain antenna is 240 and we're ready for you guys to leave. Give us a mark on the leave.

[A sketch map of the initial portion of the traverse is shown (identically) on LMP-8 and CDR-8. The average heading during the first six kilometers of the traverse will be 260 degrees, ten degrees south of west. As discussed previously, there is an offset in the low-gain antenna's pointing indicator to compensate for the Earth's position in the local sky and, therefore, the reason for the 240 degree pointing - rather than 260 - is not obvious. They also are carrying a more detailed chronopaque map, based on Apollo 15 photography, with a contour map on the back.]

141:30:33 Cernan: Okay. Here you go, Jack; we need...The SEP receiver and transmitter (are) both on, huh?
 141:30:40 Schmitt: Yes, sir.
 141:30:42 Parker: Okay. And, Gene, remember we want a mark when you pass the end of the antenna.
 141:30:50 Cernan: Okay.
 141:30:52 Schmitt: Gonna drive fairly slowly, huh?
 141:30:54 Cernan: Yep, until I get past the end. I got to get my heading changed about 10 degrees to parallel it. We're still in the same relative position, Bob.
 141:31:00 Parker: Okay. Very good.
 141:31:04 Cernan: Okay. We are moving right now.
 141:31:07 Parker: Okay. We're marking that.
 141:31:09 Cernan: Slowly. (Long Pause) Okay. Stand by, Bob.
 141:31:43 Cernan: Mark it.
 141:31:44 Parker: Okay. Copy that.

[Gene has driven about 32 meters along the antenna arm in about 40 seconds. His average speed, therefore, was a bit over 4 kph. During the drive toward the LM, Jack takes AS17-135-20550 and 20551, the latter showing a large, partially buried boulder northeast of the spacecraft.]

141:31:49 Cernan: Okay. We want to go past the LM at heading 260, Jack.
 141:31:51 Schmitt: Well, we want to get at 080 (bearing) and 0.4 (range) and get rid of this charge.

[Details of the initial stage of the traverse are given (identically) on LMP-9 and CDR-9.]

141:31:56 Parker: Okay, 17, a couple of words there as you drive along. Let me give them to you early here. One, we didn't bother to change all the numbers on the checklist; but, by and large, because we think we're 200 meters east of where we were (planning to land), you should probably increase all those numbers except for the explosive package numbers by about two-tenths to get the distance at which you will come across these areas. Again it's about 0.4 (or) 0.5 (km) that we expect to deploy EP-4. The more important number though is that it's 0.2 west of the ALSEP. As you pass the ALSEP, you might note what the range and distance are reading at that point.

[It is possible that Houston is now giving credence to Ron Evans' sighting of the area lightened by the LM descent plume. Houston's estimate of the landing point is quite good considering the sparse information available at this point in the mission. Rover navigation data at well-defined stops during this traverse will be used to refine the estimate. See the discussion at 164:48.]

141:32:35 Schmitt: Okay. Range is the one that changes on...No, wait a minute.

141:32:40 Cernan: I got it. I'll get it.

141:32:42 Schmitt: Which is it? Range changes every half...on the half kilometer?

141:32:46 Cernan: Yep. (Pause) Distance.

141:32:52 Cernan: Let me go around your (garbled).

141:32:52 Parker: Roger, Jack. The range is what changes in the middle at 50 meters and 150 meters.

[The Rover has digital indicators for bearing, distance driven, and range. The range indicator changes from 000 to 001 at 50 meters, to 002 at 150 meters, and so on. The distance indicator changes at 100m, 200m, and so on.]

141:32:59 Schmitt: Okay. The fender fix is working so far.

141:33:02 Parker: Beautiful.

141:33:04 Cernan: Let me get around your flag. There's your flag way out there, isn't it?

[This is the flag marking the southernmost geophone that Jack deployed during the first EVA.]

141:33:08 Schmitt: Yeah.

141:33:10 Cernan: (To Jack) Let me get around that. Man, that's really giving the ALSEP some room.

[Jack's LRV photos during this interval are AS17-135-20552 to 20554. They show some large boulders south of Geophone rock.]

141:33:12 Schmitt: Yeah. Okay, Bob; we're still seeing the light-colored gabbroic rocks. I think the reason I said 50 percent (plagioclase) was because, in this light, they look light-colored, and that's probably largely because of the zap-pit halos.

141:33:27 Parker: Okay. I copy that, Jack.

141:33:29 Schmitt: In the hand lens, it looked like a standard gabbro.

141:33:32 Parker: Okay.

141:33:33 Cernan: And, Bob, I'm full out at about 11...

141:33:37 Schmitt: Okay, you can turn right, now.

[Gene has been driving more or less south to get around the geophone and will now turn west.]

141:33:38 Cernan: I'm full out at about 11 clicks (11 kilometers per hour) right now.

141:33:39 Parker: Beautiful.

141:33:41 Schmitt: Oops. You drove (garbled under Parker).

141:33:46 Parker: Can you give me a call as you pass by the ALSEP as you get ready to deploy the charge, please?
 141:33:53 Schmitt: Okay. We're almost due south of the ALSEP now.
 141:33:59 Parker: Okay, ...
 141:34:00 Cernan: (Garbled under Parker) got to work my way through here.
 141:34:00 Parker: ...copy that. Go about 0.2 kilometers further than that. (Pause)

[Jack's photos during this drive west to the charge deployment site as AS17-135-20555 to 20562.]

141:34:11 Schmitt: (To Gene) It's a little rocky out here.
 141:34:12 Cernan: Yeah, it sure is.
 141:34:14 Schmitt: In the area we are now...Did you get a distance? That was...
 141:34:20 Cernan: Okay. We just clicked to (zero-zero)-four. I want to move over this way just a skosh.
 141:34:24 Schmitt: Yeah. Okay, (we're) just south of my geophone 2 flag now.
 141:34:31 Parker: Okay. If you just clicked to 4, let's go to 6 then, just past the click on 6.

[That is, at a range of 550 meters.]

141:34:40 Cernan: Okay. And they want about (a bearing to the SEP transmitter of) 080. (Pause)
 141:34:46 Cernan: Plenty good enough. I got to start heading right out here, right toward my topographic...
 141:34:50 Schmitt: Okay. Hole-in-the-Wall should be just to the left of the notch (in the rim of Camelot).
 141:34:51 Cernan: Yep. That's exactly where I'm heading.
 141:34:55 Schmitt: And I think we're coming up closer to the rim of Camelot. It's starting to look like a crater now.
 141:35:00 Parker: Okay; very good.

[Schmitt - "The drive up to the Camelot rim was a very gradual climb, unlike Cone Crater on Apollo 14 which was a crater on a knoll. The LM was probably on the ejecta blanket of Camelot, so it would have been hard to judge a change in slope. Generally, the terrain here was much flatter than on either Apollo 14 or Apollo 16, which were the highland sites. The average (vertical) variation at our site was perhaps a meter or a meter and a half; and there's one picture of the LM, taken looking back into the Sun, and there is a little low ridge blocking out the lower part of the LM."]

[Jack is probably thinking of AS17-145-22185, which he takes at the end of the EVA from down in the swale west of the LM.]

141:35:01 Schmitt: Looking down-Sun, I see no major albedo changes except for the very fresh craters which are brighter. By maybe 20 percent. The surface...

141:35:16 Cernan: How are we doing?
 141:35:17 Schmitt: (0.)5.
 141:35:18 Cernan: Okay, Bob. Here's your charge. Pick a spot, Jack.
 141:35:22 Schmitt: Okay; can you swing right out over there...
 141:35:25 Cernan: Yeah.
 141:35:26 Schmitt: ...about 10 meters ahead?
 141:35:27 Cernan: Okay.
 141:35:28 Schmitt: Give me a shallow turn. (Pause)
 141:35:31 Cernan: How's that?
 141:35:32 Schmitt: Okay. And I'll set it right there in that...Can you move forward, and I'll get it in that little depression.
 141:35:37 Cernan: Okay.
 141:35:38 Schmitt: You see on the other side of the rock.
 141:35:41 Cernan: Yeah. (Pause) Okay, Bob; 083, 0.6, and 0.5.
 141:35:53 Parker: Okay. Copy that.

[The SEP transmitter is seven degrees north of east from their current position and at a range of 450 to 550 meters. They are probably close to the upper figure because the distance reading is 600 meters. Because they have been driving around craters, this figure should be reduced by about ten percent, indicating that their straight-line distance is at least 540 meters.]

141:35:57 Schmitt: Okay. Pin 1 is pulled and safe; Pin 2 is pulled and safe; Pin 3. pulled and safe. Ever stop and ask yourself what I'm doing (pulling pins on an explosives charge)!?
 141:36:14 Parker: I copy that, Jack...
 141:36:15 Cernan: Yes (laughter).

[Schmitt - "The seismic charges had a Apollo Standard Initiator (ASI), which was the pyrotechnic initiator they used for everything - for any kind of explosive bolt initiation, for instance. It was hooked up to a radio receiver and, at 90 hours, the timer moved a metal window from between that initiator and the charge. For half an hour after the window opened, the ground could send a signal to set off the initiator and, therefore, the charge. And, if it hadn't gone off in the half hour, then the window would close again and that would be the end of it. All of them actually did go off but, if they hadn't, they would have been safe sitting up there when the people from the Smithsonian went to collect them sometime in the future."]

141:36:16 Parker: ...If you can give us a frame count, we'd appreciate it. And I might remind you two to both check that...
 141:36:23 Cernan: Don't fall over!

141:36:23 Parker: ...you're at Min cooling since you've got a long drive ahead of you there.

[Cernan - "Jack had to lean over to get the charge on the ground. Of course, we were riding low to the ground, but he had to reach to get the charge outside the fenders and sometimes he probably grabbed the antenna on the charge to set it down. Then, when we started up again, I had to be very careful not to run into the charge and knock it over. With the front-and-rear, Ackerman steering, if you turned left away from the charge, rather than the rear wheels dragging, the rear wheels were going to turn right and maybe hit the charge; so I'd turn right to avoid it."]

141:36:29 Schmitt: Hey, I lost my sample thing.

[Apparently, the head of the LRV sampler has come off. They'd had trouble getting it on during the Geo Prep at the ALSEP site.]

141:36:31 Cernan: (Garbled) on the floor?

141:36:32 Schmitt: I hope so. (Pause)

[Because of the stiffness of the suit and the bulk of the RCU and the camera blocking his view of his feet, Jack has no chance of looking for the sampler without getting off the Rover. Gene can see parts of Jack's foot pan, but not all of it.]

141:36:43 Cernan: (Asking about the charge placement) That look good?

141:36:44 Schmitt: Yeah, it's going to stay.

141:36:47 Cernan: Okay. Have you got anything (garbled). If not, I'll do a partial for you.

[Gene is suggesting that he turn the Rover in a slow circle so that Jack can take a sequence of photos for a partial pan. This technique was invented by Young and Duke during their second Apollo 16 EVA.]

141:36:52 Schmitt: Yeah. We got to do a partial. I'd like to know where that sampler is. Well, we can do without it, I guess.

141:37:01 Cernan: Well, it's sure be nice to...What did it do; come off the end?

141:37:03 Schmitt: Yeah, I think I can check it though.

141:37:05 Cernan: Getting your (photographic) pan?

141:37:06 Schmitt: Yeah. (Pause) If you go around to seeing that big block there by the ALSEP, then you can forget it.

[Jack is telling Gene that, once they are pointed at Geophone Rock, they will have finished the partial pan. The pan photos are AS17-135-20563 to 20569. The last of these

shows the large blocks south of Geophone rock that Gene drove around to avoid Geophone 4.]

141:37:13 Cernan: Okay. Okay. I'll just come on around, and I'll pick up my tracks. Do you want to get that sampler? Can you see it?

141:37:21 Schmitt: I think I'd better look.

141:37:25 Cernan: All right. Take a look. Bob, one stop here for about 2 seconds.

141:37:30 Schmitt: Hold this (UHT).

141:37:30 Parker: Okay. Copy that.

[Jack dismounts. The handle of the LRV sampler is one of the Universal Handling Tools (UHT's) that they used during the ALSEP deployment.]

141:37:37 Schmitt: Okay. It's down there.

141:37:38 Cernan: Why don't you put it on real quick and...

141:37:40 Schmitt: I don't know why...It was hard to put on. Surprised it came off.

141:37:45 Cernan: Here, let me hold the end.

141:37:48 Schmitt: You got them retracted?

[Jack is referring to the retractable locking pins in the handle; Gene is probably holding the UHT, working the trigger.]

141:37:52 Cernan: Retracted. (Pause) Still retracted; let me know when.

141:37:58 Schmitt: Okay.

141:37:59 Cernan: Okay. It's loose. Retracted. How you want it?

141:38:04 Schmitt: Retract it again.

141:38:05 Cernan: Okay. Retracted. (Pause)

141:38:09 Schmitt: No...Let go, let go...No, it's just not hooking.

141:38:12 Cernan: Okay. Try it...Push it in once more.

141:38:15 Schmitt: Okay. The best I can do. I'll just lock...I'll twist it down on there and maybe it'll hold.

141:38:20 Cernan: Okay. Twist it tight. (Pause) I got the rod. (Pause)

[Jack seems to be twisting the UHT into the sampler head.]

141:38:32 Schmitt: Okay. I'll just have to be careful.

141:38:34 Cernan: Okay. I've got it (probably Jack's seatbelt).

141:38:35 Schmitt: (Garbled).

141:38:36 Cernan: I've got it.

141:38:39 Schmitt: Okay.

141:38:41 Cernan: You'll have to put it in. Push down.

141:38:46 Schmitt: Okay. (Pause)

141:38:50 Schmitt: Ah!

141:38:52 Cernan: Okay; let's go. (Pause) Every time you pick your seatbelt up...Here it is, it's untwisted now.

(Pause) Okay?

141:39:04 Schmitt: Okay.

141:39:05 Cernan: All set?

141:39:07 Schmitt: Just about. (Pause)

141:39:10 Parker: Okay, Jack, a reminder. We're still seeing you in Intermediate. You probably will want to go to Min before you get back on.

141:39:18 Cernan: He's back on now.

141:39:19 Schmitt: I'm in now.

141:39:20 Cernan: And we're rolling.

141:39:22 Parker: Okay, copy. You're moving.

141:39:23 Schmitt: Okay. Let's go to Hole-in-the-Wall.

(Answering Parker) Yes, sir.

141:39:27 Parker: Okay. One other thing I might mention to you guys as you're driving here, Jack, before you start talking again, is that, as you go by Camelot, you might keep an eye out for blocks along the rim there, because, remember, we may be wanting to come back and move Station 5 to an area where there's blocks, unless there are blocks at the present, nominal Station 5. So you might keep an eye for that and plan for the way back. A second thing, a reminder: if you do stop for a Rover sample or one thing or another along the way, give us a call and keep us informed, because we're timing you on the way out and the assumption is, of course, that driving time out equals drive-back time. And we're under a 63-minute limit to get you from the LM out to the Station 2 because of OPS drive-back. So, keep us informed so we can keep a good tab.

[Schmitt - "In the pre-mission photos we could only see the very largest boulders and I don't think we could see any around Camelot. And we couldn't have seen any out that far from the LM."]

141:40:13 Schmitt: Okay, Bob. Okay. We'll keep you informed.

141:40:18 Cernan: Bob, I got the thing "two-blocked", and I'm averaging probably 10 to 11 clicks. It's not exactly straight-line navigation, but I think I can hold most of it.

141:40:29 Parker: Roger. Beautiful.

[Cernan - "I don't remember if 'two-blocked' is an old Navy term or what. But it means 'I've got it all the way out, hell bent for fire.'"]

141:40:31 Schmitt: Watch the crater. There you go.

141:40:34 Parker: And, Jack, a reminder...

141:40:36 Schmitt: I tell you, when Gene decides to turn...Whoo!

[Schmitt - "We were driving down-Sun and that made craters hard to see despite the relatively level terrain."]

Cernan - "One of the advantages of being the Commander and driving the Rover was that you knew when you were going to turn. It's just like what might happen if I took you on an airplane and did some acrobatics. I would know what I was doing and could anticipate the maneuvers, but you might start feeling uncomfortable, not being prepared, unless I really tried to talk you through everything."]

141:40:41 Parker: And, Jack, a reminder on photos. Yesterday, you apparently took quite a few on the way back from Station 1 to the SEP, and we're right nominal on budget now. But, considering the fact that we didn't do much sampling, if you continue to use them at the rate you did yesterday coming back from Station 1, at least as we understand it, you'll be pushing us pretty hard in the (film) budget. Should be every 50 meters or every 100 meters.

141:41:04 Schmitt: Bob, okay. And you want to hear something?

141:41:07 Parker: Roger. I'll listen now. (Pause)

141:41:13 Schmitt: Okay. The surface is not changing in terms of the detail. The surface texture of the fine-grained regolith still is has the raindrop pattern. The blocks still look very much like what we sampled yesterday around the LM. They're light-colored, apparently gabbros, with zap pits... (correcting himself) zap halos. Occasional craters show lighter colored ejecta; (that is, craters) all the way down to, say, half a meter in size. Other craters that are just as blocky as those with bright halos have no brightness associated with them. Most of the brightest craters have a little central pit in the bottom which is glass lined. The pit is, maybe, a fifth of the diameter of the crater itself. It's a fairly standard thing for most of these fresher craters, is that little central pit.

[The raindrop pattern that Jack is describing is caused by micrometeor impacts and looks rather like the pattern a light rain makes on dry, dusty ground. Jack's photos during the drive east to Camelot are AS17-135-20570 to 20588.]

141:42:20 Schmitt: Okay, we're just south of the (east) rim of Camelot.

141:42:23 Cernan: There is a light mantle on the other side. Look at that crater. Whoo!

141:42:28 Schmitt: We've got the...Ooh, and there's Camelot.

141:42:30 Cernan: Oh, Whoo! Manischewitz. Take a couple of pictures looking at that.

141:42:34 Schmitt: Okay. Can you swing a little?

141:42:35 Cernan: Yep.

[Gene turns the Rover so that Jack can take photos of Camelot without having to twist his body. These photos are AS17-135-20589 and 20590.]

141:42:36 Schmitt: Okay, I got them.

141:42:38 Cernan: That is a 600-meter crater!
 141:42:40 Schmitt: Okay. And it is very blocky...
 141:42:42 Parker: Hey, how about a bearing and range there to help us pick out the LM, also.
 141:42:45 Schmitt: ...We won't have any problem finding blocks on the rim of Camelot.
 141:42:48 Parker: Rog. How about bearing and range to help us pick out the LM location.
 141:42:50 Cernan: Okay. 083, 1.2, and 1.0.
 141:42:52 Parker: Okay. Thank you. Thank you.
 141:42:53 Schmitt: Bob, listen.

[Jack is a little frustrated with Parker's interruptions. Both Schmitt and Parker, once they start talking, tend to charge ahead and, consequently, talk over each other more than would have been the case with, for example, Gordon Fullerton or Joe Allen as CapCom and, say, Alan Bean (Apollo 12) as the LMP.]

[Cernan - "Bob and Jack were always bantering back and forth, from training right on through the flight. Although it was all meant in fun and they both had a sort of subtle sense of humor, the interruptions did sometimes bother Jack, particularly when he had something he felt was important to say."]

141:42:55 Schmitt: Okay. There's a little...
 141:43:03 Cernan: Man, are there blocks there.

[Gene has turned south and the small crater Jack describes next is shown in AS17-135-20591.]

141:43:07 Schmitt: Now that little crater in the ejecta did not..(in the ejecta) of Camelot - at least the rim of Camelot - did not bring up blocks on the rim. It may have been (an impact in) an old depression. Bob, there is (an) extremely blocky area. I think Station 5 was over there were that block area is (AS17-135-20592). The light-colored areas on the (overhead) photos are essentially blocky. They're probably 30 percent (covered with) blocks. Many of them are in the 2- to 3- to 4-meter size range. All of them look light-colored (and, from a distance), look like the gabbro we sampled. They have light-halo zap pits on them. I see only occasional greyer varieties, which I believe are the nonvesicular ones like we also sampled.

141:43:58 Parker: Okay. Copy that, Jack. Very good.
 141:44:00 Schmitt: But the light-colored gabbros are dominant.
 141:44:03 Parker: Thank you.
 141:44:07 Schmitt: Okay. Station 5 would have been - rather than in a light-colored area - would have been in a very blocky area. Station 5 is probably still very good for blocks.

[Schmitt - "The light-colored areas on the rim of Camelot turned out to be that way because of reflections off of all of the rocky material, rather from an albedo difference of the soil. And it may be that the regolith on the west side was shallower for some reason, so that more blocks were dug out there."]

141:44:19 Parker: Okay. Thank you.

141:44:21 Schmitt: There is probably as big blocks there as anywhere on the rim that we've seen.

141:44:27 Parker: Copy that.

141:44:28 Schmitt: Okay. We ought to be going between Horatio and Camelot now.

[Gene is probably driving parallel to the Camelot rim for a moment, rather driving a straight course for Hole-in-the-Wall. Jack's photos taken during the next portion of the drive are AS17-135-20593 to 20606.]

141:44:32 Cernan: No. I'm going to give them a call when we're due south of Camelot and see if they can't get a position on us. (Pause) Hold it, Jack.

141:44:39 Schmitt: Ooh, watch it.

141:44:40 Cernan: Hold it; hold it.

141:44:41 Schmitt: You can go around that one.

141:44:44 Cernan: You betcha. (Jack laughs) Whoo! That slowed the speed up a little bit. You can unwrinkle your toes now.

141:44:52 Schmitt: Okay. Oh. I wasn't worried, Gene. Watch that block there; it's probably more than 14 inches (the Rover clearance). And I got a fairly close look at the rock, and it is the vesicular...(It) looks very much like the vesicular clinopyroxene (a magnesium/iron/silicate mineral) gabbro.

141:45:10 Parker: Thank you.

[Schmitt - "The presence of vesicles usually imply that the rock solidified in the top of a lava flow where the cooling is quick enough to temporarily trap the gas that makes the vesicles. The inner parts of the flow don't cool that fast and the gas usually has a chance to escape. And what I was trying to do at Camelot was try to see how many flows the crater might have penetrated. Was there just one flow top, or several? I don't think we really had the time to do that, even when we got back to Camelot at the end of the EVA; but if you could get out and walk around, that's what you would try to do."]

141:45:11 Schmitt: Now, the surface of Camelot is mantled - or the rim - is mantled with the same dark-grey material, and it has the same surface texture: a very fine raindrop pattern. The saturation crater size does not look bigger than a half a meter, if that.

[Schmitt - "I was trying to estimate the largest size of crater that had formed everywhere on the surface. And that's roughly a function of age. Because bigger impactors are relatively rare, the older the surface, the larger the saturation crater size."]

141:45:30 Cernan: Okay, Bob, I'm going to give you 081, 1.6, and 1.4. We're south of the center of Camelot.
141:45:36 Parker: Okay. Thank you, Gene.

[They are about 140 meters south of where they will do Station 5 at the end of the EVA.]

141:45:39 Schmitt: One crater...(Stops to listen to Parker) Okay. We ought to see Horatio here pretty quick.
141:45:46 Cernan: I think it's right up in front of us.
141:45:48 Schmitt: Yeah, I think you're right. (Pause)
141:45:52 Cernan: We can definitely see the light mantle as it comes out over the valley here, and we're looking at Hole-in-the-Wall, although it's still too subtle. We're looking right at Lara, as a matter of fact.
141:46:02 Schmitt: Yeah. There's Lara, very clear; and Hole-in-the-Wall, you can see it.
141:46:06 Cernan: Yep, yep.
141:46:07 Schmitt: Yep.
141:46:09 Cernan: There's Horatio way over there where those blocks are. See it?

[AS17-135-20607 may show Horatio on the right of the picture.]

141:46:11 Schmitt: Yeah, that's Horatio. We're right on course, sir. There's a little depression we didn't talk about, though, that's between Horatio and Camelot. But it's a depression and not a blocky crater at all. As a matter of fact, the total block population has changed. Once we get away from the rim of Camelot, the block frequency is quite a bit smaller. It's down, maybe to less than 1 percent of the surface.

[That is, rocks cover about one percent of the surface in this area.]

141:46:38 Cernan: Much easier driving with the Rover. (Pause) Boy, am I glad we got that fender on. Very obvious that the Rover navigation (is easier here) because of the (scarcity of) blocks and because of the smaller (static) craters, and very subtle type craters in this area.
141:47:02 Schmitt: There are up to 2-meter, bright-halo, blocky craters - and that's blocky-walled craters...That may be instant rock rather than - I think it is (instant rock) rather than bedrock - (surrounding the 2-meter craters) in the rim area of Camelot.

["Instant rock" or, more properly, "regolith breccia" is soil solidified by an impact.]

141:47:27 Cernan: Horatio has got to be...There's Horatio, right there.

141:47:29 Schmitt: Yeah. That's Horatio.

141:47:31 Cernan: Let me give another mark on the southern rim of Horatio.

141:47:35 Schmitt: Okay. The Scarp looks very smooth from here. (There are) no obvious outcrops at this time. (Pause) (The craters) don't seem to be penetrating to any bedrock in the area we're traversing now, just to the southeast of Horatio. Horatio has a blocky wall; however, the upper several tens of meters, probably, of rim look as if it's either mantled - or composed of - the light-grey regolith material we've been driving on. The blocks do not come to the rim of Horatio.

141:48:20 Parker: Okay. Copy that, Jack.

141:48:21 Cernan: I don't know if I want to take you down there or not. Yeah, Jack, hold on; I'll take you down there.

[Cernan - "We didn't go down in any big craters; this was probably a shallow depression of some kind."]

[AS17-135-20609 may show the Rover tilt as Gene drives into a depression here.]

141:48:26 Schmitt: Horatio has quite a different appearance than Camelot. And that's the main one (that is, the main difference between Horatio and Camelot is that, at Horatio), the blocks do not get to the rim. (To Gene) Watch your roll. (Laughs) I know it's not much, but it seems like a lot.

[Apparently, Gene is driving right along the Horatio rim.]

[Cernan - "The reason the roll seemed like it was a lot was because, in one-sixth gravity, you're not anchored down the way you are in earth gravity."]

141:48:41 Cernan: I've just got to go around that crater.

141:48:42 Schmitt: Yeah. (Pause; the following has been lightly edited for clarity) It looks like - if Horatio is any gage, and this is a wild guess, Bob - but maybe an average of 20 or 30 meters (of) stratigraphic thickness (of regolith) lies above the exposures of the subfloor - (the) exposures being blocks in the wall. And some of those blocks, again, are several meters, if not 5 to 10 meters in diameter. And they're concentrated on the west wall...There are very few blocks on the east, north, and south walls of Horatio.

141:49:38 Parker: Copy that, Jack.

141:49:41 Cernan: Okay, Bob. We're on the southern rim; 078, 2.3, and 2.0.

141:49:47 Schmitt: Yeah. We're maybe 100 meters south of the rim. Actually, we're on the rim crest. We're 100 meters south of the break in slope into the crater.

[Photos taken during this portion of the traverse are AS17-135-20610 to 20622.]

141:49:59 Cernan: It's an undulating, hummocky traverse terrain in there, Jack.

141:50:04 Schmitt: Yeah.

141:50:05 Cernan: These little craters make it bumpy; but, other than that, it's really smooth sailing!

141:50:07 Schmitt: That's right. This is what I sort of expected the dark mantle to look like, rather than what we landed on. Not more than 1 percent of the surface (is covered with blocks), and that percentage continues right over the rim crest of Horatio down onto the wall until you hit the big blocks.

141:50:24 Cernan: What's this depression? That's not...No, we're not to Bronte yet.

141:50:27 Schmitt: No, I don't have any...No, we're not at Bronte...

141:50:31 Parker: Okay, 17. And how about an amps and a mobility...(correcting himself) a speed reading.

141:50:38 Cernan: I've been pushing anywhere from 9 to 11 clicks, and most of the time that's full out, and amperes are bouncing around 100 apiece.

141:50:51 Schmitt: Okay, watch these down-Sun craters. They're hard to see.

141:50:54 Cernan: I know they are. We're climbing, Jack. Because I've been full bore most of the time, and all I can get out of it is 10 clicks; and when I decelerate, she decelerates in a hurry. What's our next stop here? A sample at 3.9?

141:51:10 Schmitt: Ahhh...(Consulting his checklist) 080/3.9.

141:51:13 Cernan: Well, I'm sitting on 080 right now and 2.6. I think we've got to add a little bit to that if they're right.

141:51:21 Parker: Okay. Stand by. We'll get a new correction for you guys on that shortly. (Pause)

[Houston is using the Camelot and Horatio fixes to re-estimate the location of the SEP transmitter.]

141:51:29 Schmitt: Okay, Bob. The surface is not changing. We see no craters that seem to penetrate into bedrock out in here - that is, with blocky rims - and that's quite a contrast to the area we sampled at Station 1A yesterday. I cannot see in my field of view any blocky-rim craters. There are slight craters with fragmental walls and rims, but it looks like instant rock rather than the subfloor material.

141:52:03 Cernan: Jack, can you see over there to the left - I'll turn a little bit (for a better view) - on the dark

area of the South Massif where you get those impressed lineations? See them going from left upward to the right?

141:52:11 Schmitt: Yeah. I see what you mean; right.

141:52:14 Cernan: That's what I saw out my window.

141:52:15 Schmitt: Yeah, they go obliquely up the slope.

141:52:20 Cernan: They're more like wrinkles, they're linear wrinkles.

141:52:22 Schmitt: Yeah. Crenulations, you might say, in the slope that look something like those I saw from orbit, looking in the shadowed area...or, at the edge of the shadows.

[Schmitt - "It was a puzzle, seeing apparent lineations on the slopes of mountains. Some people, as I recall, did some simulations, building models, putting random roughness on the surface, and then dusting them and moving the light around, and they were able to create apparent lineations just with light position. Generally, I think, people don't feel that they represent any underlying structure: it's just an accident of dusting and lighting. The massifs do have layers in them - layers of debris - and I think the fact that you see what appear to be zones of blocks at the top is probably a layer of relatively hard material. But they really are gross layers."]

[Cernan - "While we were in orbit, we looked at the landing site as much as we could, partly to update our position and partly to get a feel for what it was going to be like. I wanted to get a map of it in my brain so that I'd know where we were going. Of course, the valley went by very quickly, so it wasn't like we had a chance to study it for five or ten minutes. And sometimes, if you weren't right on top of the fact of when it was coming up, it would be gone. You'd miss it. Things aren't are instantaneously recognizable from orbit and you have to know when to start looking and what you're looking for."]

[About four hours after they first entered lunar orbit, the Apollo 17 crew fired the Service Propulsion engine to put themselves into an elliptical orbit with its low point about 27 kilometers (14.5 nautical miles) above the landing site. They stayed in that orbit for nearly twenty revolutions prior to the start of the descent. From an altitude of 27 kilometers over the landing site, the horizon is about 300 kilometers ahead of the spacecraft, a distance covered in about 3 minutes and 20 seconds. The forward viewing angle into the valley was greater than 45 degrees for only about 20 seconds on each pass.]

141:52:35 Schmitt: Bob, we've seen craters as much as 20 meters - maybe 30 meters - in diameter without blocky rims.

141:52:44 Parker: Copy that, (garbled). Thank you.

141:52:46 Schmitt: The rim block population is not much different than the average for the terrain in here. (Pause)

141:53:02 Cernan: Boy, I'll tell you. If we can't recognize a change in that albedo when we get onto that white mantle, I'm going to be surprised.

[AS17-135-20616 is an excellent picture of the light mantle.]

141:53:07 Schmitt: Mark my words. Okay. The light mantle is just what Gene has said, it's...That's it, right now. There are some very bright craters in it. They stand out...Bright-haloed craters scattered over it that seem to be quite a bit brighter than anything we have out here on the dark mantle. See those blocks over there? That's the first different-colored blocks I've seen; they're sort of...

141:53:37 Cernan: Where are you looking?

141:53:38 Schmitt: Over to the right a little bit.

141:53:39 Cernan: Darker grey, a little bit.

141:53:41 Schmitt: Watch yourself here. Okay. There's a crater with a big mass of block in the bottom. It looks like it might be a secondary fragment from somewhere.

[Schmitt - "Secondary craters, formed by ejecta from other lunar impacts, have a much lower energy and they tend to be more irregular, more elongate, and may have a blob of material in the bottom. The projectiles that form primary impacts hit at about 20 km/s, and that's an explosion. Most of the ejecta leaves the Moon entirely; very little of it falls back on the Moon. At most, the stuff that makes secondaries travels half way around the Moon and hits at 1.5 km/s and doesn't throw ejecta very far at all."]

141:53:49 Cernan: Do you want to get a photo as we go by?

141:53:50 Schmitt: Yeah. Can you swing a little bit to the right?

141:53:52 Cernan: Yep.

[AS17-135-20623 to 20626 show their approach to the secondary crater.]

141:53:56 Schmitt: That might be worth a...How's our time for traverse, Bob? Do we have time for an (extra) LRV sample?

141:54:03 Parker: You're doing great, so far. We're looking for that first LRV sample at about 4.2; that's in the light mantle. (Get the sample here) if you can do it quickly; but we weren't planning on it.

[They've traveled 2.6 kilometers of straight-line distance in 23 minutes since leaving the SEP. The stops have kept their average speed to a modest 6.8 kph thus far.]

141:54:12 Cernan: Want one here?

141:54:13 Schmitt: Yeah, let's get...

141:54:14 Parker: Target of opportunity there, Jack.

141:54:16 Schmitt: Can you get...
 141:54:17 Cernan: Go ahead.
 141:54:19 Schmitt: Okay. Swing a little bit to the right now.
 141:54:21 Cernan: Okay.
 141:54:22 Schmitt: Right up across that little ray.
 141:54:24 Cernan: Okay.
 141:54:25 Schmitt: And I'll try to get a chunk of whatever (formed the crater)...Okay, I want...Keep going; keep going...
 141:54:29 Cernan: Look at that big (garbled)...
 141:54:30 Schmitt: Whoa, whoa, whoa.
 141:54:31 Cernan: Okay. Let me get the (Rover power) switch off. 082, 3.0, and 2.6. (Pause) And, Bob, I've been making 10 to 12 clicks coming across the surface; and, as I say, for the most part, that's full bore except where I have to do some rapid changes.
 141:54:50 Parker: Okay. And, by and large, the back room is interested in you guys pressing on to Station 2.
 141:54:59 Cernan: Okay, we are. (Pause) (To Jack) Just watch the LCRU.
 141:55:06 Schmitt: Okay, Gene. That's a pretty big rock in there.
 141:55:09 Cernan: Okay.

[Jack has collected a piece of rock with the LRV sampler and is now swinging the head across so that Gene can remove the dixie cup and seal it. This procedure takes far less time than Jack would take trying to get the dixie cup off himself.]

141:55:10 Schmitt: And, Bob, I think there's...
 141:55:11 Cernan: Hold it. Hold it down further...down.
 141:55:14 Schmitt: It's got quite a bit of dirt in it. (To Parker) I think this is a block from a linear-strewn field of very irregular and jagged rocks that are southwest of a crater that's 10 to 15 meters in diameter. It looks like the material that may have formed the crater, and you can look at some of the pictures and make up your own decision.
 141:55:43 Parker: Okay. Copy that.

[This sample, 72135, proved to be a breccia, a probable confirmation that it was piece of the projectile.]

141:55:44 Schmitt: (To Gene) Can you get it in there?
 (Pause) Okay. You got it.

[Gene is putting the sample in the SCB hanging from the accessory staff.]

141:55:48 Cernan: No, no. No, I didn't.
 141:55:50 Schmitt: No?
 141:55:51 Cernan: Okay. The bag (that is, the SCB)'s not open.

141:55:52 Schmitt: Well, okay. Yeah, that's bad.
 141:55:58 Cernan: Can you push it in? Pull down.
 141:56:02 Cernan: Okay. It's down. 26 Echo, Bob. We're on our way.
 141:56:05 Parker: Okay. Copy that...
 141:56:07 Cernan: Go ahead.
 141:56:08 Parker: ...And, you got a frame count, Jack?
 141:56:10 Schmitt: Oh, yeah. Let me...
 141:56:12 Cernan: And I did get my "locator" here.
 141:56:14 Schmitt: Okay. I got mine.
 141:56:15 Parker: Thank you, Jack...(correcting himself)
 Gene.

[Their locators are AS17-135-20627 and 137-20895.]

141:56:17 Schmitt: And the frame count is 95.
 141:56:23 Parker: Copy that.
 141:56:24 Schmitt: Holy cow! I'd better slow down my picture taking.
 141:56:29 Parker: Roger, Jack.

[AS17-135-20628 is taken toward the south as Gene turns to get back on course.]

141:56:33 Schmitt: We're in a little area where the fragment population may be up to 3 percent. It's getting a little more like what we saw around the LM. In fact, I would say it was comparable now.
 141:56:45 Cernan: I'm going down this slope and up the other side, Jack.
 141:56:47 Schmitt: But nothing like (the block coverage at) Station 1.
 141:56:49 Parker: Okay. Copy that. And the next planned Rover sample will be at a distance of 4.2; so, 080 and 4.2. And it will be in the light mantle if...
 141:57:01 Cernan: Okay. We got it, Bob.
 141:57:02 Parker: ...that disagrees with those numbers.

[That is, they want to be sure to get a sample in the light mantle, no matter what the Nav system says about their range and bearing.]

141:57:06 Schmitt: Okay. It's in the first prong of light mantle, as I recall. Is that right?
 141:57:10 Parker: Roger; the thumb.

[In the overhead pictures, there is a narrow finger of light mantle east of the main mass of the avalanche and separated from it by about a kilometer width of the darker material.]

141:57:15 Cernan: Okay, Bob. Your heading at 260 looks like it's right on, by the way, from what I see on the skyline.

[That is, on the 260 heading, they are pointed right at Hole-in-the-Wall.]

141:57:20 Parker: Okay. And how's the low-gain antenna holding up?

141:57:21 Schmitt: Look at that boulder...

141:57:27 Cernan: (Responding to Parker) Well, I'm moving it, so I guess you're getting it.

[Gene occasionally moves the low-gain antenna to keep it pointed at the Earth.]

141:57:29 Parker: Yeah, we're getting it. Just checking.

141:57:33 Schmitt: Bob, the blocks I see still seem to be the gabbro, except for that one sample we took, which I hope was what I thought it was...

[As noted at 141:55:43, Jack was correct in thinking that the sample was not a piece of gabbro but, rather, was a piece of the projectile.]

141:57:45 Cernan: Gee, it's blocky here.

141:57:46 Schmitt: Watch the...

141:57:47 Cernan: Ooh, that's a big crater. We got to get around here.

141:57:50 Schmitt: Okay. That must be Bronte.

141:57:51 Cernan: My God, is that big!

[The diameter of Bronte Crater is about 200 meters, about one third the size of Camelot. AS17-135-20629 is Jack's photo of the crater.]

141:57:52 Schmitt: That's bigger than I expected.

141:57:54 Cernan: Whoo! I got to go around this thing.

141:57:55 Schmitt: Yeah, yeah. There are some very...

141:57:58 Cernan: I got to go back here. (Static)

[Gene is having to make a major detour and, as he maneuvers, doesn't have a hand free to keep the low-gain antenna aimed.]

[Cernan - "The low-gain was mounted in front of the control stick at my right hand. Most of the time I could drive and manipulate the low-gain at the same time, reaching across with my left hand to move it, probably not with the greatest of ease, but I do recall being able to do that. But, you know, if you got too many things going and you were making lots of turns you just couldn't sit there twisting that low-gain until you got to some reasonably steady course."]

141:58:06 Schmitt: (Static clears)...blocks, greyer than the normal gabbro we've seen, that have very large, egg-sized

vesicles in them. (Pause) Watch it, you got one on your right there...Here you go.

141:58:20 Cernan: Yeah. I got them.

141:58:21 Schmitt: Okay. Don't mind me, Gene.

141:58:23 Cernan: No. No problem. That's all right, because some of those down-Suns are hard to see. I want to get off this slope.

141:58:29 Schmitt: I wonder if I took a picture of that block field? (Laughing) I hope I did. Getting to be so automatic that I'm not sure what I'm taking any more.

[Photos taken during this part of the drive are AS17-135-20630 to 20636. 20630 is a good photo of Hanover Crater, the sharp rimmed feature on the lower slopes of the North Massif.]

141:58:39 Cernan: Okay. I'm going to go through this niche on a high point in the saddle here.

141:58:48 Schmitt: Okay. How does it figure, Bob? I think we're just north of Bronte. Does that figure?

141:58:52 Parker: Rog. That seems to be about where you should be on the map here. We gather you're circumnavigating a little bit. Comm's dropping out from time to time.

141:58:59 Schmitt: Yeah.

141:59:03 Cernan: 080, 3.5, and 2.9; and we're on the north side of Bronte.

[Because of the stop, their average range rate has dropped to 6.2 kph.]

141:59:07 Schmitt: And it looks like Bronte has penetrated the dark mantle in here. It got the subfloor, but there's not an awful lot of blocks around the rim. There are just some small ones...(small) compared to what we saw around (Camelot)...Watch it.

141:59:23 Cernan: Yep. Yep.

141:59:24 Schmitt: (It's nothing compared with) what we saw around Horatio or in the walls of Horatio and around Camelot. Nothing, also, like we saw yesterday at Station 1. (Pause) Bob, that characteristic little dimple in the bottom of the craters is still with us, and it's invariably glass-lined in the fresh ones.

141:59:48 Parker: Okay. Very good.

141:59:50 Schmitt: Now, that's not a complete lining. It just seems to be glass agglutinates, if you will, that's holding the fragments in the bottom of the crater together. There's one on the side of an older crater. We're back into about a 1-percent (block) coverage. I suspect that the reason our block population went up there was because of Bronte.

142:00:15 Cernan: An awful lot of these smaller, glass-lined little craters around.

142:00:18 Schmitt: Yeah, and you notice, Gene, what I was saying about the little dimple in the bottom?

142:00:22 Cernan: Yeah.
 142:00:23 Schmitt: Watch the fresh ones, and (you'll see that) they all have that little dimple as if that...You see, there's one right there.
 142:00:27 Cernan: Yeah, right there.
 142:00:28 Schmitt: Man, you can predict it. (Pause)
 142:00:32 Cernan: Jack, you know, I think the white mantle is starting right over there. See on your right?
 142:00:37 Schmitt: Yeah, that's the first...
 142:00:38 Cernan: The place you can really see it is where it's reflected off the slopes of the...
 142:00:42 Schmitt: Yup.
 142:00:43 Cernan: ...of the (Scarp) cliffs out there, but I think...I hate to say it, but Charlie may be right.

[Gene is referring to the difficulty that Charlie Duke and John Young had in detecting albedo changes during the Apollo 16 traverses.]

[Cernan - "I don't know what we're going to run into next in the transcript, but I remember that when we drove onto the light mantle, although we talked about being able to see it from a distance, the albedo change was so subtle we really had to convince ourselves that we were there. It wasn't like suddenly going from dark to light, it was just fine-grained, subtle changes."]

142:00:47 Schmitt: Well, Geno, one thing that may distinguish it is (that) the bright-halo craters are brighter.
 142:00:54 Cernan: But I can see it from here...
 142:00:55 Schmitt: Yup.
 142:00:56 Cernan: ...on the floor of the valley here.
 142:00:58 Schmitt: Yeah.
 142:01:00 Cernan: On the scarp it really shows up.
 142:01:02 Schmitt: Okay. Block population is unchanged; still appears to be - where I can see large enough blocks - the gabbro, although there's not as much to look at now in terms of blocks. The surface characteristics have not changed. There are no craters that we see that are bringing up clear (that is, unmistakably) blocky rims. Most of the fresh craters have instant rock around them. (At) craters of the same size that are older and more subdued, that instant rock is apparently broken down. I suspect the small zapping breaks that down fairly quickly.
 142:01:46 Parker: Okay, 17. Copy that. You still making about 9 to 11 kilometers?
 142:01:53 Cernan: No, sir. I've been making from 10 to 12, Bob - mostly 12.
 142:01:57 Parker: Okay. Can you give me a reading on the amps this time, Geno.
 142:02:05 Cernan: Stand by. I've got a little navigating to do.
 142:02:07 Parker: Okay; standing by.

142:02:11 Cernan: Okay. I'm read...I'm reading...I'm reading 100 - bouncing - around 100 on both of them.
 142:02:14 Parker: Okay. How about amps and not amp-hours?
 142:02:15 Cernan: And I'm going up-and-down, hummocky terrain, I think with...(Responding to Parker) Oh, I'm sorry.
 142:02:21 Schmitt: Watch your...You got a hole in front of you.
 142:02:24 Cernan: Yeah.
 142:02:25 Schmitt: Ohh! There you go. Spun out a little bit.
 142:02:32 Cernan: Yeah, let me get up here. (Pause)
 142:02:41 Schmitt: Good vehicle you got here.
 142:02:44 Cernan: Yeah. It takes a little getting used to, though.
 142:02:45 Schmitt: Yeah.
 142:02:46 Cernan: I'm not sure I want to go through many of those.
 142:02:48 Schmitt: No.

[Jack's traverse pictures indicate that the maps clipped to the Accessory Staff are partially blocking his field of view.]

142:02:50 Cernan: Okay, Bob. I'll give you an amp reading as soon as I can. Just stand by for it.
 142:02:54 Parker: All right. There's no hurry. No hurry.
 02:54 Schmitt: Would you believe my camera handle's come off? (Pause)
 142:03:02 Cernan: The terrain gets a lot more locally hummocky with some well-rounded rims but very large-aspect-ratio craters - which you got to get around in here - in the 4- or 5-meter size. (Pause)
 142:03:27 Cernan: Charlie, that...(Amazed at his slip of the tongue) "Charlie!" I was thinking of white mantle. That's the white mantle we're coming up on right up here.
 142:03:29 Schmitt: Yeah.

[Gene is still pre-occupied with the problem of detecting the albedo change when they cross it.]

[Cernan - "We wanted to know when we were up on the white mantle and we expected it was going to be a very subtle change. Here, we could see it coming; but I distinctly remember that it was very difficult to find a definitive line between the light and the dark mantle."]

142:03:30 Cernan: See that on your right?
 142:03:31 Schmitt: Yeah.
 142:03:32 Cernan: That's it, there's not going to be that much difference.
 142:03:36 Schmitt: (Hard bump) Ooh!
 142:03:40 Cernan: Not going to be that much difference, but...(Warning himself) Look where you're going.

142:03:47 Schmitt: I got to watch I don't lose my camera.
It's come loose.
142:03:53 Cernan: See, now you can look where we're going
to come up on the white mantle. It's dusted with that
light...Look at it.
142:03:58 Schmitt: Yeah.
142:04:00 Cernan: We're only 100 meters from the light
mantle.
142:04:02 Schmitt: Well...
142:04:03 Parker: Okay. How about giving us the range and
bearing when you get to it.
142:04:04 Cernan: Look at this crater in here. (Responding
to Parker) We're coming right up on it now.
142:04:10 Schmitt: Yeah. There certainly is a change in the
general albedo, particularly in the craters. The craters are
much brighter in their walls than we've seen before.

[AS17-135-20637 to 20640 are from this part of the
traverse. 20637 and 20640 show bright craters.]

142:04:19 Cernan: Yeah, that's a...
142:04:20 Schmitt: Although there still is a brown...a
light...or a grey dusting over the top of it in here, but
it's clearly different - no question about that.
142:04:27 Cernan: You can't see the contact as you cross it
but we know we're coming into something lighter. You can
obviously see it.
142:04:34 Schmitt: Yeah. We ought to sample the rim of one
of these craters when we get our LRV sample, because that's
what's distinctly lighter.
142:04:40 Parker: How about a range and bearing, guys?
142:04:44 Cernan: We're at 3.8 here, and we can sample that
rim...
142:04:45 Parker: Copy the 3.8.
142:04:48 Cernan: (Responding to Parker's request) 083,
4.4, 3.8, and I've been...

[The average range rate is back up to 6.9 kph.]

142:04:48 Schmitt: How about right over there, Geno? Can
you get on the rim of that crater?
142:04:50 Cernan: Right here?
142:04:51 Schmitt: No, right to the right there...
142:04:52 Cernan: Right here.
142:04:53 Schmitt: ...That light stuff. See the big crater
here...
142:04:55 Cernan: Yeah.
142:04:56 Schmitt: ...and the light material right on the
rim?
142:04:58 Cernan: Yeah. I can get there. But I'm going to
have to not give you much of a turn because it's...
142:05:00 Schmitt: That's all right. I got the pictures.
Now, if you can swing to the left a little bit and then

back...Whoa. Now, back right. Okay. Hope my camera stays on there.

[AS17-135-20641 and 20642 show their approach to the sample site.]

142:05:11 Cernan: You like that?
 142:05:12 Schmitt: Whoa. Yeah. Whoa, whoa.
 142:05:13 Cernan: Okay, Bob. We're 083, 4.4, and 3.8; and I've been running about 20 to 25 amps, I think, on both.
 142:05:21 Parker: Okay. Copy that. (Pause)
 142:05:31 Cernan: We are in the light mantle. It's not a contrasting light like you might expect, or like we're looking at on the Scarp as the Sun shines on it, but I don't think there's any question.
 142:05:41 Parker: Okay. Beautiful.
 142:05:42 Schmitt: Yeah. The craters that penetrate into it are definitely different. However, the surface texture is unchanged. There may be fewer blocks. (Pause)
 142:06:02 Cernan: Okay; bag 27 Echo, 27 Echo.
 142:06:04 Parker: Copy that. And frame count, Jack?
 142:06:07 Cernan: (Garbled) your bag? We don't want to lose it.
 142:06:10 Schmitt: (A little annoyed with Parker's request while they are busy) Stand by.
 142:06:12 Cernan: Hold it up. (Pause)
 142:06:16 Schmitt: Okay. It's in there.
 142:06:18 Cernan: Is it in? Okay. Oops, the bags (the SCB on the accessory staff) don't stay open...
 142:06:21 Schmitt: Yeah. It will after we get a couple of samples in there. Okay; my locator.
 142:06:26 Cernan: And my locator.

[The locators are AS17-135-20643 and 137-20896.]

142:06:27 Schmitt: I hope I don't lose my camera.
 142:06:29 Cernan: I can't reach it, or I'd help you.
 142:06:31 Schmitt: Okay. (Giving Parker the frame count) 110.
 142:06:33 Parker: Copy that, Jack.
 142:06:39 Schmitt: I guess I didn't do what I wanted to do, and that's get that thing (the camera handle) really cinched down. (Pause)

[AS17-135-20644 to 20648 are photos from the next portion of the traverse.]

142:06:50 Cernan: Boy, Bob, one of the remarkable things is the Sun-angle difference on that light mantle when you're looking at the slopes of the Scarp versus what we're on. I hate to use a familiar term, but my impression right here is there is more of a raindrop influence than back at the LM, or in the darker mantle.
 142:07:13 Parker: Okay. Copy that.

142:07:15 Schmitt: Yeah. (A little skeptical) Might be.
142:07:17 Cernan: I think so.
142:07:18 Schmitt: I think the big thing is, though, that each one of these little craters is much more lightly colored. But we're still not...There's no crater in view that does...(correcting himself) that has a blocky rim. There's fragmental rims based on, almost certainly, instant rock, but no blocky rims.
142:07:37 Cernan: You know, one of the reasons those craters look lighter is because of their Sun angle. (That is, the Sun striking the) walls of some of these little craters...It's the same material we're driving on, I'll bet. Yeah, there is instant rock right there, Jack; you're right.
142:07:49 Schmitt: Yeah. (Pause)
142:07:53 Cernan: Oh, boy.
142:07:54 Schmitt: The fragment population is certainly less than 1 percent in here.
142:07:57 Cernan: Yup.
142:07:58 Schmitt: Right now. When I say fragments, I'm talking about rocks that are greater than a centimeter in (garbled, probably "average diameter").
142:08:08 Cernan: You know, it may be me, Bob; (static) but it also seems to be a little bit more difficult to drive down-Sun in this area.
142:08:15 Schmitt: Yeah, I think it is brighter, Geno. I was thinking that a minute ago, but it's hard to make a (judgment)...I think your normal albedo is greater.
142:08:24 Cernan: Here's some rocks now starting (garbled)...
142:08:26 Schmitt: And the little craters still have the central pits.
142:08:30 Parker: Okay. We're losing your comm a little bit, guys.
142:08:31 Cernan: (Garbled)
142:08:32 Schmitt: Yeah, there's a few.
142:08:36 Cernan: (Static) (Responding to Parker) We'll, we're (pointing) right at you. (Checking the low-gain indicator against the heading indicator) 270.
142:08:41 Schmitt: Yeah. There're a few blocks. They still look like the gabbro, though. Hard to tell.
142:08:48 Cernan: Well, a couple of them looked to me like they had some very light (static) crystals in them. See that?
142:08:53 Schmitt: I'm afraid those are zap pits.
142:08:55 Cernan: They could be.
142:08:56 Schmitt: I think I've been fooled by that, too, and that's what I estimated the plagioclase (content) by.
142:09:02 Cernan: Whooo! (Comm clears) I just want to keep you out of those slopes, and I'll tell you, I get you in some...
142:09:08 Schmitt: That's all right.
142:09:09 Cernan: ...(by working at) keeping you out of them.

[That is, by trying to avoid going into one crater, Gene gets them in another.]

142:09:14 Schmitt: Okay. We're getting a little more blocks in here. Of course, we're approaching the dark mantle again. Now, you can see the difference. You got to look hard for it! But, you see those craters out in there are not white anymore.

[A sketch map of the second half of the traverse in shown (identically) on LMP-10 and CDR-10.]

142:09:27 Cernan: I got to get around that slope.

142:09:29 Schmitt: Yeah. (Pause) Okay. You still got Hole-in-the-Wall picked out over there, don't you?

142:09:38 Cernan: Yeah, I got it. And, I'm trying to keep comm with them as I'm turning here.

142:09:42 Schmitt: Yeah.

142:09:43 Cernan: And, I've been keeping the thing on. I don't know if they're reading us, but I've been moving it.

142:09:46 Parker: Read you loud and clear, guys.

142:09:49 Schmitt: Okay. Looking up on the South Massif, we've got real good views of the block-strewn fields. There seems to be two dominant colorations of the rocks. The light-colored ones (are) very light tan to white, and then there are the blue-grey rocks. There's one major outcrop of blue-grey about a sixth of the way down the slope, (in) the center of the field of view we have; and it looks very much like similar blue-grey rocks right at the crest, the highest point from our vantage point.

[Schmitt - "Formation of the massifs was part of a dynamic process; and the hard layers represented by the blocks near the crest are part of the evidence of that process. You had a relatively flat part of the Moon which was hit by a great big impact. It was virtually a point explosion, just like a nuclear explosion; and then, whatever was there was folded back. And, at least with the big, basin-forming impacts, you had a lot of molten material that formed in the instant cavity; and that stuff probably moved outward, too. Dynamic pressure forced the molten material to flow up and out of the cavity and on top of the rocks that form the Massifs. And since the top layers solidified out of partially molten material, that may be partially why they're harder. And then, subsequent to that - although you're still talking about the first few seconds or minutes after the Serenitatis impact - you get these radial grabens that form due to the dilation of the area that's been impacted. Parts of the rim of Serenitatis fell and formed what's called a graben, and the Valley of Taurus-Littrow is one of those radial grabens."]

142:10:34 Cernan: Bob,...

142:10:34 Parker: Okay, give me a range and bearing, please.
 142:10:35 Cernan: ...(do) you want another sample of the dark mantle here? Could you use that?
 142:10:37 Parker: Yeah, we want (a range and bearing) as soon as you get into the dark mantle. We're estimating it's (at a range of) something like 4.3 (km), 4.5, somewhere in that vicinity.
 142:10:43 Schmitt: We're there.
 142:10:48 Parker: Okay. We're ready for another (sample), then.
 142:10:49 Schmitt: We're there. (To Gene) Now, let's...If you can...Okay, right over there, and maybe I can get a rock with it (the soil). See that batch of rocks there?
 142:10:56 Cernan: Right here?
 142:10:57 Schmitt: Whoa. Yeah. Swing it. Whoa, now swing back over. Little more, little more. Whoa. Little more.
 142:11:02 Cernan: Can you reach it?
 142:11:03 Schmitt: Now, if you go forward.
 142:11:05 Cernan: Can you reach it?
 142:11:06 Schmitt: Hold it. Right there.
 142:11:08 Cernan: Okay, Bob; 082, 5.0, and 4.3.

[The SEP is eight degrees north of east from their position; they have traveled 5.0 kilometers since leaving the LM; and they are now 4.3 kilometers from the nav initialization point. The average range rate is now 6.5 kph. The checklist range for the contact is 4.0.]

142:11:16 Parker: Copy that.
 142:11:20 Cernan: And CDR (Commander) is 3.85 (psi suit pressure) and about 70 percent (oxygen remaining) and no (warning) flags.
 142:11:30 Parker: Okay. Thank you, Geno. (Long Pause)
 142:11:45 Schmitt: I got it (the sample).
 142:11:46 Cernan: You got it? Okay.
 142:11:47 Schmitt: I got the rock. I got the rock, and there's some dirt in there. Maybe I'd better get a little bit more dirt.
 142:11:53 Cernan: Yeah. (Pause) You don't have any trouble getting dirt.
 142:11:56 Schmitt: Can you see in there?

[Because the dixie cup is one in a stack, Jack can't see into it without changing his grip on the sampler.]

142:11:59 Schmitt: Is there...
 142:12:00 Cernan: Yeah.
 142:12:01 Schmitt: ...much soil?
 142:12:02 Cernan: Oh, a little bit...
 142:12:03 Schmitt: Okay. I'll get this soil.
 142:12:04 Cernan: Couple teaspoonsfull. Twenty-eight Echo, Bob.
 142:12:08 Parker: Say again there, 17.

142:12:14 Cernan: Twenty-eight Echo.
 142:12:15 Parker: Copy that.
 142:12:23 Cernan: And that's primarily a rock fragment.
 Jack's getting a soil sample with it.
 142:12:29 Parker: Copy.
 142:12:30 Cernan: Jack, look at the wrinkles over there on
 the North Massif.
 142:12:34 Schmitt: Yeah. There's no question that there are
 apparent lineations all over these Massifs, in a variety of
 directions. Hey, look at how that Scarp goes up the side (of
 the North Massif) there. There's a distinct change in
 texture.
 142:12:45 Cernan: Okay.

[The locators for this sample are AS17-135-20649 and
 137-20897. both are excellent photos and, among other
 things, show Hanover Crater and, just to the west (left) of
 it, the scarp running up onto the North Massif.]

142:12:46 Schmitt: As a matter of fact, the lineations are
 not present on the Scarp, that we can see, where it crosses
 the North Massif. There is no sign of those lineations on
 there.
 142:12:58 Cernan: Oh, man; yeah. I can see what you're
 talking about now.
 142:13:00 Schmitt: Look over by Hanover.
 142:13:02 Cernan: It looks like the Scarp overlays the
 North Massif, doesn't it?
 142:13:05 Schmitt: Yeah.

[This observation suggests that the Scarp formed after
 the mountain was raised.]

142:13:06 Cernan: Okay. This last (sample) was 29 Echo.
 142:13:10 Parker: Okay. Copy that. And that's the soil.
 142:13:12 Cernan: Okay, now I need to get in that bag.
 (Responding to Parker) That's affirm. (Pause)

[Gene tries to put the two folded dixie cups in the SCB
 hanging on the accessory staff. Apparently, he has trouble
 reaching across and gives the samples to Jack to put in the
 SCB.]

142:13:18 Cernan: Here's another one. You're going
 to...Don't lose those.

[Jack may be in danger of losing the LRV sampler.]

142:13:22 Schmitt: I won't. I'll put it down.
 142:13:28 Cernan: Okay, Bob, we are rolling.
 142:13:29 Parker: Copy that.
 142:13:30 Schmitt: And pray for me, Bob, that I don't lose
 my camera. Okay. Hanover is quite a ways up the (North
 Massif) slope. I don't think we'd have gotten to it, as we

planned that time. But the appearance you have of the Scarp/North Massif contact is one of the Scarp being smoother textured, less cratered, and certainly less lineated. And I wouldn't be a bit surprised if it's, as Gene says, younger.

142:14:12 Parker: Okay, Jack. Copy that.

142:14:13 Schmitt: It's not just the slope, it's the materials on the other side of the Scarp, on the west side.

(Pause)

[That is, the North Massif has lineations east of the Scarp, but not at the Scarp itself.]

142:14:30 Schmitt: Okay, I'm going to have to really ease up on pictures. I forgot to give them a frame count. (Static)

142:14:33 Parker: Yeah. We didn't get a frame count. You want to give us a frame count there, Jack?

142:14:39 Schmitt: Well, Bob. The problem is (that) every time I take my hand off, my camera loosens up again.

142:14:47 Parker: Okay; I copy that. And our estimate is that if you continue to go between 50 and 100 meters between frames, we'll make it.

142:15:00 Cernan: (Static clears) Boy, I tell you. Are those Massifs getting to look big now! Holy Smoley!

[Somewhere in here, Gene takes AS17-137-20898, showing the South Massif and the Scarp. Jack's photos in this section are AS17-135-20650 to 20653.]

142:15:07 Schmitt: That frame at the LRV sample was about 115.

142:15:12 Parker: Copy that.

142:15:17 Cernan: I'll tell you, that Scarp looks nice over there, too, doesn't it?

142:15:20 Schmitt: Yeah. (Pause) Okay, we're back down in our old friend, the dark mantle. And I think the zero-phase point is not as bright as it was. (We're) passing a small crater, but the block population is still way down there in about - Whoops, watch that one - (the) one percent (range).

[Gene is making ten to twelve kilometers per hour on level terrain. However, even "level" terrain has plenty of hummocks formed by the rims of old, subdued craters. In order to maintain speed and get maximum use of their time and supplies of oxygen and cooling water, Gene is driving over blind crests without slowing, keeping his eye on the road so that he can brake and then turn if necessary. All craters big enough to be real hazards to the Rover are shown on the maps and, as well, are usually surrounded by enough ejecta that there is no real danger of coming upon one without warning. However, particularly when driving down-Sun, or when cresting a small rise, they sometimes come upon a small, fresh crater without warning and get quite a jolt. Because of the rough ride, seatbelts are absolutely essential.]

[Cernan - "You couldn't spent very much time sightseeing, and that's why Jack's doing most of the descriptions. Every once in a while you could steal a glance but, if you didn't get right back to watching where you were going, you'd get in trouble...especially the little craters."]

142:15:45 Parker: And, 17, for your benefit, we're showing you with very good net mobility rates here; and things (are) looking quite good.

[That is, their average speed is high enough that they will have plenty of time to complete the planned activities at Nansen before moving on. They are currently 4.3 kilometers from the SEP site and have been driving, stops included, for 45 minutes. Their overall range rate is 5.7 km/hr.]

142:15:54 Schmitt: Thank you. Gene's doing a great job.

142:15:59 Cernan: I'll tell you, it takes all your time to drive, though. You look around, and you're in a hole.

(Pause)

142:16:12 Schmitt: Okay here's another small crater (with) instant rock, the same little pit (at the center of the crater) and a spattering of glass holding the pit materials together. None of the glass linings look very coherent, Bob. They mainly just seem to be a sprinkling of glass that's coating (pause) the instant rock.

142:16:41 Parker: Okay, I copy that, Jack. (Pause)

142:16:53 Schmitt: The craters at about 10 to 15 meters in diameter seem to have somewhat more blocky material in their rims. But they're not clear-cut blocky rim craters. And here's one that's probably 50 meters across that has a fair number of blocks in the bottom.

[An impact will penetrate to a depth equal to about one-quarter of the diameter of the crater it produces. Blocks in a 50-meter crater would suggest regolith depth of less than 12 meters.]

142:17:15 Schmitt: Looks like it (the impact) might have just about gotten down to where the gabbro starts to be abundant again.

[Schmitt - "In principle, the term 'gabbro' has no genetic meaning but, rather, indicates a crystalline rock composed of roughly equal parts of the minerals pyroxene and plagioclase. However, here we were seeing rocks derived from lava flows that were thick enough that the rock cooled slowly enough that millimeter-sized crystals formed. They aren't very fine-grained like most basalts that cool very quickly, but neither are they as large-grained as the anorthosites found at Apollo 15 which cooled much, much more slowly, at

depth within the crust. And, of course, these rocks weren't the breccias characteristic of highlands material."]

142:17:23 Parker: Okay; I copy on that one, Jack.
 142:17:24 Cernan: (Static; garbled) start heading toward 12 o'clock (directly down-Sun); and I'm going to work my way up to Hole-in-the-Wall and from there on up, right?
 142:17:31 Schmitt: That's good.
 142:17:32 Cernan: Take a long, easy turnout.
 142:17:33 Schmitt: Yeah.

[AS17-137-20899 and AS17-135-20654 to 20656 are photos taken somewhere in this part of the traverse.]

142:17:36 Cernan: Got Hole-in-the-Wall, Bob. It's a very long, very subtle, very gentle slope. We'll just have to get some more words when we get there.
 142:17:44 Parker: Okay; we're anxiously awaiting them.
 (Pause)

[Hole-in-the-Wall is the juncture between a lobe of the Scarp and the main Scarp face, a geologic equivalent of the web of flesh between a person's thumb and forefinger. Avalanche material overlies both features. Hole-in-the-Wall was spotted in pre-mission photographs as a plausible path up to the top of the 80-m-high Scarp.]

[Cernan - "We were concerned about what we were going to find at Hole-in-the-Wall and what path we were going to take to get up the Scarp. I don't remember exactly, but I'm sure we must have looked at the Scarp from orbit."]

142:17:50 Parker: How about a range and bearing while you're at it?
 142:17:54 Cernan: I've been making 10 or 12 clicks (kilometers per hour) most of the time. (Pause; listening to Parker) Okay, 082, 5.6 and 4.9.
 142:18:04 Parker: Copy 4.9 on the range.

[The average range rate is now 6.3 kph. They are about 0.5 kilometers from Hole-in-the-Wall. The accompanying drawings are pre-mission representations of the views Gene and Jack would have of the Scarp at distances of 1 and 0.5 kilometers. These views were produced by researchers at Bell Laboratories, using the Apollo 15 photographic data.]

142:18:05 Cernan: And about 20 to 22 amps (the electric current to the Rover wheel motors) most of the time.
 142:18:13 Parker: Okay, we're losing a little bit of low-gain (signal) there, Geno.
 142:18:19 Schmitt: I think you need to tilt it up a little. Probably undershooting the Earth. I don't know.
 142:18:24 Cernan: Well, our pitch angle (the Rover's up/down orientation) changes all the time. That's the

problem. Bob, I have been within 10 to 20 degrees of you the whole time.

142:18:33 Schmitt: Okay, Bob, we're not in light mantle, I don't think. (Pause) Maybe we are.

142:18:39 Cernan: I think we are, Jack.

142:18:40 Schmitt: Yeah, I guess we are.

142:18:41 Cernan: I think we are.

142:18:42 Schmitt: According to my geology map (garbled). I guess we are. Gosh, I was going to say the craters are whiter than they have been. So, we're back in it. And even the zero-phase point's brighter, too.

[There is a great deal of glass in the lunar soil and, at the down-Sun or "zero-phase" point, the reflected sunlight can be quite bright - more so here on the light mantle than on the dark mantle.]

142:18:53 Cernan: (Static clears) I think that place where we had those small, blocky craters was within the dark mantle. They're not evident here in the lighter stuff.

142:18:58 Schmitt: Yeah, yeah.

142:19:00 Cernan: Boy, is that (South Massif) getting big. Whoo-ee! (Pause) Hold on.

[They're going into a small crater.]

142:19:07 Schmitt: Whooooee!

142:19:08 Cernan: Oh, boy.

142:19:09 Schmitt: That really gives me a strange feeling. (Jack laughs heartily).

142:19:10 Cernan: Gives me a strange feeling too. (Pause) Those are not intentional.

142:19:17 Schmitt: I understand.

142:19:19 Cernan: I'm not sure I've got enough guts to make them intentional. (Pause) Man, everything's getting to look big the closer you get. (Pause) Hole-in-the-Wall looks more promising, though, Bob.

[Up to this point, they haven't been able to see enough detail to tell whether or not Hole-in-the-Wall will be a good place to climb the Scarp.]

142:19:35 Schmitt: Yeah, I don't think that's going to be any problem.

142:19:37 Cernan: (At least not) until we get up and look back. Oh, man, what a trip this is going to be. Golly. (Pause)

142:19:45 Schmitt: That Min cooling is just about right, isn't it.

142:19:47 Cernan: No, it's just about warm for me.

142:19:49 Schmitt: Yeah.

142:19:51 Cernan: Bob, is my PLSS cooling working all right?

142:19:56 Parker: Rog. It looks like it's working to us.

142:20:01 Cernan: Okay.

[Driving the Rover takes concentration and a fair amount of effort. As indicated in the table at 151:03:03, while they are riding, Gene's metabolic rate is about 10% higher than Jack's.]

142:20:03 Schmitt: Bob, the rock fragments still look like gabbro. The craters tend to have white walls and white rims, which they don't have in the dark mantled area. The block population is way down, (and covers) one percent (of the surface) or less. However, the bigger craters do have more blocks; but nowhere does that population seem get above about five percent. And that's on the walls and the rims of the craters, say bigger than 15 meters. There's one probably 20 meters in diameter that has some blocks on it.

142:20:43 Cernan: (Glancing at CDR-10) Have you seen Nemo (Crater)? I think Nemo is right over there, if I'm not mistaken. (Pause) I don't know.

142:20:49 Schmitt: Nemo will be hard to see. But, yeah, it's probably that one right in there.

142:20:56 Cernan: Or back here. There's one back here.

142:20:58 Schmitt: Well, it's pretty...Yeah, well...Yeah, that's close to (the) Scarp. It's probably right off your wing there.

[Schmitt - "Because of the stiffness of the suits, our field of view was pretty much restricted to straight ahead. We could turn our heads a little in the suits and could gesture with our arms, but even then, Gene could really only see a gesture if I made it with my inboard arm."]

[Their current position is about 081/5.3. Nemo has a 400 meter diameter. They are about 400 meters northwest of the near rim.]

142:21:04 Cernan: Okay, I'm going straight ahead and then I'm going to make a left turn (into Hole-in-the-Wall).

142:21:10 Schmitt: Okay. We're looking at Lara (Crater). Now, Lara...I can see blocks in the northwest rim of Lara. At least, it's rugged terrain; and it looks like blocky terrain. One spot. That's all I see. It looks like it may be a couple hundred meters in average diameter. It starts maybe three-quarters of the way up the wall and goes right up to the rim.

[Schmitt - "Lara is almost certainly a crater that pre-dates the avalanche. The avalanche rode over it and, indeed, in the good photographs you can see some sub-flows (secondary slides) down the slopes into it."]

142:21:39 Cernan: Hey, Bob, Hole-in-the-Wall seems to be a...

142:21:42 Schmitt: Hey, look at that. Look at that crater!!

142:21:43 Cernan: Right there? Yeah.

142:21:46 Schmitt: That central pit goes down about half the depth of the crater, and the crater is a fresh, 3-meter crater. It almost was a cylindrical pit.

142:22:01 Cernan: Hey, Bob, Hole-in-the-Wall is just a step, headed down to the south or southeast on the Scarp. The Scarp is just about what I think we all expected it to be. It's very rolling and relatively smooth. I don't really see any outcrops (of rock) exposed anywhere out here to the south.

142:22:21 Schmitt: No. You see, now there's Station 3 area right up there.

[The Station 3 stop will be made at the base of the Scarp, just north of Lara, after they finish their activities at Nansen Crater and have driven back down onto the valley floor.]

142:22:25 Cernan: Yep.

142:22:27 Schmitt: Looks like maybe that set of...See that bigger crater over there to the right of Lara? That probably is a good place for Station 3.

142:22:37 Cernan: Yeah, way over there. Okay, we're going to find out something very shortly (about Hole-in-the-Wall).

142:22:42 Schmitt: It doesn't look very rocky, Gene.

142:22:44 Cernan: No.

142:22:45 Schmitt: (Garbled)

142:22:47 Parker: How about bearing and range, guys?

142:22:53 Cernan: Bob, I'll give it to you just as soon as I make my turn. It's not too far - 100 meters.

142:22:56 Schmitt: Are...Are you...Are you going to turn over that or go on closer...

142:22:58 Cernan: No, I'm going right up straight ahead and then go on to the inside of that place.

142:23:04 Schmitt: Yeah. That's more than 100 meters.

142:23:08 Cernan: Yeah.

142:23:09 Schmitt: (Giving a bearing and range to the LM) 081 and 5.6.

142:23:10 Parker: Copy that.

142:23:15 Schmitt: There's...Now the craters are getting very, very light colored in their rims and walls.

142:23:23 Cernan: You notice when we're in the light mantle looking at the Scarp, at this angle, it loses some of its high albedo (that is, its apparent brightness)?

142:23:28 Schmitt: Yeah. Yeah. I think we're getting...

142:23:32 Cernan: We've got a long depression to go around.

142:23:33 Schmitt: ...Your eyes get used to it.

142:23:36 Cernan: Okay, Jack, we got to watch it because I got to go around a long depression. That's a crater over there.

142:23:41 Schmitt: On the right; yeah.

142:23:42 Cernan: I don't know how I can get over there to...

142:23:43 Schmitt: I think...

142:23:44 Cernan: I may have to go up over there. I can't go down that hole. That one's not going to make it.
 142:23:49 Schmitt: What's your pitch?
 142:23:51 Cernan: Let's go back here. We can't get there. I'm going to go over here.
 142:23:54 Schmitt: What was your pitch then, Geno?
 142:23:55 Cernan: (Static; garbled) primarily. I can't go there.
 142:24:01 Schmitt: Yeah, I think you're right.
 142:24:02 Cernan: We'll go up this gentle slope. See what's on top. (Pause) Okay. Let me get my (garbled). (Pause)
 142:24:17 Schmitt: (To Houston) We made a turn to the south a little bit at 081 and 5.7. Are you going to try to drive up there?
 142:24:25 Cernan: I don't think we're going to have any choice.

[The range rate is now 6.5 kph. Up to this point in the traverse, Gene has maintained an average heading of about 260 degrees and, because of the constant heading, the range rate is equivalent to the net outbound speed. With the change in heading, the range rate will no longer be a direct measure of the net speed. From here to Nansen, Gene will drive a map distance of 2.2 kilometers in 19 minutes for a net speed of 6.9 kph. Jack's sequence of photos taken during the climb up Hole-in-the Wall is AS17-135-20657 to 20664. The white crater that Jack will mention in a moment is visible in all the photos.]

142:24:27 Schmitt: Okay. Looks to me like just to the left of that...
 142:24:31 Cernan: Yeah.
 142:24:32 Schmitt: ...white crater is a...Or even (go) right like you're headed now and then bear up to the right.
 142:24:36 Cernan: Yeah. (Pause) Find out how this (Rover) climbs in a minute.
 142:24:45 Schmitt: Oh, I think you're all right.
 142:24:47 Cernan: okay, Bob, I'm starting up the scarp at 081, 6.6, and 5.7.
 142:24:51 Parker: Okay. Copy that, Geno.
 142:24:52 Schmitt: This is the first tongue of the scarp.
 142:24:57 Cernan: I don't even think the Rover knows it's going uphill. I've got about 37 or (3)8 amps. See what's on top here.
 142:25:06 Schmitt: You're making about 8 clicks.
 142:25:08 Cernan: And I'm full bore.
 142:25:11 Schmitt: (Laughs)
 142:25:14 Cernan: Well, I'll tell you, this Rover doesn't know it's going up a hill.
 142:25:18 Schmitt: Looks to me like you may be able to head just like you're going.
 142:25:21 Cernan: Yeah. Hey, Bob, we'll make it.
 142:25:23 Schmitt: And get down...Yeah.

142:25:25 Cernan: We will make it. (Pause) Get my (low-gain) antenna adjusted.
 142:25:38 Schmitt: Okay. Whatever makes up the light mantle is - at least, the instant rock that it forms - is much lighter than anything we see (elsewhere). Those fragments probably are 30 percent lighter than any fragments we see out on the dark mantle. And that's around the fresh craters. But it is not blocky. (Pause)
 142:26:14 Cernan: Bob, are you still reading?
 142:26:16 Parker: Roger. Read you loud and clear.
 142:26:20 Cernan: Okay, I just wanted to make sure my antenna's working
 142:26:23 Parker: Roger.
 142:26:25 Cernan: We're doing a little zig-zag navigation. I literally came up a slope at about a heading of 240 (WSW). We couldn't get through the actual turn to the south because there is a big crater right at the foot of it. So we're just making our way through some relatively local undulating slopes that get pretty steep, but it seems to be no problem.
 142:26:45 Schmitt: Yeah, I think we're in good shape. Bob, I can't ... There are not any blocks big enough to really make a statement about what the (underlying) rock is. But it really doesn't look like gabbro anymore.
 142:27:00 Parker: Okay. Copy that.
 142:27:01 Schmitt: It doesn't have that...
 142:27:03 Parker: And a reminder that eventually you're going to have to turn to the south a little bit to pick up the final thing...at Station 2.

[Gene's average heading during the drive from Hole-in-the-Wall to Nansen will be about 225.]

142:27:12 Schmitt: We're not on top of that scarp, yet. We're still in the Hole-in-the-Wall rim.
 142:27:16 Parker: Okay. Copy that.
 142:27:22 Schmitt: Bob, as far as lineations in the soil or on the surface that are observable at this range (that is, close at hand), I don't see any. I think there may be a finer raindrop pattern on the light mantle than maybe there was out on the dark. But that's an awfully hard judgment to make.
 142:27:45 Parker: Okay. Copy that.
 142:27:50 Schmitt: How you doing, Geno?
 142:27:52 Cernan: Doing fine. Bob, we've slowed down (to) between about 5 to 8 - maybe 5 to 10 - clicks most of the time. I'm going to head right up there, I think. Get around this crater.
 142:28:02 Schmitt: Pretty healthy roll we're going to have here.
 142:28:04 Cernan: Yeah, I'm going to head more straight up the hill. Once I get up on top, I'll be all right. I'm going to head down in this hole and then up that way.
 142:28:11 Schmitt: Yeah, I think...

142:28:12 Cernan: I don't mind pitch, but I sure don't like roll.

142:28:14 Schmitt: I don't either. (Pause)

142:28:24 Cernan: Now I'm going to head straight up...I'm going to head straight up that slope right there. Okay.

(Long Pause)

142:28:49 Schmitt: Bob, It looks like maybe the large fragments in here are still crystalline. They have white zap pits on them. But they do not yet really resemble the gabbros.

["Zap pits" are small craters blasted into the surfaces of rocks by sand-grain-sized impactors. On the gabbros, Jack noted white halos of fractured minerals created around the craters.]

142:29:03 Parker: Okay, Jack. Copy that. Give us a hack when you get up on top of the scarp there.

142:29:09 Schmitt: Okay.

142:29:10 Cernan: Let me tell you, Bob, I've got to go cross-slope some of the time because the Rover is really working to go uphill now.

[The Rover is designed to handle loose slopes of up to 25 degrees. Steeper slopes can be handled by driving cross slope.]

142:29:18 Parker: All right.

142:29:19 Cernan: But we're almost there.

142:29:22 Schmitt: As I look up the Scarp to the west, there are some big blocks scattered around on our horizon; but, again, I would guess that we're not dealing with more than 2 or 3 percent total coverage of blocks in here, if that.

142:29:45 Cernan: Well, I think, for the most part - for the most part - we're on top.

142:29:49 Schmitt: Yeah, we're...we're on top.

142:29:53 Cernan: Bob, we're at 7.8...Correction: 078, 7.2, and 6.2.

142:29:59 Parker: Copy that.

[Since starting the drive up Hole-in-the-Wall, they've driven about 600 meters in 5 minutes for a net speed of 7 kph. They've climbed about 80 meters up from the valley floor. Jack's photo at the crest is AS17-135-20665.]

142:30:01 Cernan: Now, Jack, where was Nansen (Crater) with respect to those (boulder) tracks up there (on South Massif)?

142:30:05 Schmitt: Well, they never really had any good tracks pinned down, I don't think. You'll be able to see Nansen, I think, soon as you get over this hill.

[From the LM, Gene and Jack had seen tracks made long ago by boulders as they tumbled downhill from outcrops high on both the North and South Massifs. Some of the North Massif

tracks were visible in the pre-mission photography taken from orbit during Apollo 15.]

[Cernan - "As I recall, from orbit you really had to look for the tracks. If you could find one of the very big boulders you could trace the tracks on the slopes of the massifs. On the surface they were relatively easy to see from the LM. I don't think most of them jumped right out at you because there is so much subtlety. But, especially if you could find a boulder, you could see the tracks pretty readily."]

142:30:13 Cernan: Boy, I tell you, when we look back (into the valley toward the LM), that's going to be quite a sight if we can see into that Sun. We have been coming uphill! Well, I'd say this is the last straw to the top. And is she working! Come on, baby. (Pause)

142:30:33 Schmitt: Okay. I think you bear...

142:30:36 Cernan: I'm going to try to get over along (means "to") the base of the massif now.

142:30:39 Schmitt: Yeah. Head towards that track area there, anyway. (To Parker) There are a lot of boulder tracks coming down from the blue-grey rocks, Bob. We'll see whether or not we're going to get to those tracks at Nansen, or we might want to move over to the tracks and see if we can find the boulder that made them.

[By sampling boulders that are clearly identified with boulder tracks, they can be sure of sampling rocks derived from outcrops high on the mountain.]

142:30:59 Parker: Okay; if they're in the vicinity, it might be a nice idea.

142:31:02 Schmitt: But there's no question where those tracks come from.

[Jack's photos taken during the drive toward Nansen are AS17-135-20666 to 20671.]

142:31:05 Parker: And we gather you're slowing down to about 5 clicks now, coming up this last rise.

142:31:10 Cernan: Yeah. I'm back up to about 7 to 10 now, Bob. The slowdown is because that's about all it will take!

142:31:18 Schmitt: Bob, I have the impression that there is a dipping (meaning "not horizontal") zone of blue-grey outcrops or block concentrations up there on the Massif that trends from the high point just beneath the Earth cross-slope; and probably the apparent dip is - oh, I don't know - 10 or 15 degrees (down) to the east. It looks like those outcrops may match up along that trend.

[From a position at the base of the Scarp, it will be impossible to prove whether these were true outcrops of bedrock or just concentrations of partially buried boulders. However, given the steepness of the slopes on the upper

mountain and the fact that the visible boulders are bigger than any plausible thickness of the regolith, the odds are very good that these are genuine outcrops.]

142:31:57 Parker: Okay.

142:31:58 Cernan: Jack, I'm going to head right along this ridge because I think that's the depression we were talking about.

142:32:01 Schmitt: Yep, that's Nansen down there.

142:32:02 Cernan: Where are you looking? Right there?

142:32:04 Schmitt: I think, right below...

142:32:06 Cernan: I think you're right. I think that's it. Let me get over here, and then I'll head a little bit to the south.

142:32:12 Schmitt: Yeah, we're a little more west, I think, than we intended to be.

142:32:18 Cernan: Yeah, I think you're right. (Pause)

142:32:25 Schmitt: Bob... (Trying to read the instruments)
What is it? 078 and 6.5? (Pause)

142:32:36 Schmitt: Bob, I've had an impression, and I can't prove it yet, that we're dealing with more heterogeneous rock. Possibly there are breccias in here. But it's awfully hard to tell right now. They're very light-colored rocks, I think even lighter colored than the gabbros.

[Lunar breccias are rocks made up of fragments of other rocks, and even soils, welded together during large impact events.]

142:33:06 Parker: Okay. We'll soon find out.

142:33:12 Schmitt: I'm afraid those...I think we can follow those (boulder) tracks. The pictures, maybe...

[Jack means that they can visually follow the tracks from the boulders up to the source outcrop.]

142:33:18 Cernan: Yeah, I think we can see some of those coming down.

142:33:22 Schmitt: I think the ones from the big outcrop of blue-grey rock, though, are the ones going into Nansen.

142:33:29 Cernan: Bob, my best guess - let's see, 077, 7.7, 6.6 - is that we're coming up on the northern side of Nansen.

142:33:37 Parker: Okay. We copy that, Geno.

[A box of Apollo 17 planning material given by Parker to the Johnson Space Center History Office contains a large map of Taurus-Littrow with the names of features written in with a colored felt-tipped pen. From the evidence of that map, the original name of the feature Gene and Jack are approaching was "Amundsen", but that name was then crossed out and replaced with "Nansen. They are currently about 500 meters from the north edge of Nansen.]

[Schmitt - "The printing on the map is not mine and I don't specifically remember changing the name; but I wouldn't

be surprised if I oscillated back and forth between Amundsen and Nansen. Amundsen gets so much credit, at least in the United States, that I may have decided that Nansen was the unsung hero of Arctic exploration. Or, somebody may have pointed out that Amundsen already has a crater at the Moon's South Pole."]

142:33:42 Cernan: And, let me tell you, this is quite a Rover ride.

142:33:45 Parker: It sure sounds like it.

142:33:52 Cernan: But it's quite a machine, I tell you! I think it would do a lot more than we'd let it.

142:34:01 Schmitt: (Laughing) That's right. (Pause) I think that big crater up there on the side (of the mountain) is the one that you can see in the photographs, just above Station 2.

[This crater shows well in AS17-135-20672 which was taken at about this point in the drive. Station 2 is just out of sight below the central fiducial.]

142:34:16 Cernan: Yeah. I think if I come up here, do a hard left turn; you unbuckle your belt, you'll roll right down into the bottom of Nansen.

142:34:20 Schmitt: I'm afraid you're right...

142:34:23 Parker: Okay. And remember we're going to about 068 (bearing) and about 7.4 (range) will be Station 2 (with the actual position being 071/7.6). At least that's our estimate.

142:34:32 Cernan: Okay, there's Nansen over there, huh?

142:34:34 Schmitt: Well, I think so.

142:34:35 Cernan: Yeah. I think you're right. It's got to be it. Got to be it.

142:34:43 Schmitt: Yeah, Bob, I think we're into a breccia population now. I think the blocks in the light mantle are largely breccias. They're mottled in their characteristics. The white zaps do not seem to be nearly as apparent. They tend to be chalky when they get hit. At least, in the large craters (meaning "large zap pits"), the walls are chalky looking. (Pause) Oh, yeah! We've got boulders in Station 2.

142:35:16 Cernan: Yeah, they're there.

142:35:20 Schmitt: Yeah, sir. (Pause) Boy, I tell you, if I hang on to this camera until you stop and can tighten it up, it'll be a miracle.

[Throughout most of the drive, Jack has had to keep a hand tightly closed around the camera. Because he has had to grip constantly against the stiffness of the pressurized suit, his hands are now aching, despite switching them as often as seemed prudent.]

142:35:28 Cernan: Bob, how long have we been driving?

142:35:30 Parker: Stand by. We estimate you've got about a kilometer and a half to go - a little over a kilometer, anyway. Stand by, we'll check on the time. You're doing great.

142:35:44 Schmitt: Man, this has been a trip.

142:35:46 Cernan: Man, I tell you. You know, we're really up on top of this thing. Whoo!

142:35:49 Parker: You guys have been driving 64 minutes, and that counts the time to stop and deploy the (explosive) charge (for a seismic experiment) and pick up the Rover samples.

142:35:59 Schmitt: Hey, Bob. We're very clearly going downhill now, into the trough area that surrounds the Massif, between the mantle and the massif. But the trough is much greater in extent than just Nansen scale. It's probably a kilometer wide. I never realized that it was so much of a depression in here.

[Jack's final three photos taken during the approach to Nansen are AS17-135-20673 to 20675. 20674 shows the trough, with the two large Station 2 boulders near the right edge of the frame. Nansen is off the frame to the right.]

[Schmitt - "Nansen isn't actually an impact crater but, rather, is an anomalously-deep, elongated depression that is part of the trough. It isn't filled as much as other parts of the trough. From the gravity measurements we know that, just before the mare lavas filled the valley, the difference in elevation from the valley floor to the tops of the South Massif may have been something of the order of four to five kilometers. That is, there appears to be now about two kilometers of mare basalt filling the valley. Originally the elevation difference was even more than four or five kilometers because there is strong evidence that the mountains have been subsiding over time, enough so that you never accumulate a talus at the base. The evidence of this is the trough that runs along the base of the massif. If you imagine a steeply dipping-fault between the South Massif and the original valley and the mountain subsiding relative to the valley, then the fault tends to open and either the talus tends to accumulate or you get a trough or both. Most people think that, once those mountains formed, they stayed relatively quiet; but the trough implies that there's been activity essentially up to the present. Otherwise, you would have filled up those troughs. Essentially, the gap is opening up as fast - or faster - than talus is accumulating, from a volume point of view. The average exposure age of the talus material is very low and does not correspond to the age of the mountain. The mountain formed 3.9 billion years ago and the exposure age of the soils in the trough is a few hundred thousand years."]

142:36:30 Parker: Okay. How about a range and bearing readout.

142:36:31 Schmitt: I'm not sure we're going to be able to see the LM.
 142:36:35 Cernan: (Responding to Parker) 074, 8.2, 6.9.
 142:36:38 Parker: Copy that.
 142:36:39 Cernan: We won't be able to see the LM from down here. We'll be too low to see it. Fact is, I don't think I can see that far. (Pause)

[Cernan - "I'm an engineer and I think the greatest asset that education gave me was the ability to think logically and, rather than getting engrossed in the detail of a problem, be able to back off and start to figure out where you are, what it's all about, and start to focus in on the important parts. Too many people try to put the screw in the hole before they find out it's the wrong screw for the hole. In looking at the valley from orbit, I started out looking at it geographically and then topographically; and then, when we got down in among 'em - among the rocks and boulder - I could start to look at it geologically. To start with, I wanted to be sure that when I got down in that valley I would always know where I was. When I was near Nansen, I wanted to be sure in my mind what was to the north and what was back to the east, even if I couldn't see very far in those directions from the ground. I wanted to have a feel for where I was; not from a navigation point of view but from a geographic point of view. And then I wanted to understand the topography, which you can't fully appreciate until you literally get down to the surface. From orbit, Tracy's Rock (at Station 6) doesn't mean anything; but, when you get down in there, you can appreciate the slopes and the sizes of the boulders and the craters. And then, once you have the big picture, you can get into the geology. Basically, I'm a pilot. I was also a well-trained geologic observer, but I wasn't a geologist and probably never would have been and never will be. So, being a pilot, I like to know where I am all the time; I like to know what my surroundings are; I like to know what environment I'm in; I like to be able to anticipate; I like to be able to prepare. When you're a flyer, the environment that surrounds you - if you will, the 'geography' - includes the weather and the traffic. Not just the mountains, but a lot of things. And on the Moon, if you have a feel for the geography and the topography, when you start rambling through this valley you're not going to be too surprised by what you find. You're going to anticipate - which is very important - and, in many cases, you're going to know what to expect. Now, when you get on the slopes, and you get among the boulders, and you pass over the rims of those craters, those are the things you can't see or feel from orbit. So the Moon does take on a new dimension at the surface; but, at least you've got this background, this feel for the environment that you got from orbit; and that helps you.

"People ask all the time if I was ever scared; and my answer to that, without hesitation, is 'No.' 'Apprehensive?

'Yes.' But I was never scared. Because, to me, fear is what happens when you're confronted with the unknown. Now, it's not that we didn't have many surprises on our flights. But we were aware of where we were, of what we were doing, and of what the risks were. We had a broad knowledge of our own personal capabilities and had confidence in our abilities to handle the unknowns. We had a broad knowledge of the hardware we were flying and how to manipulate it around problems. Could the Saturn V have blown up on liftoff, could we have not had ignition on the lift-off from the Moon, could a suit have sprung a leak? Sure, all those things could have happened. But you don't sit and worry about them. If I tell you to walk through a door into a dark room and walk out a door on the other side without telling you whether there's bears, rattlesnakes, alligators, or bogeymen in that room, you're probably going to be scared. But if I say 'This room has a Grizzly Bear over in one corner' - and you're dedicated to getting to the other side - you're going to learn all about the life of a Grizzly Bear: when he eats, when he sleeps, what he does in the darkness. You're going to understand all those things and you're going to develop confidence in your ability to deal with him. Now, a Grizzly Bear can act in an unusual way just as a spacecraft can; but, while you may be apprehensive as hell when you open that door, you won't be scared because you will have thought through all of the things that are likely to happen."]

142:36:55 Schmitt: The surface patterns are still the same, Bob. The main difference being that we're getting probably a gradual increase in block population; and the blocks seem to be of a different character. They may be breccias.

142:37:14 Parker: Okay. Copy that.

142:37:15 Schmitt: And around the crater here that's maybe 75 meters in diameter, there's probably 5 percent blocks - fragments, I should say - greater than a centimeter (in size).

142:37:29 Cernan: Boy, look at all the dust without that fender (Means "with the replacement fender on"). I hate to think of what it would have been like with that (replacement) fender gone.

[Gene can see how much dust the front wheels are throwing up under the fender and is thinking what it would be like driving without the replacement.]

142:37:34 Schmitt: Yeah. (Pause) There's a good-sized block, sort of blue-grey.

142:37:40 Cernan: Looking up there, Jack, I ought to get some 500s looking right up that hill, but...

142:37:45 Schmitt: Well, you may want to do that out a way a ways (from the Massif).

[Gene is talking about getting pictures with the 500-mm camera; Jack is suggesting that they would get a better view from a position farther to the north.]

142:37:48 Cernan: Some of that stuff is mantled, or buried, in the massif material. Some of (the rocks) just seems to be laying on it, of course.

142:37:58 Schmitt: Yeah. Well, I think it has to do with how long it's been there. You'll tend to get the downslope movements forming uphill fillets, and that's what a lot of it looks like.

[Out on the valley floor, fillets are formed exclusively by ejecta from local impacts splashing against the sides of rocks and building up skirts of soil. On steep slopes, downhill movement of regolith can also contribute to fillet formation.]

142:38:09 Cernan: Most of it is uphill fillets. Most of it is pretty sharp. (To Parker) But my guess, from back at the LM, that those blocks on the massif were much more angular, I think, is a good guess because that's what they look like to me here.

142:38:28 Schmitt: And looking up into our blue-grey outcrop area, I still have even more the impression that there's a planar orientation that dips off to the southeast. Maybe just fracturing, but (it's) pretty clear up there, I think. (Pause) It may be shadows.

142:38:51 Cernan: The LM (means "the Earth") is now 50 percent of the massif height away from the massif. How's that? I think we will keep it (Earth) on top. (Pause)

[From the spacecraft, the Massif summit is at an elevation of 11 degrees and the Earth at 45 degrees. Now, as they get closer and closer to the base of the mountain, the summit fills more of the sky and Gene's first statement suggests that the summit elevation from their current position is about two-thirds of 45 degrees, or 30 degrees. At 143:20:14, Fendell will use the TV to look at Earth and one can estimate that it is about 20 degrees above the apparent summit and, therefore that the apparent summit is at an elevation of about 25 degrees at Station 2. The agreement with Gene's estimate is quite satisfactory. Another reason to believe that Gene is not talking about the LM is the fact that he is driving southwest, away from the spacecraft so that, even if they were not down in the trough, he wouldn't be able to see it. As for the second half of Gene's statement, if the Earth disappeared behind the mountain, they would have to communicate with Houston through the LM, probably at a considerable loss of signal quality, so he'd rather not lose sight of Earth.]

142:39:01 Schmitt: That is a high mountain!

142:39:03 Cernan: Jimmeny Christmas! Listen, if the Earth goes behind it, we're changing Station 2. (Laughter)
 142:39:11 Schmitt: Gonna be nip and tuck, pardon the expression.

[Cernan - "I think some mountains on Earth impress you as being taller than the Massifs. Up to the west of Calgary, the northern Rockies look very tall and impressive and they do rise up to 11 or 12,000 feet above sea level. But there, you're in a valley that is probably already at 6 or 7,000 feet and, so, the peaks are really only 4 or 5,000 feet above you. The Massifs, on the other hand, rise maybe 8,000 feet straight up from the valley floor. What was really impressive about the Massifs, however, was how massive they were; they were so massive they overpowered you. Visually, they weren't overly impressive; they didn't have the cliffs and abrupt breaks and snow-cover that you see in the Rockies; but they were massive, jumbo mountains. I use the word 'jumbo' because they weren't antagonistic-looking mountains; they weren't jagged; they weren't rugged; they were just jumbo in size. Mt. Rainier near Seattle gives you something of the same feeling. Not from Seattle, itself, because that's too far away, but maybe from twenty or thirty miles from the mountain. But Rainier is just one mountain and we were in a valley surrounded by jumbo mountains. On Earth, I've certainly never seen anything else like them."]

142:39:15 Schmitt: Okay. As we get closer, actually, we're out of the block area. And that blocky region of 5 percent may have been just associated with that crater. I still see no lineations, although...

142:39:32 Cernan: Look at these wrinkles (on the Massif), though, Jack...

142:39:34 Schmitt: Yeah. I was talking about the mantle.

142:39:35 Cernan: Oh.

142:39:36 Schmitt: But you're right about on the Massif.

142:39:39 Cernan: The same wrinkled lineations we saw sloping uphill to the west on the eastern half of the massif are still very evident at this Sun angle (and, therefore, may be real and not an optical illusion).

142:39:51 Parker: Okay, 17; And we're estimating that you should be there within...

142:39:54 Schmitt: (To Gene) Come back up!

142:39:55 Parker: ...about 5 minutes to meet the walkback constraints.

[During mission planning, it was assumed that, should the Rover fail at any point during the traverse, the astronauts could walk back to the LM at an average speed of 2.7 km/hr, using cooling water about 25 percent faster than they would have during normal activities (1290 BTU/hr rather than 1000 BTU/hr). On this traverse, the longest ever conducted during Apollo, cooling water budgets are rather tight and, at Station 2, Gene and Jack are about as far as

they can get from the LM and still have a reasonable amount of time to do geology.]

[Cernan - "We had lots of discussions about walkback and the rules that we came up with were generally compromises. If some of the real conservative people had had their way, we wouldn't have gone more than a mile from the LM; but we finally decided that we wouldn't consider a worst-case worst case of both the Rover and one of the PLSS's failing. Otherwise, there wouldn't have been much point in taking the Rover. If you didn't fight for what you thought was right, you'd go all the way to the Moon but be so limited in your capabilities that you couldn't get anything done because you were afraid of a failure. When you go all the way to the Moon, you've got to take some risks. It's like having a two-foot putt to win the Masters and then lagging it because you don't want to three-putt. You don't want to take unnecessary risks; but the Rover had four drive motors and two sets of batteries and the chance of both the Rover and one of the PLSS's failing was pretty small."]

142:40:00 Cernan: Well, we're...Bob, we're almost ready to park.
 142:40:04 Parker: Okay. Beautiful. (Pause)
 142:40:12 Schmitt: (Responding to Gene) Well, I wouldn't have gone so far as to say that.
 142:40:15 Cernan: Well...
 142:40:16 Schmitt: We're getting close.
 142:40:19 Cernan: I'll give them their 5 minutes. We'll make it by then.
 142:40:24 Schmitt: Bob, the boulder tracks are really just chains of small craters, for the most part. (Pause)
 142:40:43 Parker: Okay; copy that. That's interesting.
 142:40:46 Cernan: I don't think they can tilt the television camera high enough to see the top of the massif. (Pause) Jack, we're on the edge here, but I don't know. Is that the...Well, let me go up here.
 142:41:07 Schmitt: No, you're doing great.
 142:41:08 Cernan: We're 071, 8.9, and 7.4.
 142:41:12 Schmitt: See, there's Nansen off to my right now.
 142:41:14 Cernan: Yeah, I just want to make sure that I'm not driving down a hole here...which I am, but...I don't want to drive down (into) Nansen.
 142:41:23 Schmitt: No, you won't. The end of Nansen is over there near those blocks. Right over there. (Pause)
 142:41:39 Schmitt: Look at those blocks! Unfortunately, the good boulder tracks are over into Nansen.

[That is, on the steep Massif slope that rises up out of the south side of Nansen.]

142:41:49 Cernan: Going down here very slowly.
 142:41:52 Schmitt: I think (a) station (pause) just about anywhere near the big blocks...
 142:41:59 Cernan: Yeah, that's where I'm going to put it.

142:42:00 Schmitt: ...would be a good Station 2.
 142:42:02 Cernan: That's where I'm going to put it.
 (Pause)
 142:42:08 Schmitt: We could try to...Let's see. (Pause)
 142:42:15 Cernan: Yeah, that's where we're going to make
 Station 2; right up there.
 142:42:16 Schmitt: What? Straight ahead?
 142:42:18 Cernan: Yep.
 142:42:19 Schmitt: Yep. Okay.
 142:42:21 Cernan: Boy, you're looking right into Nansen.
 142:42:25 Schmitt: Yeah. We're right where we wanted to be
 for Station 2. And it looks like a great place. Big blocks.
 It looks like quite a bit of variety from here. Different
 colors, anyway. Greys and lighter-colored tans.
 142:42:41 Cernan: Okay, Jack, I'm going to do a 180 (degree
 turn) and park the Rover at 045.

[Gene will park the Rover pointing northeast. The main reason for this is that the high gain antenna will then point back over the Rover and Gene will be able to look into the boresight while standing comfortably in front. The checklist pages describing the stop at Nansen are LMP-11, 12 and 13. Gene has identical pages. Generally, the items listed for the Apollo 17 geology stops are generic tasks which leave plenty of room for real-time decisions by the crew and the Backroom.]

142:42:50 Schmitt: There's a blue-grey rock and a lighter-colored tan rock.
 142:42:55 Cernan: See where they can look in here.
 142:42:56 Schmitt: Are you going to park it?
 142:42:58 Cernan: Right on the other side of this little crater heading (garbled).

[There is a burst of static as Gene does his turn.]

142:43:10 Parker: (Garbled) heading.
 142:43:20 Cernan: (Garbled) 45 (garbled). Okay, Bob you ought to have us again. 045 (garbled). (Static fades as Gene realigns the antenna) 9.1, 7.6. Are you reading, by the way?
 142:43:31 Parker: Roger. Reading you loud and clear.

["045" refers to the northeast heading at which Gene has parked the Rover.]

142:43:37 Cernan: Okay. Let me get (my seatbelt) undone here. Amp hours are 98 (and) 98. Batteries are 90 (degrees) and 112, and the motors (are) forward left is off-scale Low, and right is 340. Forward rear is off-scale Low, and right is 240. I expect we've got a bad meter (on the right rear).
 142:44:04 Parker: Okay. Copy that on the 340. And you want to give me the bearing one more time there, Gene. All I got was the distance (driven) at 9.1 and the range.

142:44:16 Cernan: Yes, sir. Zero-point-one, 9.1, 7.6. We are right at Station 2. (Pause)
 142:44:27 Schmitt: Look at Nansen!

[For some reason, Gene is mis-stating the bearing to the LM. It is really 071. His net speed for the whole trip out from the SEP transmitter has been 6.4 kph - 7.9 kilometers of map distance in 73 minutes. Measured along their meandering, 9.1-kilometer path, their average speed has been 7.5 kph including several stops.]

142:44:28 Parker: (Responding to Gene) Okay. We copy that. When you're at the station, here's a couple of things...

142:44:31 Schmitt: My goodness gracious.

142:44:36 Parker: ...(charging ahead with rapid-fire instructions) we'd like for you guys to look at in the (housekeeping) overhead. In addition to them. We'd like the TV lens to be dusted, in addition to the regular dusting. That'll take the lens brush, remember.

142:44:41 Schmitt: (To Gene) Can you try to tighten that (camera handle)?

142:44:42 Parker: You might check the low-gain antenna elevation to make sure it's at 45 degrees. We think you commented on that, and I think you're right now looking at tightening Jack's camera handle.

142:44:57 Schmitt: (To Parker) I'll work on that. Gene, you go ahead with the other...

142:45:00 Cernan: Okay. Yeah, we are at 45 degrees (low-gain-antenna elevation), Bob. Let me check it. I'll lose the comm on you a second. I've got to turn it towards me. (Pause; brief static) Mark it at 045.

142:45:21 Parker: And, 17. Jack, we'd like you to check the SEP for us. I suspect we'll have to turn it off and open the mirrors and dust them

[The SEP receiver/recorder on the back of the Rover has been overheating.]

142:45:35 Cernan: Boy, when you get this (TV) picture... (Pause)

142:45:48 Cernan: You('ve) got High Gain.

[TV on.]

142:45:50 Parker: Roger. Thank you. We have TV. (Pause) Geno, we ...

142:46:06 Cernan: Oh, Manischewitz!

142:46:06 Parker: ...did not get a good bearing from you guys. We might also check the LMP's camera.

142:46:11 Cernan: Okay. I'll give it to you again.

[Gene is working at the front and right side of the Rover, occasionally coming into view.]

142:46:15 Schmitt: That's fixed. Oh, you mean for pictures?

[Jack initial thought is that Parker is asking about the camera handle, and then realizes that he is asking about a frame count.]

142:46:19 Parker: Roger. (garbled)...

142:46:20 Schmitt: Okay, LMP...

142:46:28 Cernan: Okay; 071 is the bearing (to the SEP transmitter).

142:46:33 Parker: Okay. Copy that.

142:46:35 Schmitt: 142 (frames) on the LMP's camera. The (SEP) temperature is 105.

142:46:47 Parker: Roger. Let's turn off the (SEP) power and the recorder, open the blankets, and dust it.

142:46:57 Schmitt: Power's off; blankets are open; and, Gene, you'll have to dust it.

142:47:05 Cernan: I'll get it. I've got a lot of dusting to do here, Jack.

142:47:10 Schmitt: Okay. (Looking at his checklist) Let's see what we've got to do.

142:47:14 Cernan: We've got a lot of housekeeping to do right now.

142:47:14 Parker: And, Jack, I presume when I told you, you turned off the receiver, didn't you? Not just the DSEA?

[This Data Storage Electronics Assembly is a removable unit which will be brought back to Earth. As it turns out, good data has been obtained during the drive out from the LM and more will be collected on the return to the LM from Station 4.]

142:47:22 Schmitt: That's affirm. I turned off both switches.

142:47:23 Parker: That's what I thought. Thank you.

142:47:25 Schmitt: Oh, my scoop! My scoop just came off (the extension handle)! That's interesting. I'd better check the rake. Vibrated loose, I guess. (Long Pause)

[Jack is at the gate. Reattaching the scoop to the extension handle is a relatively simple matter of pushing the spring-loaded collar toward the scoop and rotating the collar to engage the latching pins.]

[Cernan - "The only time we did any traverse training pressurized was at the Cape. The rest of our geology traverse training was done in street clothes. But we needed to get in the suit and actually work with core tubes and the other equipment, actually get down into the nuts-and-bolts of it and handle the drill, handle the core tubes, assemble the Rover, and work with the things that were going to give you difficulty in the pressurized suit. Some things, like working the locking mechanism on the extension handle weren't very difficult; but things like aligning core tube threads

were much harder to do than they were in shirtsleeves. That kind of training was very, very valuable. So, in the later stages, we'd do pressurized training down at the Cape maybe once or twice a week for the last couple or three months. It wasn't something I'd particularly look forward to, because it was hard, hard work."]

[The scoop and rake are each attached to an extension handle seated in a bracket on the gate. Even though the locking mechanism had released, as long as the back of the Rover didn't bounce too much, the tools wouldn't have jumped off the mating post on the end of each handle.]

[Schmitt - "The failure of the lock was probably caused by the dust which, I'm sure, had worked it's way into the sockets by this time. By the third EVA, a lot of the sockets just weren't working: you either couldn't get them loose or couldn't get them connected because of the dust. Dust is going to be the environmental problem for future missions, both inside and outside habitats. And, unfortunately, although there's a lot of lip service paid to it, I don't detect a great deal of imaginative thinking about how you deal with the dust."]

142:47:53 Cernan: I'll get the battery covers.

[Fendell pans the TV to look at the replacement fender; the TV lens is dirt spattered.]

142:47:55 Parker: Okay; and Jack, and we'd like to get an EMU check on you.

142:48:00 Schmitt: Stand by. (Long Pause)

[Fendell pans to Gene who is dusting the left-side batteries. Jack is at the gate, re-attaching the scoop to the extension handle.]

142:48:14 Parker: And, Jack, we'd like to go to India (Apollo magazine 138) on the magazine for you. (Long Pause)

142:48:34 Schmitt: Okay, magazine India. My goodness, we'll never get started.

[Jack, a bit frustrated about all of the housekeeping chores, goes to Gene's seat and sticks the scoop in the ground while he gets a film magazine. Gene has moved out of the field of view.]

142:48:40 Cernan: Man, we are down in a dep(ression)...Look at where we came down, Jack. And that was just one of the hills. Got to go back up and then down some.

[Cernan - "As I recall, when we went down into the trough it was like going down a hillside. It wasn't a deep trough, but it was enough to give you a close, local horizon that hid the rest of the valley."]

142:48:47 Cernan: (To Parker) Hey, thank you for that fix on the fender, by the way, because I'd hate to see what it would look like without it. (Pause)

142:49:05 Parker: Okay. And John (Young) suggests that we might just check it momentarily while you're here to make sure it's still holding on good and tight. Both the clamps and the tape.

142:49:15 Cernan: Yeah, that's on my list. (Pause) If it stayed on through that ride it may never come off! Okay. (Pause) Have you got a lens brush in there, Jack?

142:49:37 Schmitt: Yup.

[Jack finishes loading the film magazine in his camera. Although we don't see him remove the old magazine on this film change, he has probably put it on Gene's seat. When he picks up the new magazine, he removes a dark slide and puts that on the seat, and then inserts the new magazine before putting the darkslide into the old magazine and stowing it under Gene's seat. Readers may want to note that the replacement fender will fail mechanically during the drive from Station 9 back to the LM at the end of EVA 3.]

142:49:38 Cernan: Well, hold it a minute. I've got to get this SEP. Do you want me to dust the SEP, is that what you said?

142:49:42 Schmitt: Yeah.

142:49:45 Cernan: Do you want the covers open?

142:49:47 Schmitt: They should be open and dusted. (Pause)

142:49:54 Cernan: Okay. The SEP is open. It's about 100 degrees.

[Jack gets a lens brush from beneath Gene's seat.]

142:49:57 Schmitt: 105 (garbled).

[Jack drops the lens brush and retrieves it.]

142:50:02 Cernan: 105? Okay. And it's dusted. (Pause)

142:50:07 Schmitt: Here's your lens brush; if you need it.

[Jack reaches across the seats. It's a very small brush.]

142:50:10 Cernan: Okay, thank you. My camera look all right to you?

[Gene is asking Jack to see if his 70-mm camera lens is clean.]

142:50:13 Cernan: Let me get yours; lean over here, and I'll get yours. (Pause)

[Jack leans across the seat so that Gene can clean his camera lens.]

142:50:21 Cernan: Okay. I'll get mine, too. (Pause)
 142:50:34 Parker: And, Jack, we're suggesting that you're getting a little warm. Maybe Intermediate (cooling) might help.
 142:50:40 Schmitt: Bob, I feel the same way; but I want to get this camera fixed. (Pause) I mean (get) the film changed.
 142:50:46 Parker: Okay.

[Schmitt - "During the pre-mission training, we spent a lot of time outside and pressurized, training for the EVA's down at the Cape in a simulated traverse area. You couldn't work ten hours like we did on the Moon, but we would work for like four hours. And we wore ourselves out before somebody had the bright idea - and I hope it was me, but I don't remember - of hooking the liquid-cooled garment up to some ice water. I'm surprised we didn't kill somebody from heat stroke. It was just too much. We shouldn't have been doing it. We didn't having any significant cooling for a long time - just an inadequate liquid-air cooling system in the lightweight PLSS's - and, then, during training for some mission, probably 15, we decided to have somebody walk behind the pressurized astronaut with a backpack full of ice water, and a hose going into the suit attached to the liquid cooled garment. And, of course, that made all the difference in the world. I think that was my suggestion, but I can't be sure; so much of that stuff happened synergistically. But I was worried and I know I made a big point to a lot of people for a long time that you were going to hurt somebody, that they were just getting too hot, including me."]

[Jack relates a variant of this story in his EVA 1 commentary at 118:39:52. The first half of this EVA 2 review was actually done some months before the EVA 1 review.]

[Cernan - "I don't think we had the ice-water cooling for the Apollo 14 EVA training; for me, that showed up on Apollo 17. Although Apollo 14 was a January launch and ours was a December launch, we trained all year long. It got hot down there at the Cape, and you worked hard. I never felt we were going to kill anybody; but the ice water did help. It made a big difference. It allowed you to work more efficiently and kept you from getting as hot and tired and irritable, and you got more out of training than you would have otherwise."]

[Gene swings the TV around so that he can dust the lens.]

142:50:53 Cernan: (Joking with Houston) Can I change your oil?
 142:50:56 Parker: Oh, thank you, Geno. It looks much better. (Pause)

[Gene raises his visor; he has a light growth of beard and a relaxed expression.]

142:51:08 Cernan: How about any other service I can be?

[Gene finishes and moves away; Fendell starts a clockwise TV pan.]

142:51:13 Schmitt: (To himself) Okay. (Talking louder to Parker) Okay, Houston, the number of blocks plotted on the map are not nearly enough. In the greater than 1-meter range, there are many hundred blocks on the massif flank of Nansen (that is, on the south side of Nansen) and up around Station 2, where we are. There are only one or two blocks on the light mantle side of Nansen. It looks as if the material in the bottom of Nansen is overriding the light mantle materials of the north wall (of Nansen). That's just an impression. They (the South Massif talus)'re slightly lighter albedo than the north wall of Nansen.

142:52:06 Parker: Okay. Copy that, Jack. Looks fantastic up there.

[AS17-138-21033 is a good view to the northwest into Nansen from the lower of the two Station 2 boulders.]

142:52:11 Schmitt: And I suggest that we do our raking...(Responding to Parker) That's right; I just told you everything you can see...(I suggest that we do our raking) fairly close to the Rover to get sort of the general population of talus material coming off the massif. (Pause)

[Fendell finds Gene at his seat; Jack is in the distance, behind the Rover to the southwest with the lower slopes of the South Massif in the background. Gene gets the gnomon from its sheath behind his seat and goes to the gate.]

142:52:37 Cernan: Bob, on my mark...I've got everything: hammer, gnomon, film. Okay. Mark it; you have a gravimeter measurement going.

142:52:49 Parker: Roger. Copy the mark.

[Fendell pans away counter-clockwise.]

142:52:53 Schmitt: Okay, Bob. The blue-grey rocks are breccias. They're multilithic, grey-matrix (pause), matrix (dominated) breccias, I guess. There are fragments in them, but it doesn't look like more than about 10 or 15 percent fragments.

[Schmitt - "When I was estimating the percentage of fragments, (the 10 to 15 percent figure) was related only to fragments large enough that they seemed to jump out of the matrix, that were clearly of a larger size than the matrix components. My guess is that the minimum was of the order of a few millimeters in size and that the estimate was really

biased toward the larger fragments of centimeter size and more."]

142:53:10 Schmitt: Some of the light-colored fragments seem to have very fine-grained dark halos around them. The zap pits (in the dark matrix) do not have white halos, so I suspect they are not crystalline (rocks). They might be the vitric or glassy breccias. At least, the one big rock we have here.

142:53:43 Parker: Copy that.

[Schmitt - "When the small impacting particles that form the zap pits hit, if there's crystalline rock - particularly plagioclase - at the impact point, then the halos look white. And in this case I'm saying that, because the halos don't look white, the rocks are not coarsely crystalline on the scale of the zap pit."]

142:53:45 Schmitt: There's a very rough foliation in them (the blue-grey breccias) - and I'm not sure - it's shown by the elongate knobs on the surface. It looks like a fracture foliation of some kind.

142:54:00 Cernan: Jack, that rock has almost got to have come down (from the outcrops high on the mountain), don't you think?

142:54:04 Schmitt: Oh, no question about it. I'll bet you it's the same as the blue-grey rocks we see up higher. Here's some more blue-grey ones over here.

142:54:11 Cernan: Let's start taking...Oh, yeah. Look at the size of some of these light fragments in here.

142:54:18 Schmitt: Yeah, but it still...It looks like they're dominantly matrix breccias. There are light-colored fragments, and they (the fragments) may be crystalline.

[Fendell finishes his counterclockwise pan at the Nansen/South Massif contact and reverses direction.]

142:54:34 Cernan: Okay...

142:54:35 Schmitt: They are. They're very light colored; they look like the shattered anorthosites. They have white halos (around zap pits)...I think that's what those fragments are.

142:54:48 Cernan: Jack, let's get a piece of this one right here (Boulder 1).

142:54:51 Schmitt: Okay.

142:54:52 Cernan: It's the biggest one here.

[Schmitt - "Boulder 1 was very weakly indurated but had a lot of layers in it; it was pretty easy to sample because it wasn't as tough a breccia as some of the others were. Boulder 2 was up on the slope and was about head high. We got a series of four or five samples, I think, and, as we'll hear described, we got a soil sample from a permanently shadowed place underneath an overhang. Boulder 3 was the one

in which we found the crystalline dunite, which turned out to be very old. After the mission, there was a scientific consortium, called the Consortium Indomitable, headed by John Wood of the Smithsonian Astrophysical Observatory at Harvard, which published a suite of papers about Boulder 1."]

142:54:53 Schmitt: Set her up (the gnomon). This is the blue-grey (breccia) variety, Houston.

142:55:00 Parker: Okay. Copying that. (Pause)

[Jack's down-Sun before is AS17-138-21029 and Gene's cross-Sun stereo pair is AS17-137-20900 and 20901.]

[Schmitt - "The gnomon gave you the local vertical, a 40 centimeter scale, a shadow which gave you azimuth, and also had a grey scale and three international color references for photometric calibration. In principle, the shadow, if visible in both pictures of a stereo pair, could be used to control azimuth for topographic analysis. The vertical scale of known length provided other control parameters. I am not sure anybody ever did such an analysis, given the way resources dried up after the Apollo program. I don't think anybody's ever used those photographs or the data contained in them for analysis. But we gathered it.

"The gnomon is the residuum of an original concept Gene Shoemaker had for gathering data with a stereo camera mounted on something called a Geologic Staff; the camera would have been taking pictures continuously, with the orientation of each frame recorded automatically. In fact, it started out as a video camera. Unfortunately, NASA never saw fit to fund that. They finally, belatedly, funded development of a stereo camera, but they were forced to do it through a small business contract. And, instead of it going to a company like Kodak which had already built a stereo camera for use on the Moon - namely the Gold Camera (which is another story) for Apollo 11 - this one wound up going to a small company that couldn't handle it. They spent a lot of money and never produced a camera. It was just too much for them. Kodak did the Gold Camera, which I think in some ways was a more difficult job, in six months."

"The Gold Camera took close-up stereo pictures of the lunar soil and that was NASA's homage to Tommy Gold and his gadfly irritation of the system. (Flown only on Apollo 11 and 12.) He cost us an awful lot of time and money; although I have to admit those were nice little pictures. I don't know if anybody's ever used them for anything; they are close-up documentation of the pristine lunar soil or, at least, as pristine as you can get close to the LM. But you see, Tommy was the one who, fairly late in the game, kept coming back and saying that the astronauts were going to sink out of sight in a thick layer of lunar dust. And even after Surveyor landed, this kept coming up because, from his radio telescope investigations he was seeing the upper few microns of the surface and he was seeing this "faerie castle" structure. It really is there - in the very top surface -

but there was absolutely no scientific, geologic, or logical reason to think that, on centimeter scales and larger, the surface wasn't well tamped by the meteors. And when Surveyor landed, it didn't sink down at all; and that should have been conclusive."

"Harold Urey was another guy who was way outside his field and said many things that seemed to many people to be off the wall; but Harold's intellect was such that, in the final analysis, his suggestions were not the kind you could ignore. And in a lot of cases he was right on things that geologists were wrong on, mainly because geologists got too immersed in the details. Harold was able to look at the Moon in a cosmological sense and at least some of his conclusions - not all, but at least some - were quite good. He even wanted to go. In the late sixties, at a meeting in La Jolla, he volunteered to me that he would take a one-way trip. He said 'NASA is doing it all wrong. They ought to just let me go one-way, and then you wouldn't have to pay all the money to get me back.'"

[Readers interested in a further discussion of Urey's and Gold's lunar participation should consult Don E. Wilhelms excellent 1993 book "To a Rocky Moon".]

142:55:08 Cernan: I'm going to take that little knob off up there.

142:55:11 Schmitt: Okay; well, you can work that block over...

142:55:12 Cernan: Yeah.

142:55:14 Schmitt: We can get several examples. We ought to sample across that layering...that foliation.

142:55:18 Cernan: One comment. When you look down into the bottom of Nansen, it looks - like, I guess, would sound obvious - that some of the debris that has rolled off of the South Massif covers up the original material there that covers the north wall of Nansen. There is a distinct difference. You've got that very wrinkled texture in the north slopes of Nansen, and you've got the South Massif debris in the south slopes of Nansen. And the debris, of course, overlays the north slope. And all the rock fragments, all the boulders that have come down, are all on the south side of the slope of Nansen.

142:56:05 Parker: Okay; got that.

[Schmitt - "While Gene was doing this description, I was probably looking closely at the boulder, very engrossed. And, while it's true that Gene is repeating essentially what I had said earlier, it shows both how engrossed he'd been in his housekeeping tasks and how good a feel he had for observation. He picked up all of the same things that I'd picked up earlier and, as he always did when he put his mind to it, did an excellent job.

"It was brought to my attention on, I think, an Apollo 12 training trip to Hawaii, that stratigraphy was something of interest to the other astronauts. I think Dale Jackson

was leading the exercise. And after we'd done our exercise and were all gathered around, Dale asked each of the other astronauts to give their impression of what had happened geologically, of what they had seen. And then, after they had each had a chance to do that, he asked me to summarize it and I fell back on a technique I always used in order to organize my thoughts, and that was to talk in terms of oldest unit to youngest. I just put them in sequence and talked about how the relationships between units developed as I went through in my mind oldest to youngest. And Dick Gordon - although it could have been Al Bean - asked me how I kept my thoughts organized. And that emphasized in my mind how easy it was for them to understand the concept of superposition; it's the most fundamental concept in geology, the first ever documented by natural scientists, namely by Steno (Nicholas Stenonis), a Dane who lived in the 1600's. Anyway, it was something that I kept putting into the training program to make sure they all realized how easy it was to organize your thoughts in terms of what's on top of what. Gene picked it up and did it well. He could have done a lot more than he actually did. Some of his more rambling descriptions - for instance, when he did his hurried horizon description from the LM - are a little bit harder to follow but, in this particular case, you can see that Gene has his thoughts pretty well organized. "]

142:56:06 Schmitt: Okay, Houston. I take back what I said about no (zap pit) halos. There are light - not very sharply light - but light halos around zap pits in the matrix. The matrix glass is dark, and it seems to have a greenish cast; but it's very dark.

142:56:25 Cernan: Oh, look at that blue! Look at the white fragments in there. (Pause)

142:56:36 Schmitt: Let me come and help you there.

142:56:37 Cernan: Man, there's some boulder rolling rocks here, Jack. (Laughs)

[Fendell pans past the back of the Rover. Gene and Jack are hidden by the gate.]

142:56:41 Schmitt: Okay, don't wreck the fillets. There's an overhang we've got to get into. (Pause)

[Schmitt - "This was what we called a target of opportunity. We had been looking for situations where you could get a sample from underneath a boulder overhang where it has been protected for some time from the solar wind; and, if I remember correctly, that was to give us a better handle on when the boulder rolled into that position and began to shelter the soil underneath it. The solar wind age on the fillets on the boulder should be distinct from the age of the soil underneath the overhang. I don't know who thought that up, but I tell you, the synergism in the planning for these

things was so great that there's just no way that any one individual can ever take credit for anything."]

142:56:53 Schmitt: Okay; (sample number) 514 is the...Okay, I'll take it back. On the fresh surface, these look like fragment (dominated) breccias although the fragment size is fairly small. There are dark grey fragments and the light fragments we talked about. The grey ones are very fine grained and dense, although I see flashes that indicate they may be crystalline. The light-colored fragments are as I described earlier, I think.

142:57:19 Parker: Copy that.

[Fendell looks at the rear of the Rover. Nobody is in sight.]

142:57:22 Schmitt: 514.

142:57:26 Parker: Okay; Jack...

142:57:27 Cernan: (Garbled) this other one (garbled).

142:57:27 Parker: ...if you could tear yourself away in the middle of that sometime to give us an EMU read-out, we'd appreciate it. We haven't gotten that from you yet on the EVA.

142:57:34 Schmitt: Okay. I'm...Stand by. Gene's got a rock to go (in a sample bag). (To Gene) That's from up higher?

142:57:42 Cernan: That's a little higher. See that chop up there?

[Fendell pans counterclockwise.]

142:57:44 Schmitt: (To Parker) Okay. The first rock was from about...(Sample number) 514 was from a meter above the base of the rock; 515 is from about a meter and a half.

[Schmitt - "I'm sure that the sample bag system evolved with time but, by the time we flew 15, we had a standard Teflon bag with the little metal strip in it; and they were all pre-numbered. We didn't try to take them out in sequence. They were on dispensers in sequence but, as I recall, we didn't worry about getting dispenser 1, dispenser 2, dispenser 3. You didn't have to; once you had the number of a sample, they could find it. In thinking more about it, Neil (Armstrong) went out and just tried to get as many different kinds of rocks as he could and put them in a bag; I bet you we didn't have individual bags on 11. On Apollo 12, though, I suspect that we did (true), because we knew they were going to move around more.

"The metal strip was sealed into the upper hem of the bag in such a way that, when you took a bag off the holder it would spring open a little bit. But I think we had to squeeze in on the ends so that it would open even more. Then, when you had the sample in the bag, you folded the metal strip to provide a mechanical seal."]

142:57:54 Schmitt: Here, can I get this in your (SCB)...(Pause) Can you get some on either side of those two now?

142:58:07 Cernan: Yeah.

142:58:15 Schmitt: (To Gene) Okay. You're (SCB cover's) open. I'll leave you open for a minute.

142:58:18 Cernan: Well, okay. Just so they don't fall out. Am I in?

[Gene is asking if Jack has finished putting the samples in his SCB.]

142:58:20 Schmitt: No. Let me get this other one.

142:58:22 Cernan: Okay. (Pause)

142:58:28 Schmitt: Okay, go ahead.

142:58:31 Cernan: Let me try from back here.

142:58:34 Schmitt: Of course, that's a north/south overhang.

[Schmitt - "A north/south overhang won't provide continuous sunshading and what we really wanted was an east/west overhang."]

142:58:36 Cernan: Yeah. That one? Yeah, you're facing right into the east.

142:58:39 Schmitt: Yeah, yeah.

142:58:40 Cernan: I don't know if I can get a piece back here or not.

142:58:43 Schmitt: How about right where you...Yeah.

142:58:45 Cernan: Right here? I can get that.

142:58:47 Schmitt: Yeah, that's good. Oh, beautiful!

[Jack is pleased that Gene knocked the sample off so easily.]

142:58:49 Schmitt: Hit the gnomon.

142:58:50 Cernan: Well, I already...It didn't move. It just tilted it.

142:58:53 Schmitt: This it?

142:58:54 Cernan: Yeah, that's it right there. (Pause) Let me set my working tool (the hammer) down here.

142:59:05 Schmitt: Got a bag?

142:59:06 Cernan: Coming right up.

[Jack has picked up the rock fragment with his scoop and is waiting for Gene to get a sample bag open.]

142:59:11 Schmitt: Boy, that dust. Once you get it on there, you might as well forget it. (Pause) 494. 494 is from a half a meter above the base of the rock.

142:59:20 Parker: Understand, 0.5 meters up.

[Fendell reaches the limit of his counterclockwise pan and reverses direction. Here, Jack is saying that, once a

rock gets covered with dust, it is impossible to say much about it.]

142:59:21 Schmitt: And these are samples from across the layering... (Stops to listen) These are samples from across the foliation. I missed that, Bob.

142:59:33 Parker: Okay. Copy that now.

[Schmitt - "What we never worked out with Bob was that, when he heard something, he had to tell us that he heard it. And that invariably interrupted the next thought. It should have been only when they didn't understand that they would interrupt us, but we never got Bob to do that. And the total amount of time lost was significant."]

[Jack's comment should, however, be tempered by the observation that there were times when either he or Gene, realizing that they hadn't heard from Parker in a while or hadn't gotten confirmation of a transmission, would ask if they were being read. Parker would often try to judge when Jack had finish a thought before making an acknowledgment. Given the 2.5 second round-trip communications delay, that was sometimes difficult. In listening to the other missions, CapComs like Bruce McCandless (11), Ed Gibson (14), and Joe Allen (15) tended to interrupt less often than Parker did; however, on the other side of the coin, none of the other crews had as much to say. Obviously, this was occasionally a point of tension between Parker and Schmitt and was partly a product of their personalities.]

[Cernan - "It was never a problem. It was an open conversation between the three of us, plus Parker had fourteen people over his shoulder telling him what to do. He had to listen to them, listen to us, and get instructions up to us in between our comments to him. Frankly, I don't think any time was lost. Everything that was said needed to be said. And, let me tell you, when you're flying in an airplane or working on the Moon and it gets quiet on the airways for five minutes, I'll say 'Hey, Whisky Bravo, are you still with me?' If I don't hear other airplanes or the center or anybody else - which doesn't happen all that often except sometimes late at night - I'll do that. From my point of view, the occasional interruptions were a small price to pay for knowing that we'd been heard."]

142:59:37 Schmitt: (To Gene) What do you think? Can you get that one up there?

142:59:40 Cernan: Yeah. I might either get that or this other piece up here. Without busting my butt.

142:59:44 Schmitt: Well, don't take any chances.

142:59:45 Cernan: Yeah, I'm not going to. How about this one? Here's a whole big piece.

[Fendell has been looking for Gene and Jack, and people in Houston are wondering where they've gone.]

142:59:53 Schmitt: Okay. That's a good representative fragment.

142:59:56 Cernan: Can you get it? I can't reach it without my camera hitting (the boulder). That's a football-size fragment.

143:00:02 Schmitt: (To Parker) Okay, this next sample...(To Gene) Can you get a bag out, and we'll try to put it around it. Around the end. (Pause) Bob, it's highly variable. This is a light-matrix breccia; whereas the other three fragments were dark-matrix or dark-fragment breccias. The big rock (fragment that Jack is discussing now) is a light-matrix breccia with dark fragments, and it's the one that has the (dark) halos around the light fragments. And that's in 495, barely. It's not even in it. It's just...495 is wrapped around it.

143:00:50 Cernan: It's not going to stay.

143:00:51 Schmitt: It's not going to stay, is it?

143:00:55 Cernan: No. Well...It's a football-size fragmental rock.

143:01:00 Schmitt: Why don't you see if you can stuff it in there...with the bag down.

143:01:06 Cernan: Yeah, we'll be able to identify 495 when we get back. Okay, it'll stay.

143:01:11 Parker: Okay; we copy that, Gene. And...

143:01:11 Schmitt: Is the bag on it now?

143:01:12 Cernan: Well, yeah,...It's on it, facing down.

143:01:13 Schmitt: Great.

143:01:14 Parker: ...do you guys see any tracks coming down to these boulders? Do have any feeling that you can place (the source of) these that way?

143:01:23 Schmitt: Bob, unfortunately, no. The main tracks are out into Nansen, and I don't think we can get over there.

143:01:29 Parker: Okay; that's those biggies that we see on the maps, huh?

143:01:34 Schmitt: Yeah. Coming up, I was looking; and there are no obvious tracks coming down here.

143:01:41 Cernan: Watch your shadow, Jack.

[Gene is reminding Jack to keep his shadow out of critical parts of the photograph.]

143:01:42 Schmitt: I'll get it. Wait a minute; that gnomon is probably not...Well, that's right; you got stereo earlier.

143:01:48 Cernan: Yeah, I reset it.

[Jack is southwest of the Rover but not yet above the break in slope and can now be seen through a gap in the top of the gate.]

143:01:49 Schmitt: The gnomon was moved a little between the samples.

143:01:51 Parker: Okay. We copy that.

143:01:52 Schmitt: Do you need to take a vertical pan?

143:01:53 Cernan: Yeah, I've gotten it all. I'm getting it all.

143:01:55 Schmitt: You getting the flight line? I'll get a flight line this way. (Pause) Post-sample flight line.

[Gene's flight-line stereo and vertical pan are made up of AS17-137-20902 to 20909. they make up a portrait of the sunlit face of boulder 1. Jack is taking a similar set comprised of AS17-138-21030 to 21035.]

[Schmitt - "A flight-line stereo was a series of stereo photographs rather than just a pair. For a pair, you would just take one step left or right between the frames but here, you took a series of steps in a line, taking a picture after each step. It was a series of stereo pairs which could be convergent stereo if the camera was always pointed at the same point, or parallel stereo if you didn't turn the camera. For analytical purposes, convergent stereo was better, but we didn't worry too much about that and usually took the pictures roughly parallel.]

143:02:11 Cernan: Okay, Bob. I'm on frame count 42.

143:02:14 Parker: Copy, 42.

[Jack puts the sample in Gene's SCB.]

143:02:19 Cernan: Did you get a locator from here, Jack?

143:02:20 Schmitt: Yes.

143:02:21 Cernan: Okay. (Pause)

[Schmitt - "We would take "locator" back to something like the Rover, just so that there was something in the picture that could be used to work back to where the sample had been taken. We'd just turn around and take a picture of the Rover or of the horizon. Originally it had to do with the LM being in the picture as a locator because, from the geometry of the Lunar Module and knowing how it had landed, you could work back along a ray to where you were and, as well, get a distance based on the size of the Lunar Module. I'm sure that in this case the locator was back to the Rover."]

[Actually, Jack has forgotten to take a locator at Boulder 1, but will take one at Boulder 2.]

143:02:29 Schmitt: Okay. I got flight line on the north/south trend; Gene got east/west.

143:02:35 Cernan: You going to get that sample under there?

143:02:36 Schmitt: Yeah, we got to get the soil.

143:02:39 Cernan: There may be an overhang. And look at that, that rock is fragmented; let's see, it's southeast/northwest. There's a split.

[That is, the boulder is split into two major fragments, with the dividing plane oriented SE/NW.]

143:02:50 Schmitt: Yeah, that one right over there is okay. Hey, did you want to get this?
 143:02:53 Cernan: Yeah, I'll get that.
 143:02:54 Schmitt: This fillet?
 143:02:55 Cernan: You got it?
 143:02:57 Parker: And, 17...
 143:02:58 Schmitt: (To Houston) This is a fillet from underneath the rock.
 143:03:02 Parker: Roger. And an update on the rake samples when you get around to it. We'd like to get one up on the massif slope as much as you can, if you can get over to it. And then the second one down near the Rover.
 143:03:13 Cernan: Okay.

[Fendell gets a good view of the rake.]

143:03:16 Schmitt: Okay, Bob. This fillet is (from) up underneath an overhang. I got it from about...(To Gene) I got to get uphill from you a little bit.

[Schmitt - "In order for me to pour the soil in the bag, I wanted to get him downhill."]

143:03:30 Schmitt: (To Parker) It's about...(To Gene) That's good. (To Parker, finishing the thought)...oh, a third of a meter under an overhang And it's the upper 3 centimeters of soil.
 143:03:43 Cernan: And it's bag 496.
 143:03:45 Schmitt: Now let me get one out away from the overhang a little bit.
 143:03:50 Cernan: Okay.
 143:03:52 Parker: Okay. You think that's permanent shadow?
 143:03:57 Schmitt: No.
 143:03:58 Cernan: No. It's facing east.
 143:04:00 Parker: Okay.

[Schmitt - "We were looking for an east-west overhang, preferably on the north side of the rock, where the sunlight and the solar wind might not have reached."]

[The best examples of boulders casting permanent shadows were found at Station 6 on this flight and Shadow Rock at Station 13 on Apollo 16. As it turned out, the solar wind saturates newly exposed soil in a matter of only decades and then retains the solar wind gases during the gardening process. Very little difference was found in solar wind abundances between surface samples and samples from the bottom of the deep cores or permanent shadows.]

143:04:01 Schmitt: Okay. And a sample down to a depth of about 5 centimeters, about two-thirds of a meter from the boulder, on the south side, is in 497.
 143:04:19 Parker: Copy that.
 143:04:22 Schmitt: Now, let me get a skim sample, Geno.
 143:04:25 Cernan: Okay. (Pause)

[Schmitt - "A skim sample was the thinnest section of the surface of the regolith that I could get, intended to be a sample of the most modern solar wind effects. And then, you try to get stuff from underneath that.]

143:04:31 Cernan: I got to take a set of pictures after that, by the way. Show where they are.

143:04:36 Schmitt: I can piece them into my flight line stereo.

143:04:39 Cernan: Okay. They were in both of the "before" pictures on those rocks.

143:04:44 Schmitt: Okay; about a centimeter-deep skim. Careful

143:04:51 Cernan: You're in a hole. You better come out.

143:04:54 Schmitt: Yeah. (Pause) Boy, that's hard on the hand (manipulating the scoop) even in 1/6 g.

[They are visible through the gap in the gate again.]

143:05:04 Cernan: Okay.

143:05:06 Schmitt: And that was...(Pause) Okay.

143:05:11 Cernan: And I didn't park that Rover in a very good spot for them to watch what's going on, I guess; but that was the heading.

143:05:16 Schmitt: Oh, shoot. They're missing all of it.

143:05:18 Cernan: We didn't work in the right spot; that's all.

143:05:21 Parker: Every now and then we get a peek at you guys. But only every now and then.

143:05:27 Schmitt: Sorry, Bob.

143:05:31 Cernan: Oh, wait a minute.

143:05:36 Schmitt: You know, that's the way it happens.

143:05:38 Parker: Skim sample bag number, please.

143:05:39 Cernan: Okay. It's back on.

[Something has come loose, possibly Gene's pack of sample bags. Fendell pans away to look at some nearby boulders and small craters at maximum zoom.]

143:05:45 Cernan: Okay, Bob. I missed that. I didn't give it to you; but I think...Well the next bag I take out, you can check the num(ber)...Well, wait a minute, I'll do it for you.

143:05:55 Parker: No. That's okay. I suspect it's 498.

143:05:55 Cernan: (Not having heard Parker yet) I'm almost positive it was 498.

143:05:58 Parker: Okay. We'll put that down.

143:06:00 Cernan: Yeah, I did, too. (Pause)

143:06:09 Schmitt: Okay, Bob, looking at the blocks directly down-Sun, the grey-matrix breccias seem to be fragments, or schlerin anyway (elongated fragments with vague boundaries, usually elongated by either compression or shearing), within the white-matrix breccias.

143:06:32 Parker: Okay. I copy that.

[Schmitt - "I think one reason you hear the word 'Okay' so much is that we were using it as a trigger for the VOX, the voice-activated communications circuit, so that you don't cut out your first real word. I don't think it's something we talked about; it just developed."]

[A quick check of the transcripts from the other Apollo missions indicates that all of the astronauts frequently used "Okay" and most often at that start of utterances.]

143:06:37 Schmitt: And I got a couple pictures down-Sun to show that texture.

[These are AS17-138-21036 and 21037.]

143:06:41 Parker: Okay. And one thing we'd like to do would be to sample a variety of blocks, in terms of looking at differences in the blocks...from block to block.

143:06:51 Schmitt: Rog. We're going to do that. We're going after a lighter-colored block, now. (To Gene) Are you going up there?

143:06:56 Cernan: Yeah.

[Gene is about to climb the slope to Boulder 2.]

143:06:58 Parker: Okay; and if you're going up the massif, why don't we try and get the rake sample up there now. When you finish these rocks.

[Fendell returns to them.]

143:07:06 Cernan: Hey, Jack...Jack, don't come up here unless you bring the rake. It's a long trip. No sense coming up here twice. I can go get this sample. I'd get the rake, if I were you. Don't walk back up twice.

143:07:17 Schmitt: Well, I don't...(Contemplative mumble) I'm not sure they're going to gain anything by coming up to the top (higher than the Rover). Okay.

[Jack starts for the Rover; Gene, visible in the gap, starts climbing the slope to the southeast.]

143:07:25 Schmitt: You're not going to gain a thing, Bob.

143:07:27 Parker: Standby.

143:07:28 Schmitt: You're still on the talus. (Pause) You guys...Oh, well. (He decides not to waste time arguing) The rims of the small craters in the talus are softer than the normal terrain. My foot goes in maybe 10 centimeters where normally it only goes in a centimeter.

[Jack reaches the Rover.]

143:07:49 Parker: Okay. As long as it's above the break of the slope, Jack, we don't have to get very far up the slope.
 143:07:56 Schmitt: (Testy) That's right!!

[Jack mounts the scoop on the gate, takes the rake.]

143:07:57 Parker: And, Jack, since you're back at the Rover, how about giving us a Grav reading before you leave.
 143:08:06 Schmitt: Because I'm late sampling, that's why. But I'll do it anyway.
 143:08:09 Parker: Roger.

[Gene has placed the gnomon near Boulder 2 but then goes downhill to take a couple of pictures of Earth, which he could see above the rock as he approached it. He leans backward to take the shots. These are AS17-20910 and 20911.]

143:08:20 Schmitt: Okay, 670, 155, 201; 670, 155, 201.
 143:08:30 Parker: Okay. Copy that, Jack. Press on.

[Jack leaves the Rover but forgets the scoop and comes back to get it. Gene moves the gnomon.]

143:08:33 Cernan: Okay, Bob, I'm at another boulder up the slope here. It looks quite similar to the one we just sampled, except there is a lot of flake fractures on it. Non-uniform, non-directional, but quite different, at least from that other rock, in terms of its fracture pattern. The texture looks to be quite similar. Boy, I'm glad I don't have to walk to the top of this thing (the South Massif).
 143:09:05 Schmitt: Hey, look, Gene, on these rake samples, there is just no point in carrying a rake all the way up here...

143:09:11 Parker: Negative, Jack, as long as you're above the break...

143:09:12 Schmitt: ...because all we needed was a break in the slope.

143:09:16 Parker: As long as you're above the break in the slope; that's right.

143:09:17 Schmitt: Well, that's all right. It's being done; but let's watch those kind of calls please.

143:09:24 Cernan: (Acting the peacemaker, smoothing ruffled feathers) They can't appreciate the toughness of going up this slope, though. We can; we've got to tell them that.

143:09:29 Schmitt: Well, we did.

143:09:30 Parker: Yeah, that's what we were saying. Don't go above just at the base of the break in the slope, Jack. Don't climb all the way up there with it.

143:09:36 Schmitt: Oh, relax!

[Schmitt - "I made a suggestion right at the beginning about where to do the rake sample; and they were coming back as if they never heard that. It seemed at the time that Parker wasn't screening requests from the Backroom and that

he should have said, 'Hey, he's already told you that.' That's why I was getting annoyed."]

[Cernan - "There were just so many things going on in that Backroom and in the Control Center; Jack's been back there and he knows it. There were a lot of things that Bob had to filter out and there was a lot of time pressure. Coordination was the key and I think it worked pretty well. It was our job to let them know what we could do and couldn't do. And, while there were times when they may have wanted something we couldn't get for them, I don't ever remember anyone pushing once we advised against what they were asking us to do or we said it couldn't be done. I mean, it was our flight; they were there to help us and the mission simulations we did with the Backroom involved were an important ingredient in our training."]

143:09:39 Cernan: Okay, we're all set, Bob. No problem. (Pause) Garbled).

[Jack switches to a two-footed hop as he gets on the steeper slope below the boulder. After a few hops straight uphill, he starts moving cross slope.]

143:09:50 Schmitt: We want to get away from that big rock (to get the rake sample) because it's probably shedding. Hey, that's a different rock, Gene.

143:09:56 Cernan: Yeah. Well, it looks like the same texture, but it's got that flaky fracture pattern all over it. I'm going to get a (flight-line) stereo while I'm at it.

143:10:08 Schmitt: Yeah. (Pause)

[Jack plants the scoop in the ground. Gene is taking a series of cross-Sun pictures showing the entire south face of the boulder. These are AS17-137-20912 to 20923.]

143:10:13 Cernan: This ought to cover any samples I take off of that thing. (Pause) I'm going to get myself a zap of cold water. (Pause) Man, we've got to be a million miles away from the LM.

[Jack leans on the boulder for a close examination. Gene double waves to reach his cooling control.]

143:10:36 Schmitt: Okay, this is a crystalline rock, Houston. It's got nice white halos around the zap pits. The (centers of the) zaps are not dense black glass, but a dark greenish...a very dark greenish-grey.

143:10:54 Cernan: Are those halos or fragments?

143:10:55 Schmitt: No, they're halos. Well, there are fragments, I think, also. But, right now, (I'd say) it's fairly crystalline, but it is heterogeneous. Matter of fact (laughs) there's a big fragment of a porphyry caught up in this thing, I think.

[A porphyry is a rock with two distinct crystal sizes.
 [Schmitt - "We had learned from the rocks brought back on the earlier missions that the zaps were a very good indicator of what was underneath because, not only did they shatter the crystalline fragments, but they knocked off the patina. There was a light, brownish patina on all of these rocks that we had found out was a very thin, partial covering of brownish glass, probably due to the splattering from these zap pits. The more recent zaps knocked the patina off around the little pit and you could see better.

"I spent a good deal of time between missions studying the rocks. I did the first real hand-specimen study of the Apollo 11 basaltic rocks and then I worked with other samples off and on, mostly just to get familiar with the rocks. I had quite a few sessions, just going through the rocks, taking notes, and fixing in my mind what other people had seen. And then I got some of the other crews over to the Receiving Lab to look at rocks."]

143:11:11 Cernan: Did you get a locator, by any chance?
 143:11:12 Schmitt: I haven't done a thing.
 143:11:13 Cernan: Okay. Well, I want to start taking some (samples).

[Fendell pans away counter-clockwise.]

143:11:16 Schmitt: Gene, we got to get some of that.
 143:11:19 Cernan: That's what I want. That's where I'm going right now.
 143:11:21 Schmitt: And there's a chunk there we can get. That's a big fragment within this crystalline rock, ...
 143:11:24 Cernan: Take a picture of that...
 143:11:26 Schmitt: ...an inclusion.
 143:11:27 Cernan: Take a picture of that and then your locator, I'll get it.

[Jack's down-Sun before is AS17-138-21038 and he's locator to the Rover is 21039. In the locator, notice the disturbed soil around Boulder 1. Note also, Jack's footprints farther to the right. this was his path back from the rover with the rake.]

143:11:32 Schmitt: Go ahead (and get a sample). I've got it (that is, the locator). (Pause) Got it?
 143:11:52 Cernan: Yeah, I've got it.
 143:11:55 Schmitt: Beautiful. Looks like a porphyry!
 143:11:57 Cernan: Boy, it does look like a crystalline rock.
 143:11:58 Schmitt: Looks like an andesite porphyry is what it looks like.

[Schmitt - "This is a good example of using the appearance of terrestrial examples to help in a description. 'Andesite' implies a specific composition but, when you're in

the field you're not so much saying that you think it's that composition as you're saying what it resembles based on your experience. I think that, somewhere else, we've talked about the trouble some members of the scientific community gave Buzz Aldrin when he said something looked like mica. There's absolutely nothing wrong in field geology of saying what something looks like; you'll find out what it really is later.

"One of the reasons that these things looked like porphyries is that they were crushed. They were crystalline rocks - rocks that had crystallized out of a magma body - that had been crushed by impacts, and the largest uncrushed fragments stood out against the pulverized matrix. So you get a coarse crystal in a fine-grained matrix and that's why I used the word 'porphyry'."]

143:12:00 Cernan: (Garbled) got some very large crystals in there. They're very reflective, elongated crystals.

143:12:09 Schmitt: (To Houston) It's a relatively angular inclusion. It's about a half a meter in size, and it's a square cross section. Well, it's irregular; but generally square cross section. It's in bag 516, and it looks like it's a high feldspar rock. It may be an anorthositic gabbro, but it does look like a porphyry.

[Schmitt - "I've just noticed that, at the start of this speech, my words were slurred, almost as if I were very dry or had too many drinks. I may have just been getting tired, because I'd just climbed the slope."]

143:12:49 Cernan: There's a big chunk where I've got...I can't get it out, though; it's buried in the rock...Oh, a half-an-inch, elongated...I can't see whether they are colorless or not, but they are certainly reflective crystals. See that up here? See right there?

143:13:09 Schmitt: Yeah.

143:13:10 Cernan: And then in the big rock, you've got massive things - like this big fragment here - that's 5 inches across.

143:13:16 Schmitt: Well, that may be a spall point, Gene; that's a lighter color, in general, because of a zap or something.

143:13:23 Cernan: Let me get some more samples off it.

143:13:25 Schmitt: Yeah, we need to get some of the host rock here.

143:13:27 Cernan: Okay. We'll get a piece here.

143:13:29 Schmitt: Okay now, you're still sampling the one we just got. So we'll get another one (of the same inclusion). Okay. The same kind...The contact of that (inclusion with the host) rock looks like it might be finer grained, but it's about the same...in 517. That's the inclusion side of the contact. (Pause) Keep going after the other one, Gene, I'll get this in your bag.

[Houston is discussing a ten-minute station extension.
Fendell is looking into Nansen.]

143:14:04 Cernan: Bob, you could probably see this rock if you look over this way. We're high enough.
143:14:08 Parker: Yeah, we saw it, Geno. Quite a sight; quite a goodie.
143:14:13 Cernan: Okay. Let me see if I can't get this one here. There it is.
143:14:19 Schmitt: Okay. The host rock for the inclusion - which appears to be also crystalline but may be a recrystallized rock of some kind...
143:14:28 Cernan: Can't see it too well.
143:14:29 Schmitt: ... (of) metamorphic... (It) also looks like it's (got a) high plagioclase (content)...high feldspar, anyway. That's in bag 518. And that was a fairly loose but in-place fragment along a fracture zone.
143:14:52 Parker: Okay, ...
143:14:53 Cernan: Will you hold this a minute? I'm going to try to get the rest of it up there.
143:14:55 Parker: Okay, 17. And for your thinking in the next few minutes, you might also factor in the question the Backroom raises about taking 10 minutes out Station 4 and adding it into this station, given the wealth of interest that seems to be occurring here. You might think about that. You haven't been to Station 4, so it's a little hard to judge. But if you think 10 minutes can be very profitably spent, you might as well do that.
143:15:21 Schmitt: Okay, Bob, we'll think about it. This is a medium-green
143:51:24 Cernan: I can't get any more of that.
143:51:24 Schmitt: ...anorthositic gabbro, and it looks like it has some pastel-green olivine crystals in it. (To Gene) Did you get it?
143:15:33 Parker: We copy that.

[Fendell is still looking into Nansen at high magnification.]

143:15:34 Cernan: I can't get any more of it, Jack, up there. I can't reach it.
143:15:36 Schmitt: Okay, and that small chip of that is in 519. It's the same host rock, much like the previous sample.
143:15:46 Cernan: There's a good sample for you.
143:15:47 Schmitt: Okay. (To Parker) And another chunk of the host...Oops, be careful.
143:15:53 Cernan: Yep.
143:15:54 Schmitt: It's still there.
143:15:56 Cernan: Yeah, I've got it.
143:15:58 Schmitt: I need to get rid of this (sample)...
143:16:01 Cernan: Okay?

[Fendell pans clockwise.]

143:16:02 Schmitt: It's in there. I haven't closed your bag (Gene's SCB) yet. (Pause) And we've got to get one soil sample up the hill here. Oh, we're going to get the rake...
143:16:14 Cernan: We ought to get a soil sample, though, up here, so...
143:16:16 Schmitt: We'll get the rake sample right over here on this slope.
143:16:18 Cernan: (Having just chipped off a rock fragment) Where did that thing go, Jack?
143:16:20 Schmitt: Right here.
143:16:22 Parker: Okay. Was that last sample in 518, as well?
143:16:25 Cernan: (To Jack) There it is. That's it right there.
143:16:31 Schmitt: (Responding to Parker) No. We haven't put it in yet.
143:16:35 Parker: Okay.
143:16:37 Cernan: Bob, that will go in 499.
143:16:38 Parker: Copy that. (Pause)

[Fendell examines the North Massif.]

143:16:41 Schmitt: (To Gene) Can you get it? (Pause) Okay. (To Parker) Bob, this is a fairly uniform-looking rock. It does have some widely-spaced fractures across it. It's clearly crystalline and has crystalline inclusions in it.
143:17:07 Cernan: Here, Jack...
143:17:08 Parker: Copy that.
143:17:09 Cernan: Might get the soil from around that thing.
143:17:10 Schmitt: Bob, both rocks look like they might be in the anorthositic class...
143:17:15 Cernan: Your bag is still open part way, too.
143:17:16 Schmitt: ...of rocks. It's just that one has the appearance of being a finer grain matrix. Looks like a porphyry in the boulder.

143:17:28 Parker: Okay. And a reminder, as you photograph it, to remember that the photograph in the southwest quadrant there will be the best ones. Around the corner on two sides there will be the best ones to show the structure through the whole rock.

143:17:40 Schmitt: Yes, sir. (Thinking about what Parker has just said) Oh, the southwest?

143:17:44 Cernan: South and west.

143:17:45 Parker: Roger.

143:17:47 Schmitt: South and west. Yeah.

143:17:48 Parker: Roger.

143:17:49 Cernan: No, the west's in shade.

143:17:50 Schmitt: No, no. You mean the...

143:17:51 Parker: Southwest...

143:17:52 Schmitt: South and east.

143:17:53 Parker: Roger. The southwest face...Or it faces not quite south.

[Fendell is looking at the sky.]

143:17:59 Cernan: Okay. I've got a stereo. I'll just continue my stereo around here. Hey, Jack, you can get way under there, and I know you could get soil. I don't know how long it's been shadowed, but it's been shadowed as long as this rock's been here.

143:18:10 Schmitt: Okay. I'll do that.

18:11 Cernan: Way out under there. I've got to stereo this one. I've already got it.

143:18:19 Schmitt: Well, I'm getting it from this way, and they like that. Did we kick any dirt in under there?

[Soil kicked under the overhang will contaminate any shadowed samples. One of the aims of collecting these samples is to look at the influence of solar wind exposure on the abundances of various elements and, of course, an admixture of unshadowed soil would, of course, muddle the analysis.]

[Cernan - "In the suit, shuffling around, you're not the most agile person in the world and, if you're not careful, you'll kick dust onto a pristine surface that you want to sample. When you're working, you're not necessarily watching how you're walking. You're not necessarily clumsy, but it's like waddling around in some big, old, fat galoshes and you just naturally disturb a lot of the surface in the area where you're working."]

143:18:23 Cernan: No. I don't...No, I don't think so. Go way down in there. Let me get a couple of "after" pictures. Yeah, we want to get two sides of these rocks, and you can see their structure. (Pause)

143:18:49 Schmitt: I've got that (picture), Gene.

143:18:51 Cernan: Okay.

[Gene has just taken AS17-137-20924.]

143:18:53 Schmitt: I took those. I took that stereo.

[Fendell reaches the rear of the Rover. Jack has taken AS17-138-21040 to 21042.]

143:18:58 Parker: Okay, and if I could remind you guys to get a pan ...

143:19:02 Cernan: Did you get under there?

143:19:04 Schmitt: I think so.

143:19:02 Parker: ...from up there before you leave the high uphill area there. There's no point in climbing up there twice. Remember?

143:19:08 Cernan: Yes, sir, Bob. How much time we got here now?

143:19:10 Parker: Stand by. (Pause)

143:19:19 Schmitt: (To Gene) Okay. You got your bag?

143:19:20 Parker: Okay. We got 12 or 13 minutes left at this station; unless you take that extra 10 minutes that we were offering you.

143:19:27 Cernan: Let's take it, Bob.

143:19:30 Schmitt: We got to get the rake.

143:19:31 Cernan: Let's take it; we'll need it.

[Fendell is looking at Earth over the Massif.]

143:19:33 Schmitt: Okay. Let me try again (to get the overhang sample).

143:19:34 Cernan: Okay.

143:19:36 Schmitt: I don't know whether I can or not.

143:19:38 Cernan: Do you know how far under you're getting, by any chance?

143:19:41 Schmitt: Yeah. (To Houston) I got under an east-west overhang about 20 centimeters...Way back. Quite a ways back; it goes even farther, but that's about as far as I can reach back and sample

143:19:54 Cernan That's enough, Jack let me...

143:19:56 Parker Okay. I copy that...

143:19:58 Schmitt That's in bag 500.

143:20:00 Parker And, 17, if you want to take a minute, you might look up in the sky and notice that our (TV) camera is taking a beautiful picture of Mother Earth.

143:20:10 Cernan: Isn't that pretty over...Can you see the Massif, too?

143:20:14 Parker: Now we're coming down to look at the Massif. Had a beautiful picture of the Pacific there? Ed (Fendell) finally found it. Now we see the Massif.

[Schmitt - "Ed had been in charge of the Communications Console for as long as I could remember."]

[Cernan - "The Earth looked big; and, like the Moon looks down here, it probably wasn't as big as it looked. Yet, because the Earth's beauty was so predominant, there was also a feeling that it was the most precious possession a man

could stow in his memory. There was the beauty of the colors of the oceans and the clouds: multiple shades of blue, from the azure of the Caribbean to the deep dark blues of the Pacific; the shades of white of the clouds and the snow; and the black of space around it. There you were, standing on the surface of the Moon in full sunlight, looking at the Earth, a quarter million miles away, surrounded by the blackest black. Not darkness, but the blackest black a human being can conceive in his mind. I think the perception that the Earth looks bigger than it really is probably comes from the majesty of its colors and from the fact that you are there one the Moon, looking back at it. It's an overpowering figure of life in the sky."

"Even on the TV, it is a spectacular view. It's a half Earth and you can see clouds and the blues of the oceans. With your naked eye, you could make out continents. You can imagine working on the slope of the Massif on top of the Scarp and, every once in a while you have to look over your shoulder to look at what's looking at you and think about where you are and what you're doing. Sometimes, it still hardly seems like it was real. It sometimes almost seems like we were too nonchalant, worrying about fractures and rocks and rake samples and all that when the Earth was over our shoulders."]

[At maximum zoom, three Earths would fit across the vertical width of the TV screen and about five horizontally. From the lunar surface, Earth's angular diameter is 1.9 degrees and, before Fendell went to maximum zoom, it appeared as though Earth was about ten diameters or 20 degrees above the apparent summit.]

143:20:26 Schmitt: (Probably having stowed the sample in Gene's SCB) Okay.
 143:20:27 Cernan: And, Bob, I took an "after" picture (AS17-137-209250) of where Jack just got that soil sample under the rock from; and I'm on (frame) 60.
 143:20:36 Parker: Copy that.
 143:20:37 Schmitt: Are you through with the gnomon?
 143:20:38 Cernan: Yeah.
 143:20:39 Schmitt: I'll set it up for the rake.
 143:20:41 Cernan: Okay. I'll go up there and get a pan, Jack.
 143:20:43 Schmitt: Okay. You get that pan...
 143:20:44 Parker: I didn't get that soil bag number, Jack.
 143:20:46 Schmitt: We've been here... (Answering Parker) 500.
 143:20:51 Parker: Copy that. (Long Pause)

[Fendell returns to Jack, who is positioning the gnomon at the rake site.]

143:21:05 Schmitt: We're on a pretty good slope, Geno.
 143:21:06 Cernan: You betcha. And do I know it.

143:21:09 Schmitt: (To Gene) Hey...Bob, how long have we been at this station?

[Jack plants the scoop.]

143:21:15 Parker: Stand by. (Pause) You've been here about forty minutes right now. Can you believe it?
143:21:21 Schmitt: Is that right?
143:21:23 Cernan: All ready? Jack...
143:21:26 Parker: And we're going to give you that extra 10 minutes out of Station 4.
143:21:29 Cernan: I can't believe we've been here...
143:21:33 Parker: That leaves you about 20 minutes; then you'll have to be moving.
143:21:35 Cernan: Boy, this pan may be looking right smack in the sides of the Massifs. Only way you can get it is to lean back, and I can't lean downhill. (Long Pause)

[Jack is taking down-Sun photos of the rake site. The rake head is sitting on the ground with the handle sticking up at about a forty-five degree angle. The rake head is quite heavy, about 1.50 kilograms compared with 0.82 kilos for the extension handle. The before pictures of the rake site are AS17-138-21043 to 21046.]

143:21:57 Parker: (Warning Jack and making a mis-identification) Hey. Watch out for that crater behind you there, Geno.
143:22:04 Cernan: I'm standing in the crater so I can get level.
143:22:07 Parker: Yeah, we see that.

[Gene's pan photos are AS17-137-20926 to 20956. 20492 is a good shot into Nansen.]

143:22:08 Cernan: Well, I have some good pictures of Nansen, anyway, and...(Long Pause) You know, I look out there, I'm not sure I really believe it all.
143:22:31 Schmitt: Bob, my down-Sun pictures on the rake were taken at f/8. I'm sorry.
143:22:38 Parker: Okay, copy that. We'll take it into account.

[A nominal down-Sun picture of a rake sample would be taken at f/11, at a distance of eleven feet, and at 1/250th of a second exposure.]

143:22:42 Schmitt: This isn't an easy (task)...Okay, I got to get out of my shadow or I can't see what I'm doing. (Long Pause)

[Jack gets the sample by dragging the rake uphill. He stands facing the mountain, slightly uphill of the gnomon, and begins each stroke with the rake at his side and then

pulls it forward. It looks like a very awkward motion. At the end of the stroke, he hops forward and drags the rake a little farther.]

[Schmitt - "Any tool that you have to drag along the ground is going to be difficult to use and, by this time, anything you had to do with your hands wasn't easy."]

143:23:19 Cernan: I'll be right down there to bag that rake (sample) for you.

143:23:22 Schmitt: I got to get it first.

[After finishing the pan, Gene turns and takes four photos of the Earth over the South Massif. These are AS17-137-20957 to 20959. He then takes two more pictures of Earth over Boulder 2. These are AS17-137-20960 and 20961.]

143:23:25 Cernan: (Laughing and joining Jack) Man, I tell you; can you come downhill in a hurry. Going uphill is a nice job. Bob, I'd say we can meet our walkback constraints, if anyone's interested.

143:23:40 Parker: Okay. I expect it's all downhill from here.

143:23:45 Cernan: Well, no, sir. Not exactly;...

143:23:47 Parker: Can you guys see the LM, or are you too far down to see the LM?

143:23:48 Cernan: ...that's why I said we could meet our walkback constraints. (Responding to Parker) Oh, no. The LM is over about three rises in the Scarp before we can even see it.

143:23:58 Parker: Okay, I thought that might have happened.

143:24:00 Cernan: I'm not even at a level of the last hill we came over.

143:24:07 Parker: Okay.

143:24:08 Cernan: I don't know if you've looked up that way (with the TV).

143:24:10 Parker: Roger. We had a feeling for that. I was just checking. (Pause)

143:24:20 Cernan: We can meet them (the walkback constraints), but I wouldn't stretch them.

143:24:22 Parker: Okay. (Pause)

[Schmitt - "By this time in Apollo, the walkback constraints had been well established. My main effort was to make sure they weren't too constraining. Left to their own devices, the some of the planners would have been much more conservative than was necessary."]

143:24:33 Schmitt Not many small, walnut-sized fragments in here, Bob. Gotten about seven or eight (in the rake sample).

143:24:39 Parker: Okay. I copy that. (Pause)

[Schmitt - "The people examining samples had concluded that there was a significantly larger variety in the walnut-size range than there were in the major rocks that were

scattered around. Apparently, rocks thrown into a site from distant places were concentrated in the walnut-size range."]

[After finishing each rake swath, Jack has been moving sidehill to stand on the just-raked ground and begin the next swath. He had started the series with a long swath at 143:22:42, took nine more short ones requiring only a step or two each. Now, he finishes the series with an extra long swath taking by running uphill, dragging the rake behind him. Fendell is at maximum zoom. In his suit, Jack stands roughly six feet tall and he fills about half of the TV's six-degree-high frame. This suggests that he is about 120 feet from the Rover. The distance given in the Preliminary Science Report is 45 meters or 150 feet. Gene goes to Jack and gets a sample bag off of his own holder, ready to receive the rocks Jack has collected with the rake.]

143:24:51 Schmitt: Gene, you got a bag?

143:24:52 Cernan: Yes, sir. Right here. How you doing?

143:24:55 Schmitt: My hands are getting tired.

143:24:57 Cernan: Yeah. Bag 501. (Pause)

[Jack gets another short swath.]

143:25:07 Cernan: No, there aren't a lot; but that'll fill up a bag.

[Throughout the EVA's, the astronauts show a tendency to speak more loudly to Houston than to each other, despite the fact that, in both cases, there is a radio link through the LCRU.]

143:25:12 Schmitt: This (a) kilogram-of-sample site, too?

[Jack is wondering if he is now supposed to use the rake to get a bag full - roughly a kilogram - of soil.]

143:25:14 Cernan: I'll have to look (at the checklist); I think so. I think they all are, aren't they?

143:25:17 Schmitt: Practically.

[Jack pours the rocks in the bag that Gene's holding. The checklist does not explicitly call out a kilogram of soil at this site.]

143:25:19 Parker: And this is one that we would like to get the kilogram of soil from, Jack.

143:25:24 Schmitt: Okay. I'll use my scoop for that.

[Jack gets his scoop.]

143:25:27 Cernan: Bag 501.

143:25:29 Parker: Copy that, Gene. (Pause)

143:25:36 Schmitt: Okay, what do we have left here?

143:25:39 Cernan: (Consulting his checklist) We want to get a...I got the high pan. (Pause)
143:25:50 Schmitt: I don't know how we used up all the time, but we did.
143:25:53 Cernan: Okay, (on) my pan, by the way, I got extensive vertical coverage down into Nansen, Bob.

[Jack angles the scoop head.]

143:26:00 Parker: Okay. Copy that, Gene. Thank you.
143:26:01 Schmitt: Well, the soil's getting into my (scoop hinge)...
143:26:03 Cernan: I don't know where the hour went that it took to drive here.

[Gene gets another sample bag.]

143:26:10 Schmitt: Maybe time's different in space. "Adventures in space and time."
143:26:15 Cernan: We changed 2 hours and 40 minutes. I don't know whether that makes us older or not.

[Jack gets a scoopfull of soil but drops some as he lifts the scoop. Gene's "we changed 2 hours and 40 minutes" is a reference to a delay in launch from Earth. Not wanting to alter the timing of events at the Moon, NASA decided to have them fly a quicker-than-planned trajectory to the Moon so that they reached lunar orbit at the planned time. In addition, NASA put all of the mission clocks ahead by 2:40 so that, while we are currently at 143 hours, 26 minutes on the mission clock, it has only been 140 hours, 46 minutes since launch from Earth.]

143:26:23 Schmitt: Ooops...(Pouring) Awrrrrrrr...
143:26:27 Cernan: Try again. I got half of it. I got three-quarters of it. 502, Bob, will be the kilogram.

[Jack gets a second scoopfull.]

143:26:34 Parker: Copy that.
143:26:35 Schmitt: And that's a sample down to about 5...about 4 centimeters. Don't get (the sample bag) too close to your camera. Okay.
143:26:43 Cernan: Oh, that's a big bag full. Want to put it in mine?

[They have been putting most of the samples in Jack's SCB and Gene is offering to take some of the load.]

143:26:47 Schmitt: It's all right. I can't feel it (that is, the weight of the SCB). You might as well...(Pause)

[Jack presents his SCB to Gene, who is twisting the sample bag shut.]

[Cernan - "We tried to distribute loads but, compared with the weight of the backpack, the weight of the SCB never bothered me. In one-sixth gravity you just couldn't put that much into one of the SCB's and I just never felt like I was carrying any extra weight."]

[At the end of the EVA - and after some redistribution of samples - they report SCB weights of 24 and 35 terrestrial pounds. At the end of EVA 3, they report two other bags at 32 pounds each. In lunar gravity, then, a full SCB would weigh 5 or 6 pounds and, while it was noticeable hanging from the side of the PLSS, it was not troublesome.]

143:26:53 Cernan: How's your cooling? Okay?
 143:26:55 Schmitt: Cooling's fine. My hands are tired.
 143:26:57 Cernan: Well, that's natural.
 143:26:59 Schmitt: Okay, ...
 143:27:00 Parker: Okay. And guys, do you see any more different blocks up there that are worth sampling before you go on down on to the flats (down near the Rover, below the break in slope) and sample the light mantle?
 143:27:11 Schmitt: We haven't had a chance to look around any more than you've heard.
 143:27:14 Parker: Okay.
 143:27:15 Schmitt: You want a rake in the light mantle here?

[Fendell pans away.]

143:27:16 Parker: We want a rake in the light mantle. You might as well get that down by the Rover later on.
 143:27:20 Schmitt: (To Gene) Get an "after" (photo)...Get an after, Gene. (Calling after him) Gene, get an after.
 143:27:24 Cernan: Yeah. Got it, got it, got it, got it.
 143:27:28 Parker: Then you might look around...
 143:27:29 Schmitt: I'm sorry, Bob. Go ahead.

[Fendell returns to them.]

143:27:30 Parker: ...for a couple of documented samples there, up on the slope of the massif, before you move down the flatter, light mantle areas by the Rover. Just do the other sampling.
 143:27:39 Schmitt: We will.

[Jack starts downhill; Gene takes the "after", which is AS17-137-20962.]

143:27:42 Cernan: Okay, Bob. Jack got the "befores" on the rake and I got the "after".
 143:27:46 Parker: Okay; we have that. (Pause)

[Jack stops at two rocks slightly uphill from Boulder 3.]

143:27:55 Schmitt: Okay, Bob, here are two rocks side by side, a meter or two in diameter. And one is the anorthositic gabbro, if I can use the term; and the other is that two-cycle breccia.

[Here, Jack is using 'anorthositic gabbro' to describe light-colored, crystalline material such as that found in Boulder 2. The 'two-cycle' breccia is the blue-grey material of Boulder 1. Gene comes downhill using the two-footed kangaroo hop.]

143:28:12 Cernan: Man, that's the way to come downhill.
 143:28:15 Schmitt: Just don't stub your toe.
 143:28:18 Cernan Yeah, that's the way to come downhill.

[Cernan - "When you were going uphill, you had to take little steps and get your toes dug in. Because you didn't have as much weight holding you down as you would have on Earth and because you're center-of-mass was so high because of the backpack, it was harder to keep your balance. But coming downhill, the only trouble was - like being on a ski-slope - if you came straight downhill using that kangaroo hop, you'd get going really fast. And, if you stubbed your toe, you'd go tail over tea kettle."]

143:28:19 Schmitt Hey, Gene.
 143:28:20 Cernan: Yeah.
 143:28:21 Schmitt: Set up right there (Boulder 3). Let's get that...Let's get that big clast.
 143:28:23 Cernan: There's a fracture right in there I want to get the...Oh, the clast.
 143:28:27 Schmitt: Yeah.
 143:28:28 Cernan: (Very pleased by Jack's discovery) Yes, sir. Good eye, good eye.
 143:28:31 Schmitt: Big white clast in the two-cy(cle)...(correcting his terminology) in the grey-matrix breccia.

[Gene positions the gnomon.]

143:28:35 Cernan: Good eye! Man, that's a prize. Let me get this over here so I can (garbled).

[Jack plants the scoop and takes a down-Sun before of Boulder 3. This is AS17-138-21047.]

143:28:39 Schmitt: I think you can even get it.

[Jack is saying that he think that Gene can chip the rock with the hammer. Gene backs away to take a cross-Sun stereo while Jack takes the down-Sun. Throughout the sampling of this boulder they demonstrate just how good a sampling team they have become. They don't talk a great deal

about what they are going to do; they both know what needs to be done and more or less who is going to do what.]

[Schmitt - "The purpose of the training, in my mind, was to make everything that could be routine be as routine as possible so that you didn't have to think about it and didn't have to talk about it."]

143:28:40 Cernan: I can get both sides. I want to get this big...Yeah, I think I can get that. I'm going to try.
(Pause)

[Jack turns to the east to take a "locator" of the Rover (AS17-138-21048) then turns back to the rock and takes another before (AS17-138-21049).]

143:28:51 Schmitt: Oh. I can't believe the trouble I have with f-stops. Okay.

[Gene gets the hammer from his shin pocket. Jack gets the scoop.]

143:29:03 Cernan: Now, I want to try to take this piece off first. (Pause as Gene hammers)

143:29:10 Schmitt: Pretty hard, isn't it.

[Hammering sounds - a soft "plock" - can be heard through Gene's suit. He takes seven whacks at the top of the boulder on the east end.]

[Cernan - "Although we can hear on the tape that the microphone in my suit was picking up the sound of my hammering, I don't ever remember hearing it. I could certainly feel it; and I've always contended that it's a very fine line between hearing noise and feeling noise. With that hammer, when you hit something the shock went through your whole body; but I'm not sure I ever heard the noise, probably because my ears were covered with the Snoopy helmet."]

[What seems likely is that, when Gene hits the rock, the hammer rebounds against the palm of the pressurized glove, creating a sound wave in the suit loud enough to be picked up by the microphone at Gene's lips. In brief, the suit acts like a drum.]

143:29:11 Cernan: That boulder's going to roll. Man, that is hard. There's the same clast over there.

[Cernan - "The boulder was just sitting on the soil and, as I remember, when I hit it with the hammer, it moved. That's how I knew we would be able to roll it if we wanted to."]

[Gene takes three whacks on the east face.]

[Cernan - "This is a good example of the posture you have to assume to go after a boulder that's not much more than knee high. You have to bend down in your suit to get

whatever sort of leverage you can with the hammer and then swing it from the side. Normally, we'd hit it straight on in a vertical plane but, because you don't have much mobility in the suit, I was bending my right knee, bringing the hammer up across my chest (to the left), and then swinging it down to my right. So I was actually back-handing it to get at the face. You just adapted to whatever the suit would give you. And, here, when I bent down, leaning a little into the hill, the suit was actually so stiff it helped me maintain that folded-knee position without dropping all the way to my knees. This is a good example of what it took to operate in the suit and on a slope."]

143:29:23 Schmitt: Well, we get...

143:29:25 Cernan: That clast is soft.

143:29:27 Schmitt: Can you use your blade end?

143:29:28 Cernan: Yeah. Yeah, let me get that little piece, anyway, to start with.

143:29:35 Schmitt: (Grabbing the fragment with the scoop)
Got it.

[Gene hits the east face twice more.]

143:29:38 Cernan: There's two more pieces.

143:29:40 Schmitt: Okay.

143:29:41 Cernan: Before we cover them up, let's get them. I got to get a sample of that mother rock.

[Jack gets one of the fragments, flexing a knee so that he can get low and skim it off of the surface with the scoop blade.]

143:29:47 Cernan Okay, there you go. The other one's right there. (Pause)

143:29:53 Schmitt Okay.

143:29:54 Cernan: Now, Let me see if I can't get a sample...

143:29:55 Schmitt: Want to try to hit that one more time. I think we've got another one coming there.

[Gene takes two whacks on an east corner.]

143:30:01 Cernan: There's another little one. (Pause)

[Jack gets the sample.]

143:30:10 Schmitt: That looks almost like a rhyolite from here. I don't believe it, though.

[Schmitt - "A rhyolite is a volcanic rock, usually having large crystals in a fine-grained matrix, low in iron-magnesium silicates, high in quartz and feldspar. This inclusion wasn't a rhyolite, but had a similar texture."]

[Gene hits the corner eight times.]

143:30:15 Cernan: No, that's not going to come off.

143:30:16 Schmitt: I think that's it. Got a bag? (Pause)

[Gene lays the hammer on the rock and gets a sample bag from his camera bracket.]

143:30:22 Schmitt: (To Houston) Okay, this is a fine-grained, but crystalline, white clast in the (blue-)grey breccia; and it's mixed with soil. We had to pick up a little soil. 503.

[Gene takes the scoop from Jack, grabbing it near the head, and pours the fragments in the sample bag.]

143:30:35 Cernan: I guess they're all there, aren't they?

143:30:37 Schmitt: I think they are. There are three clasts, anyway...(Correcting himself) three fragments that we got off. Chips.

[Gene puts the bag in Jack's SCB.]

[Schmitt - "One of these fragments turned out to be the oldest dated rock ever sampled on the Moon. It was dated at 4.6 billion years, plus or minus 0.1 billion years, in a mineral isochron analysis. They really had to work at it because there wasn't a lot there; it was mostly olivine and to do a mineral isochron you've got to do separates of a number of minerals. I don't know what they found in there, ilmenite or something. And then you have to extract the lead isotopes and do an analysis on them. The revolution in mass-spectrometry techniques as a result of Apollo was just phenomenal. It was literally getting down to the point where they were counting atoms as they were coming off the samples. And that, in turn, has led to this dilemma we have in environmental consideration here on Earth in that we can now measure very small quantities of 'supposedly toxic' substances which we never knew were there before. And I say 'supposedly' because some things don't become toxic until they reach certain levels of concentration. And, at very low levels, things like copper and selenium are even necessary for good health."]

143:30:44 Cernan: Let me get a piece of the rock it's in. And I'm going to take a close-up stereo of that.

143:30:48 Schmitt: Okay. Don't get it...Okay. (Long Pause)

[Gene gets the hammer and knocks a piece off on the third stroke. The piece comes off to Gene's left and he tries to grab it. He manages to touch it and, in so doing, knocks it into Jack's left wrist. The fragment bounces off of Jack's wrist and slowly falls to the ground behind him.]

143:31:02 Cernan: See it?

143:31:03 Schmitt Yeah. (Pause) See it!? You hit me with it!

143:31:09 Cernan Well, I tried to catch it. Bob, you still there?

[Gene puts the hammer in his shin pocket.]

143:31:14 Parker: Roger. Still there. Listening with great delight.

[Jack collects the fragment, about ten feet southeast and slightly uphill.]

143:31:18 Cernan: Look at the size of the piece that came off there, though, Jack.

143:31:20 Schmitt: I got another piece of it up here.

[Perhaps four feet east and two feet uphill.]

143:31:24 Cernan: And I'd roll that downhill...

[Gene examines the ground northeast of the rock, the direction he thinks it will roll.]

143:31:25 Schmitt: Okay, the host rock for that inclusion of white material will be in bag...What is it?

[Gene gets a bag.]

143:31:37 Cernan: 504.

143:31:38 Schmitt: 504. Two chips with soil. (Pause)

[Jack pours the samples in the bag. Public Affairs reports that crew heart rates are in the 90s.]

143:31:46 Cernan: Getting heavy?

143:31:47 Schmitt: What? The bag?

143:31:48 Cernan: Yeah.

143:31:49 Schmitt: No. Just the scoop.

143:31:50 Cernan: Just make sure they're closed so they don't...

143:31:53 Schmitt: I wore my hand out holding that camera together coming out here.

[Gene puts the sample bag in Jack's SCB.]

143:31:56 Cernan: We're getting some samples this time. I want to get an "after", and I want to get a close-up stereo of that. And I'm going to get some pictures around this block, too.

[Gene is standing just north of the rock; Jack moves east just far enough to get his shadow off the rock. Gene's after is AS17-137-20965.]

143:32:05 Cernan: Okay. There's an "after" and now I'm going to get sort of a close-up stereo around it. That ought to do it.

[Jack turns around and moves a few steps east and a little downhill to a small crater full of rocky debris. Gene's close-ups are AS17-137-20965 to 20973. He has used his tongs to make sure he is at the right distance from the rock for a good focus. The best of these pictures is probably 20971.]

143:32:18 Schmitt: Hey, Bob, while he's doing that, there's a real good example of a pit-bottom crater up here even on this talus slope. I'll try to take a stereo of it.

143:32:33 Parker: Okay, Jack, that sounds great. I guess there's always a problem of getting the in-place glass, if you think that's appropriate at this point. Word along those lines, though, is we'd like to have you in the Rover moving in 11 minutes; so it's probably not appropriate at this time on that.

[Jack moves two short hops downhill for another stereo picture. In all, he takes three pictures of the crater: AS17-138-21050 to 21052.]

143:32:49 Schmitt: Okay, there isn't any glass in this crater. (Gesturing) You can see it with your TV.

143:32:51 Parker: Okay; copy that.

143:32:53 Schmitt: It's just bigger than the average crater. And it still has that pit, the pit being about a third of the inner diameter of the crater...make it a fourth of the rim diameter, that's easier.

143:33:11 Parker: Copy that.

[Gene is now SW and a little uphill of Boulder 3.]

143:33:12 Cernan: Jack?

143:33:13 Schmitt: Can I look at that closely?

143:33:16 Cernan: Look at what?

143:33:18 Schmitt: Hold the rake a second. (Pause)

[Jack hands Gene the rake and leans on the boulder.]

143:33:24 Cernan: We got to be moving in how many minutes, Bob?

143:33:26 Parker: We'd like to have you moving in one-zero (10) minutes, which means: allow the usual 3 or 4 or 5 minutes for closeout before that time.

143:33:36 Cernan: Okay, we'll get hustling.

[Jack gets up with some difficulty, using the rock and the scoop for support.]

143:33:40 Schmitt: Okay, Bob, that white-colored inclusion we sampled looks like a strange...

143:33:47 Cernan: Look out, Jack.

[Standing uphill of the rock, Gene pushes it with his right foot. Jack moves quickly out of the way to the east. The boulder rocks forward slightly then falls back. Gene gives it a harder kick and the boulder turns over twice as it rolls.]

143:33:53 Parker: It's the old boulder-rolling trick.

[Schmitt - "There was a lot of boulder-rolling discussion on the field trips. Mostly, Gene just rolled this one for fun but, by doing so, he exposed the soil underneath and we got a sample of it."]

[On Apollo 12, Conrad rolled a rock into Head Crater in order to generate a signal for the ALSEP seismometer. And, on Apollos 15 and 16, the crews turned boulders over so that they could sample the soil underneath.]

33:54 Cernan: How about getting a soil sample under there?

[As it reaches him, Jack kicks the rock toward the north but it is stopped by a small rise. He tries another kick, but with little effect.]

143:33:57 Parker: Don't hit the Rover.

143:34:02 Cernan: Get that sample under there, Jack. Under that rock.

143:34:07 Schmitt: Okay. Got a bag?

143:34:09 Cernan: Got a bag.

143:34:12 Schmitt: The soil from right underneath the rock - down to about 4 centimeters (depth) - (is going) in 505.

[Gene is standing a little uphill, so Jack has to raise his arm quite high to pour the sample into the bag. Jack skims a second sample while Gene closes the first bag.]

143:34:23 Schmitt: And I'll try to skim it here a little, too. (I'll) get the upper centimeter.

143:34:39 Cernan: Bob, this big white clast, I'm not sure there aren't some smaller ones in some of those other big boulders. That's just an intuitive guess.

[Gene has the second bag open, just as Jack raises the skim sample.]

143:34:46 Schmitt: Oh, there are.

143:34:47 Cernan: But we never saw any as obviously big and gross as this one.

[Jack does a little jump to get the skim sample out of the scoop and into the bag.]

143:34:51 Cernan: Fact is, this particular boulder I photographed, I had three of them other than the one we sampled. And that's 505 and 506, in that order.

[Jack presents his SCB.]

143:35:04 Parker: Okay; we copy that.
 143:35:06 Cernan: On the soil.
 143:35:09 Parker: And by now, probably the best thing for you guys...
 143:35:11 Schmitt: Bob, that rock...
 143:35:11 Parker: ...to do is to go back to the Rover and pick up the rake sample. Go ahead, Jack.

[Gene has the samples in Jack's SCB and turns to get the gnomon.]

143:35:19 Schmitt: That...(Turning uphill to get the rake)
 (To Gene) I'll get it (the rake).
 143:35:21 Cernan: Okay.
 143:35:22 Schmitt: (To Parker) That white clast...I looked at it, and it has light, pastel-green, fairly-rounded crystals in a fine-grained white to light pinkish-tan matrix. And you can figure that one out. Looks like olivine in something.

[Schmitt - "As it turned out, it was olivine in olivine; almost a pure olivine rock. So it's interesting that I made that guess up there. Olivine has a vitreous luster and a light greenish color but, again, in this case it was chunks of olivine in a crushed matrix of olivine that had been through the mill for four-and-a-half billion years."]

[Gene is using the kangaroo hop to get downhill; Jack is using alternating steps and doesn't seem to be moving as quickly. To get started, Gene used a few alternating steps to get up to speed.]

[Schmitt - "The cross-country skiing motion, I think, takes less energy than the kangaroo hop because I was just sort of moving my ankles, not flexing the suit as much. I always seemed to wear out faster when I tried hopping versus the semi-stride."]

143:35:49 Parker: Roger on that. Sounds like a rainbow.
 143:35:51 Schmitt: It might be a...(Responding to Parker)
 No, the colors aren't that distinct, Bob. I'm just giving you shades.
 143:35:59 Parker: Okay; Roger.

[Jack reaches the Rover. He has been carrying the scoop in his left hand with the handle forward and the head back and pointing at the ground. He tosses it like a baton, getting it to rotate so that, after he catches it, he can mount it on the gate with the head pointing up.]

[Schmitt - "You got to where you were doing things like that all the time. Things moved very slowly and the best flexibility you had in any part of the suit was in the wrist; so you took advantage of it."]

143:36:04 Cernan: Hey, Bob, have you panned down into Nansen and seen this rock that's, oh, 30 or 40 meters from us? To give you an idea of the kind of upslope filleting you have on some of those boulders.

143:36:16 Parker: Okay, we'll...

143:36:17 Cernan: It's down to your right.

143:36:18 Parker: Okay. We'll send Ed (Fendell) over there to look at it.

143:36:22 Cernan: Well, I'll help him (by manually pointing the TV). I don't think you got enough time.

[Jack stows the scoop; Gene stows the gnomon and then goes to turn the TV.]

143:36:27 Parker: Okay, we'd like you guys to get going on the rake sample. We'd like light mantle on the rake there.

143:36:28 Schmitt: (Talking to Gene under Parker) Where's your gnomon? We've got to get a rake sample.

143:36:34 Cernan: Okay.

143:36:35 Schmitt: (Headed north from the Rover) I'm going to have to move out here a ways, Geno.

143:36:38 Cernan: Okay. Coming right there. (Pause)

[Gene points the TV into Nansen.]

143:36:44 Cernan: Right there is what I'm looking at.

143:36:45 Parker: Okay. We're going to check it out; thank you. (Pause)

143:36:54 Cernan: (Getting the gnomon out again) And there's no sense trying to get 500's up...Well, we'll see what happens.

[Gene takes the gnomon to Jack.]

143:37:01 Parker: Okay. Also, there's no time to get 500's either, unfortunately. We're planning on Station 4, which will be a better perspective distance anyway.

143:37:12 Cernan: Yeah, I was going to say there's no sense in trying to get them up the Massif; I don't think you'll see anything up there.

143:37:16 Parker: Okay. (Pause)

[Jack is taking a black-and-white pan from the second rake site northeast of the Rover. Jack's pan is AS17-138-21053 to 21073. 21069 is a great picture of Gene. 21073 shows the Station 2 boulders.]

143:37:22 Schmitt: Gene...

143:37:23 Cernan: You getting your pan?

143:37:24 Schmitt: Yeah, I said...

143:37:25 Cernan: Where do you want it (the gnomon for the rake sample)?

[Fendell pans counter-clockwise.]

143:37:26 Schmitt: Well, right over there where there's some fragments. And you get the...

143:37:28 Cernan: I'll get the "before" and the "locator".

[These are AS17-137-20974 and 20975 are cross-Sun befores of the rake site, showing Jack taking his pan. 20976 and 20977 are locators to the Rover.]

143:37:30 Schmitt: Okay, and then I'll get the "down-(Sun)".
(Long Pause)

[Fendell pans clockwise.]

143:38:02 Cernan: Okay. (Pause)

143:38:10 Schmitt: (Laughing) (It's) tiring to take pictures.

143:38:12 Cernan: Yeah. Let me tell you, you just got to think an order of magnitude bigger than what you're normally are accustomed to thinking.

143:38:20 Schmitt: Okay, pan's complete.

143:38:21 Cernan: Let's get the rake sample so we can move on. (Pause) Bob, I couldn't get those 500's anyway. It would require me to pitch up (lean back) too far, and there's no way I could do it.

[Fendell finds Gene and Jack well north of the Rover.]

143:38:37 Parker: Okay. No, we're definitely not in favor of that, Gene, at this area.

143:38:43 Cernan: I know. I'm just mulling it over, but there really isn't any way I could get them.

143:38:47 Parker: Okay.

[Jack is taking swaths by running forward three or four steps, dragging the rake behind him. Each of the swaths, then is about two meters long.]

143:38:51 Schmitt: Boy, I tell you...

143:38:53 Cernan: How are your hands? Let me rake that a little bit.

143:38:55 Schmitt: Well, it's all right; there just aren't any rocks. Should have brought the scoop and used the old shovel trick.

[Jack has made at least five rake swaths by this time.]

143:39:00 Cernan: There's a couple; keep going. (Pause)
There sure aren't (many), are there?

143:39:13 Parker: Okay, do you have any feeling (that) you have that hard layer underneath there like you did yesterday, when you raked at Station 1, Jack?

143:39:19 Cernan: There's one under the gnomon you can get.

143:39:23 Schmitt: Several I thought were rocks turned out to be clods.

143:39:25 Cernan: Yeah, that's what most of them are is clods. How do you get clods if it's never been wet? You're not getting any. You've had three in there ever since the last four scoops.

143:39:35 Schmitt: There just aren't many.

[Jack raises the rake to pour the fragments in the sample bag Gene is holding. He has taken at least seven swaths.]

[Schmitt - "We were out on the light mantle, which we thought was an avalanche. If it is an avalanche, you wouldn't expect many rock fragments; they would have worked their way downward in a gas-lubricated avalanche (flow) and all that would be at the surface would be fines. If the surface were old enough, you would find a few fragments, all of them thrown in from elsewhere."]

143:39:38 Cernan: 507.

143:39:39 Parker: Okay, copy 507, very few.

143:39:41 Cernan: Three rocks. Yeah, you got about four rocks about 2 inches and smaller.

143:39:48 Schmitt: And let me get the down-Sun which...

143:39:52 Parker: Okay, let's just get the soil and...

143:39:53 Schmitt: (To Gene) Okay. And we want to get the soil.

143:39:54 Parker: ...press on. We'd like to move in 3 minutes, 3 minutes.

143:40:02 Cernan: Okay, you got it (the down-Sun picture)?

143:40:04 Schmitt: Yeah.

[Jack's down-Sun after of the second rake site is AS17-138-21074.]

143:40:05 Cernan: Okay. Let me put this in your bag (SCB) and...Forget the soil.

143:40:08 Schmitt: (Puzzled) Forget the soil?

143:40:10 Cernan: He wants us moving in 3 minutes. So let's go.

143:40:13 Schmitt: Well...

143:40:14 Parker: No, get the soil, guys. Get the soil. Don't forget the soil; get the soil.

143:40:19 Schmitt: Yeah, we want it.

143:40:22 Cernan: (Hearing Parker) I'm sorry, I thought you said to skip it.

143:40:24 Schmitt: (To Gene) Got your bag?

143:40:25 Cernan: (Just getting a bag open) Yep.

143:40:26 Schmitt: May be a little messy.

143:40:28 Cernan: That's all right. (Pause)

143:40:40 Schmitt: (Pouring) One-scoop-Schmitt, they call me. That's good.
143:40:42 Cernan: (To Parker, calling) That's bag 508.
143:40:44 Parker: Copy that.

[Gene opens Jack's SCB after getting the sample bag sealed.]

143:40:50 Cernan: You'll have to start putting some of these samples in my bag. You're getting a full bag for Christmas here.
143:40:57 Schmitt: Is it so full we ought to change it?
143:41:00 Cernan: Yep. Let's do that after we get to the next station, though.
143:41:04 Schmitt: Well, okay.

[Schmitt - "I suspect that I didn't want to drive a long distance on the Rover with a full SCB; if the top came open we could have lost samples."]

143:41:05 Cernan: We ought to start moving out of here.
143:41:06 Schmitt: Yeah, let's go.

[Jack starts toward the Rover using a high-speed, long-stride lope which he has earlier described as a cross-country skiing stride.]

143:41:08 Cernan: Let me get one "after" of the area.
143:41:10 Schmitt: That we messed up. (Pause)

[Having taken the picture (AS17-137-20978) Gene starts back to the Rover, carrying the gnomon.]

143:41:23 Parker: Beautiful station, guys; just simply beautiful. Almost deserves a Falcon code.

[Gene is going at a rapid pace. Fendell follows him for a while, then does a final site pan.]

[Schmitt - "Gene started out doing the kangaroo hop for a little ways and then went into a left-foot-forward skip. He wasn't getting very high off the ground because you can see his toe kicking dirt almost every step. Anybody wanting to estimate how fast two relatively tired people could go should look at this sequence. This one sequence could give you a lot of information about walkback. I'm glad we didn't have to do that."]

143:41:31 Cernan: Man, I'll tell you. (Laughing) Falcon 109. I couldn't help that, Bob; it's just too beautiful. (Pause)

[Cernan - "It was a good station; we got a lot done. We'd joked around with the Falcon code - which I'd learned in the Navy - during training but, you notice, it was Parker who

brought it up. There were about twenty Falcon phrases, and Falcon 109 was 'Beautiful; just fucking beautiful.'"]

143:41:45 Cernan: Hey, Jack, will you look where we kicked up this stuff. There's some light...Well, I can't see it now, I'm looking...

143:41:50 Schmitt: I can see. There's a light-colored fragment (means "layer") I think we break into.

143:41:52 Cernan: Yeah, we kick it up.

143:41:53 Schmitt: They're light-colored clods.

[Schmitt - "The way I responded to Gene makes me think that I had noticed the buried layer of lighter material and had filed it away in the back of my brain while we were working. And it's a good thing he brought it up, because otherwise we wouldn't have noticed it at this point."]

143:41:55 Cernan: And when I was walking uphill, I really wasn't sinking in - probably - more than an inch or two.

[Schmitt - " I think Gene is comparing the depth of his footprints in the light mantle with those he made in the talus slope where we sampled the boulders. From the fact that we got (rock) fragments on the talus slope but not in the light mantle tells me that we had a finer material on the light mantle and I expect we were sinking in farther down there. This section is confusing, there's a lot of (verbal) shorthand."]

143:42:00 Schmitt: You want to take this bag off of me?

143:42:01 Cernan: Yes, sir.

143:42:02 Schmitt: I'll get one out. We can use this one.

143:42:04 Cernan: Yeah. Because we want to get rolling.
(Pause)

[Fendell looks into Nansen again. Sometime before they leave Station 2, Gene takes a picture of the rear of the Rover. It is AS17-137-20979.]

143:42:10 Parker: Okay, 17, there's a couple of things here, while your getting undone there. There's our housekeeping to close out. Change those bags. We'd also like to get the SEP turned on, and you might read us the temperature when you turn it on. And other than that, stowing the TV and low-gain antenna (meaning to say "high gain") and you're on your way. We've taken care of the gravimeter already.

143:42:35 Schmitt: Did our (gravimeter) reading change much, Bob?

143:42:38 Parker: Which one?

[Schmitt - "I was wondering if we got a big gravity change as we got up onto the Massif. We did, but I don't know if anybody ever told me about it."]

[There is no further discussion of the Station 2 gravimeter reading anywhere in the transcript.]

143:42:39 Schmitt: (To Gene) Make sure that's locked on there.

143:42:42 Cernan: Yeah, it is locked; make sure the cap's locked. (To Parker) Okay, bag 8 is on the gate, and Jack's getting bag 4.

1143:43:42:48 Parker: Okay; copy that. (Pause)

[That is, Gene is putting SCB-4 on Jack's PLSS. Note that Jack had been wearing SCB 8.]

143:43:00 Cernan: Boy, I know my camera's going to be...

143:43:01 Parker: You copy on the SEP receiver turn on and temperature?

143:43:06 Schmitt: Right.

143:43:09 Cernan: (To Jack) Is my bag closed? (Responding to Parker) We got that, Bob.

143:43:14 Schmitt: Your bag is closed.

143:43:15 Cernan: Okay.

143:43:17 Schmitt: Okay...

143:43:18 Parker: Okay. 17, take all that back, we've just had a change of heart back here. And we're not going to turn the SEP on, just cover it up. And you might give us a temperature reading as you go by; that'll help us think what to do with it.

[Schmitt - "They were realizing that the SEP was running awfully hot and, probably because we were going to retrace our tracks, they thought that they might save it for the final traverse by leaving it off and covered."]

143:43:30 Schmitt: It's about 98.

143:43:31 Parker: Copy 98; then leave them both off.
(Pause)

143:43:38 Schmitt: Okay.

[The SEP has cooled down from 105 F during the stop.]

143:43:41 Parker: 17. John (Young) and Charlie (Duke) are kind of advising you to put that full SCB (8) underneath the seat to make sure the top doesn't bounce open and lose some of those rocks.

[They have just mounted SCB 8 on the gate.]

143:43:52 Cernan: Well, you can't take better advice than from those who have been here!

143:43:56 Parker: Roger on that.

143:43:58 Cernan: Their advice has been pretty good, so far.

143:44:02 Parker: I won't pass that on to them. I think they... (Pause)

143:44:15 Cernan: These locks (on the tool gate) are clamming up (with dust), Jack. I can't unlock that one now. (Pause) Can you lock that one? (Pause) They're all getting sticky.

[Fendell finds them at the gate. The locks referred to here are clamps to hold SCB's on the gate.]

143:44:35 Schmitt: That one just didn't want to work any more.
 143:44:38 Cernan: Let me see.
 143:44:40 Schmitt: It isn't moving either way.
 143:44:44 Cernan: This one was sticky, too. Let me see.
 (Pause)
 143:44:49 Schmitt: Out's Open, right?
 143:44:50 Cernan: Huh?
 143:44:51 Schmitt: Out is Open...
 143:44:52 Cernan: Out is Open, yeah. Let me try once more, if I have to...
 143:44:55 Schmitt: Here I got it.
 143:44:56 Cernan: Okay, those are really getting dusty. I'll hit those with a dust brush next time around. (Pause)

[Jack carries SCB-8 to his seat.]

143:45:08 Schmitt: Charge that time up to John and Charlie! (Pause)

[Jack is saying that they wouldn't have lost the time if they hadn't been told to remove the bag from the gate and put it under the seat. Of course, a little lost time would be minor compared with lost samples.]

143:45:22 Schmitt: Okay. What haven't we done?
 143:45:24 Cernan: Okay. I got to get the (TV) camera. Okay, Bob, I'm taking your camera.
 143:45:31 Parker: Okay, looks like it's in the right place, you won't have to turn it around. Good coordination.

[Fendell has the TV pointed down and aft, the proper position for the traverse.]

143:45:37 Cernan: Yes, sir. Okay. We read the TGE; I'm going (LCRU) Mode 1.

[TV off.]

143:45:40 Parker: Roger on that. Okay; we lost the picture. (Long Pause) And give me a call when you guys get rolling.
 143:46:07 Cernan: Okay.
 143:46:09 Parker: And we'd like frames when it's convenient on you guys.
 143:46:16 Schmitt: Okay, Bob. (Pause) Okay. LMP is at 46.

143:46:20 Parker: Copy that.
 143:46:21 Cernan: And CDR is at - if I stop long enough - 113.
 143:46:28 Parker: Copy. 113. (Pause)
 143:46:34 Cernan: Oh, look at that! Boy, I tell you.
 (Pause)

[Heavy breathing as they mount the Rover.]

143:46:49 Schmitt: (Looking at the traverse map, LMP-14)
 Okay, Geno, more or less follow our tracks back until we get over the big hump and then we can start picking our way to (Station) 3. I've got 3 pretty well spotted.
 143:47:02 Cernan: Okay; low gain is set, and heading about 035...Oh, let me set this thing out of the way again. This has been giving me more trouble.
 143:47:18 Schmitt: What's that? The hammer?
 143:47:20 Cernan: Yeah, the handle.
 143:47:22 Schmitt: Oh, getting caught in there?

[The hammer is in the pocket on Gene's right shin and is probably catching on the bottom of the console.]

143:47:25 Cernan: Okay, Bob. We're ready, we're rolling. You need any readings?
 143:47:30 Parker: No, no readings called out (in the checklist). And when you get going, I'll give you a little advice on what we're going to do on the way to Station 3.
 143:47:41 Schmitt: Well, let me tell you a few things first, Bob.
 143:47:43 Parker: Okay, start telling me.

[Cernan - (Laughing) "This is a typical exchange between Jack and Bob. Sometimes it almost got to be a test of wills."]

[Schmitt - "We were there to learn. I wanted to be sure that I didn't get distracted and forget some pertinent observation. The Backroom wanted as much information as we could give them and during this time when we were driving away from the station was a good time to do the equivalent of making some field notes."]

143:47:45 Schmitt: I think those two...
 143:47:47 Cernan: We're rolling!
 143:47:50 Schmitt: All right. Those two major kinds of blocks that we sampled there...(they were) about the (only) two varieties we saw in the area, (and) it's a long extrapolation I realize, but they do resemble in color, and I believe in texture, the blue-grey rocks and the light-tan rocks up on the Massif. So I feel confident that - fairly confident - that we sampled at least the two major units visible from a distance in the South Massif.

[Jack sounds a little tired.]

143:48:24 Parker: Excellent. Excellent.
 143:48:28 Schmitt: I think that there is some...(correcting himself) a lot of post-mission work to be done on correlating the angularity and possibly even the albedos of the rocks we sampled with those on the Massif. We should have good pictures of both from a distance and up close.
 143:48:48 Parker: Okay. I'm reminded...
 143:48:51 Schmitt: So we may be able (garbled)...
 143:48:52 Parker: ...that extrapolation is the nature of our art.
 143:48:55 Cernan: (A slow, deliberate laugh) Ha-ha-ha-ha-ha-ha.

[Schmitt - "I think that this is the pilot laughing at the scientist's admission of imprecision."]

143:49:03 Schmitt: And, Bob, I'm not going to...How am I on the film?
 143:49:06 Cernan: Oh, my golly! Look at that valley!
 143:49:10 Parker: Stand by. I'll get that for you, Jack...
 143:49:11 Cernan: I think there's a...
 143:49:11 Parker: I think you're doing fairly well, now. And before you guys get too far, a couple of comments we want to do on the way. There is a Rover sample stop in your checklist, it used to be at 073 and 6.3; it's the first thing there, halfway out to Hole-in-the-Wall. And we're now going to have that Rover sample stop at 078 and 7.0. That should be along your tracks going home. So, about 078 and 7.0, we'll have the Rover sample stop. And the gravimeter people have won today, and we're going to stop and get off the Rover and get a gravimeter reading at that location. We're taking out (time from) some stop, I'm not sure quite where. And right now, Jack, you're right-on on the film says a little note in front of me.
 143:50:00 Schmitt: Okay. I'll take pictures, then.

[The planned Rover sample stop is not shown on the checklist map but, rather on the list of traverse tasks on LMP/CDR-15. AS17-138-21075 and 21076 are taken during the next minute or so.]

143:50:03 Cernan: Bob, we're on the top, coming off the highest lobe of the scarp looking back into the valley. And it's quite a scene back there, but we still cannot see the LM. (Pause) That may be it. I don't know.

[They are about 300 meters from Station 2.]

143:50:16 Schmitt: Hey, turn a partial pan; I know it's into the Sun.

[Jack will take a series of pictures as Gene turns the Rover in a circle. These pictures are AS17-138-21077 to

21092. Because of the glare of the Sun, the up-Sun frames - 21065 and 21066 - don't show much detail.]

143:50:20 Cernan: Wait a minute. Wait a minute. Okay. Let's take one from right here. I want the whole thing (that is, the whole valley). (Pause) You ready to start?
 143:50:26 Schmitt: Yeah, I got it.
 143:50:27 Cernan: Start taking. Take the whole thing.
 143:50:32 Schmitt: Go ahead.
 143:50:34 Cernan: Get around this crater.
 143:50:35 Schmitt: I got a pan down the valley. This is just going to be right into the (Sun)...
 143:50:39 Cernan: Yeah. Don't take that one. Get it up as we come around. You get it?
 143:50:41 Schmitt: There we go.
 143:50:42 Cernan: Okay. That's the one we want. And you got the valley?
 143:50:47 Schmitt: Yeah. Keep going.

[The whirring sound of film advancing in Jack's camera can be heard.]

143:50:48 Cernan: Okay.
 143:50:49 Schmitt: Keep turning around over there, and I'll get that scarp. That's beautiful.
 143:50:54 Cernan: Isn't that something? Man, you talk about a mysterious looking place. (Pause)
 143:51:03 Schmitt: They can cut some frames - some parts of those pictures out - and make a nice photograph. (Laughing) (With the) TV camera, (and) maps (in the way). (Pause)

[The pan turned out to be relatively uninteresting because of the Sun glare. Pictures taken during the next minute or two are AS17-138-21093 to 21095.]

143:51:13 Schmitt: Okay, looking at the light mantle: No more comments except that by that rake sample and just looking, there's certainly are fewer fragments than we saw at Station 2. The main thing that we can tell about the light mantle and when we're on it, of course, is the light-colored craters. The fresher craters all appear to be light colored. As they get older, the albedo goes down and potentially (that can be explained if the craters) have been dusted with material from the dark mantle or from other sites. Either that or it's just the lunar patination that we're all familiar with.

[The light color of the small, fresh craters is probably related to the light layer of soil that Gene noted (at 143:41:45) a short distance below the surface. In just a few minutes, they will find more of it at the Scarp gravimeter stop. The 'patination' process to which Jack refers comes in two varieties: (1) small impacts on boulders create a patina

of brownish glass and (2) small impacts in the soil create small blobs of glass which tend to darken a soil as it ages.]

143:52:xx Cernan: You know, it's a shame. They could have had TV coming down here because my heading isn't going to change much at all. The high gain could have been on the whole time.

143:52:xx Schmitt: Bob, none of the craters out here in the light mantle appear to show bedrock. Almost all of them are instant rock craters.

143:52:25 Cernan: Say, Bob. Give me that bearing and range again for the...

143:52:28 Schmitt: 7.0 right here.

143:52:30 Parker: 078 and 7.0.

143:52:32 Cernan: ...up on the hill. How about 071 and 7.0? Will that do?

143:52:38 Parker: Yeah. I think that that will be enough to hack it.

143:52:44 Cernan: Well, if not, we can go down there.

143:52:46 Parker: No, no, no. Good Lord. Stay on the road you're on.

143:52:52 Cernan: Well, I'm not on any road, but I'm stopping here.

143:52:56 Parker: I thought you guys were making a road.

143:52:57 Cernan: 071.

143:52:58 Parker: Roger.

143:52:59 Cernan: Let me turn it off.

143:53:02 Parker: Yeah, also...

143:53:03 Cernan: (Garbled) 9.8 and 7.0.

143:53:07 Parker: Okay. And the Rover numbers (roll and pitch) should be fairly flat for the ole gravimeter.

143:53:15 Schmitt: Uh, oh.

143:53:16 Cernan: (Responding to Parker) Well...That means we have to change here.

143:53:19 Schmitt: Hey, right over here to my right...

143:53:21 Cernan: Okay.

143:53:22 Schmitt: Maybe it's the best we can do, but it's still going to be on a slope.

143:53:25 Cernan: Well, I'll level it off on a (garbled)...

[Because they will take the gravimeter reading without putting the instrument on the ground, Gene is trying to level the Rover by using a crater rim to prop up one or more of the wheels.]

143:53:26 Cernan: (Garbled)?

143:53:28 Schmitt: Yeah; go ahead. I'm off (the Rover). Do you see...

143:53:31 Cernan: Yeah, I see it. Right there.

143:53:32 Schmitt: On the rim of that crater that's built up a little bit? (Brief static)

143:53:36 Cernan: Right up here.

143:53:39 Schmitt: What's your...Can you tell your roll?

143:53:43 Cernan: Okay, now that's about zero (roll) right there.
 143:53:45 Schmitt: What's your roll?
 143:53:48 Cernan: Let me turn this off. Boy, this roll indicator isn't very...Oh; zero.
 143:53:52 Schmitt: Zero?
 143:53:53 Cernan: Yeah.
 143:53:54 Schmitt: I'll punch it (the gravimeter). You'll change it (the roll) as soon as you get off.
 143:53:57 Cernan: Now it's zero.

[Note, that it is very difficult to decide who has said what during the last few lines, a fact which also makes it difficult to decide what has been happening. The person speaking at 143:53:54 sounds like Gene, but this section doesn't make sense unless the speaker is actually Jack or, alternatively, unless Jack didn't get off the Rover at 143:53:28.]

143:53:59 Schmitt: Oh, you got to get off anyway.
 143:54:01 Cernan: Do I have to get off for this?
 143:54:02 Parker: Roger. Both of you get off.
 143:54:03 Schmitt: (Because of the) gravimeter reading.
 143:54:04 Cernan: Why should I have to get off?
 143:54:06 Parker: So you don't move the ole gravimeter.

[This is evidently not standard procedure and, at least in this instance, improvising costs precious time.]

143:54:07 Schmitt: Think you can hold still?
 143:54:08 Cernan: Yeah. I'll hold still.
 143:54:09 Parker: No. Negative on that, Gene.
 143:54:10 Schmitt: Okay, Bob. (To Gene) Give me your sampler cause that's the other thing I have to do.
 143:54:14 Parker: Yeah. We'll get Rover samples, at least.
 143:54:16 Cernan: Unless you need me off?
 143:54:18 Parker: Roger. We want Gene and Jack both off.
 143:54:20 Cernan: Well, if you need me off; Jack, just punched it.
 143:54:22 Schmitt: Okay. Hold still. They don't know anything about your PLSS noise.

[Jack is suggesting that vibrations produced by Gene's fans and pumps might disturb the TGE.]

143:54:26 Cernan: I better get off.
 143:54:27 Schmitt: Yeah, I think you oughta.
 143:54:28 Parker: Gene, we'd like both of you off.
 143:54:30 Cernan: 071, 9.8, and 7.0, Bob.
 143:54:36 Parker: Got that. (Long Pause)
 143:54:53 Cernan: Don't push it yet...Did you?
 143:54:55 Schmitt: No. (Pause)
 143:55:02 Cernan: (Now off the Rover) Okay. Go ahead and push it.

143:55:06 Schmitt: Let me wait until it settles down here.

[They may be standing at the gate, waiting for the Rover to quiet.]

143:55:12 Cernan: This thing is all (garbled, possibly "taped shut"), isn't it? This thing doesn't change.

[There had been some discussion of taping the SEP covers at 140:47:54, but no decision was made. Unless Jack did some taping without comment - which seems unlikely, the covers won't be taped until the start of EVA-3 at 164:01:01. Consequently, the identity of "this thing" remains a mystery.]

143:55:17 Schmitt: No, that should be good...
 143:55:19 Cernan: Yes, it does change.
 143:55:21 Schmitt: A couple of times.
 143:55:22 Cernan: Huh?
 143:55:23 Schmitt: Cycle it a couple of times.
 143:55:24 Cernan: No, the settings.
 143:55:25 Schmitt: Oh, I don't know...Yeah, they'll change. Okay. Quiet Rover. Gravity. Mark it.
 143:55:33 Parker: Copy that.
 143:55:35 Cernan: Say, Bob, I need a quick f-stop for the 500.
 143:55:38 Parker: Standby.
 143:55:40 Schmitt: It's the same film.
 143:55:41 Parker: Stand by.
 143:55:45 Schmitt: Hey, Bob, can I punch it (the gravimeter) again?
 143:55:49 Parker: Ah...Yeah. Go to Standby and then punch it again.
 143:55:50 Schmitt: you don't have to wait for it to time out, do you?
 143:55:54 Cernan: Standby, Jack. (Hearing Parker) Okay.
 143:55:56 Schmitt: Mark it.
 143:55:57 Parker: Copy that. (Long Pause)
 143:56:12 Parker: Okay. And, Geno, f-stop for the 500 millimeter should be the same as for the 70.
 143:56:18 Cernan: Okay. (Long Pause)
 143:56:36 Parker: And, Jack, I presume you're getting some Rover samples here off the Rover. (Long Pause)
 143:56:58 Schmitt: Bag 30 Easy.

[Schmitt - "Note the change from 'Echo'."]

143:57:05 Parker: Copy. 30 Easy. Are you guys finding much in the way of rocks here?
 143:57:15 Schmitt: I'm looking. I'm going to get you some instant rock out of a small pit crater...(correcting himself) pit-bottom crater.

[AS17-138-21096 and 21097 are befores of the pit-bottom crater.]

143:57:25 Cernan: Bob, up to frame count 36 is the outcrop - or boulders - at the top of the South Massif.

143:57:36 Parker: Okay. (Pause)

[Gene panned from left to right along the summit. The pictures are AS17-144-22003 to 22015. 22013 is the best of them]

[Jack is using the LRV sampler.]

143:57:44 Schmitt: Bag 31 Easy. Instant rock out of a 2-meter pit bottom crater - off the inner wall.

143:57:56 Parker: Copy that.

143:57:57 Schmitt: Well, let's make it 30 centimeters down from the rim.

143:58:03 Parker: Okay. (Long Pause)

143:58:29 Parker: Okay, 17. We've got about 30 seconds left for that gravimeter reading. You want to start finishing up your tasks and getting back toward the Rover.

143:58:43 Schmitt: Okay. (Pause)

143:58:49 Cernan: Okay, Bob. And through frame count 57 are the North Massif from part of the western portions to part of the eastern portions.

143:59:00 Parker: Okay; and what was that frame count? (Pause) Okay. Copy the 57, there.

[AS17-144-22016 to 22035 are photos of the North Massif and the Sculptured Hills. 22024 to 22026 are excellent photos of the Scarp on the North Massif.]

143:59:16 Schmitt: Here's something different...Here's a little... (Long Pause)

143:59:30 Parker: And, guys, we're ready for the gravimeter reading. And we'd like a frame count on you, Jack. I guess if you'd prefer...

143:59:35 Schmitt: A chunk of yellow-brown rock that apparently has several spots behind it, probably indicating direction from which it came...Oh, no...What is that? That's a reflection. (Laughs) That really fooled me. A reflection off the Mylar. (Laughs) Crazy. Well, what the heck, I'll sample it anyway.

[The rock isn't yellowish-brown after all. The spots of color are produced by sunlight reflected off the gold-colored foil covering the LCRU. Jack's black & white before photos of the spots of orange light are AS17-138-21098 and 21099.]

[Schmitt - "It really did look yellow or orangish and it's interesting that later on I hesitate on calling the orange soil 'orange' at Shorty, because I had already been fooled."]

144:00:07 Cernan: Okay. Let me get my (low-gain) antenna set so...It's not quite...

144:00:10 Schmitt: Is it (the gravimeter) through reading?

[Jack wants to put the sample in the SCB on the Accessory Staff.]

144:00:12 Cernan: Yeah, it's through reading. (Pause)
(You'll) probably read us better now, Bob.

[Gene forgot to re-aim the low gain antenna when he parked the Rover at this stop. However, the signal quality wasn't noticeably different from normal and didn't change just now when he re-aimed the antenna, probably because Houston had switched to reception through the LM, rather than the Rover low-gain antenna, as indicated below.]

144:00:24 Cernan: I've got Family Mountain and some of the hills way off to the right (north) of Family Mountain. I'm at (frame count) 67 on the 500 and I'll give you the reading on the gravimeter.

[These photos are AS17-144-22036 to 22045.]

144:00:30 Parker: Okay. Copy. 67 and Family Mountain.

144:00:35 Cernan: Did you get the other words on the 500?

144:00:36 Parker: Roger. Copied them all.

144:00:41 Cernan: Well, you were reading at probably a 90-degree low-gain angle.

144:00:45 Parker: Roger. We've been reading through the LM also.

144:00:46 Schmitt: Thirty-two Easy is just another small fragment. (To Gene) You know what I need?

144:00:53 Cernan: Okay, 670, 123, 501; 670, 123, 501.

144:01:00 Parker: Okay. Copy that, Geno. And we're ready for you guys to go on at your earliest convenience.

144:01:06 Schmitt: (To Houston) Do you want me to load (more bags into) the LRV sampler? (To Gene) Go ahead.

[Gene may be getting some dixie cups to put in the sampler.]

144:01:09 Cernan: Yeah, There you go. (Long Pause)

144:01:28 Parker: And, Jack, is that your last LRV sample bag?

144:01:32 Schmitt: I only had one left, but it (the sampler)'s loaded now.

144:01:35 Parker: Okay. (Pause)

144:01:44 Cernan: You did get the (gravimeter) reading, right, Bob?

144:01:46 Parker: Roger. Got the reading.

144:01:51 Cernan: Okay. We're buttoning up.

144:01:53 Parker: Okay. And if you don't have one left for that sample at Hole-in-the-Wall, Jack, we'd like you to get a new set of sample bags.

144:02:03 Schmitt: We got it.

144:02:04 Parker: Okay. Got it. (Pause) And still understand that thirty-two Echo was your last sample.

144:02:13 Schmitt: Thirty-two Echo. Got three (samples) here.

144:02:15 Parker: Okay.

144:02:16 Schmitt: Oh, oh.

[Apparently, Gene has fallen while trying to get on the Rover and, as he will comment in a moment, has uncovered some light-colored soil in the process.]

144:02:18 Schmitt: Okay?

144:02:20 Cernan: Yeah.

144:02:23 Schmitt: Need some help?

144:02:24 Cernan: Nope. I've got the Rover.

[Gene is probably holding on to the Rover as he pulls himself to his feet.]

144:02:27 Schmitt: Was that me?

144:02:28 Cernan: No. That was interesting. Bob, about 2 inches below the surface here, you run into that blue-grey material down there and it's in little clods, and it breaks apart in your hands.

144:02:47 Schmitt: Yeah, that's right.

144:02:48 Cernan: Did you get some of that in your Rover sample?

144:02:50 Schmitt: No, but I got it out of that instant rock crater.

144:02:55 Cernan: We oughta...Just grab a quick Rover sample and we'll take off.

144:02:56 Schmitt: That's why...

144:02:58 Cernan: That was a pretty interesting (laughing) episode.

[That is, it was a serendipitous stumble.]

144:03:04 Schmitt: Yeah. Well, you know, we haven't been trenching like we should or we would have...

144:03:06 Cernan: (Finishing Jack's thought) We would have found it.

144:03:09 Schmitt: But, really those craters are giving us the same information: that there's a light-colored material underneath. (Pause)

144:03:23 Parker: Okay. 17, we're ready for you guys to move on and we'd like to eliminate the Rover sample at Hole-in-the-Wall.

[This is the sample stop at 080/5.5 listed on LMP-15.]

144:03:34 Cernan: Okay, Bob. We're getting on now.
 144:03:37 Parker: Copy that.
 144:03:41 Cernan: We got on a minute ago. (Chuckles)

[That is, Gene was getting on the Rover when he fell.]

144:03:47 Parker: And, do I understand that these Rover samples, Jack, are in your pockets?
 144:03:53 Schmitt: No. They're in the bag on the Rover.
 144:03:56 Parker: Okay.

[Jack is referring to the SCB hanging from the accessory staff.]

144:03:58 Schmitt: Forty Yankee.
 144:03:59 Parker: Copy that.
 144:04:02 Schmitt: That's light-colored soil from a depth of about...It's mixed with a little of the upper surface, but (it's) mostly light-colored soil from a depth of about 15 centimeters.
 144:04:17 Cernan: Wonder what I'd do for an encore? (Pause)
 144:04:26 Schmitt: It looks like the light mantle in here is covered with dark to a depth of about 5 or 10 centimeters.

[Schmitt - "All over the Moon, the gardening process reaches a fraction of a centimeter deeper every million years, and the depth to the light material is fairly consistent with an avalanche age of about 100 million years that was determined from solar-wind exposure measurements."]

[Simulations of the gardening process described in the Lunar Sourcebook (Heiken, G. H., Vaniman, D. T., and French, B. M., eds, Cambridge University Press, 1991, p.89) suggest that the rate at which the gardened layer thickens slows with time. This is slowing is due to the rarity of larger impactors. In a typical simulation, the depth to which soil is turned over once might be 0.6 cm after a million years, 1.5 cm after ten million years, and 4 cm after a hundred million years. However, at any given place, the history of the regolith will be very complex and variations on vertical scales of a few tens of centimeters can be expected over periods of a few tens of millions of years.]

144:04:40 Cernan: You might want to go Min, Jack, on your diverter.
 144:04:43 Schmitt: Right now, I'm sort of warm.
 144:04:44 Cernan: Okay. When we start driving, you might want to go...I'm going to zap myself with a cold. (Pause)
 144:04:51 Schmitt: I can do it on here.

[There is a cut-out in the seat through which Jack can reach his PLSS controls.]

144:04:54 Cernan: Did you take any pictures at all while you were there?

144:04:55 Schmitt: Oh, yeah. I didn't take a pan. Why don't you turn right to (garbled)?
144:05:02 Cernan: Okay, Bob. If you read, we're rolling.
144:05:04 Parker: Okay. Mark that.
144:05:07 Cernan: Making a right-hand turn for a pan.
144:05:09 Schmitt: (Turn) left.

[Schmitt - "If he turned right, it tended to force me to take pictures through the TV antenna; whereas, if he turned left, I got a better field of view".]

144:05:15 Cernan: Let me see where we're going. I (static) again. You know, a little more and that hole would have been in the way.
144:05:26 Schmitt: We left some of our litter. Not a complete pan but it will show the location. (Pause)
144:05:37 Schmitt: Okay. LMP frame count (is) 80.
144:05:40 Parker: Copy that; 80.

[The photographs in Jack's LRV pan are AS17-138-21100 to 21108.]

144:05:44 Schmitt: Okay. Geno, you're heading for a spot that's about 080/5.5, approximately.

[Schmitt - "This is the nominal location of the planned LRV sample, which I read from the cuff check list without remembering that they had already cancelled it."]

144:05:51 Parker: Yeah, you guys following tracks home or not?
144:05:53 Cernan: Do you have an update? (Answering Parker) No.
144:06:03 Parker: Okay; and...Roger. (Pause) Hole-in-the-Wall should be at about 080 and maybe 5.7. And we're not going to stop to get a Rover sample at Hole-in-the-Wall.
144:06:13 Cernan: What about Station 3? (Pause, listening to Parker) Okay, that sounds reasonable because it's just nothing but lots of rolling terrain.
144:06:25 Schmitt: Okay. Bob, I think we have a good sample of only-partially-contaminated light mantle in that last Rover sample that Gene accidentally discovered was right under our feet. It's almost certainly the light-colored material that we've been talking about in the walls of the craters. And, as a matter of fact, that instant rock sample I took was light-colored and probably represents the same stuff, indurated slightly.
144:06:56 Cernan: That light-colored mantle has that bluish tint that you saw in those rocks.
144:07:01 Schmitt: Yeah. (To Parker) I still don't think there's anything...We ought to...We ought to get a core in this light mantle sometime; and probably Station 3 is going to be the place. I hope that's still in the agenda.
144:07:19 Parker: Rog. It's still in the agenda.

[Photographs taken during the drive to the top of Hole-in-the-Wall are AS17-138-21109 to 21113.]

144:07:24 Cernan: Say, Bob, can you update the mileage on Station 3?

144:07:29 Parker: Okay, you want mileage to it or do you want the range and bearing at it?

144:07:35 Cernan: Well, range and bearing at it.

144:07:37 Parker: Okay. Stand by.

144:07:42 Cernan: Because Hole-in-the-Wall is fairly nebulous.

144:07:45 Parker: Okay, we're going to say about 089 and 6.1 for Station 3.

144:07:53 Cernan: Okay. (Pause)

[The checklist gives a Station 3 position of 087/5.6 and they will actually stop at 087/6.0.]

144:08:02 Parker: Do you want to give us another range and bearing right now?

144:08:03 Cernan: Do you get the feeling that we're the only ones out here, Jack? Looking around...(Responding to Parker) 073 (bearing to the SEP transmitter, 10.3 (distance driven), 6.6 (distance to the SEP transmitter).

144:08:10 Parker: Copy that. (Pause)

144:08:16 Schmitt: Bob, I have a feeling that whatever darkens the...Ooh, there's a beautiful little glass-lined crater...pit-bottom crater. Whatever darkens the light mantle is not a one-time-only mantling of darker material. It's something that happens over a period of time, continually, because craters of all sizes and apparent degradation are darkened and there are lighter craters that are light to varying degrees. It seems to be a continuum of albedo change.

144:09:08 Cernan: You know that little crater on the side of the North Massif that we're thinking about going to doesn't look nearly as light-colored or haloed as it does in (overhead) pictures, does it?

144:09:18 Schmitt: You mean Hanover? Yeah, (I agree). No, (it isn't as light-colored as it seemed in the overhead pictures). (Pause)

144:09:32 Cernan: Now, let's see where we are, I don't want to run into that big crater at the foot of the (Scarp)...

144:09:38 Schmitt: I think you're almost to the rim.

144:09:39 Cernan: Yeah, I want to go down here if I can. My tracks are over there to the left, I haven't crossed them yet.

144:09:45 Schmitt: 073, 6.3 (bearing and range to the SEP transmitter).

144:09:49 Parker: Copy that.

144:09:52 Schmitt: LMP's frame count is 86.

144:09:58 Parker: Copy 86. (Pause)

[Jack's most recent picture is AS17-138-21113, which shows the outer (east) bounding ridge that defines Hole-in-the-Wall.]

144:10:09 Schmitt: Boy, that's a sight, isn't it?

144:10:12 Cernan: That's spectacular.

[Gene has turned north and they can now look along the scalloped, multi-lobed edge of the Scarp toward Hanover and the North Massif. Photos AS17-138-21114 to 21118 show all of these features with considerable clarity. Gene's photo AS17-137-20980 was also taken at about this time.]

144:10:14 Schmitt: I don't know why something that's all approximately the same hue should...

144:10:20 Cernan: The lack of color has got to contribute to the inability to judge distance.

[Cernan - "Ever since I've been back from the Moon, I've attributed the difficulty we had in judging size and distance to the lack of references like telephone poles, roads, trees, and so forth. I'd forgotten that I said this about the lack of color contributing to the problem, and I'm sure it's true. It's interesting that I made the observation at this point in the traverse. Here we were, high up on top of the Scarp in very hummocky, rolling terrain, looking out across the valley and across to the North Massif. You've got a bland-looking landscape, and I'm sure that what I was seeing were foreground features that just blended into the background. I'm sure that the overall grey color and the lack of major color changes contributed to the inability to develop accurate depth perception."]

144:10:25 Schmitt: See the lobes coming out...(See what look like) lobes coming out from the Scarp. The Scarp, rather than being a line in there on the plain, appears to be lobes. I got a couple of shots of that. Whereas when it gets up on the (North) Massif, it's a fairly continuous curve; although it does appear to be younger; at least there's less relief on it for the first few kilometers of that bend there (on the North Massif).

[Schmitt - "We don't know for sure, but the Scarp is probably an actual fault scarp and, out to about halfway across the valley, toward the South Massif, the landslide material is draped over it. And what I'm commenting on here is that on the southern end of the Scarp where we are now, the Scarp seems to be a series of scarps or steps whereas up to the north to seems to be one continuous line."]

144:11:00 Cernan: We're going to have to go down like the way we came (up) because there's that big crater down at the bottom, I'm afraid.

144:11:05 Parker: Yeah, I think we agree with that suggestion, too.

144:11:13 Schmitt: Bob, the so-called Scarp impresses me as less of a scarp than a series of lobes which roughly have a north-south trend. And we've been driving over various hummocks within those lobes. (Pause)

144:11:42 Parker: Okay, copy that.

144:11:47 Cernan: I think we made a gross mistake in not trying to let them get TV. My heading hasn't changed much at all here. They would have had a spectacular view. Look at it out in that valley, Jack.

144:11:56 Schmitt: Yeah.

144:11:59 Cernan: Good lord. I still don't know where the LM is...I see it, I think. The shadow...A blob. It's the only sharp shadow out there right in the...because you sure can't make out the craters from here, can you? Okay, hold on. Over the hill and down the rail. (Pause) Man, I tell you, this machine is fantastic.

144:12:33 Schmitt: Yeah. Watch it. (Laughs)

[Photos AS17-138-21119 to 21124 cover the northward drive to this point. AS17-138-21125 to 21130 show the descent to the bottom of Hole-in-the-Wall.]

144:12:36 Cernan: Quite a machine.

144:12:38 Schmitt: Likes to spin when you turn going down hill.

144:12:40 Cernan: Quite a machine. (Pause)

144:12:46 Schmitt: I think you've got something right ahead of you.

144:12:48 Cernan: I got it.

144:12:49 Schmitt: See the instant rock.

144:12:51 Cernan: I got it. There's that crater (at the bottom of Hole-in-the-Wall). It doesn't look nearly as bad from here, but it sure is deep when you get up there. I'll meander around and over this next little lobe then I'll head down that next one - the first lobe we came up - and then along it.

144:13:08 Schmitt: Okay, there's Lara, and I think we can see Station...Watch it, watch it, watch it. (Pause)

144:13:17 Cernan: Okay, I'm going through it slow. (Pause)

144:13:26 Schmitt: Beautiful. (Laughs) I figured we'd buckle the LCRU with that one.

[The LCRU hangs off the front of the Rover and, if the nose were to pitch down into a particularly steep-walled crater, there would be a chance of having the LCRU hit the surface.]

144:13:33 Cernan: I bet they can watch this road. (Laughing) My heart rate just dictates the kind of terrain we're going over.

[NASA Public Affairs reports that both Gene and Jack have heart rates in the 80s.]

[Cernan - "Listening to the tapes, I'm really starting to re-live the ride. This ride up to Station 2 and back is much clearer in my memory than the ride to and from Station 1 was, because this was really spectacular terrain and driving the Rover and riding on it was really a challenge and was really fun. It was not your ordinary trip to the Moon. This was a unique place, probably the most unique and challenging for the use of the Rover because of the heights to which we climbed and the terrain which we were in. The lobes of the Scarp weren't vertical cliffs; they were lobes, as Jack describes, or rounded plateaus and they made it a challenging ride. You can hear it in our voices and see it in some of the pictures. It's a shame that the TV pictures and the still pictures don't really give a full appreciation of how steep some of those rolling hills were in this part of the valley. All you'd need would be a fishing pond and a few trees and it would be a great place to build a house."]

144:13:45 Schmitt: Okay...(Pause) Houston, we're navigating and not talking. Sorry. But the light mantle is a uniform surface and I think you've heard just about everything we have to say so far.

144:14:05 Parker: Roger. Your comm's great and you guys are doing (garbled).

144:14:07 Schmitt: The fragment population hasn't changed, nor has the crater population, as near as I can tell. I hope the LRV photos will give you more details than that. Okay, Gene, do you have the target over there, that set of...

144:14:28 Cernan: Yeah, I got to get over to this next knoll and I'm going to be off the Scarp. We're about three-quarters of the way down. (Pause) Isn't that sharp shadow out there the LM? See it way out there? Almost under the Sun. It's got to be. It's the only sharp shadow out there. Right under the Sun, straight down there.

144:14:54 Schmitt: Probably.

144:14:56 Cernan: Okay, I'm going to try to make it down this. Hold on!

144:14:59 Schmitt: (Garbled)

144:15:00 Cernan: This is the one we climbed up.

144:15:01 Schmitt: Oh, there's Nemo (Crater) over there to my right.

144:15:03 Cernan: Yes, sir, this is the one we climbed up. Would you believe that?

144:15:05 Schmitt: Well, I don't know.

144:15:06 Cernan: Yeah, I would.

144:15:10 Schmitt: The problem is any crater on the side...

144:15:13 Cernan: I don't want to give us a roll...I'll use...

144:15:18 Schmitt: I think you're all right.

144:15:20 Cernan: We're all right. I don't know, that's got...

144:15:23 Schmitt: Keep your speed down because if you have to turn, it doesn't like it on a downhill slope.

[On Apollo 15, Dave Scott did a 180 degree spin-out as he and Jim Irwin drove down off the Apennine Front.]

[Cernan - "One-sixth gravity just did not hold the Rover to the ground very well. You always bounced around a lot and, if you had any speed, that just aggravated the bounce. Where 'the rubber meets the road' (an advertising slogan of the Firestone Tire Company in the 70's) was not a very tight fit and, if you were going downhill and you had to turn left or right, the tendency of the Rover to spin or roll was pretty great."]

144:15:26 Cernan: Man, that's got to be...(The) pitch-angle (indicator)'s pegged, and I don't know what that means. (Pause) Okay! Right off the Scarp!...

144:15:42 Schmitt: We're off the scarp.

144:15:45 Parker: You guys cut each other out but I take it that means you're at the edge of the Scarp.

144:15:50 Schmitt: We're off!

144:15:51 Cernan: We're off! We came down!

144:15:52 Parker: Roger. You're down the Scarp.

[AS17-138-21131 was taken at about this point. AS17-138-21132 to 21135 will be taken during the next couple of minutes.]

144:15:53 Cernan: Hey, will you look at the hill we came down! Same one we went up?

144:15:57 Schmitt: I'd rather not.

144:16:00 Cernan: Oh, I don't know, I'm impressed. (Pause) Okay, now where we got to go? (I'm headed) 345 (NNW) roughly. And we want to go to (a bearing and range of) 087/6.1...

144:16:09 Schmitt: Okay. You're...I think you're headed right...right for where we want.

144:16:12 Cernan: Yep.

144:16:13 Schmitt: See that bright crater? You can just start to see Station 3 over there now.

144:16:17 Cernan: Okay, navigation says I've got more than 90 degrees ...I should be increasing range. Bob, we're at 079, 11.5, and 5.7.

[Gene wants to go to 087/6.1 and is currently at 079/5.7. He is driving on a heading which is a bit more than 90 degrees from the LM bearing and, therefore, is increasing both his range and bearing.]

[Cernan - "This is the way I think when I'm flying an airplane: to increase both bearing and range, I need to be more than ninety degrees to the left of the LM bearing. And if I wanted to stay at the same range and increase my bearing, then I'd 'fly an arc' and keep my heading at 90 degrees to the LM bearing."]

144:16:24 Parker: Okay, beautiful, guys. Really going smooth.
144:16:26 Cernan: And I'm headed northwest.
144:16:31 Parker: Roger. In fact, we understand it's been going so smooth down here that they haven't even spilled any coffee in the SPAN room yet this mission.

[Schmitt - "The SPAN room was where the troubleshooting started when there was a problem. It was an engineering room, and I used to spend a lot of time in the SPAN room with other missions when I was helping out with various engineering problems. One time I was in there with George Abbey - and I can't remember now quite why it happened - but, up above their consoles, the people in the SPAN room had a pegboard where they stuck all their messages, and it wasn't structurally very sound. Somehow I hit the board, which knocked over the coffee cups they had in front of it, and the coffee spilled onto the consoles."]

144:16:42 Schmitt: Thorson must not be on duty.

[Schmitt - "Dick Thorson was the guy who was on duty in the SPAN room the day I spilled the coffee"]

144:16:46 Cernan: I'm glad we don't have any (coffee) sitting on the LCRU!
144:16:52 Schmitt: Right over there is Station 3, I think. Oh, actually, I guess...Hmm. (Pause) I guess they would want it...Is there?...I can just start to see two craters...
144:17:05 Cernan: You know what the problem is?
144:17:06 Schmitt: ...that are closer to Lara.
144:17:07 Cernan: I got a full planar view of the high gain and I can't see a thing out there.
144:17:11 Schmitt: That's right.

[Two frames taken at the end of the EVA3 traverse indicate the nature of Gene's problem. AS17-134-20476 is a tourist picture of Gene taken from in front of the Rover and shows the TV antenna mounted forward of his seat. Jack was standing fairly close to the vehicle and the antenna isn't as tall as it appears in this image. AS17-143-21924, taken from behind the Rover gives a better indication of the antenna's potential for blocking Gene's view. In this frame, the antenna is pointed to the side and doesn't block Gene's view very much. However, on this drive to Station 3, the antenna is apparently pointed fore or aft and Gene has to look through the full antenna. As can be seen in AS17-143-21932, Gene's picture of the Rover parked at the V.I.P. site, we can see that the antenna is relatively transparent when there is no sunlight reflecting off the wire mesh into the line of sight. During this drive to Station 3, the combination of their heading and the antenna pointing is such that there is enough sunlight reflecting off the antenna into Gene's eyes to make the antenna appear opaque. The effect is illustrated

in AS17-134-20453, a picture taken from the front of the Rover.]

144:17:13 Cernan: Full planar view. All I can do is see underneath it. (Pause) Gonna take it (a crater) broadside. See, I can't see a lot of craters now that they're out in front. Oh, I guess I can see them, most(ly). Here's a nice sharp little hole; look at that.

144:17:32 Schmitt: Yep. Bob, the texture of the light mantle - (that is, the) surface texture - is really no different on the Scarp, on its flank, or out here to the east of the Scarp. Fragment population, crater population, everything looks about the same. If there is such a thing as a light mantle, it seems to be uniform across the Scarp.

144:17:59 Parker: Okay, I copy that, Jack.

144:18:01 Schmitt: There are your tracks. Hey! We crossed somebody's tracks!

[AS17-138-21136 show the outbound tracks. 21137 shows the Scarp lobes.]

144:18:07 Cernan: We sure did. We just made a loop.

144:18:07 Parker: Hope they look like yours.

144:18:12 Schmitt: That was at 081/5.7.

144:18:16 Parker: Okay, copy 081/5.7. Do they look like your tracks?

144:18:22 Schmitt: Well, here's another set.

144:18:23 Cernan: Yeah, this is where we went to the big crater and I came southeast in order to get around it, remember? We saw that hole?

144:18:30 Schmitt: Yeah.

144:18:35 Cernan: Look at that big turn I made. Ha ha! That was a quick change of mind when we came over that ridge.

144:18:42 Schmitt: Yes, sir.

144:18:45 Cernan: Okay, we're still headed northwest, Bob. (Pause)

[Jack's photos taken during the remainder of the drive to Station 3 are AS17-138-21138 to 21142.]

144:18:51 Schmitt: Okay, Bob, I guess one thing we don't have a handle on yet is - (and) I think we sampled them once in a Rover sample - what are the fragments out here (that are) mixed with the light mantle?

144:19:07 Parker: Okay, I copy that.

144:19:08 Schmitt: I think I got one at our last gravimeter stop, a small one, and I guess there's one other Rover sample, but, at Station 3, we probably ought to make sure we get a representative suite of those fragments.

144:19:21 Parker: Roger. Agree to that.

144:19:25 Cernan: Hey, Bob, how long have we been out?

144:19:28 Parker: Say there again, Gene? (Pause) How long have you been out?

144:19:32 Cernan: How long have we been out?

144:19:34 Parker: Three plus four five, (that is, three hours, forty-five minutes since depressurizing the cabin to below 3.5 psi).

144:19:40 Cernan: Thank you. We're at 083/5.7. (Pause)

144:19:54 Schmitt: Well, it certainly doesn't look like the geology of Norway, but it certainly is interesting. (Pause)

[Jack had done his Ph.D. dissertation work in Norway for a year and a half. Several of the names he gave to features in the valley have Norwegian origins.]

144:20:00 Cernan: That must be Lara right there, huh?

144:20:01 Schmitt: Yeah.

144:20:02 Cernan: On the left. You can see the blocks on the other side of her.

144:20:04 Schmitt: That's right. I told them about those earlier. That's the only...I think, Gene, you want to bear a little bit...

144:20:09 Cernan: Hold on...

144:20:10 Schmitt: ...a little bit to the left. See those two craters, two bright craters, that are just this side of Lara?

144:20:18 Cernan: No...well...I'm not...

144:20:17 Schmitt: You're pointed right...almost right at them, now.

144:20:22 Cernan: Okay, I can barely see them now through that high gain.

144:20:23 Schmitt: Okay.

144:20:24 Cernan: But I can see...I know where we're going now.

144:20:25 Schmitt: Those are the two I think they wanted us to be at, and I think that's a good choice - if we can get up there.

144:20:30 Cernan: Ah. I want to get some 500s (of) the way that scarp flows up on top of...Well, it looks like it flows up on top of the North Massif. Now it may look like the North Massif may drape material down upon it. Look at that.

144:20:43 Schmitt: Well, (pause) not really. The texture is so different. It just doesn't look like as old a surface.

144:20:51 Cernan: But definitely different. (Pause)

144:20:53 Schmitt: Yeah. (Pause) Wish they had never said anything about pictures, because I've tended to not take enough (in order) to do better.

144:21:04 Parker: Okay, but Jack, you're doing quite well in the picture department;...

144:21:06 Cernan: (Giving a range and bearing) 085/5.8

144:21:06 Parker: ...You're not getting too far behind or ahead. Copy that (bearing and range), Gene.

144:21:11 Schmitt: No, but I mean I'm not sure I'm getting the coverage I should.

144:21:17 Parker: Okay. We'll look at the frame counts when you get to Station 3.

144:21:21 Schmitt: Oop, oop! (Pause) Oh, there's another big crater with a pit in it.

144:21:31 Cernan: (Nonchalantly laying claim to a lunar speed record) What was it, 17-1/2 or 18 clicks we hit coming down the Scarp, Jack?

144:21:36 Schmitt: I don't...(Laughs) I'm in Min cooling now. (Pause)

[Cernan - "I may have been exaggerating a little about 17-1/2 or 18 clicks, but I know we were going at least 14 or 15 clicks coming down there. We were really moving. (Smiling) But, then, what can I say? There it is, documented: 17-1/2 or 18 clicks."]

144:21:54 Cernan: Oh, look at that. Wait until you get over here and look at that South Massif.

[Unless Gene has mis-spoken, he has turned enough that he can look south toward the mountain.]

144:21:58 Schmitt: Is that...

144:22:01 Cernan: Well, I don't know where we're going to get a good...(Pause)

144:22:08 Schmitt: Well, let's see. You know, that big block up there might be worth going to.

144:22:13 Cernan: 087 at 5.9. I think that's the best station we've got right here.

144:22:16 Schmitt: Well...

144:22:17 Cernan: Let's see what's over on your right. Let's see if we can get at that scarp over there.

[Gene is driving in a northwesterly direction and "on your right" could be north along the Scarp.]

144:22:22 Schmitt: I've sort of lost track (of the two bright craters)...

144:22:23 Cernan: We're about there (pointing at the map).

144:22:24 Parker: I think we expected you guys to be a little bit farther north...

144:22:26 Cernan: I think we want to be more to the left.

144:22:26 Parker: ...We were guessing a heading (means "reading") of 080 for the bearing (to the LM) which really kind of says you were going a bit farther north than this.

[Parker is confused. 080 was the bearing at the cancelled LRV stop. Houston estimates that Station 3 will be at 089/6.1. Gene is currently at 087/5.9, a short distance southeast of where they want to be.]

144:22:35 Cernan: Well, there's that fresh crater, there, Jack.

[They are planning to stop at near one or the other of two fresh, 15-to-20 meter craters in the area. One of them is in sight.]

144:22:38 Cernan: (Realizing that what Parker has just said doesn't make sense) 080?

[Cernan - "We were going north and, as we did, the bearings to the LM were going to get higher and higher. We would have had to have gone south to get to a bearing of 080."]

144:22:40 Parker: Roger. 080 is where we think...
 144:22:42 Schmitt: All of a sudden I've lost track.
 144:22:45 Parker: Standby.
 144:22:47 Schmitt: There's nothing wrong with that except that...(Pause) I think we ought to go back to that big block.
 144:22:51 Cernan: Heading 080 is...Heading north is not going to...
 144:22:54 Parker: Roger. I just realized that, Geno.
 144:22:58 Cernan: I'm 087 now!
 144:22:59 Parker: Yeah, I realize that, Gene; my mistake. Somebody's got a wrong thing down here.
 144:23:07 Schmitt: Gene, I think...
 144:23:08 Parker: That's the Hole-in-the-Wall (stop). My mistake.
 144:23:13 Schmitt: I think we need to go back there a little bit.
 144:23:15 Cernan: Yeah, we're at 087/6.0. I think that's probably (garbled). Let me get up on the top, here.
 144:23:19 Parker: Okay, 17, that's a great stop. That was my mistake, I was reading the Hole-in-the-Wall coordinate.
 144:23:25 Schmitt: All right, Bob, we've got us some boulders over here that are in the light mantle.
 144:23:32 Parker: Okay, now, let me brief you on Station 3. It's going to be a very brief station to make up for the...
 144:23:36 Schmitt: We can see a little bit down into Lara, now, too.
 144:23:38 Parker: Okay, it will be a brief station to make up for the time we added on at the...

[For the next few moments, we have period of overlapping conversation. Gene, with Jack's help, is orienting the Rover so that it is level and the sun-shadow device reads zero. They will ignore Parker until they are finished. Some of the Rover dialog is lost under Parker.]

144:23:40 Schmitt: How'd we get up here, again?
 144:23:42 Cernan: I just drove (garbled). (Pause) (Garbled) 045 (Garbled)
 144:23:48 Parker: ...First of all, remember we want to get the nav update. Let me go into a heading of 270 more or less and give us the nav read-out so we can start that here.
 144:24:00 Cernan: (To Jack) Can you get where you want to from here? No, this is no good. I wanted to get a high spot. (Pause) Yeah, let's...Let me park down here, Jack.
 144:24:09 Schmitt: Well, you should have stayed up there.

144:24:12 Cernan: Yeah, I want...(Pause) This is good right here. (Pause)

144:24:16 Schmitt: It's not going to be very level for the gravimeter.

144:24:18 Parker: Gene, remember, we want to head for the west so we can get the nav update.

144:24:27 Schmitt: (Garbled) you park right out here and we can work those blocks right up behind us.

144:24:30 Cernan: (To Parker) Okay, you want a nav update here?

144:24:32 Parker: Roger. That's affirm.

144:24:34 Schmitt: (To Gene) You need to get your (low-gain) antenna.

144:24:39 Cernan: Why don't you get off, Jack? Oh, I was looking at the wrong dang (checklist page)...Oh, no, I'm not. Okay. I'll get a nav update (as per CDR-15). (Pause) (To Jack) Get off and look around. I'll give them a nav update, Jack, and we'll press on. (Pause) Yes, sir, you're right, Bob. (To Jack) Hey, get your (scoop)...

144:25:05 Schmitt: I will. (Long Pause)

144:25:20 Cernan: Okay?

144:25:21 Schmitt: Go ahead.

144:25:22 Cernan: What do you need? Take your scoop or whatever you need.

144:25:24 Schmitt: Oh, you're going to move?

144:25:25 Cernan: Yeah. I want to give them a nav update real quick.

144:25:27 Schmitt: Oh, I'm sorry. (Pause) Okay. I've got the scoop (off the gate).

144:25:31 Parker: Okay. And, Jack, an update for you. We're going to want you to do some documented sampling on your own. I'll get with you guys on the rest of the station plan, shortly. Go ahead, Gene, we're ready.

144:25:46 Schmitt: (To Gene) Okay, I ought to get the gnomon, I guess.

144:25:49 Cernan: Okay, let me find a level spot; I'll come back towards you.

144:25:53 Schmitt: I'll get it. (Pause)

144:25:58 Cernan: Well, there is no (level spot). Well, okay, if you got any...

144:26:00 Schmitt: No, go ahead, make your park.

144:26:02 Cernan: Yeah, I'm looking for a level spot, but my God, there sure aren't very many.

144:26:08 Schmitt: That's probably pretty good. (Pause)

144:26:13 Cernan: It will be in a minute.

144:26:14 Parker: It doesn't have to be all that level, Gene. (Long Pause)

144:26:27 Cernan: Okay; 087,12.6, 6.0.

[The bearing to the LM is 087 (east), the range is 6.0 kilometers, and they've driven 12.6 kilometers. The latter figure includes about an 800 meter excess over the map distance due to the need to drive around craters. The map distance to Station 3 is the sum of the 0.3 kilometer

eastward displacement of the SEP transmitter from it's planned location, 6.1 kilometers from the planned SEP site to Hole in the Wall, 2.3 kilometers from there to Nansen, another 2.3 kilometers back to Hole in the Wall, and 0.8 kilometers from there to Station 3.]

144:26:30 Schmitt: I got your gnomon.

144:26:32 Cernan: Sun shadow is zero. Pitch...If I can get it over to read it. Pitch is...Pitch is zero. (Pause) Roll is zero. About one (degree) left, Bob.

[The pitch and roll indicators are part of a single instrument mounted on the left side of the control console, as can be seen in a drawing reproduced at 117:45. Normally, the pitch indicator faces Gene and, in order to read roll, he has to rotate the instrument 90 degrees.]

[Cernan - "While it is possible that I was leaning over to the right and maybe down a little bit to read the pitch indicator without parallax, what 'get it over to read' sounds like is that the indicator had flopped up and was showing me roll when I wanted to read pitch first."]

144:26:56 Parker: Okay, copy. And how about...

144:26:57 Cernan: About one left.

144:27:00 Parker: And how about heading?

144:27:03 Cernan: Heading is 282.

144:27:06 Parker: Okay, go ahead and park. We'll give you an update when you get done. (Pause)

144:27:09 Cernan: What else do you need?

144:27:10 Parker: That's all we need. Go ahead and park on your 045. We'll give you an update when you are done.

144:27:21 Cernan: Jack, is it worth coming right there?

144:27:26 Schmitt: Looks like a pretty good location.

144:27:28 Cernan: Okay.

144:27:30 Schmitt: We can sample the rim materials of this crater. (Pause) Bob, I'm at, let's say, the east-southeast rim of a, oh, 30-meter crater - in the light mantle, of course - up on the Scarp and maybe 300...(correcting himself) 200 meters from the rim of Lara in a northeast direction.

144:28:08 Parker: Okay, I copy that.

144:28:09 Schmitt: It probably shows up as a bright crater on your map. There's only about a half a centimeter of grey cover over very white material that forms the rim.

144:28:23 Parker: Okay. And, Gene, give me a call when you get parked and I'll give you an update on what we want to do.

144:28:38 Cernan: Okay, I am parked.

144:28:40 Parker: Okay. We'll take the Rover read-out first.

144:28:45 Cernan: Okay. 087, 12.7, 6.0; 105 and 100. On the battery temps: 100, 120. The rear motors are off scale low and the forward motors are 0 and 240.

144:29:03 Parker: Okay, we copy that. Understand that 240 now instead of a 340. And what is the heading, 045?

144:29:13 Cernan: Heading is 043.
 144:29:15 Parker: Okay. We copy that.
 144:29:16 Cernan: If I ever gave you a motor temperature of 340, that figure was erroneous.
 144:29:23 Parker: Okay; Roger. And what we'd like you to do, Gene, is we'd like you to get the CSVc by yourself, that will essentially be your sole task at this station. We'd like Jack to do some solo sampling. We'd like to get one pan and the gravimeter, and then we'll leave this station. We're going to absorb some of the time we spent with the extra gravimeter reading and some of the time we absorbed at Station 2 in the longer stay time in sampling at Station 3. That's our plan. So it will be CDR (Commander) for the CSVc - or the long can, excuse me - and LMP (Lunar Module Pilot) for solo sampling and then a pan by Jack, I presume, and then the gravimeter and then leave. And, Jack, you might check your film. We aren't quite sure where you are right now, before you get too far from the Rover.
 144:30:17 Schmitt: Okay, Bob. (Long Pause)

[Gene will take a core sample, hammering a connected pair of drive tubes into the ground. The long can (Core Sample Vacuum Container or CSVc) is designed to hold one of the drive tube sections. The tasks originally planned for Station 3 are listed on LMP/CDR-17. TV on.]

144:30:46 Cernan: Bob, you got (pause) any preference up in this area where you want that long can?
 144:30:54 Parker: Negative. That's something that was sort of near the Scarp, but you're parked so near the Scarp and that's something, remember when we do it in solo, we only did it with the Rover, so you'd have to stay right there beside the Rover and do it. No expectations of doing it otherwise.

[Schmitt - "Gene needed someplace to lay the long-can cap. When we did it together, I'd hold the cap."]

144:31:09 Cernan: Well, that's what I figured.
 144:31:10 Schmitt: Gene. I think you're in good shape.
 144:31:13 Cernan: Yeah, I don't have any other choice.
 144:31:15 Schmitt: Matter of fact, if there is a scarp, and if it is a fault...
 144:31:18 Cernan: I'm right...
 144:31:19 Schmitt: ...you're right on it because the projection of it would be uphill a little bit.

[They are parked just east of the top of the scarp. Fendell pans counter-clockwise.]

144:31:22 Cernan: Yeah, I'll be right on the side of it. I'm parked on the side of it if it exists.
 144:31:25 Parker: Okay, and, Jack, what's your frame count?
 144:31:35 Schmitt: (Having difficulty reading the indicator) Well, (pause) 122.

144:31:43 Parker: Okay, copy that.
 144:31:44 Schmitt: Bob, I've dug a trench in the...
 144:31:44 Parker: (To Jack) You can work the rest (of the Station) without a mag change. (Making a mis-identification) Go ahead, Gene.
 144:31:44 Schmitt: What do you need, Gene? (Pause) (Realizing whatever it is that Gene needs) Oh, yeah. (To Parker) Bob, I dug a trench in the side of this crater. I've got down-Sun pictures of it. There's quite a marbling of light and dark soil or fine grain material. It looks as if there's a uniform, about 3-centimeter (thick) layer of light material over that marbled light and dark. On the very top surface, there's a half centimeter of light grey, and when I say "dark", I mean a "medium grey".

[Fendell briefly catches Gene on his way to the gate. Jack's cross-Sun and down-Sun before pictures of the trench are AS17-138-21143 to 21147. 21148 and 21149 are the afters he has just finished taking.]

144:32:33 Parker: Okay, copy that. Sounds like a great sample site.
 144:32:38 Schmitt: Okay, I'm going to start sampling the soils, and then I'll get you the fragments.

[Fendell finds Jack on the rim of a small, raised-rim crater northwest of the Rover.]

144:32:43 Parker: Okay, I presume that we'll at least have the single upper core which we can use to sample that stuff in the soil (that is, the light-colored, subsurface material which, presumably, is similar to the material Gene had discovered at the Station 2 and at the Scarp gravimeter stop). And we...
 144:32:57 Schmitt: Oh, there's no guarantee (that we can reach it). This is a crater rim.
 144:33:00 Parker: Okay. And, Gene, are you still near the Rover?
 144:33:07 Cernan: Yeah, I am.
 144:33:09 Parker: Okay, we'd like to get the SEP blankets opened, Gene, and dusted if they're dirty, so they can cool some more.
 144:33:18 Cernan: (Unhappily) Oh, boy!
 144:33:20 Parker: (Sympathetically) Yup.

[Fendell looks at Jack, scooping soil with his back to the Rover. The low-gain antenna is in the way.]

144:33:21 Cernan: (Resigned to the dusting) Okay! Now I can't give you the gravimeter reading while I'm working on the Rover, so I'll have to time it when I get away from it.
 144:33:29 Parker: Okay. Roger on that. I think you'll be pounding on the hammer for a long while while you can take the gravimeter reading.

[Jack pours soil in a sample bag; he gets about a half cup.]

144:33:36 Cernan: Yeah. Well, we'll see. Let me get your brush back. (Pause)

[Jack plants the scoop in the ground and closes the bag.]

144:33:50 Schmitt: Okay, bag 520 has a skim sample of the upper light-grey soil. Don't know where I'm going to put these things, I've got to come down and get a bag.

[Jack goes to the Rover to get an SCB. There are sample bags hanging from his camera.]

144:34:10 Schmitt: Have you punched the gravim(eter)?...No.

[The gravimeter will remain on the Rover for this measurement. If Gene had started the measurement, Jack couldn't have gotten an SCB off the Rover without ruining the measurement.]

144:34:13 Cernan: No, I can't punch it until I get out of here. (Long Pause) These (SEP) switches are in Off and Standby, right?

144:34:29 Schmitt: They should be.

144:34:31 Cernan: Okay, that's where they are and the temperature is about 104 and...

144:34:35 Schmitt: No, they should be Off. Isn't it Off?

144:34:37 Cernan: No, it was Standby.

144:34:38 Schmitt: No, push it Off.

144:34:40 Parker: Okay, it doesn't matter whether it's Standby; it won't be (garbled) that temperature anyway, but put it Off.

144:34:46 Schmitt: Okay. It might have gotten hit when I changed the blanket. (Pause)

[Fendell is looking at a small crater north of the Rover.]

144:34:59 Cernan: I've got to go to Intermediate cooling here. (Pause) (I'll) zap me with a cold. (Pause) Nice to know those PLSS's got charged okay last night.

144:35:16 Parker: Yeah, 17, the PLSS's look great.

144:35:21 Cernan: Okay, back to Intermediate. How's Ron doing?

144:35:25 Parker: They're both looking...Stand by. (Pause) Ron's doing great, too. He's sitting here busily...

144:35:37 Cernan: No, no.

144:35:38 Parker: Go ahead.

144:35:43 Cernan: I mean Captain America.

144:35:45 Parker: Yeah, I'm just inquiring of Bob (Overmyer, the Command Module CapCom). I think he's doing great. He's just passed a little bit north of you a couple of minutes ago and took some pictures of you. (Long Pause)

[The TV jostles as Gene works around the Rover. Fendell returns to Jack at the rim of Ballet Crater, so named because of later events.]

144:36:17 Cernan: Okay! I do my work around the LMP seat here. That's lock. That must be unlock. Okay, unlock. (Pause) Rake is off. (Pause) Core (tube) is coming in.

[Gene is out of sight at the gate and, having removed the long-can cap and having taken the rake off of one of the extension handles, is fitting the extension handle on the drive tubes. Jack has a sample bag in his left hand and gets the scoop in his right. If he has gotten an SCB off of the Rover, it isn't currently visible.]

[Schmitt - "As I recall, I spent a few tens of seconds trying to find a place to set it so that it would stand; and I think I ended up off to the side a bit with it."]

144:36:54 Schmitt: Okay, Bob, the upper...The upper 5 centimeters...(adjusting his estimate as he looks at the layer) 3 centimeters mixed with that upper half centimeter, is the next sample.

144:37:09 Parker: Copy that. (Pause)

144:37:19 Cernan: Okay, Bob, I guess I'm going to go pound away (on a drive tube); and, Jack, I'm going to hit the gravimeter.

[Jack plants the scoop.]

144:37:24 Schmitt: Okay. (Pause)

144:37:30 Cernan: Okay. Mark it.

144:37:31 Parker: Copy that.

144:37:36 Schmitt: And 521 is the sample bag.

144:37:41 Parker: Copy that. (Long Pause)

144:37:57 Cernan: Well, the first core has gone down pretty good, Bob.

[The drive tube sections are each 42 cm long.]

144:38:01 Parker: Okay, great.

[Fendell leaves Jack.]

144:38:04 Schmitt: Oh, you won't have any problem in here coring. (Pause)

144:38:13 Cernan: Oh, man, I tell you, I wish I was putting a drill hole in here. This is pretty nice. (Pause)

[Fendell backtracks and goes by Jack again as he refurbishes his trench and gets the next sample.]

144:38:30 Schmitt: Okay, Bob. The next sample is mostly the medium-grey fraction of the marbling. It's mixed, though.

(Long Pause) That's in bag 522. (Pause)

144:39:34 Parker: Copy that, Jack.

[Schmitt - "With two of us working together, bagging samples was fairly easy; but it was a lot harder solo. A lot harder. You had to hold the bag in one hand, and somehow or another get your scoop out over it so that you could dump something in it. And it was not easy, because you're moving your arms against the pressure in the suit while gripping both the bag and the scoop."]

[Jack sounds tired. Fendell finds Gene, southeast of the Rover, pounding the core with the flat of the hammer. It is going in at about 2 inches per stroke. Because he is working above waist height, the suit allows him to swing the hammer in a vertical plane.]

144:39:38 Cernan: Okay, I think I got it. I think I got it, Bob.

[Gene stops hammering; puts the hammer in his shin pocket and looks at his checklist.]

144:39:41 Parker: Okay. (Pause) And, Jack, when you get done with this trench you might hit one or two of those blocks there, but then we'd... Since we're really trying to cut this station down to a minimum, after that you'd probably better get to the pan.

[Gene goes to the Rover.]

144:40:02 Cernan: Bob, what do you think, can I read a gravimeter?

144:40:05 Parker: Yup, if it's not flashing...

144:40:07 Cernan: The light's out.

144:40:09 Parker: Yeah, it should be just done.

144:40:15 Cernan: 670, 049, 701; 670, 049. 701.

144:40:21 Parker: Okay, I copy that.

[Gene gets a 70-mm camera from Jack's seat.]

144:40:24 Schmitt: Bob, the white fraction in the marble zone (is) in 523.

144:40:34 Parker: Copy that. (Pause)

144:40:41 Cernan: Bob, I forgot to give you the core numbers, but I will.

[Gene takes a stereo pair of the drive tube from the south. These are AS17-137-20981 and 20982.]

144:40:45 Parker: Okay. (Pause) And don't forget to put your little note in the long can there.

[Gene puts the camera on Jack's seat so that he can work more easily with the core and the long can.]

144:40:55 Cernan: Oh, I'll get the note in there. I'll get it in there. (Pause) Nobody will ever know! (Long Pause)

[Schmitt - "There was no note. Gene and Bob were just teasing the scientists, threatening to contaminate the sealed sample. This was a real-time 'put on' that Parker came up with; and Gene just fell in with the spirit of it instantaneously. I'm pretty sure it wasn't planned, although it could have been based on something that had come up in training."]

[Cernan - "I don't remember this, but I don't think there was any note. It was just a little bantering back and forth between Bob and I to make people wonder. I'd like to know if that can's ever been opened, because I think they were going to keep it sealed for some indeterminate length of time."]

[In a recent conversation, Parker recalled that this sample was going to be preserved in pristine condition until significantly better analytic techniques became available. During training, they had joked about putting in a note. The long can would be a time capsule and the note would be a surprise greeting from the past. Of course, an actual note would have contaminated the sample and would have spoiled the joke.]

[Gene grunts as he pulls the core out of the ground.]

144:41:37 Schmitt: Okay, Bob, 524 is what I think is a blue-grey rock, probably the breccia. It got a little dust covered.

144:41:47 Parker: Copy that.

[Twelve of the fifteen rocks Jack collected at Station 3 turned out to be breccias, four of them blue-grey and very similar to the blue grey boulders sampled at Stations 2, 6, and 7.]

144:41:48 Schmitt: From just off the rim of this little crater.

[Gene examines the end of the core and then brings it to the TV camera.]

144:41:56 Parker: Okay, copy that. It's a blue-grey rock, it's not part of the trench, right? You finish with the trench?

144:42:02 Schmitt: Yes.

144:42:04 Cernan: If you see it, Bob, it's full. See that?

[Gene is assuring Houston that, even in this soft soil, little of the core has been lost during extraction.]

144:42:08 Parker: Roger. We see a long thing in your hand there, Gene. (Long Pause)

[Gene has the tip of the core in his left hand and the body of the core in his right; he is standing at the right side of the Rover, facing forward, the core tube perpendicular to the Rover chassis and the tip pointing toward the rear-facing TV camera. We only get an oblique view of the dirt filling it. He flips the core 180 degrees, the top of it going up past his left shoulder, and turns his body 90 degrees so that he is facing the Rover, the core is parallel to the Rover chassis. Now, the tip is in his right hand, pointing forward and straight into the TV. It is chock full of soil. Individual pebbles or small clods are clearly visible.]

144:42:24 Schmitt: Well, I didn't think that was supposed to happen. (Pause)

144:42:30 Cernan: Well, I know... Jack? Shoot. Thought I had them (the core tube caps) on the Rover.

[Gene leans over Jack's seat. During the Rover preps at 141:03:27 Gene put a core cap dispenser on SCB-7 which, at 141:05:46, he then put under Jack's seat. At 141:16:50 he put another dispenser on SCB-8, which Jack wore until the end of Station 2. At 143:42:42 Gene briefly hung SCB-8 on the tool gate but then, at Houston's suggestion, Jack put it under his seat. Jack is currently wearing SCB-4.]

144:42:36 Schmitt: What?

144:42:38 Cernan: Oh, the core cap covers. I'll get them.

144:42:40 Schmitt: No, you got some there in that little (pause) pocket.

144:42:43 Cernan: Yeah, and there's so many bags in here, I can't get at them.

144:42:46 Schmitt: No, I mean the pocket on the Rover, on the back. Remember?

[It is not clear what pocket Jack is referring to here. Possibly a pocket on an SCB on the gate.]

144:42:51 Cernan: No, they're not. I took them out (of SCB-8) and put them on you.

144:42:52 Schmitt: Oh, okay.

[Apparently, Gene transferred the SCB-8 dispenser to SCB-4, the one Jack's is now wearing, when he changed Jack's bag at the end of Station 2.]

144:42:53 Cernan: The rest of them are in this bag (SCB-7). I'll come and get them. (Pause)

[Gene goes to Jack at the crater. Fendell starts panning.]

144:43:02 Cernan: See, there's others, but I don't want to get under your seat. We got those bags packed in there like gangbusters. How are you doing there by yourself?

144:43:10 Schmitt: Well, it's hard.

144:43:12 Cernan: Your hook (attachment for the SCB on the PLSS) came off. If you wait a minute, I'll hook it on this bag.

144:43:22 Schmitt: Okay. (Pause) I didn't think the sample bags could come off the camera. But they can.

[A twenty-bag packet of sample bags is attached to the camera bracket and that attachment isn't working properly. The Apollo 16 crew had a similar problem and the attachment had been redesigned in between the missions. As Jack tells Parker at 144:58:51, he has bent the "mounting point". At the end of the EVA, Jack will take a bag holder into the cabin with the camera and, during the rest period, will fix the attachment hardware. His bag holder will work perfectly during EVA 3.]

144:43:30 Cernan: Well. Doggone it.

144:43:33 Schmitt: What's your problem?

144:43:36 Cernan: (Might) just as well fix this bag now. Let me get this bag. It's going to come off at the bottom (attachment to Jack's PLSS tool harness) if I don't. It's going to come off again. I don't think the harness is tight enough now.

144:43:53 Schmitt: Want to tighten the harness?

[Fendell is examining layering on the East Massif.]

144:43:56 Cernan: Yeah. I got to, Jack.

144:43:58 Schmitt: Okay.

1144:44:43:59 Cernan: Let me get your harness. I might just as well do it, so it's right. (A little exasperated) If it's worth doing at all, it's worth doing right. (Pause)

[Cernan - "This is something that my father used to say, and I'm glad I said it on the Moon. 'If it's worth doing at all, it's worth doing right.' And then he add: 'Or you're just going to have to do it over again.' His name was Andy. Andrew George Cernan. And he also used to say 'I'll only ever ask of you to do your best.' Whether it was in studying, or playing football or playing the clarinet - which I tried to do but never did very well. 'You may not be better than everyone else at everything,' he said, 'but if you do your best, sometime, your going to shine in something. And there's only one person in the world who knows what's your best: and that's you.' A good man."]

144:44:18 Cernan: Now, let me try getting that bag back on. No, don't bend over; I can't get down there.

144:44:23 Schmitt: Okay.

144:44:24 Cernan: You're plenty short enough.

144:44:26 Schmitt: Thanks. Thanks a lot. (Laughs)

144:44:28 Cernan: This bag, that hook...There's something changing the geometry.

144:44:34 Parker: Okay, don't worry about it too much, guys; I'm sure the bag will stay on without the hook.

144:44:35 Cernan: (Garbled under Parker) (Responding to Parker) Yeah, it will; (that's) the conclusion I just came to.

144:44:43 Schmitt: You through?

144:44:44 Cernan: Yeah, go ahead. (Long Pause)

[Fendell pans past Jack, who is going to his Rover seat. Fendell then looks north along the Scarp toward Hanover.]

144:45:38 Schmitt: Okay, Bob, what I know is a blue-grey breccia is in bag 525.

144:45:47 Parker: Okay, copy that. (Pause) And, Jack, (are) you just scooping up little rocks along the surface there...in your little xenolith mode?

[A xenolith is a foreign rock; and Parker is suggesting that Jack collect as many different types of rocks as he can find.]

144:46:02 Cernan: Bob?

144:46:03 Parker: Go ahead, Gene.

[Fendell finds Jack back at the near rim of the crater. An SCB is now on the ground beside him.]

144:46:05 Schmitt: (Responding to Parker) Yeah, you read my mind. I do want to get one of these light-colored rocks, though.

144:46:15 Parker: Go ahead, Gene.

[Jack goes to the north rim of the crater and gets a scoopfull of soil.]

144:46:20 Cernan: Bob, when I broke the cores apart, there's just a lot of dry clods; and the bottom core's full, the top core about - oh, I got to look - it's dark down there, but about an inch (to an) inch and a half of the core has just zero-g'd or 1/6 g'd itself right out.

[That is, a small amount of dirt fell out of the core tube. Meanwhile, Jack's scoop has fallen to the ground. In order to free both hands for closing a sample bag, he leaned the scoop against his thigh, but it slipped off and fell.]

144:46:45 Parker: Okay, we copy that. I guess we still just cover it, and see what we got. Might just again trying compacting it after that's through...after you're done with the lower core.

144:47:00 Cernan: Yeah. I'll do that. (Long Pause)

[Jack bobs down on one knee and grabs the scoop. He has no trouble getting back up. He then goes to the SCB to stow the sample.]

[Schmitt - "Facing up a slope like that, it was easy to get down and back up."]

144:47:22 Parker: And, Geno, how about some core numbers.

144:47:23 Schmitt: (That was) bag 526.

144:47:26 Parker: Copy; 526.

[Jack gets another sample bag off the hook on his camera bracket, but drops the whole packet.]

144:47:37 Cernan: Okay, into the long can...I'll give it (the core tube number) to you; wait a minute.

[Jack leans on the scoop and retrieves the packet of bags easily.]

144:47:33 Schmitt: That may have been a piece of gabbro. But again, I can't be completely sure.

144:47:39 Parker: Copy that. Go ahead, Gene.

[Parker is anxious to get the tube number recorded.]

144:47:44 Schmitt: It's either that or anorthositic gabbro we saw up on the front. Up on the massif.

144:47:52 Parker: Okay.

144:47:53 Schmitt: And my bags aren't staying on my camera worth a darn.

[Jack is trying to reattach them to the camera bracket.]

144:47:56 Cernan: Forty-six, Bob, is gone into the long can.

144:47:58 Parker: Copy that. (Long Pause)

144:48:16 Cernan: Boy, another exercise in dexterity.

[Jack reaches for his cooling control, doing the double wave to reach back far enough.]

144:48:18 Schmitt: Okay, the LMP has gone to Intermediate (cooling). (Long Pause)

144:48:40 Cernan: And, by the way, I'm at about 49 percent (oxygen remaining) and 3.85 (psi suit pressure) and Intermediate cooling and no flags.

[With some difficulty, Jack hops up the soft, southern rim of the crater to look at a 12-inch by 6-inch rock.]

144:48:46 Parker: Okay, copy that, Geno. Have you got a number for the upper core when you're done? I guess you're probably putting the other one (the lower) in the long can, aren't you, right now?

144:48:55 Cernan: Yeah, yeah, yeah; that's right.

144:49:00 Parker: And somewhere here along the line, Jack, I guess maybe when you get those, you ought to stop and take the pan.

144:49:08 Schmitt: Okay, Bob.

144:49:11 Cernan: Okay, Bob, the long can is sealed and I guess nobody knows what's in it but me.

144:49:16 Parker: No one ever will, probably.

144:49:22 Cernan: And I may not even tell. (Pause)

[Jack demonstrates the difficulty of solo sampling. He is collecting four small rock fragments. He must hold the scoop by the end of the handle so that he can reach the ground and get a fragment. The scoop head is angled at 90 degrees and, after collecting each of the fragments, he tosses the scoop up, catches it near the head, tilts the scoop so that the fragments tumble to the heel of the scoop, and then lowers the scoop to collect the next fragment. The final time, he pours the fragments into a sample bag with some difficulty. By the end of the third EVA, he will have learned how to do solo sampling fairly efficiently.]

144:49:30 Cernan: It does not...None of the material in that core - in either the top section or the bottom section - looks unlike that stuff just beneath the surface that we sampled at that special (Scarp gravimeter) stop back there. It's a bluish-grey, and it tends to clod and break up in your hands. And that's core 31. The upper is 31.

144:49:49 Parker: Copy. Thirty-one on the upper.

[Jack picks up a rock with the scoop. He rests the scoop handle against his crotch, but it falls again.]

144:49:59 Cernan: Oh, man. (Pause) Bob, you've got better than...Oh, you've got two-thirds of a(n upper) core after I packed it down a little bit.

144:50:23 Parker: Okay, thank you, Geno. Copy that.

144:50:29 Schmitt: Okay, that little set of four samples is in 527, barely.

144:50:36 Parker: Okay, we hope it was worth the effort.

144:50:43 Schmitt: Oh, it's all worth the effort; it just hurts (the hands).

[Jack goes to the SCB.]

144:50:46 Parker: Okay. We're ready now for your pan and don't forget your scoop.

144:50:52 Schmitt: I won't...Aaaahh! (Pause)

[Jack has knocked the SCB over, scattering full sample bags. He drops to his hands and knees, facing upslope, gets the SCB standing upright, retrieves the sample bags, and stows them in the SCB without getting up.]

144:51:05 Schmitt: You don't mind a little dirt here and there, do you, gang? (Pause)

144:51:16 Parker: No. (Long Pause)

[Jack leans back to get his PLSS over his heels and kicks upright. He makes it, but drops the SCB in the process. He goes to one knee to retrieve it but stumbles and falls on his chest. He gets up successfully and goes to the scoop.]

144:51:46 Cernan: Oh, dadgummit! (Pause) Well...

[From later evidence, Gene is having trouble re-attaching the rake to the extension handle. Meanwhile, Jack's unused sample bags have fallen off his camera again.]

144:51:53 Parker: Hey, Gene, would you go over and help Twinkletoes, please?

[Jack drops the SCB on the ground.]

144:52:01 Schmitt: I tell you, (if) you fix that camera bracket so the bags stay on and I'll be a lot better off.

[Jack turns away from the TV camera while he examines his 70-mm camera to see how dirty it is.]

144:52:05 Parker: Roger.

144:52:07 Cernan: Want some help, Jack? I'll be there.

144:52:08 Schmitt: No! I don't need any help.

144:52:09 Cernan: Okay.

144:52:10 Schmitt: I just need better bags.

144:52:11 Parker: Jack, you might worry about whether your camera lens is dirty or clean, Jack. I don't know what you'd do about it.

144:52:19 Schmitt: I'm very worried about that.

144:52:20 Parker: I don't know what you'd do about it, but you might worry about it.

144:52:23 Schmitt: I don't have a thing to do...(Pause)
It's clean. (Pause)

144:52:36 Cernan: Well, I'll be a son of a gun!

144:52:37 Schmitt: What's your problem?

144:52:39 Cernan: (Chuckles) I can't get this thing (the rake) locked on.

144:52:42 Schmitt: What the...

144:52:43 Cernan: The rake!

144:52:44 Schmitt: The rake!?

144:52:46 Cernan: Yeah. That should lock. And I turn that like that. There it comes.

[Gene is attaching the rake to the extension handle; he had removed the rake head so that he could attach the extension handle to the drive tube. Jack is now facing south, still trying to clean his camera.]

144:52:53 Parker: Jack, if you haven't started your pan, could we get an EMU check from you?

[Schmitt - "This request for an EMU check was actually a code phrase which meant 'In our opinion, you need to slow down a bit; and, if you want to give us an EMU check, we'll take it.'"]

144:53:00 Schmitt: Well, it's about 50 percent. About 3.85.

144:53:04 Parker: Okay, copy that.

144:53:05 Schmitt: And no flags. (Long Pause)

[Jack takes a panorama while standing on the outer crater slope. When facing uphill he has to bend his knees and get on his toes to properly point the camera; when facing downhill, he only has to bend his knees. The pan photos are AS17-138-21150 to 21177. 21166 shows Gene at the Rover at about 144:54:00 where he talks about cleaning up Jack's seat. The Station 4 stop, Shorty Crater, is the very dark feature visible in front of the North Massif in 21161.]

[Cernan - "There wasn't anything very exotic about taking pans. In training, we'd use real film and get it developed to see how we did. Basically, you wanted to get the horizon and it was pretty obvious what you had to do to get what you were looking for. It was just common sense. The only real variation was when I was facing upslope, sometimes I would take a picture of the foreground, lean back and get the horizon, then come down, turn a little, and take a picture straight in front of me, and then lean back to get the horizon again. That would give not only a horizontally overlapping pan but a vertically overlapping one as well for the local area that had a big upslope to it. I did that on my own because I figured that film was the least of our worries. And there were other times when I might take the camera off and sighted along the top surface to make sure I was getting things like the flag. And, of course, you had to use a lens-barrel sight when you used the 500."]

144:53:36 Cernan: (Talking to the rake) Come on. Get back in there (into the stowage bracket on the gate). Okay, that's all put away. That (rammer) goes back on your back.

[Gene needs to put the rammer on Jack's PLSS. He had used the rammer to push followers into the drive tubes to compact and constrain the soil.]

144:53:47 Parker: Why don't you go over towards Jack, Gene, and then the two of you can pick up the scoop and the bag together and get back towards the Rover after that?

144:54:00 Cernan: Yeah, I'm cleaning up his seat here. I'll do that.

144:54:04 Schmitt: I think I can hack it.

[That is, he thinks he can manage by himself.]

144:54:08 Parker: And then, at that point, we're ready for you guys to leave.

144:54:12 Cernan: Whew...Okay. (Pause) Jack, I've got the rammer I've got to put on you. I'll just leave it on your seat right now.

144:54:28 Schmitt: Okay.

[Jack finishes the pan.]

144:54:33 Parker: We're watching you, Jack.

144:54:37 Schmitt: What's that?

144:54:38 Parker: I said we're watching you, but don't let that inhibit you.

144:54:44 Schmitt: Bob, I don't let anything inhibit me. And I don't stay mad very long.

[Schmitt - "I was acknowledging that I'd been mad at him."

[Jack gets the scoop by stepping on the head, thereby raising the handle.]

144:54:52 Parker: That was very good!

144:54:55 Schmitt: (Laughs, having dropped the scoop again)

144:55:01 Cernan: Well, there's an easy way to do everything.

144:55:05 Schmitt: The question is can you hang on to it once you've done it? (Pause)

[Jack manages to grab the upright SCB without trouble this time and then tries to get the unused sample bags. Gene arrives with the tongs.]

144:55:18 Cernan: Let me get those, Jack. Don't get down there. Let me get those.

144:55:22 Schmitt: (Facing away from Gene) Where are you? They don't stay on my camera anymore.

[With his tongs, Gene easily gets the sample bags. Jack goes to the Rover.]

144:55:29 Cernan: Well, we'll fix it. There's no reason why they shouldn't, according to this. (Garbled)...

144:55:34 Schmitt: (Garbled) the samples from that...Oh...I need it...I gotta go up there. Wait! (Calling loudly after

Gene) Take an "after". Cross-Sun, from over to the north of the gnomon.

144:55:45 Cernan: You didn't get an after, huh?

144:55:46 Schmitt: No.

144:55:46 Cernan: (Garbled)

144:55:47 Schmitt: Oh, I got it; I'll get it. If you'll mount this thing (the SCB Jack was using).

[Gene goes to the Rover.]

144:55:52 Cernan: Just set it there. Just set it there. Take four deep breaths. Bob, what else do you want us to do here?

144:55:58 Parker: Nothing! Get on the Rover and leave.

144:56:00 Schmitt: Get the heck out.

144:56:01 Parker: Don't forget the gnomon.

144:56:03 Cernan: Okay. We're going back to get that "after", and we won't forget it. (Pause)

144:56:13 Schmitt: I think you might be able to decipher this station, Bob.

144:56:21 Parker: That's the general idea.

[Jack's afters of the trench are AS17-138-21178 to 21180. This has been a very frustrating station for Jack. He had done some training doing solo sampling, but this station, more than any other in all of Apollo, offers support for his contention that, "We should have always sampled in pairs. It was just a lot more efficient."]

[Cernan - "Working in pairs has its advantages and we certainly saw that at Station 2. But, here, I was getting a core sample and that was a one-man job. There's no sense in two people doing that, so what is the other man going to do but something like take a pan and do some solo sampling? It's always nice to have the other guy to help and point things out, but you can still get a great deal of sampling done by yourself. Sampling seems to go smoother as a two-man operation because of the constraints of the suit: one guy can hold the bag and the other guy can pour a sample in. But it's also something you can learn to do by yourself. And, even when there are two of you doing the sampling, you have to wonder if you're really getting your money's worth out of the second guy. So, I'm not hard over on it like Jack is. This station was set up to be two one-man operations, particularly the core sample. Jack got a little frustrated. He dropped things, and his bags kept coming off, and he fell down. And all that adds up to the frustration that he feels about this station. But if one-man sampling had gone smoothly - which it could have - then he probably would have had a different attitude. Maybe the design of the tool should have been a little bit different or maybe there should have been different techniques, but I don't think that there should be a hard-and-fast rule about two-man sampling."]

[Schmitt - "I have no problem with the fact that we tried to do solo sampling; I'm just saying that it wasn't

very efficient. So I'll modify my position to say 'whenever possible'. Although, who knows? Maybe if we had worked in sequence - done the core together and then done the sampling together - it probably not have taken any more time and it certainly wouldn't have been as frustrating."]

[As mentioned above, by the end of the third EVA, Jack will be doing solo sampling fairly efficiently.]

144:56:23 Parker: And be advised that the switchboard here at MSC (Manned Spacecraft Center, now the Johnson Space Center) has been lit up by calls from the Houston Ballet Foundation requesting your services for next season.

144:56:34 Schmitt: I should hope so.

[Schmitt - "They eventually named this Ballet Crater."]

144:56:39 Cernan: Well, we can't use that one. The right-hand gate lock is...

[Gene is referring to the bag locks on the gate. He is trying to secure the SCB that Jack was using at the crater rim. On camera, Jack is going for the gnomon. In response to Parker's 'Ballet' comment, he does two, big, one-footed hops on his right leg, with his left leg extended up and back, flexed at the knee. He is on the outer slope of the crater, hopping toward the rim. After the second hop, he loses his balance and falls on his hands and knees. Clearly, he is playing. Fendell pans away.]

144:56:46 Schmitt: (Asking Parker about his ballet style) How's that?

[Schmitt - "I don't remember this, but I'm sure I was playing. It wouldn't have been out of character, and it was a major effort to get the heel up high."]

[Cernan - "You have to develop confidence in the suit. You didn't want to roll down into a rocky crater and bust up the PLSS, and you didn't want to tear the suit on a rock. You were cautious and were aware of the possibility of busting something on the suit if you did something extreme. But the suit had to be designed so that, in ordinary operations, what you did was more constrained by the inherent mobility and flexibility of the suit rather than by safety. You wanted to be sure that safety considerations simply didn't arise. Jack would have been a lot more careful had he been walking through a boulder field but here, on this little crater rim, there weren't any rocks, and this little bit of playing wasn't particularly dangerous at all."]

144:56:47 Cernan: ...non-functional ...

144:56:48 Parker: Okay.

144:56:49 Cernan: ...and the left one is almost nonfunctional.

144:56:50 Parker: Okay.

[Fendell pans back to Jack, who has gotten up, apparently without difficulty.]

144:57:00 Cernan: Once you get it (the bag latch on the gate) open, you can't get it locked. I'll dust them if I get a chance, but it's locked on the left side.

144:57:07 Parker: Okay, well, we'll keep those bags underneath the seat, anyway.

144:57:09 Schmitt: Here, I'll work on it.

[Jack returns to the Rover.]

144:57:10 Parker: I think the samples are safer under there, anyway.

144:57:15 Schmitt: We don't have any room! Well, we can take bag 7 out.

144:57:20 Cernan: That one's locked...in good shape. Let's press on. We got the (gravimeter) reading? Let me put the rammer on your back and see if we can't get this (sample bag holder) on your camera. (Pause)

[Fendell pans north, looking at the near-field.]

144:57:42 Schmitt: Are we going to run the SEP this time?

144:57:44 Cernan: I don't know; he hasn't said anything. I expect he will.

144:57:47 Parker: No, we will not turn the SEP on, guys. You might cover it with the (thermal) blankets as well as you can. And how about a temperature reading before you leave, when you do that?

144:57:56 Cernan: It's one hundred.

144:57:58 Parker: Copy that. 100, and understand both switches are Off and the covers are closed.

144:58:05 Cernan: Well, the covers are closed now. They weren't.

144:58:07 Parker: Okay. Roger....

144:58:08 Cernan: They're not going to stay closed.

144:58:09 Parker: ...That's what I mean.

144:58:10 Cernan: (To Jack) Okay. Turn the other way. Left. Let me just slip this (rammer)...

144:58:16 Schmitt: Well, I don't know why it (the bag holder on his camera bracket) isn't staying on, but it certainly isn't.

144:58:19 Cernan: Move over and turn...Okay.

144:58:22 Schmitt: Is that the same one? I may have bent it.

144:58:27 Cernan: I think you did, now.

144:58:28 Schmitt: Yeah. I just bent that, didn't I?

144:58:35 Cernan: Yeah, that's not going to stay on. Yeah, you bent it (chuckles) very well.

144:58:40 Schmitt: Wonder how I did that?

144:58:41 Cernan: I don't know. You'll lose these bags.

144:58:45 Schmitt: Okay, well, we'll...

144:58:46 Cernan: I got bags.
144:58:47 Schmitt: We'll revise our procedures.
144:58:49 Cernan: I got bags.
144:58:51 Schmitt: (To Parker) I guess I bent my camera
brack(et)...mounting point...the camera point.
144:58:56 Cernan: Turn around.

[Fendell finds them at Jack's side of the Rover.]

144:59:02 Schmitt: We may have to think about a fix there.
144:59:07 Cernan: We might be able to fix that in the
cockpit.
144:59:09 Schmitt: Yep.

[Cernan goes to his seat.]

144:59:10 Parker: Okay...
144:59:11 Schmitt: Okay, are we all through, have you got...
144:59:13 Parker: ...(we'll) worry about that when you get
back in (the LM). (Pause)

[Jack waves into the TV.]

144:59:26 Cernan: Okay, where are we here?
144:59:29 Schmitt: I'll get on.
144:59:30 Cernan: Okay.
144:59:31 Schmitt: Oh, I guess I need to get another film
mag, huh?
144:59:33 Parker: Okay, how about frame counts on both you
guys before you start?

[Jack goes to the gate.]

144:59:43 Schmitt: 152 for the LMP...
144:59:45 Parker: We suggest magaline...(correcting
himself) magazine Juliet, please.
144:59:51 Schmitt: (Laughing) Okay, we'll get "magaline"
Julieing.

[This is Apollo magazine 133.]

144:59:55 Cernan: CDR's on 118.
144:59:58 Parker: Okay, copy that, Geno. (Pause)
145:00:06 Schmitt: Fire, fire, two frames. You know, I'd
enjoy this if it weren't so much fun.

[Jack advances the film two frames so that, when he
removes the magazine, he won't lose any pictures.]

145:00:16 Cernan: Okay, you going to change your mag.
145:00:18 Schmitt: Yeah.
145:00:19 Cernan: (I'll) shoot a 500 while you're doing
that. (Jack laughs) No sense in me sucking my thumb
145:00:24 Schmitt: I know.

145:00:25 Parker: 17, we'd really like the...
 145:00:26 Cernan: (Laughing) Any time you want to do something, though.
 145:00:28 Parker: ...we'd like to press on as quickly as possible.

[Fendell finds them at Cernan's seat. Jack hands out the 500 mm camera.]

145:00:31 Cernan: I got it.
 145:00:32 Schmitt: Got it?
 145:00:33 Cernan: Got it.
 145:00:34 Parker: In case you didn't get...
 145:00:35 Schmitt: Take a portion of the scarp over there you can see.
 145:00:38 Parker: 17, do you copy? Houston.
 145:00:42 Cernan: What?
 145:00:43 Parker: We'd like to press on...
 145:00:44 Cernan: What?
 145:00:45 Parker: ...as soon as possible, please.
 145:00:48 Schmitt: Yes.
 145:00:49 Cernan: We are, Bob, but he's got to change his mag.
 145:00:53 Parker: Roger.
 145:00:54 Cernan: I'm going to stand here and look around.
 145:00:57 Parker: Okay.

[Jack has a film magazine from under Gene's seat. He has taken the dark slide out of the new magazine and has put the dark slide on his seat. He then removes the old magazine and puts that on the seat.]

145:01:05 Cernan: Okay, I'm picking up with (500 mm) mag - or (correcting himself) with frame 56 - and I'm going to try to get a little bit of where the scarp overlaps the North Massif. I can't see much of it...(Pause) All I could get was three frames of that. Now I'm picking up the South Massif. (Long Pause)

[Jack has finished loading the new film magazine, having secured a latch across the top. He gets the dark slide and inserts it into the used magazine. This is delicate finger work.]

[Schmitt - "It still amazes me that we could manipulate that dark slide, particular with our hands so tired."]

[Gene's four pictures of Hanover and the Scarp on the North Massif are AS17-144-22047 to 22050. The first of these is a superb picture. His photos of the South Massif summit are AS17-144-22051 to 22071. 22056 is the best display of outcropping.]

145:02:23 Cernan: Okay, how are you coming, Jack?
 145:02:26 Schmitt: Okay. Oh, I ought to put that (used mag) in there so you've got room for your (500 mm) camera.

145:02:34 Parker: You got a final frame count there, Gene?
 145:02:43 Schmitt: (To Gene) Okay, I'm all set. (Pause)

[Jack goes around the back of the Rover to his seat.]

145:02:51 Cernan: Okay, Bob. When I finished the South Massif, I was on 94 and now I'm on 99. I took five more pictures back over to the northeast.

[Gene's photographs of the summit of the Sculptured Hills, of Wessex Cleft, and of the eastern slopes of the North Massif are AS17-144-22072 to 22077.]

145:03:02 Parker: We copy that. (Pause) And we assume you guys are ready to go by now.

145:03:10 Cernan: Yes, sir. And, Bob, they were all (taken) with the lens cap off.

145:03:17 Parker: Splendid.

[Schmitt - "I think that during training, somebody took a bunch of pictures with the lens cap on, and it was always a big joke afterwards. On the 500 mm, you don't look through the lens to sight it. So you could leave the lens cap on and not know it. It was built that way because, with your head inside the helmet and the camera outside, the camera was a long way from your eye and a viewfinder would have been useless."]

[At other stations when we get to see the 500-mm being used, a gunsight is visible on the lens barrel.]

[Cernan - "With the 500 mm, unlike the 70 mm, if you moved it just a little bit you didn't get what you wanted. So the bullseye helped us a lot."]

[Fendell watches Jack as he mounts the Rover. He grabs the SEP mast with his left hand, kicks his feet up and bounces down on to the seat.]

145:03:26 Cernan: Okay.

145:03:27 Parker: Okay. And, Jack, what's the heading say?

145:03:28 Schmitt: (To Gene) Why don't you fix that high gain so you can see?

145:03:32 Parker: We'll get the reading we need for the nav update. Do you think you can give us the heading right now?

[TV off.]

145:03:40 Schmitt: Okay, heading is four (pause) one (41)...I think. I'm at a little bit of an angle. Better let Gene do it for you.

145:03:50 Parker: Okay. We're waiting.

145:03:51 Schmitt: I've got some parallax. I think it's four-one, though.

145:03:59 Cernan: What you looking at?

145:04:01 Schmitt: The heading.

145:04:02 Cernan: 043 is what I gave 'em earlier.

145:04:07 Parker: Yeah, we were wondering if it drifted while you were there, because we're going to give you, now, a...

145:04:10 Cernan: Bob, let me...

145:04:11 Parker: ...going to give you one to update it, if it has drifted at all.

145:04:15 Cernan: Okay, it did drift, 041 is a good number.

145:04:18 Parker: Okay. Stand by. (Pause) Okay. That's fine. No torque necessary, Geno.

145:04:30 Schmitt: I'm strapped.

145:04:33 Cernan: You liked the drift, huh?

145:04:35 Parker: Great.

145:04:36 Cernan: Okay. Oh, Dadgummit!

145:04:39 Schmitt: What's wrong? Oh, the hammer (caught again under the console)?

145:04:42 Cernan: Yeah. Every time. Okay, let's go.

145:04:46 Schmitt: All right, sport...

145:04:47 Cernan: I'm going to head...

145:04:49 Schmitt: We didn't really do all the things we wanted to do, but I think we did everything we could.

145:04:52 Parker: We did everything we wanted to (garbled).

145:04:55 Cernan: Okay, let's get ready to roll.

145:04:56 Schmitt: (Garbled) flight line stereo.

145:04:59 Cernan: Okay, Bob...Oh!

145:05:01 Schmitt: (Looking at his checklist page LMP/CDR-19.) You got the TGE, (TV) camera...The low gain is 060.

145:05:06 Cernan: You get the gnomon in?

145:05:07 Schmitt: Didn't you get it? Wait a minute.

145:05:09 Cernan: You took the "after". It's not sitting out there.

145:05:12 Schmitt: No, I thought I handed...Didn't you stick it in?

145:05:14 Cernan: Yes, I stuck it in. I got it.

145:05:18 Schmitt: Okay. We can look back. (Laughs; Pause; Static)

145:05:23 Cernan: (Garbled), Bob.

[Gene is probably reporting that they are rolling.]

145:05:28 Schmitt: I sure thought I handed it to you, Geno.

145:05:29 Cernan: You did, and I put it in.

145:05:33 Schmitt: Okay, that's good. (Pause) Okay! Whoo-boy, rest the old hands. (Pause)

145:05:55 Parker: Okay, we've recommendations for Minimum (cooling) for you. Gene...(Correcting himself) Jack.

145:06:02 Cernan: I think I am in Minimum.

145:06:03 Parker: Jack, what was...Sorry. (I mean) "Jack".

145:06:04 Cernan: I am already.

145:06:06 Schmitt: Yeah, I'll go to Minimum. Yes, I will. (Pause)

145:06:15 Parker: And give us a mark rolling, please.

145:06:18 Cernan: Yeah, Bob, I gave you one. We've been rolling for about 30 seconds.

145:06:23 Parker: Copy that.

145:06:24 Cernan: We're at 087 and 5.9 on the range.
 145:06:28 Parker: Copy that. And the drive to Station 4 will be nominal and we'll get a Rover sample at about 094/5.1 but it will be the track as indicated on the map and the cuff checklist. (Pause)

[The checklist calls for a drive of 0.6 kilometers on a heading of 069 from Station 3 to reach an LRV sample point at 089/5.1. After getting the sample, they will drive 1.5 kilometers on a heading of 052 to Shorty.]

145:06:52 Schmitt: Okay. (Pause) Going to Shorty.
 145:06:05 Cernan: Okay. On our way.

[Jack's first three photos of the traverse are AS17-133-20194 to 20196.]

145:07:09 Schmitt: You got your checklist there?
 145:07:11 Cernan: Yeah, I got it in front of me.
 145:07:12 Schmitt: Okay. And, we're heading...
 145:07:15 Cernan: Heading is 069, around...Well...I got it. I know where we're going.
 145:07:19 Schmitt: Yeah, that's pretty close.
 145:07:21 Cernan: I know we're next to that bend (in the traverse path indicated on the checklist map), but I know where we're going. My next is 094/5.1 is what I want for that sample.
 145:07:26 Schmitt: Yeah. Zero what?
 145:07:30 Cernan: I think he said 094/5.1.
 145:07:31 Schmitt: He meant...052 is what's nominal.

[Jack is misreading his checklist. 052 is the heading of Station 4 from Station 3 given on page LMP-18.]

145:07:34 Schmitt: What's the sample again, Bob?
 145:07:36 Parker: Five point one; zero nine four, five decimal one. (Pause)
 145:07:48 Schmitt: (Realizing his mistake) Oh, okay, that's the heading.
 145:07:50 Cernan: All right. You got 094/5.1.
 145:07:52 Schmitt: Yeah, got it. (Pause) You going to drive by this big rock?
 145:08:03 Cernan: Want to look at it? Can't see it. I can't see when that (reflection off the) LCRU shines into my eyes. (Pause)

[Cernan - "I have a vague recollection about this. We were starting to come back northeasterly. We were still in the very early morning sun, even on the second day and there, and there was a lot of reflective material on the front of the Rover which meant that you had to be very careful.]

[Jack's photos taken during the approach to the rock are AS17-133-20197 to 20201.]

145:08:23 Schmitt: Looks like one of the (blue) grey breccias. (To Parker) Big 3- to 4-meter block out here all by itself on the light mantle. I got some pictures. It was at 088/5.6.

145:08:35 Parker: Okay, copy that.

145:08:36 Schmitt: And it looked like a grey breccia. I'm not sure, though. All I could see was the surface texture, and it had the nodular or elongate nodular texture that those breccias had up on the South Massif.

145:08:52 Parker: Okay, copy that, Jack.

145:08:58 Schmitt: (Calling) Where are you, Shorty?

145:09:02 Cernan: And the battery temperatures are 100 and 130.

145:09:06 Parker: Copy that.

[AS17-133-20202 to 20204 cover the next minute or two of the traverse.]

145:09:08 Schmitt: Okay, Bob, as far as any of the things we talked about trying to see at the surface - dynamics or a variation of the light mantle - I think you've heard it all. There isn't much to say about the dynamics right now. I have a feeling that the surfaces are old enough that all those kind of detailed relationships have been obscured. Filletting is just about the same all over here. It varies, but there are no systematics that I've seen.

[Schmitt - "In working with Ron Schrieve, an old friend of mine at UCLA who is an expert on landslides and avalanches, we had come up with a list of things that one might see to verify if this was actually an avalanche deposit that we were driving over. And this discussion refers to the list of things that one sees in terrestrial avalanches. And what I was saying was that 100 million years or so of gardening has pretty well destroyed the kind of detailed features that Ron had indicated one might see on a fresh avalanche. Now, one thing that I thought I observed at the time but which hasn't come up yet in the transcript - which makes me think it must have come up when I started studying the photographs after the mission - was that it appeared that the larger the crater in the surface of the light mantle, the larger the blocks that were on its rim. Combining that observation with the lack of any sizable rocks in the rake samples suggested that you get fine material on top and coarser and coarser material as you go down in the light mantle, which is what you would expect to happen in an avalanche. The larger fragments having a smaller surface area to volume ratio, and would naturally sink to the bottom of the flow. And that's really the only possible evidence we saw that it was actually an avalanche, other than the general form and characteristics."]

145:09:46 Parker: Okay, copy that. Do we ever see a Rover flag come up when you've got high temperatures there on the battery. Have you seen the flag up yet?

145:09:54 Cernan: No, you didn't. No, you did not; you did not.

145:09:56 Parker: Okay, that may be telling us something, we hope (about a gage problem rather than a battery problem). Press on.

145:10:04 Schmitt: Okay. LMP is in Minimum (cooling).

145:10:06 Parker: Copy that, thank you. (Long Pause)

145:10:24 Cernan: Okay. (I) ought to cut left up here a little bit.

145:10:26 Schmitt: Yeah, I think so.

145:10:29 Cernan: Ooh!

145:10:33 Schmitt: Don't...Keep her going.

145:10:35 Cernan: (Laughing) Good lord! What was the aspect ratio (depth divided by width) of that little thing.

145:10:39 Schmitt: Yeah, that's what they call a pit crater. Hey, can you swing a little bit and let me get that fragment (rimmed) crater? See that one on your left there? (Static as Gene turns)

[Jack's photos of the approach to this crater are AS17-133-20205 to 20207.]

145:10:53 Cernan: (Garbled) crater we've seen up here (on the light mantle). Got your pictures?

145:11:04 Schmitt: Yeah, I got them.

[Gene is probably saying that this is either the first really blocky-rimmed crater they've seen on the light mantle.]

145:11:06 Cernan: Okay, Bob. We're at 090/5.3 for a quick Rover sample of a very, very fragmental crater. The ejecta is about 50-percent small, angular fragments; much different than we have seen before in terms of the type of patterns.

[Gene is taking a turn at description while Jack grabs a quick sample. This is another example of efficient team work. The documentation photos for this sample are AS17-133-20208 and AS17-137-20983.]

145:11:24 Parker: Okay, copy.

145:11:26 Cernan: Okay, and that's in bag 41 Yankee.

145:11:33 Parker: Copy that.
 145:11:37 Cernan: And we're on our way.
 145:11:39 Parker: Great.
 145:11:44 Cernan: Get your (after) picture, Jack?
 145:11:49 Schmitt: Yeh. LMP frame count is one-five.
 145:11:53 Parker: Copy that.

[Jack's first photo after the stop is taken as they drive off the ejecta blanket of the fragmental crater. This picture is AS17-133-20209. Photos taken between this stop and the next Rover sample at 145:14:50 are AS17-133-20210 to 21217.]

145:11:58 Cernan: (Very pleased with their performance)
 About a 30-second stop! Okay, I'm 090, 5.3 now, Bob. We're heading toward your stop.
 145:12:01 Parker: Okay, 090, 5.3.
 145:12:03 Schmitt: See Shorty out there yet?
 145:12:04 Cernan: Well, I... (Long Pause)
 145:12:17 Schmitt: Bob, I couldn't tell whether that was just... It looked like that might have been a crater that had got to bedrock. There may have been a high point, or let's say a thin point, in the light mantle, and it got down to bedrock. But I can't... It's the most blocky-rimmed crater we've seen for a long time.
 145:12:33 Cernan: Yeh. All these others are nowhere near that... Look at that.
 145:12:37 Schmitt: No. It was about 15 meters in diameter. (Long Pause)

[This is stop LRV-5. When the bag was opened after the mission, the contents were subsequently split into Apollo samples 74110 through 74119. As indicated in - or can be inferred from - the Preliminary Science Report, samples 74110 - 74114 contain the soil that was in the bag while samples 74115 through 74119 are described as "friable clods", an indication that most of the "fragments" around the crater are regolith breccias - or "instant rock" - formed from soil compacted in the impact that dug the crater.]

145:12:51 Schmitt: Bob, there are no obvious lineations - at the scale we can observe - on the light mantle. I think the pan photography and the metric stuff (cameras in the SIM Bay of the CSM) may be what you'll have to use for any directional trends out in here. Depending on what we decide the origin (of the light mantle) is. (Pause)
 145:13:24 Cernan: Bob, (are) you still reading?
 145:13:27 Parker: Roger. (Making a mis-identification)
 We're still reading you, Jack.
 145:13:32 Cernan: Okay. Are you reading us through the LM or through the low gain?
 145:13:35 Parker: As far as I can tell, we're reading you through the low gain. It's been working just great tonight, Geno.

145:13:42 Cernan: Okay, that's great...

145:13:44 Schmitt: (In a tone of mock outrage) Tonight?

[Jack is noting that, while it may be nighttime in Houston, it's daytime at Taurus-Littrow.]

145:13:45 Cernan: ...because I just scraped bottom on the LCRU. If it's still working, I'm glad to hear that.

(Static)

145:13:54 Cernan: Okay, we're 093 and 5.2. We're almost there. Going to be right on the rim of that crater. (Pause)

145:14:08 Parker: Okay. And, 17, the word from the Backroom is: with that last Rover sample you got, we'd like to go straight to Station 4. We won't get the one here at 094 and 5.3...(Correcting himself) 5.1, excuse me.

145:14:23 Schmitt: Bob, I thought the purpose was to sample the light mantle?

145:14:29 Parker: We talked to them about that, but they...

145:14:31 Schmitt: We didn't sample light mantle at that last one.

145:14:33 Parker: I agree. I talked to them about that. But they are so anxious to get to Station 4, I guess they don't want to do it.

145:14:42 Schmitt: Well, how about it, Gene? A little real time (crew decision)...

[Cernan - "It's hard to recall, but I've got to believe that we were forced into that decision because we had already stopped and had positioned ourselves to get that sample. And, when you're there, it makes sense to get it. And, heck, it didn't take 30 seconds."]

145:14:45 Cernan: I think we got to, right here.

145:14:47 Schmitt: I think we got to.

145:14:48 Cernan: 094, 5.1. You got your picture?

145:14:50 Schmitt: Yeah.

[This may be AS17-133-21218.]

145:14:51 Cernan: Okay,.

145:14:51 Schmitt: That's good enough.

145:14:53 Cernan: You happy?

145:14:55 Schmitt: We'll get the sample (pause) anyway.

145:14:58 Cernan: Okay. 094, 5.1.

145:15:00 Parker: Copy that.

145:15:02 Cernan: That's good, Jack. (Pause) Sample is in 42 Yankee.

145:15:08 Parker: Copy that.

145:15:13 Cernan: And we are rolling! And give me a bearing and a range to (means "at") Station 4.

145:15:19 Parker: Roger. It will be bearing of 100 and range of 4.6.

[The checklist indicates a Shorty location of 101/4.1. The actual Shorty stop will be at 102/4.4. See, however, the discussion at 145:23:32.]

145:15:29 Cernan: Okay. We're now at 094 and 5.0.
 145:15:32 Schmitt: LMP frame count is 25.
 145:15:36 Cernan: Was that one-zero-zero, four point six?
 145:15:39 Parker: Roger, Gene. (Long Pause)

[Jack's photos taken during the next stage of the traverse are AS17-133-21219 to 21222.]

145:16:08 Schmitt: Houston, there aren't very many rocks that just sit on the surface. All of them seem to be slightly buried to moderately buried. (Pause) That one looked like it might be vesicular. There's a trench...(a) linear set of craters. (Pause)
 145:16:40 Cernan: Hold it, babe. We got to do a little detouring.
 145:16:45 Schmitt: Okay, what we're looking for is 101...
 145:16:51 Cernan: Yeh. 100, 4.6. I'll detour. I'll just get down this slope. I don't see Shorty though, do you?
 145:16:58 Schmitt: Wait a minute, is that it? Is that it out there straight ahead?
 145:17:07 Cernan: Well, let me get down this slope.
 145:17:08 Schmitt: Something's dark out there. I think that's it.
 145:17:10 Cernan: It might be right over there to the left a little bit?
 145:17:13 Schmitt: Your left, yeah.
 145:17:14 Cernan: Yeah, right over there. I think I can cut it right across there. That's going to be about the right place.
 145:17:19 Schmitt: Seems a little far from here, but...Maybe not. (Pause) Oh, I forgot to take pictures again. Trying to shade my eyes. (Pause) That Scarp certainly is spectacular going up there by Hanover, isn't it?
 145:17:51 Cernan: It just rolls over the side, doesn't it?
 145:17:53 Schmitt: Yeh. (Pause) I don't know what else we can say about it, though. (Chuckles) Okay, we're getting a good view of the North Massif, and the cross-hatched lineaments that Gene has talked about are over there, also. They seem to be a set that plunge about, oh, 30 degrees to the east and another set that plunge about the same to the west. Plus the boulder tracks, which we see occasionally over there. And there are areas of boulder fields up on the Massif itself, such as we saw on the South Massif. As a matter of fact, it looks like there's one just above where Station 6 may be. Straight ahead of us there, Geno.
 145:18:59 Cernan: Uh-huh.
 145:19:02 Schmitt: About bearing 060 from our present position, which is 098 and 4.8. (Long Pause; brief, light static)

145:19:25 Cernan: If I change that heading, that
(reflection off the) LCRU comes right in on me. (Pause)
145:19:32 Schmitt: I don't see anything like layering up
there. Although the upper boundary of those boulder fields
on the North Massif, and, as a matter of fact, on the South
Massif...
145:19:47 Cernan: That's Shorty straight ahead of us, I
think.
145:19:49 Schmitt: Yeah.
145:19:51 Cernan: Yep, that's got to be it.

[Photos taken during the approach to Shorty are AS17-
133-20223 to 20227. In 20223, Shorty is on the right. In
20226, Shorty is hidden by an intervening ridge. 20227 is
the best of the approach pictures.]

145:19:52 Schmitt: ...(continuing the interrupted thought)
all tend to have a linear boundary. That's the upper portion
of the field; the lower portion is strung out downslope.
(Pause) That looks like it might be Shorty.
145:20:07 Cernan: Yep. We're at 099/4.7, Bob.
145:20:11 Parker: Okay, great. Sounds like you're just
about there.
145:20:16 Cernan: Yeah, I think we got it in front of us.
145:20:18 Parker: Okay. (Pause)
145:20:26 Schmitt: Bob, looking at the Sculptured Hills (at
the east end of the valley), I think Gene's comments the
other day about Bear Mountain would apply. There's a small
relief - or small amplitude hummockiness - to the surface.
It's formed by a cross-hatch of...Let's say the slope I'm
looking at is sort of (a) west-facing slope on the other side
of Wessex Cleft (a vale between the North Massif and the
Sculptured Hills), (and) it's formed by lineaments plunging
about 10 degrees to the north and about 10 degrees to the
south. And the combination gives some hummocks that are
quite distinct. (Pause)
145:21:14 Cernan: Well, you know it's hard to see a(n
ejecta) blanket here, but that's got to be Shorty right
there.
145:21:18 Schmitt: Okay...
145:21:19 Cernan: It's the only real large...
145:21:22 Schmitt: We want to park...I don't think we'll see
a blanket...
145:21:24 Cernan: I don't either.
145:21:26 Schmitt: Well, at least we're going to see where
the break in slope is for the rim. (Pause) My goodness.
145:21:35 Cernan: Oh, look at the boulder sitting on that
rim.
145:21:38 Schmitt: It's different.

[AS17-133-20227, the best of the approach pictures, was
taken at about this point and shows the boulder.]

145:21:40 Cernan: It is darker. Let's go over there.

145:21:42 Schmitt: No question.
 145:21:44 Cernan: We're at 101, 4.5.
 145:21:46 Parker: Copy that.
 145:21:50 Schmitt: Okay...
 145:21:51 Parker: Let us know when you stop and where you're...
 145:21:53 Cernan: (Looking at LMP/CDR-20) Which rim did I want to park on?
 145:21:54 Schmitt: Well, I think we ought to park over here near that big boulder.
 145:21:57 Cernan: Yeah, if I can get up there. I think I can.
 145:22:02 Schmitt: You can swing in, you know, and just park parallel to the...Of course, that will put them looking back. What...Can you park any direction?
 145:22:09 Cernan: Well, yeah, but 045 gives me a good...Let me work on it.
 145:22:13 Schmitt: Okay.
 145:22:14 Cernan: Let me get up there slowly. I'll put them on this low saddle here. 045 will give them a good heading.

[Cernan - "As I recall, we had worked out all the parking attitudes based on for battery cooling, TV coverage, and a number of things."]

[AS17-133-20228 is taken as Gene turns to park.]

145:22:22 Schmitt: Shorty is a crater, the size of which you know (about 100 meters in diameter.) It's obviously darker rimmed, although the fragment population for most of the blanket does not seem too different than the light mantle. But inside...Whoo, whoo, whoo!
 145:22:38 Cernan: Man, are you going to get a picture now.
 145:22:40 Schmitt: Oh, yeah.
 145:22:41 Parker: We can hardly wait.

[They are probably getting their first look into the crater.]

[Schmitt - "I don't remember coming up to the rim of Shorty very well. I can remember looking into the crater. Apparently, from the dialog here, it looked as if we were headed into the crater; although, from the photographs of where we parked the Rover, it doesn't look like we were that close to going down into the crater."]

145:22:42 Cernan: That's about as far as I want to take it!
 145:22:45 Parker: Okay. And when you stop and get off, give me (the) word and I'll read you up some revised plans for Station 4.
 145:22:57 Cernan: Okay, Bob, we're heading 041; bearing is 102; distance, (1)5.1; and 4.2 on the range. Amp-hours are 92 (and) 90; 102 (degrees) and 128 on the batteries. Off-scale low on the fronts; and off-scale low on the rears

145:23:22 Parker: Copy that. And did I understand 4.2 on the range, Gene?

[Cernan - "I didn't say "4.2" very clearly, but I can hear it and that's what it was."]

145:23:31 Cernan: Yes, sir!

145:23:32 Parker: Okay. Copy that.

[As indicated in the Rover navigation work-up at 164:48 06, a range of 4.2 kilometers gives a SEP transmitter position in error to the west by almost 200 meters. A reading of 4.4 would be more compatible with the known locations of the SEP transmitter and the Station 4 stop. Readers should note that, although Gene's "4.2" has always sounded to me (and to the original NASA transcriber) like "4.4", he is quite positive that what is recorded on the tape is 4.2. The fact that Parker seems to have heard 4.2 is additional supporting evidence of Gene's contention. If true, the only other comparable nav system error is the Station 2 reading which gives a 200 meter easterly error. These uncertainties are comparable to the range reading observed by the Apollo 15 crew when they returned to the LM at the end of their second EVA. On this second Apollo 17 EVA, the residual error back at the LM will be less than 100 meters. As a final piece of evidence, we have Gene's report that they were at a range of 4.5 one minute before he had the Rover parked. To get to 4.2 in one minute, he had to reduce his range by at least 200 meters and probably a bit more. The implied minimum speed of 12 clicks is at the upper bounds of plausibility, especially if we deduct time for final maneuvering into the final orientation for parking. I believe that the bulk of the evidence supports 4.4 and I have used that figure in the Rover navigation work-up reported at 164:48.]

145:23:34 Cernan: I don't know whether you're wrong, or we are (about the LM location), but...

145:23:38 Parker: Sounds like an interesting crater, in any case.

145:23:39 Cernan: ...this is an impressive one. (To Parker) Wait until you see the bottom of it.

145:23:43 Parker: Okay. (Pause)

145:23:48 Schmitt: Okay, Houston. Shorty is clearly a darker-rimmed crater. The inner wall is quite blocky but...Except for the western portion of it, which is less blocky than the others. The floor is hummocky, as we thought it was in the (Apollo 15) photographs. The central peak, if you will, or central mound, is very blocky and jagged. And the impression I have of the other mounds in the bottom is that they look like slump masses that may have come off the side.

[TV on.]

[Schmitt - "The tiredness is clearly gone from my voice. Getting there provided a new surge of adrenaline. Visually, this was a lot more exciting than Station 3, and it got even more exciting with the discovery of the orange soil. Station 3 was a lot of work; and this one turned out to be fun."]

145:24:40 Parker: Okay; copy that and...
 145:24:42 Schmitt: That's just what they look like. I'm not sure that...They have a bench appearance.
 145:24:47 Parker: Okay, and the number 1 and 2 priorities at this station will be samples from the crater rim and the pan from the crater rim. Over.

[Gene leans in front of the rearward-facing TV to dust the rightside battery covers. The tasks planned for Station 4 are listed on cuff checklist pages LMP/CDR-21. Because of the imminent discovery of orange soil on the rim of Shorty, this list of tasks will be abandoned.]

[Cernan - "This is very interesting. You can a reflection in my visor of me dusting the battery covers."]

145:25:00 Schmitt: Okay, we've got a large boulder of very intensely fractured rock, right on the rim, right near the Rover.

[Jack is moving toward the boulder.]

145:25:14 Schmitt: It looks like a finely vesicular version of our clinopyroxene gabbro. It's obviously crystalline and has generally that same appearance. There is, in one spot here, some inclusions of a darker grey rock also intensely fractured. The fracture systems, I think, will show up well in the flight-line stereo.

[Gene has finished with the battery covers and moves to his side of the Rover.]

145:25:49 Cernan: Bob, do you have TV?
 145:25:50 Parker: Rog. We have TV, and you might brush the (TV) lens for us before you run away.
 145:25:57 Cernan: Yeah, I'll get it. I've got to get my battery covers cleaned.

[Fendell pans to Gene dusting the leftside battery covers.]

145:26:02 Schmitt: Okay, I'm going to take a pan while I'm waiting for you.

[Jack is not going to try solo sampling this time.]

145:26:04 Parker: And we're going to want the SEP opened and dusted as well here. With the switches turned off.

[Gene dusts his RCU. The brush looks like a 6-inch paint brush.]

145:26:15 Cernan: O-kaay! O-kaay.

145:26:22 Schmitt: Oh, hey! (Very brief pause)

[Jack has just seen the orange soil. He is cautious, having been fooled by sunlight reflected off the LCRU at the Scarp stop.]

145:26:25 Schmitt: Wait a minute...

145:26:26 Cernan: What?

[Fendell starts panning slowly counter-clockwise.]

145:26:27 Schmitt: Where are the reflections? I've been fooled once. There is orange soil!!

[Schmitt - "The orange soil was several meters away from the Rover, up closer to the boulder. The orange spots of light that I saw reflected off the LCRU at the Scarp stop were tiny things; the Mylar covering the LCRU was crinkled, and you only got small spots every once in a while when the Sun angles were just right. When I spotted the orange soil, I probably hadn't even started the pan. What I probably saw was the scuff marks I'd made when I went over to the boulder. Actually you could see the orange through the regolith, but it was more obvious after you'd stirred it up."]

[The patch of orange soil will become discernible in the TV picture once Fendell has panned around to the boulder.]

145:26:32 Cernan: Well, don't move it until I see it.

[Cernan - "Quite frankly, when Jack said he saw orange soil, I began to wonder if he hadn't been on the Moon too long. Until I saw it myself."]

145:26:35 Schmitt: (Very excited) It's all over!! Orange!!!

145:26:38 Cernan: Don't move it until I see it.

145:26:40 Schmitt: I stirred it up with my feet.

145:26:42 Cernan: (Excited, too) Hey, it is!! I can see it from here!

145:26:44 Schmitt: It's orange!

145:26:46 Cernan: Wait a minute, let me put my visor up. It's still orange!

[Cernan - "Like a pair of ordinary sunglasses, the visor attenuated the light but didn't really change the colors. If it was red, it was red; if it was blue, it was blue. But you could see the colors better with the visor up. I do that flying; I take my sunglasses off if I really want to see

things clearly. So lifting up the visor was a natural thing for me to do."]

145:26:49 Schmitt: Sure it is! Crazy!
 145:26:53 Cernan: Orange!
 145:26:54 Schmitt: I've got to dig a trench, Houston.
 145:27:00 Parker: Copy that, I guess we'd better work fast.

[Gene passes in front of the panning TV, on his way to the SEP. At some point during this exchange, Jack has started his pan. What seems likely is that he went over to the boulder to examine it and then moved back part way toward the Rover to start his pan. Because he always started his pans with a down-Sun shot, he would have been facing the boulder and would have seen the disturbed orange soil before actually taking a picture. Having made his report to Houston, he then started the pan while he waited for Gene to finish his housekeeping chores at the Rover. The pan consists of frames AS17-133-20229 to 20256, Note that 20248 shows Gene replacing the dustbrush in its bracket on the front of the Rover. This picture was, therefore, taken at about 145:27:34. Note that we know from the TV record that Jack's Station 3 pan took about a minute and a half to complete. Both that pan and the one taken here at Shorty consist of about 27 frames, so we can fairly safely assume that the Shorty pan also takes no more than a minute and a half to complete - less if Jack hurried a bit or could take pictures more quickly because, here, he is standing on level ground. 20248 is the 20th frame in the pan, and its timing suggests that Jack started the pan at - or, perhaps, a little later than - 145:26:30. This estimate is consistent with Jack's recollection that he didn't actually do the pan until after he reported the orange soil to Houston.]

145:27:01 Cernan: Hey, he's not going out of his wits. It really is.
 145:27:07 Parker: Is it the same color as cheese?

[This may be a serious question. Many American cheeses are orange.]

[Schmitt - "You'll have to ask Parker, but I think he was thinking of green cheese, as in 'The Moon's made out of green cheese.' My guess is that he wasn't convinced that we weren't trying to pull their leg again. And for good reason, because every once in a while we'd do that, either inadvertently or advertently."]

[Parker says that it was a serious question - but with a joke thrown in.]

145:27:09 Cernan: Temperature on the SEP's about 102.
 145:27:15 Schmitt: It's almost the same color as the LMP decal on my camera.
 145:27:21 Parker: Okay. Copy that.

[Gene passes in front of the TV going around the front of the Rover to replace the dustbrush on the left corner of the LCRU and then go to his seat to get the lens brush for the TV camera. Jack's pan shows him replacing the dust brush on the LCRU.]

145:27:23 Cernan: (Looking toward the orange soil near the boulder) That is orange, Jack! (Pause)
 145:27:34 Cernan: Boy, this brush is getting harder to get on and off, too. But I sure don't want to lose it. Man, I may start putting that under my seat. (Pause)
 145:27:50 Cernan: Well, zap me with a little cold water. Okay, the SEP has been dusted. I think I gave you 102 or something like that (for the SEP receiver temperature).

[Schmitt - "The dust is going to get into anything that's not hermetically sealed. After a while, moving parts don't move any more with dust in them. We had a bracket for the dusting brush, and that bracket was now full of dust and he couldn't get the brush handle in it. One lock on the gate was no longer usable; and I was having an awfully hard time getting my scoop on and off."]

[Fendell finds Jack just west of the Rover finishing his pan. He takes the last frame a second or two before 145:28:15 and then hops west toward the scoop. He had dropped it, probably prior to starting the pan, and apparently contemplates going to one knee to get it; but he then kicks the scoop a few feet north.]

145:28:15 Schmitt: Fantastic, sports fans. It's trench time! You can see this in your color television, I'll bet you.

145:28:25 Cernan: How can there be orange soil on the Moon?! (Pause) Jack, that is really orange. It's been oxidized. Tell Ron (Evans) to get the lunar sounder over here.

[Schmitt - "I don't know what Gene had in mind, but I suspect that the sounder was just an instrument in the Command Module that he remembered that you could point at something. But the sounder wouldn't have had anything to see here, because of it's coarse resolution, if nothing else. Of course, Ron started to see orange areas from orbit as soon as he heard about it. He saw orange in the southwestern part of the Serenitatis Basin, in what's called the Sulpicius Gallus region. And, when Gene and I got back into orbit, we were able to confirm and I mapped quite extensive regions of the orange and other colors. And, as we left the Moon, we were looking back at a full Moon and, for a little while, we had good color/tint definition."]

[At this moment, Evans is about ten minutes from LOS (Loss of Signal) on his 29th orbit. News of the discovery of the orange soil won't be passed up to him until shortly after

he reappears around the Moon's eastern limb at 146:14. At that time he will have the following exchange with Houston.]

[CapCom: While you're doing your pre-sleep checklist, you might be interested that, at Shorty, the surface crew found some very, very orange soil, a great deal of it. Indicates strong oxidation and possibly indicates water and/or volcanics in the area. And they're really...Jack's kind of like a boy at Christmas time. I'll tell you, a little kid at Christmas time on that one.]

[Evans: (Laughing) I bet he would be. Hey, that's a great find, by gosh!]

[CapCom: Yeah, that's the first time we find...It's orange. Boy, you can see it in the television; it's bright orange soil. No question about it.]

[Evans: I'll be darned.]

[CapCom: And, as luck would have it, they found it all and got working, and then they had to pull out of Shorty due to constraints, walkback constraints in the area. You know, consumables versus walkback.]

[Evans begins his rest period about ten minutes later; his wake-up call will come at 154:40; and it won't be until he gets a chance to look at Shorty at 166:17:51 that he becomes convinced that there is an orange tint around the crater and in certain other areas. His observation is reported to Gene and Jack at 171:02:56 and is reproduced there. It is important to note that, throughout the mission Evans has been conscious of variations in shades and tints and has reported his impressions. At 158:35:09, he remarks that "You know, to me the Moon's got a lot more color than I'd been led to believe. I kind of had the impression that everything was the same color. That's far from being true." However, the shades and tints are subtle and it will take a look at Shorty before he is convinced that he can see the orange from orbit.]

[Cernan - "When I heard that Ron had seen some orange patches from orbit, I was concerned that maybe the power of suggestion had taken over. You can stand on the Moon and suggest colors to yourself and you begin to see those colors. You could tint the bland grey color of the Moon blue or green or brown. By this time I was absolutely convinced that Jack and I could see the definitive color delineation between the orange and the grey (at Shorty), but I was concerned that Ron was being influenced by the power of suggestion. But, when we got back into orbit, I ate my thoughts because we really did see areas that you could definitively define as orange. Now, whether we would have seen those orange patches had we not seen orange soil on the surface, I don't know. If we had not found orange soil on the surface, we might have seen the orange areas from orbit and have just passed them off as reflections of some kind; because, who would have expected to find orange soil on the Moon? But, having known it was on the surface, we could feel comfortable about being able to say that we could see the orange from orbit."]

145:28:39 Schmitt: It looks just like an oxidized desert soil, that's exactly right.

[Schmitt - "The reason that this was a little more exciting than it might have even been otherwise was that, in our thinking about the origins of Shorty, we really had two major possibilities, with a number of observations related to each one. Number One was what we really believed and what turned out to be true: that Shorty was an impact crater that had penetrated the light mantle and was exposing the dark-mantle and/or sub-floor basalt beneath. The other alternative, just because of the lack of resolution and information from the pre-mission photographs, was that it was a dark-haloed volcanic crater; and, if that were true, one of the things that we had on our list to look for were signs of alteration, possible fluid-induced alteration of materials around the crater. And normally, on Earth, that alteration is colored, fumarolic alteration from oxidation. And so, when we saw orange, that was the immediate thought that everybody had. 'My God, there's a volcanic emanation here that's altered the soil.' Well, it turned out that that wasn't true, of course. It was volcanic material, but it was volcanic glass that had been spewed out of some fire-fountain-like eruptions 3.5 billion years ago that somehow had been protected from mixing with anything else, even though it was now at the surface. It had almost certainly been covered almost immediately by a lava flow, so that it was protected from meteor disruption and stirring. And then, when Shorty formed, somehow the pyroclastic ended up in the rim and a few other places in nearly pure form. There are some issues having to do with its origins that we can get to in a moment, but that's what cause all the excitement. We had sort of halfway predicted that we would find it there, even though it turned out not to be what we predicted we would find. They had a camera running in the Backroom, and what it shows is that, when that call came over, everybody sort of jumped up in the air and there was just total loss of control in the back science room."]

[Jack goes on hands and knees to get the scoop and, to get up, pushes sharply with his hands to get on his knees. He rotates backwards and, as his PLSS gets over his feet, he rises easily. He may have put his feet in a small crater to get leverage. This would explain his kicking the scoop earlier. Once he's up, Jack goes about ten feet farther west carrying the scoop. Fendell pans counterclockwise.]

[Cernan - "This is not meant as a criticism, but I think that Jack tended to fall more than the rest of us did. And it's maybe because he became more aggressive. And, thank God for one-sixth gravity. You would have dropped things anyway because of the lack of nimbleness and dexterity and you would have wanted to get down to pick things up and chip rocks and what have you. And one-sixth gravity made getting back up a lot easier than it would have been otherwise. You developed

a personal technique - the way you skipped or hopped, the way you got on and off the Rover, the way you got up when you fell."]

145:28:50 Cernan: Well, I'm going to clean their glasses so they know we're (not crazy)...(To Fendell) Can you wait a minute on that pan you're taking?

[Gene moves the TV so that he can dust it.]

145:28:56 Schmitt: I already took it.

145:28:57 Cernan: No, I mean the television camera. (To Fendell) I'll put you back where I had you. (Pause) Now, I'll put you right (back) where you finished your pan.

[Gene repositions the TV.]

145:29:15 Schmitt: You know (pause) that orange is along a line, Geno, along the rim crest.

145:29:27 Cernan: What? Circumferential?

145:29:29 Schmitt: Yeah. Man, if there ever was a (chuckles)...I'm not going to say it. (And then does, anyway) But if there ever was something that looked like a fumarole alteration, this is it.

145:29:39 Cernan: (To Parker) Okay, let me give you a gravimeter. Mark it.

145:29:41 Parker: Okay, mark the gravimeter.

145:29:43 Cernan: And she is flashing. Oh, never mind, Bob. I'm going to go to Standby. I got to get my gnomon. (Pause)

[In getting the gnomon, Gene will disturb the Rover and, therefore, the gravimeter. Therefore, he doesn't want to start the measurement until he has the gnomon. Fendell returns to Jack, who is digging his trench.]

[Schmitt - What we dug was half of a trench. That is, we'd only try to maintain one wall - the east-facing wall - and tear down the other one so that you could see in."]

145:29:57 Schmitt: Hey, I think we hit one of those things we've got to reconsider on, Houston.

145:30:06 Parker: Yeah. The problem is we're looking at PLSS constraints right now, as luck would have it, of course.

[That is, they need to leave fairly soon because of walkback constraints.]

145:30:15 Cernan: Mark it. Gravimeter.

145:30:16 Parker: Roger. Copy that.

[After watching Jack dig his trench, Fendell looks down at the left-front wheel. The TV camera then gets stuck in that position.]

145:30:19 Cernan: What's wrong with the TV? Aren't you watching this? (Pause)

145:30:26 Parker: It seems to have died slowly there. (Pause)

145:30:35 Cernan: Well, stand by.

[Gene raises the TV, thereby disturbing the gravimeter.]

145:30:42 Cernan: Now, I'm going to give you another Standby and another Mark.

145:30:46 Parker: Okay. (Pause)

145:30:58 Cernan: Standby. On. And Mark it.

145:31:00 Parker: Copy that.

[Fendell returns to Jack; the orange is faintly visible in a video tape copy made in 1989.]

145:31:04 Schmitt: Okay, Bob, I've trenched across the trend of the yellow...(correcting himself) or the orange. There is light grey material on either side.

[Gene joins Jack and looks west into the trench.]

145:31:16 Cernan: Oh, man, that's incredible!

145:31:19 Schmitt: Okay, Gene, we're going to have to...

145:31:20 Cernan: That's incredible.

145:31:21 Schmitt: You need to get a down-Sun color...

145:31:25 Cernan: That's incredible.

145:31:26 Schmitt: ...as well as...I'll get my black-and-white.

145:31:28 Cernan: I'll get it. (Long Pause)

[Schmitt - "I think there have been others, but this is a particularly good example of where Gene deferred to me in organizing how we would approach a geological problem, just as I would defer to him on the Rover stuff and things like that. It worked out pretty well; that had all been sorted out, almost without us knowing it, during the training cycle."]

[Cernan - "You can't specifically train for every moment of the mission, so the key is that you train for knowledge of each other and you train for teamwork. And, when you come up with something new and different, you just defer to each other's capabilities. In this particular case, Jack had pretty much surrounded the orange-soil project, if you will, and had in his mind what we needed to get. So we went ahead and did it."]

[Gene puts the gnomon on the ground and takes a cross-Sun picture from the south while Jack takes a down-Sun from the east. Unfortunately, all of the pictures Jack took after finishing his pan are badly overexposed. This are frames AS17-133-20257 to 20268, which are not reproduced in the Journal. Gene's cross-Sun stereo pictures taken here are AS17-137-20984 to 20986. Notice the width of the orange band

that Jack has exposed and how the orange color fades toward the far end, which is nearest the crater rim.]]

145:31:45 Schmitt: We also got to get that rock up there.

[This is the two-meter-high boulder a few feet west of the trench.]

145:31:47 Cernan: Yeah, we'll get that. Okay, let's start sampling that trench. We've got to get...That's...

145:31:53 Schmitt: Okay.

145:31:54 Cernan: ...That's phenomenal. Look at where the contact between the grey and the...

145:31:56 Schmitt: Yes. Right, and it's on both sides (of the circumferential band)...

145:31:58 Cernan: Before you disturb it, let me just get a couple of close-ups of that.

[Gene does a deep knee bend to get the close-up from a few feet southeast of the trench. These photos are AS17-137-20987 to 20989.]

[Cernan - "You can see here how I could bend down without kneeling - without getting to a static position - to get some close-up pictures. In one-sixth gravity you can go down slow enough and you can waver in that almost-kneeling position - uncomfortable and hard to sustain - long enough to get a couple of pictures at a 125th of a second."]

145:32:02 Schmitt: Hey, can you get a down-Sun? I think your color will be best down-Sun.

145:32:05 Cernan: Okay.

145:32:06 Schmitt: Go to f/11. Get a little closer, Geno, if you think you're minimum. (Pause) There you go. (Pause)

145:32:20 Cernan: Let me get one more.

[Gene goes a few feet east for the down-Sun. This is AS17-137-20990.]

145:32:21 Schmitt: Hey, you want any of this bagged in the can, Bob? Canned in the bag...or whatever it is?

145:32:30 Parker: Stand by. They're debating that right now.

145:32:34 Cernan: (Garbled)

145:32:35 Parker: Roger. Let's get the short can for some of that and...

145:32:37 Schmitt: Okay, the color is...[Listens to Parker] Okay, let us get the...

145:32:42 Cernan: Better sample it first, then we'll get it. (Pause)

[They move in to sample: Jack with the scoop, Gene opening a bag.]

145:32:51 Schmitt: It's quite indurated.

[Jack means that the soil is cohesive. He goes to one knee to scoop soil from the bottom of the trench; but he spills some of the soil getting up.]

145:33:00 Cernan: Aah...Go back and get that one. Go get a new chunk!

145:33:04 Schmitt: I'll go get a new chunk.

[Schmitt - "It came out in chunks. It was cohesive. It eventually fell apart as they worked with it in Houston, but it was cohesive enough that when we put it in the bags it was in chunks."]

145:33:05 Cernan: Give me that, and get a new one. Give me that. Get some more.

[About a cup full of the orange soil has stayed in the scoop; Jack pours it into the bag.]

145:33:08 Schmitt: I'm going to slow down here.

145:33:09 Cernan: Yep, just take it easy.

145:33:12 Schmitt: I can't see into this.

[Jack is standing east of the trench, casting a shadow on it.]

145:33:13 Cernan: I can't see when your shadow is there.

145:33:14 Schmitt: Can you get around on the other side?

145:33:15 Cernan: Yep.

145:33:17 Schmitt: Because I can't see to sample. (Pause)

[Jack goes to the south end of the trench, Gene to the north. Jack goes to one knee to sample and then kicks surface material into the trench as he gets up.]

145:33:29 Schmitt: Oh. Well.

[Jack does a deep knee bend and gets a sample this time.]

145:33:34 Schmitt: Yeah, that's it. (Pause)

145:33:42 Cernan: See if you can get a sample right across that contact too.

[Jack pours the sample into the waiting bag.]

145:33:45 Schmitt: I will. Okay, bag that one.

145:33:49 Cernan: Bag 509 has got the orange material from, oh, about 2 to 3 inches down.

[Gene closes the bag while Jack extends the trench southward to well past the edge of the orange band). Gene then puts the sample in Jack's SCB.]

145:34:00 Parker: Copy that. (Long Pause) Okay, we're suggesting Intermediate (cooling) for you, Jack.

[Jack is working hard. He gets another sample.]

145:34:21 Schmitt: Okay, the light grey, which is on either side...We sampled the...

[Jack pours.]

145:34:33 Schmitt: Want me to get some more?

145:34:35 Cernan: Yeah, a little more.

[Jack gets a sample by scooping sideways, knees bent.]

145:34:40 Schmitt: All of this is getting mixed a little bit with about a half-centimeter thick light-grey or medium-grey covering over the whole area.

[Jack pours, and then presents his SCB for loading. He changes his cooling while he waits.]

145:34:53 Cernan: Bob, the grey material that's adjacent to the red material is in - what would I say - [bag] 510.

145:35:01 Parker: Copy that.

145:35:02 Cernan: I had it, and I can't see it now.

145:35:04 Schmitt: And the LMP is Intermediate.

145:35:05 Parker: Copy that.

145:35:06 Cernan: 510, Bob.

145:35:07 Parker: Copy that.

145:35:08 Cernan: And that orange band is about a meter wide, I think.

145:35:13 Schmitt: About a meter.

[Schmitt - "Post-mission analysis showed that the orange soil turned out to be very small, spherical beads of glass, rich in titanium and low in silica and with the intensity of the orange color apparently related to the titanium/iron ratio."]

145:35:14 Cernan: You can't get to the bottom of it though, can you?

145:35:16 Schmitt: I haven't been able to yet.

145:35:18 Parker: Okay...

145:35:19 Schmitt: [Moving to the north end of the trench] Just to be sure, why don't we sample this side of it, too.

145:35:24 Cernan: Then I'm going to go get the can.

145:35:26 Schmitt: Okay...One...

145:35:28 Cernan: If I can remember where we put it. Bob, where did we put the small can?

[Gene opens a bag; Jack pours.]

145:35:30 Schmitt: It's in bag 7 under my seat.

145:35:34 Cernan: Okay. (Commenting on the amount of soil Jack has poured in the sample bag) That's good.

[The short can or Special Environmental Sample Container (SESC) is 13 cm tall and has a 6 cm inside diameter. Like the long can (CVSC) used to transport one of the Station 3 drive tubes and, like the rock boxes (SRC's), the short can has a knife edge/indium seal to protect the sample from terrestrial and spacecraft gases. In order to increase the chances of getting a good seal, both the knife edge and the indium are protected with Teflon covers which Gene will remove just before he closes and latches the lid. In addition, Gene will put the short can in the rock box at the end of the EVA, doubling the chances that at least one seal - the short can itself or the rock box - will be good. Some of the knife-edge seals on previous missions were compromised by dust despite the precautions taken.]

145:35:37 Schmitt: 511 has the grey from the other side of the orange band.

145:35:41 Cernan: And the other side happens to be the crater side.

145:35:46 Schmitt: That's right. North side.

[Gene puts the sample in Jack's SCB.]

145:35:51 Cernan: Okay. Why don't you look around a minute, and I'll get that can.

[Gene goes to the Rover.]

145:35:54 Schmitt: Okay. I'm going to see if this goes on down here as a zone. (Pause)

[Jack comes about halfway back to the Rover then drags the scoop north along a crater radial.]

145:36:10 Schmitt: It looks like it's an ellipsoidal area if my footprints are any indication.

145:36:14 Parker: 17, Houston. We'd like to get the double core here instead of the small can. Double core, please, instead of the small can.

145:36:23 Cernan: Okay.

145:36:24 Schmitt: Did you want it in the orange?

[A chorus of voices in Houston says "Yes".]

[Schmitt - "The reason I asked the question was not so much because I disagreed but, as I did several times during the EVA's, I wanted to make the Backroom think a little bit, just to make sure they thought through some of the options they had. Based on the information we had up to this point, it looked like something vertical in the rim of the crater; and, fortunately, we did what they suggested and didn't

change because, otherwise, we might not have hit the underlying black soil."]

[Twenty years after the fact, Gene questions whether Jack was quite so logical at the time.]

145:36:26 Parker: Roger. That affirm. We can put cores in grey soil all the time.

[Jack is removing the scoop from the extension handle so that he can attach it to the drive tubes.]

145:36:36 Schmitt: Well, it's a vertical stratigraphy. Do you want to go sideways a little with it? (Pause) Or you just want to get it as deep as you can, huh?

[What Jack means by "vertical stratigraphy" is that the orange soil deposit appears to have vertical contacts.]

145:36:52 Parker: I expect we want to get...Let's go as deep as we can in the orange, please, there, Jack. And the one problem at this station, Jack, is not that...

145:37:00 Schmitt: (Responding to Parker's "deep as we can") All right.

[Jack goes to the Rover.]

145:37:01 Parker: ...we can decide priorities between this station or any other station. It's the fact that we're running up against the walkback constraints here in just a very few minutes, about two-zero (20) minutes.

145:37:12 Schmitt: Okay.

145:37:15 Cernan: Okay, Bob, and the bottom [core] will be 44, and the top will be 35.

[Jack turns to look into Shorty; Fendell camera pans clockwise toward the crater.]

145:37:22 Parker: Copy that. (Pause) And after the core, we'd like for you to go over and sample some of the big rocks there on the rim, if you could very quickly. That'll be the next order of priority after that.

145:37:40 Schmitt: We will.

145:37:41 Cernan: Yes, sir.

[Gene crosses the TV picture, carrying the core tubes.]

145:37:42 Parker: And I'm not sure whether your pan will look down into the crater or not, Jack. But if it didn't, we'd like to get another one from there. Hey, there's the crater [on the TV].

145:37:49 Schmitt: It (the 70-mm pan) did (include the crater).

145:37:51 Cernan: Yeah, look into it yourself and then, I'll also get you a stereo pan before we leave. I can do that.

145:37:58 Parker: Roger. That's some crater!

145:38:02 Schmitt: (To Gene) Got your hammer?

145:38:04 Cernan: Yeah. I've practiced too long on taking stereo pans of craters, without getting one here.

145:38:10 Schmitt: I got mine from right down there, Gene. So...

145:38:16 Cernan: What is that right there?

145:38:19 Schmitt: What?

145:38:20 Cernan: That right there.

145:38:22 Schmitt: I don't see. Oh, it's a piece of glass, probably.

145:38:26 Cernan: Boy, it sure is.

145:38:29 Schmitt: Hey, how about right up here, [just west of the trench, for the core]? (Pause) You know, we just about got [laughs] to the upper edge of this little ellipsoid zone. I think we're going to have to...We've messed up most of it. Let's try right over here.

145:39:00 Cernan: I've got a little piece of glass in my pocket.

[Once he gets back in the LM, Gene will describe his piece of glass in some detail at 149:12:10.]

145:39:03 Schmitt: Bob, the upper portion of the core is going to be a little bit disturbed, because we've walked around the area so much.

145:39:11 Parker: Okay. Copy that.

145:39:16 Cernan: That was a little piece of black glass...

145:39:20 Schmitt: (To Gene) You may want to get uphill...

145:39:21 Cernan: ...solid black glass.

145:39:23 Schmitt: Okay. That...Did you get a...Hold it, and I'll get a shot.

145:39:26 Cernan: Take your picture.

[This photo, like the others Jack has taken since finishing his pan, is badly overexposed.]

145:39:28 Schmitt: That's about as far as I could shove it in (by hand).

145:39:33 Parker: Okay. And, 17, while you're doing that, was the grey mantle over the top of this, or was this showing all the way through to the surface?

145:39:43 Schmitt: No, it was over the top. About a half a centimeter over the top.

145:39:46 Parker: Copy that.

145:39:48 Schmitt: He's getting about 3 centimeters a whack.

145:39:52 Parker: Very good.

145:39:55 Cernan: I'll tell you, it's a lot harder going in than that double core was back there [at Station 3].

145:40:00 Schmitt: Yeah, it's pretty hard. (To Parker) It acts like it's inherently cohesive. It breaks up in angular fragments.

145:40:08 Parker: Copy that.

145:40:09 Schmitt: The central portion of the zone actually has a crimson hue, or a red hue. Outside of that it's orange. And outside of that, it's grey.

145:40:22 Cernan: [Breathing heavily] Wait a minute, Jack.

[Fendell returns to astronauts. Jack is facing west with his back to the camera; Gene is facing him. The core tube is out of sight between them.]

145:40:23 Schmitt: That's all right, take it easy. I'd offer to hit it, but I don't think I can, my hands are so tired.

145:40:32 Cernan: I'm going up to Max (cooling) here for just a minute or two.

145:40:35 Parker: Copy that.

145:40:36 Cernan: Okay, let me hit some more. Ready?

145:40:40 Schmitt: Yeah, go ahead.

[Jack is holding the core tube while Gene hammers it, and Gene is very anxious about that. He stutters a couple of phrases before he gets the thought out.]

145:40:41 Cernan: Why don't you ...I'm afraid ...Jack, it's stable enough. Why don't you get out of the way? I'm afraid if I leave go of this thing, you'll get it in the head.

[Jack moves out of the way to the south. Gene raises the hammer to level with the top of his helmet and swings down to hit the top of the extension handle at about waist height. He is hitting with the flat of the hammer to get a better chance of connecting.]

[Cernan - "You had to hold the hammer tightly with your fingers. It was like gripping your golf club too tightly: all your muscles tighten up and your swing goes to hell and you get tired. And to make it harder, the core wasn't going down all that readily. It was just a heavy bit of work, particularly clutching the hammer."]

145:40:45 Schmitt: Okay. Have at it. He's still getting a centimeter a whack, poor guy. Let's see. I didn't get a locator, I better get a locator. (Pause) Oh, it's in the [pan]...No, it isn't. (Pause)

[Usually, a locator is a shot taken at the sample site of either the LM or the Rover.]

145:41:05 Cernan: The only thing I question is our ability to get it out. (Pause)

[Gene stops to rest. Jack takes a picture of the Rover as a locator. Gene then hits the core a half dozen times more and stops. Jack's visor is halfway up.]

145:41:16 Cernan: [Breathing heavily] Man, that's really hit bottom.
 145:41:17 Schmitt: Has it?
 145:41:18 Cernan: Yeah.
 145:41:19 Schmitt: Okay, do I have core tubes on me now? I mean caps?
 145:41:22 Cernan: Yes.
 145:41:23 Schmitt: Caps.
 145:41:24 Cernan: Yes, sir.
 145:41:25 Schmitt: And the rammer.
 145:41:26 Cernan: Yes.
 145:41:27 Schmitt: Okay...Only...

[Gene hits the core seven times more.]

145:41:29 Cernan: That's all the way down. But, I really...
 145:41:31 Schmitt: That's it. Thanks, Geno.
 145:41:32 Cernan: ...I really wonder about getting it out.
 145:41:33 Schmitt: Well, we'll give it the old college try.
 145:41:35 Cernan: Yeah, we ought to be good at getting cores out by now.
 145:41:37 Schmitt: It'll come out.
 145:41:38 Cernan: Whew! Okay.
 145:41:40 Schmitt: It wouldn't dare not come out. Wait a minute...
 145:41:44 Cernan: Is there enough to hold on to?
 145:41:45 Schmitt: Whoops. Which side you got?
 145:41:47 Cernan: I was just getting this out for you. Let me. I can get this side better.

[Gene stands south of the core, facing east, and grabs the tube in his left hand. Jack stands to the north, facing west, and grabs with his left hand.]

145:41:51 Schmitt: Okay.
 145:41:54 Cernan: You ready?
 145:41:56 Schmitt: Okay.
 145:41:57 Cernan: Go. Okay, pull slowly.

[The core comes out about a foot with apparent ease.]

145:41:59 Cernan: Slowly so I can cap it all right. Let me get a cap.
 145:42:02 Schmitt: Okay.
 145:42:03 Cernan: Okay. Hold it. Hold it. Let me get a cap. Turn.

[Gene gets a core tube cap off of the left side of Jack's PLSS.]

145:42:05 Schmitt: All right, get the cap.
 145:42:07 Cernan: Okay. Now, wait a minute.

145:42:08 Schmitt: Are you ready?
145:42:11 Cernan: Okay, very slow. Even the (outside of the) core tube is red!

[Jack finishes pulling the tube out of the ground.]

145:42:15 Schmitt: Look at that!
145:42:16 Cernan: Even the core is red! The bottom one's black and orange, and the top one's grey and orange!

[Jack raises the bottom of the tube for Gene to examine and cap.]

145:42:23 Schmitt: The fact is, the bottom of the core is very black compared to anything we've seen.
145:42:27 Cernan: Hey, we must have gone through the red soil because it's filled, but it's filled with a black material.

[Schmitt - "Post mission analysis showed that the black soil was mostly beads of devitrified (crystallized) glass of the same composition as the orange, but with a different cooling history."]

145:42:33 Schmitt: Let me see, Gene.
145:42:34 Cernan: Dark grey, almost a very, very fine grained...
145:42:36 Schmitt: That might be a magnetite...
145:42:39 Parker: Fantastic.

[Schmitt - "It turned out to be beilmenite."]

145:42:39 Schmitt: (Garbled)
145:42:40 Cernan: I got it.
145:42:41 Parker: Fantastic.
145:42:42 Schmitt: Go ahead.
145:42:43 Cernan: Okay.
145:42:45 Cernan: [Capping the bottom of the core] But it, it, it...
145:42:47 Schmitt: Let me...God, it is black isn't it?
145:42:51 Cernan: Yeah. I've got to get it so I can get the...Boy, it is black and is it contrasted to that orange stuff.
145:42:57 Schmitt: Very black. Well, not very black. It's a good dark grey.
145:43:03 Cernan: Very dark bluish grey.
145:43:04 Schmitt: Yeah...contrast.
145:43:05 Cernan: Okay, turn that thing so I can push this cap a little bit. Just turn.
145:43:09 Schmitt: Which way?
145:43:10 Cernan: Either way. Just turn the whole tube.

[Schmitt - "I think Gene had gotten the cap partially threaded on and wanted me to finish the threading by turning the tube in my hand while he held the cap."]

145:43:11 Schmitt: Oh, okay.

145:43:12 Cernan: It's just easier to turn the tube than my hand...

145:43:13 Schmitt: [Laughs]

145:43:14 Cernan: ...some more. I don't want this cap to come off. Okay. I'm going to Intermediate cooling. Okay. Now you don't have any caps, so let's take this back to the Rover.

[This time, Gene doesn't have to use the double wave to reach his cooling control.]

[Cernan - "You can see in the TV how much inertia I got into my arm to get it back there. I didn't move back slowly at all. I already had my hand chest high and I sort of raised my hand and then moved back very rapidly. You just couldn't go back slowly and sneak up on it. Other times, when my arm was down more, I'd have to do the double pump; but, here, my hand was already up there. You adapted mentally and physiologically to find the easy way to do things like this and, rather than bust my butt trying to stretch and push that suit to go back, I'd just bring my hand up chest high and, with the strength I'd need if I was swinging the hammer, just swing my arm back there. Then, once your hand was back there, the suit was stiff enough that, before it rebounded, you could reach the control and not have to forcibly hold your arm back there."]

145:43:26 Schmitt: Where's the hole?

145:43:27 Cernan: Why don't you take a picture of the hole, while you've got a camera there?

145:43:31 Schmitt: Be careful with that (core).

145:43:32 Cernan: Yep.

[Gene goes to the Rover.]

145:43:36 Parker: The caps are in SCB-7. They're under the LMP's seat.

145:43:38 Schmitt: (Standing south of the core hole) Well, the hole's mostly in shadow.

145:43:43 Parker: And, 17...

145:43:44 Cernan: (Responding to Parker's confirmation about the caps) Yeah, I got them Bob.

145:43:45 Parker: ...And, 17, for your thought...We have to be leaving here... Not "like". We have to be leaving here in fourteen minutes. On the move, because of walkback constraints.

[Jack goes to the Rover. the walkback constraints are based on an assumed walking speed of 2.7 km/hr. Houston thinks they are 4.2 kilometers from the SEP transmitter and 4 kilometers from the LM, so the walkback would take an assumed 88 minutes. The EVA started at 140:35 and, in 14 minutes,

they will be 5 hours 22 minutes into it. An 88-minute walk back would get them back to the LM at 6 hours 50 minutes. Although estimate undoubtedly differs slightly from the calculation being made in Houston but, the important point is that Houston has a firm requirement to get them back at a time close to 7 hours into the EVA.]

145:43:55 Parker: And we'd like to get a quick sample of the basalt up there on the rim, and Gene's stereo pan, and then press on. And I emphasize that it's walkback constraint we're up against in 14 minutes. 13 now.

[Jack gets about halfway to the Rover when Parker gives the go-ahead to sample the boulder. He turns, gets the gnomon, and positions it at the east base of the boulder.]

145:44:09 Schmitt: Okay, Bob, I'll sample it by hand. But it'll be documented. And I'll get it in a bag in a minute since I don't have any.

145:44:19 Cernan: Come back this way when you do. I need that rammer again.

145:44:22 Schmitt: Oh, okay. Well, I better come there first, I guess.

145:44:26 Cernan: Well, I don't need it right this second...

145:44:29 Schmitt: Okay.

145:44:30 Parker: Why don't you leave the core there Gene, and you can take your stereo pan while Jack's getting that sample. And then you can get together and ram the core home.

[Schmitt - "When we knew we only had a little bit of time, we got things done a lot better than when we did a station for no specific purpose, like Station 3. Station 3 was a disaster. We got a lot done, but it was a very poor use of time. This one was both productive and fun."]

[Jack is standing southeast of the boulder taking photographs. these photos are also badly overexposed and the next usable photos he will take will be once he gets back on the Rover for the drive to Station 5.]

145:44:40 Cernan: (At the Rover, disassembling the core) Okay. Bob, the bottom of the upper core is also dark.

[Jack moves to take down-Sun pictures of the boulder.]

145:44:47 Parker: Copy that. (Pause) Sounds (like the orange layer is) a little thin. (Long Pause)

[Jack leans on the boulder to examine it, then pulls off a hand-sized sample. He then moves southeast to take some "after" pictures.]

[Schmitt - "The boulder had been intensely shocked. It was falling apart."]

145:45:15 Cernan: And, like you might expect, the top of the bottom core is dark, too!
 145:45:18 Parker: How about that. (Pause)

[Jack picks up the gnomon and heads for the Rover.]

145:45:28 Schmitt: (Garbled; pause) If I ever saw a classic alteration halo around a volcanic crater, this is it. It's ellipsoidal; it appears to be zoned. There's one sample we didn't get. We didn't get the more yellowy stuff, we got the center portion...

145:45:45 Cernan: Let me get those caps, Jack.

145:45:46 Schmitt: Okay.

145:45:47 Cernan: What's holding...That's what's holding it, holding it from coming out.

[Gene is trying to get a core cap out of the dispenser.]

145:45:57 Schmitt: (Let me) steal a (sample) bag.

145:45:59 Cernan: Okay. (Pause) Here.

[Gene hands Jack a sample bag. Jack's visor is up and we can see his face. He has probably had the visor up ever since he first found the orange soil.]

[Schmitt - "Here, when I was bagging the sample, I was using the RCU and the top of my camera as a work bench that was immediately available."]

145:46:10 Schmitt: (To Gene) Okay, I got it. (To Houston) Okay, the basalt (from the large boulder) is in bag 512.

145:46:21 Parker: Copy that. (Long Pause)

[The pockets on the side of Gene's SCB are clearly visible. Gene picks up something with his tongs.]

145:46:40 Schmitt: I'm getting in your bag (SCB) here, Gene.

145:46:41 Cernan: Got it? (Pause)

145:46:45 Schmitt: Okay. (Pause)

145:46:54 Cernan: Jack, our lock is on the outside here, so we ought to watch this gate.

[Gene is at the left rear of the Rover. Jack is gathering the gnomon legs in his fist prior to stowage.]

145:46:59 Schmitt: What happened?

145:47:00 Cernan: Not going to worry about it. This (gate) lock is on the outside of that lever lock. You'll see what I mean when you look at the lock. (Pause) Okay, I'm going to go get my pan.

145:47:13 Schmitt: Okay.

145:47:16 Cernan: The cores are not rammed yet. You want to ram them while you're here?

[That is, compact the material in the core by ramming a "follower" on top of the soil so that it won't get shaken and mixed.]

145:47:19 Schmitt: What did you do with my extension handle? Oh, it's...

145:47:21 Cernan: Here. And if you want to ram them (probably handing Jack the rammer)...

145:47:23 Schmitt: Okay.

145:47:24 Cernan: ...here you are. They're not rammed.

[Gene heads east; Fendell follows him.]

145:47:28 Schmitt: I'll get them.

145:47:31 Cernan: Okay, Bob, I'm going several meters around to the east and (slightly) towards the south to get this pan.

145:47:38 Parker: Copy that.

[Gene takes this pan from about 40 meters east of the Rover.]

145:47:43 Cernan: I'm going upslope. I'm circum...I'm on the circum...Oh, you know, on the rim. And I'm up. Oh, that ought to be a beautiful shot, if I could see what my settings are.

145:47:57 Schmitt: Okay, the lower core is "chucky-jam" full. (A favorite expression of one of Schmitt's college professors, R. H. Jahns.) I don't think I've budged that thing.

145:48:06 Parker: Okay. Copy that. (Pause)

[Fendell catches up with Gene at the southeast rim of the crater.]

145:48:21 Parker: Okay, and, Jack, I copied - aside from three trench samples - I copied one single bag of basalt samples. Is that correct?

[The TV picture shakes as Jack works at the Rover.]

145:48:35 Schmitt: That's right. 512.

145:48:36 Parker: Copy that.

145:48:37 Cernan: (Looking west) Hey, Bob, from where I am, (I can look at a place) about 100 meters around the west side of the rim of this crater (where) the mantle on the inside of the rim turns from this grey material we've been sampling, in here, to a very dark grey material. And there's a lot of orange stuff that goes down - radially down - into the pit of the crater.

[Schmitt - "A first-rate observation."]

[Cernan - (Tongue slightly in cheek) "I really do appreciate getting an A-plus on the quiz. I really wondered;

it's taken a long time (nearly 19 years) to find out how I did."]

145:49:03 Parker: Okay. Copy that. Outstanding!

[Gene's color pan consists to frames AS17-137-20991 to 21027. The frames showing the radial streak of orange that goes down into the crater are 21007 to 21012]

145:49:08 Schmitt: Hey, Bob, those cores didn't feel like the follower went down at all.

145:49:14 Parker: Okay.

145:49:15 Schmitt: Shouldn't it have gone a little bit?

145:49:17 Parker: Not necessarily, if it's pretty compact stuff. You were having a hard time getting it in.

145:49:24 Schmitt: Well, I thought there was a little space up there, but maybe I just didn't feel it.

145:49:27 Parker: Not very much...

145:49:28 Schmitt: I don't think there's much danger of them coming apart.

[Gene finishes the pan.]

145:49:30 Parker: Okay. Great.

145:49:34 Cernan: I got to take a couple of more pictures at that contact slope over there. You can't see it from where you are, Jack, but I guess we got to leave. Otherwise it would be nice to sample that dark stuff up on top.

[Gene moves about ten feet west. As he moves, he kicks flat sheets of dust a few inches off the ground. The sheets reflect sunlight into the TV camera, creating a short-lived patch of light.]

145:49:45 Parker: We need you guys rolling in 7 minutes.

145:49:51 Cernan: We can get a...Oh, I bet I'm out of film! Well, I got them all anyway, Bob. I'm at (frame) 162. I'm out of film.

[Gene heads back toward the Rover.]

145:50:06 Cernan: (Gesturing toward the west) That stuff (inside the crater rim) - and you're looking at me with the camera - that stuff is up toward that boulder. About as far away from that boulder on the other side as we are on this side. And we want a hack at that boulder, too. Jack, let's see if we can't get that boulder, anyway. (Pause) But I don't have any film.

145:50:25 Parker: Guys, we don't have that much time.

145:50:31 Cernan: I know, Bob, I know. (Pause) There's a lot of little pieces - not a lot - but enough that I've seen five or six of them. Little pieces of obsidian-like glass. I got one in my pocket. Unbagged. Undocumented. (Pause)

This boulder that you were looking at with the TV, I'm going to take a sample. Undocumented.

145:51:00 Schmitt: I got it! I got it!

145:51:02 Cernan: Oh, you got it?

145:51:03 Schmitt: Yeah.

145:51:04 Parker: Yeah.

145:51:05 Schmitt: Let's go.

145:51:06 Cernan: I'm sorry, I didn't know you got that.

(Pause)

145:51:10 Schmitt: Bag 461 has another sample of basalt that I picked up right near where we dug the trench.

145:51:21 Parker: Copy 561 (sic).

[Gene grabs the TV and turns it to point into the west portion of the crater.]

145:51:22 Cernan: Okay, Bob, I'm going to give you something with the TV. I want to show you where that dark material starts.

145:51:33 Schmitt: (Putting a sample in Gene's SCB) Hold still, now.

145:51:34 Cernan: (To Parker) Okay. As you look at the inner rim - as it goes down (cough) to the right - you see a lot of boulders, a lot of rocks - that are protruding out. Where that rock pattern thins out, just beyond that is an orange - a visible orange - radial pattern, and then beyond that is a definite change in albedo where you get the grey material, and a definite change in the number of rocks on the slope.

145:52:08 Parker: Gene, Roger...

145:52:09 Cernan: And that particular...

145:52:10 Parker: Copy that.

145:52:11 Cernan: ...material can...(Hearing Parker)

145:52:12 Parker: And if...

145:52:13 Cernan: ...and that particular

material...(Hearing Parker again) That par...(Stopping a last time for Parker) Let me finish, Bob! That particular rim material there continues around to the due north, and then there's a drastic change again where you see the inner rim completely terraced with this boulder fill.

145:52:34 Parker: Okay, copy that, Gene...

145:52:35 Cernan: And I can't bet on it, but I can see it...

145:52:36 Parker: ...and you can talk about it when you get home.

145:52:40 Cernan: Okay. As long as you're happy, I am.

145:52:42 Schmitt: Wait, Gene. Wait, wait, wait.

145:52:44 Cernan: I got to get the film changed, Jack...

145:52:46 Parker: All right, Gene, change the film at the next...

145:52:47 Cernan: ...(garbled).

145:52:48 Schmitt: Okay.

145:52:49 Parker: ...station. We can save time that way.

145:52:51 Cernan: All right.

145:52:53 Parker: And we would like the SEP turned on before you leave...
145:52:56 Cernan: (Garbled).
145:52:57 Parker: ...and we'd like EP number 1 taken, Jack, so you can deploy that at Victory.

[This is another explosives package for the seismic experiment.]

145:53:04 Schmitt: Okay.
145:53:06 Cernan: I'll get your scoop for you. Have you been leaving it cocked like that?
145:53:10 Schmitt: Yes.

[The scoop head can be rotated by squeezing a pair of flat plates on either side of the pivot. By pushing the plates, a locking mechanism releases. There are detents at angles to the handle of 0, 40, and 90 degrees. Here, Jack has been using the 40 degree detent.]

145:53:11 Cernan: Of course, we haven't been taking any SEP measurements, and I don't know what difference it makes.
(Long Pause)

[Fendell finds Earth, which is a bit more than half illuminated.]

145:53:33 Cernan: Okay, everything is locked on. I guess I owe you a reading, Bob?

[Gene's "I guess I owe you" was said so quickly that, despite numerous listenings, none of us could figure out what he said until, during a final review of the manuscript, I was finally listening to it in the right frame of mind. Parker's next statement makes it clear that he didn't understand what Gene said and thought he was talking about comm quality.]

145:53:38 Parker: We've been reading you loud and...
145:53:39 Cernan: (The gravimeter reading is) 670, 012, 501; 670, 012, 501.
145:53:46 Parker: Okay, we copy that, Geno, and...
145:53:49 Schmitt: Okay, got the...
145:53:50 Parker: Charge number 1 and we need the SEP, On...
145:53:53 Schmitt: We got the gnomon, we got the rake... (Pause)
145:53:58 Cernan: SEP on, Jack? I'll get charge number 1 for you.
145:54:00 Schmitt: Okay. I'll get the SEP on.
145:54:01 Cernan: I'll just hand it (the charge) to you (after Jack is seated).
145:54:03 Parker: And what's your frame count, Jack?
145:54:05 Cernan: Charge number 1.

145:54:07 Schmitt: Okay, (SEP) power's On, recorder's On, the temperature is one-twelve (112).
 145:54:16 Parker: I copy that. (Pause)
 145:54:26 Schmitt: Can you get it (the charge), Geno?
 145:54:27 Cernan: Yep. (Pause) You get in (and) I'll hand it to you.
 145:54:36 Schmitt: Okay.
 145:54:37 Cernan: And then I'm going to get the TV.
 145:54:38 Parker: And, Jack, what's your frame count, please?
 145:54:42 Schmitt: Wait, Bob, I can give you that on the Rover.

[TV off]

145:54:45 Parker: Okay. I thought you were on there.
 145:54:47 Cernan: Okay, camera Mode switch is 1; (TV) camera's going Aft. Well, I guess that's the breaks of life. Low gain I'll set when I get on. I'll give you (Jack) this (charge) when you're ready. First thing I got to do, Bob, is change film at the next station.
 145:55:12 Parker: That's affirm.
 145:55:15 Schmitt: And, Bob, LMP is at (frame count) seven-five
 145:55:19 Parker: Say again, there, Jack, I missed that.
 145:55:24 Schmitt: Seven-five.
 145:55:25 Parker: Copy that. Thank you. (Pause)
 145:55:31 Cernan: I must be getting fatter, you know it.

[The seat belt feels snug.]

145:55:33 Schmitt: Fatter?
 145:55:35 Cernan: Well...
 145:55:37 Schmitt: Depends on how you get in. (Garbled) your hammer.
 145:55:40 Cernan: Okay, we got a (warning) flag on the Rover.

[The warning flag is a thin metal plate, hinged at the top of the control console and held down by a spring. It is painted with diagonal red stripes and is triggered by thermostats in the batteries, nominally at 125 F, and in the drive motors at 400F. The warning flag can be reset.]

145:55:43 Schmitt: Your hammer's caught again.

[Schmitt - "We could see part of each other's footpan, but not all of it because of the console."]

145:55:45 Cernan: That's all right. We got a flag on the Rover, and I'm reading 136 on battery number 2.

[On the first day, the battery temperatures had been higher than expected and, prior to the second EVA, engineers

at the Marshall Spaceflight Center in Huntsville had re-examined the question of battery sensitivity to temperature and advised the Flight Director and the crew that temperatures below 140 degrees Fahrenheit wouldn't be a problem.]

[Schmitt - "The temperatures were getting up there; but Marshall also had pretty good safety margins on those batteries. The fact that they were getting hotter was a concern, but they never caused a problem."]

145:55:54 Parker: Say again on that one, Gene.

[Schmitt - "My first inclination in the MOCR would have been to turn around and say 'Did anybody get that?,' rather than call right up and distract the crew."]

145:55:57 Cernan: I'm reading 136 - make that 132 - on battery number 2, and we did get a flag.

145:56:03 Parker: Copy that.

145:56:09 Cernan: Okay, Jack, I'm going to make a very sharp right turn here, because I do not want to go down that hill (into the crater).

145:56:18 Schmitt: Okay. We're moving, Houston.

145:56:21 Parker: Roger. You're moving exactly 37 seconds early.

145:56:28 Cernan: Early!? I could have gotten that dark mantle on the other side of that crater. That's all it would have taken me.

145:56:35 Schmitt: So you saw a radial orange (soil distribution inside the crater wall), huh?

145:56:38 Cernan: Yeah, it was. Radial, Jack. You could see it very...It'll be in the pictures. Oh, man, I can't drive into that heading (because of sunlight reflection off the LCRU.) Let me get my...

[Gene will drive 1.5 kilometers west from Shorty to get to Victory Crater, where they will make a very brief stop to deploy the seismic charge. However, because of the bright Sun, Gene will tend to tack, turning slightly north and then slightly south to avoid the worst of the glare.]

145:56:45 Schmitt: That was on the inside of the crater?

145:56:47 Cernan: On the inside rim of the crater.

145:56:49 Schmitt: Yeah, that's where the surface stuff keeps slumping off as it's exposed, probably.

[Jack and Gene had both been so busy that they hadn't been able to listen carefully to each other's conversations with Parker. In Gene's case, he had completely missed the fact that Jack had already sampled the boulder; and, here, Jack wants to confirm the details of Gene's observation - which he may have only half heard - of the radial pattern of orange soil.]

[Schmitt - "I can't say I remember this exactly, but I'm confident that, as we were driving away and I was finally taking a deep breath, I was beginning to review the thirty minutes we'd had at Shorty and what it all meant. So I wanted to make sure I understood what Gene had seen."]

145:56:56 Parker: Quite a station, men. We thought...
 145:56:58 Cernan: I'm going to get myself...Okay. I'm Min.
 145:56:59 Parker: ...Station 2 was a good station! (Pause)
 145:57:05 Cernan: Okay, I'm Min. Man, I'll tell you, that heading is going to put us right...Okay, Bob, give me a...Dang. Wait a minute.
 145:57:15 Parker: The heading you should be generally taking...
 145:57:17 Schmitt: Where we at?
 145:57:18 Parker: ...toward Victory is 090, Gene.
 145:57:23 Cernan: Okay, can you give me a bearing and range at Victory?
 145:57:27 Parker: Okay. Stand by.
 145:57:28 Schmitt: (To Gene) Did you get the TGE read?
 145:57:30 Cernan: Yeah, I did. I got it read. They got everything (they wanted at) that station; but not everything I'd like to give them.
 145:57:36 Parker: Okay, it's going to be...
 145:57:37 Schmitt: Houston...
 145:57:38 Parker: ...105 and 3.1.

[They will actually make their stop at 106/3.2. Houston has again revised it's estimate of the SEP transmitter location and, indeed, now knows where it is to high accuracy.]

145:57:41 Cernan: Okay. (Pause) Man, I tell you that LCRU is terrible when it flashes into you.
 145:57:48 Schmitt: Well, you can always zigzag.
 145:57:50 Cernan: Yeah, that's what I've got to do. I've got to tack into that Sun. (Pause)

[Cernan - "Driving up-Sun was mean. It was like what happens in flight when the Sun's directly overhead and you look down. You just lose your visibility because of the glare."]

145:58:00 Schmitt: I got it.
 145:58:02 Cernan: Okay. We got to go to Victory.
 145:58:08 Schmitt: Houston, I didn't have time to really think at that station; but that could...I think, based on having seen the alter(ation)...If I hadn't seen that alteration and all I'd seen was the fractured block on the rim - which looked like the stuff (the blocks) in the bottom - I might have said it was just another impact (crater). But having all the color changes and everything, I think we might have to consider that it could be a volcanic vent.

[Schmitt - "I started to talk too soon. I should have waited a few minutes; but I imagine the adrenaline was still flowing. I was trying to get to a point in my thoughts where I could start to interpret a little bit."]

145:58:43 Parker: Roger. It surely was different, anyway.
 145:58:46 Schmitt: I'm not sure how we prove it. We didn't have time to prove it.
 145:58:53 Parker: We noticed. (Pause) I guess that's the breaks of the game, sometime.
 145:59:03 Cernan: Hey, Bob, I forgot your numbers at Victory. How about giving them to me again?
 145:59:05 Parker: Okay. 105, 3.1. And it'll be a heading of 090...
 145:59:11 Cernan: Okay. Thank you.
 145:59:12 Parker: ...that's the general heading in that direction.
 145:59:15 Cernan: Okay. 105, 3.1.
 145:59:19 Parker: I guess we always have Station 9 to look forward to, guys. That may be the same thing...We'll probably be out of time when we get to that one, too.
 (Pause)
 145:59:25 Cernan: Nobody likes a pessimist. (Long Pause)

[From the evidence of the overhead photography, there was a suggestion - as had been made for Shorty as well - that Van Serg Crater could be a volcanic feature. A visit to Van Serg (Station 9) is planned for EVA 3.]

[Schmitt - "We were pretty quiet in here (for about forty-five seconds) and it seems to me that we were in a bit of a letdown after Shorty. We'd been on an emotional high and had been going so fast and needed stop talking and take a deep emotional breath."]

[Cernan - "Being on the Rover was one of the few places where you could relax. Physically, you were constrained and had to relax. The only thing I had to do was drive - which took a little more attention than usual because of the Sun - and observe as best I could. Sometimes, not talking is very restful. When you're talking - particularly in a case like this, you've got to think; and thinking takes energy. And, after a while you get tired of hearing yourself talk. We'd done an awful lot in the last few minutes at Shorty and we needed to rest both mentally and physically."]

146:00:11 Cernan: Hey, Bob, a note on those (battery) radiators: I have been dusting the covers at every stop, whether that's any help or not.
 146:00:19 Parker: Okay; we copy that. (Pause)
 146:00:27 Schmitt: Okay, sports fans. We're still about on the...Well, I think we moved...Yeah, we moved out into the Tortilla Flat area, I guess. (It's) not very flat.
 146:00:43 Parker: That's affirmative. (Pause)

[In the overhead photographs, Tortilla Flats is a dark area between the main body of the light mantle to the west and a thin finger of light mantle to the east.]

146:00:50 Cernan: Those kind (of shallow craters) I can go through...If I can see them coming.

146:00:54 Schmitt: 102, 3.8. And where's Victory?

146:01:01 Parker: Dead ahead.

[Schmitt - "Victory is a 'V'-shaped depression that was probably made out of three craters. It commemorates Winston Churchill. Although it's a political symbol, I think we actually got that one by the nomenclature committee."]

146:01:02 Cernan: Boy, Victory is going to be subtle, I'll tell you. (Pause) Bob, how long we been out?

146:01:12 Parker: Stand by. 5 (hours) plus 26 (minutes); 5 plus 26.

146:01:15 Schmitt: Hey, Bob, I recommend that, if we ever do this again, let me get off and pick the charge off when we want to deploy it. It really adds to the fatigue of the hands.

146:01:35 Parker: I tell you...

146:01:36 Cernan: Couldn't you just hook it onto your fingers?

146:01:37 Parker: We copy that, Jack. And Charlie (Duke)'s got a big smile on his face here. (Pause)

[At the House Rock stop on Apollo 16, at 167:32 of that mission,, Duke hooked his sample bags onto his middle finger because the mounting bracket on his camera had failed.]

146:01:49 Schmitt: (Dramatically) Mark my words.

[Schmitt - "This sounds like something that somebody might have said repeatedly during training, but I don't remember anything about it."]

146:01:52 Cernan: There's Victory over there, I'll bet. See that's the long edge.

146:01:56 Schmitt: Yeah, yeah. I can't see over there, but...

146:01:57 Cernan: Okay.

146:01:58 Schmitt: ...got too much Sun in my eyes.

146:02:01 Cernan: That's the right way to go. That'll be about it, too, (on range and bearing). (Pause)

146:02:08 Cernan: Man, I don't think I've really seen the LM, except (garbled)...

146:02:10 Schmitt: (Garbled) big rock in front of you.

146:02:12 Cernan: I got it.

146:02:13 Schmitt: Okay. (Pause) Well, you can't tell much about the countryside going into the Sun, can you?

[Schmitt - "What I had hoped to do, as we crossed the edges of the light mantle on either side of Tortilla Flat, was to pick up anything at the contact that we might use to identify it. And, in retrospect, because we hadn't been able to see a sharp contact on the (down-Sun) drive to Station 2, with the Sun in my eyes there was just no way I was going to make any useful observations in here. So that's why there's not much information coming out of us at this point. Going down-Sun to Station 2, we had the highest albedo reflections coming right back at us and we could see the brighter crater walls on the light mantle. But going into the Sun you're mostly looking into shadow and there's also the obscuration caused by the dust on your visor."]

146:02:21 Cernan: Put your upper visor down. That'll give you a whole different perspective.

146:02:26 Schmitt: It doesn't vise very well. It's stuck.
(Pause)

[Schmitt - "The upper visor was the middle (laterally) part of the visor assembly that had a sunshade on it. It was fitted in a slot and you could grab the sunshade and pull it down. Mine had gotten a lot of dust in it."]

146:02:42 Cernan: That's got to be Victory over there, Jack.

146:02:43 Schmitt: Yep. (Long Pause)

[Cernan - "In looking at some of the pictures that Jack took during the drive, you see things in one picture that you didn't see in the last. Everything was new. Every time you went over another hill, every time you went over a saddle, or went into another valley, you came into something that you didn't know was there or didn't expect to look like it actually looked. It was true exploration of a virgin territory; particularly with the mobility that the Rover gave."]

[Jack's photos taken during the drive to Victory are AS17-133-20269 to 20277.]

146:03:03 Cernan: We're at 103, 3.4.

146:03:06 Parker: Copy that. (Pause)

146:03:13 Cernan: That is Victory.

146:03:17 Schmitt: (To Parker) We're still seeing the pit-bottom glass... (Starting again) The glass-lined, pit-bottomed craters. How's that (for terminology)? (Pause)

146:03:30 Parker: Otherwise known as...

146:03:31 Schmitt: That's geology-ese if I ever heard it.

146:03:32 Parker: ...the GLPBC.

146:03:36 Schmitt: Took you a while (to come up with the acronym), didn't it?

146:03:43 Parker: It's 11 o'clock (p.m. Central Standard Time) down here, guys.

146:03:48 Cernan: It's 11 o'clock up here, too, Bob.

[Schmitt - "A coincidental thing at this point in the transcript is that Professor McKinstry - after whom Van Serg Crater (Station 9) is named - had done a paper on geologese in which he made fun of what geologists sometimes use as terminology.

"These pit-bottom craters really were quite common. I think that the depth of the bench in a pit-bottom crater varied with size. So I suspect, then, that it has to do with a relationship between the impact energy and the confinement of the regolith with depth. The more energy you have, the deeper it can penetrate before you have a hiatus in the relationship between confinement pressure, if you will, in the regolith and the excavation capability of the impact. I'm sure the soil mechanics people would have better ways to put that; but some of those pits were remarkable and, in my mind, it's a little hard to understand how those craters formed. It may reflect what people have said these impacts really are: small linear explosions. Near the upper surface, where there's no confinement, you get essentially a point explosion-type excavation. But, as you get near the depth of maximum penetration, you get more of a linear explosion back out. Who knows? They were quite common and the fresh ones, like all of the fresh craters, had a little glass in the bottom of them. I suspect they prevalent everywhere on the Moon, but you're going to have to be clever to recognize them in the pictures. In a few places we sampled the glass and (in one case) even tried to get an oriented sample. One of the theories was that these impacts would cause local magnetic anomalies and we wanted to see if, as the glass cooled through the Curie point, it would retain memory of the field."]

146:03:51 Cernan: There's a square boulder. Look at that one!

146:03:55 Schmitt: Yeah, it's square all right...or at least one side of it is.

146:04:00 Cernan: No, three sides of it are square. It just fractured that way. That's by accident, looking at it. So how do we get over here?

146:04:06 Schmitt: Go left, probably. And along the rim.

146:04:08 Cernan: Yeah, that's where I'm going to go. Hold on.

146:04:12 Schmitt: I'm holding. (Pause; brief static) Whew! (To Parker) If Charlie is smiling because my hands are tired, why did he let me get the charge off? (Assuming a slightly sarcastic tone) Fine backup crew we got. (Pause)

146:04:40 Parker: You guys didn't really mean to say that, did you?

146:04:46 Schmitt: 106, 3.2 (bearing and range to the SEP transmitter). We're approaching the rim of Victory. (Static; pause)

146:04:57 Schmitt: And the LMP frame count is somewhere around seven...Well, eight-five, maybe.

[Cernan - "Dust was getting to be a big problem. This was a long EVA and we'd done a lot of driving. I don't think dust was a problem reading the Rover console because that was pretty vertical, but I noticed at one of the earlier stations I dusted the top of my RCU so that I could read it better."]

[Jack's photos taken during the approach to Victory are AS17-133-20278 and 20279.]

146:05:03 Cernan: That's Victory; look at it go to the left and look at it go to the right. That's Victory; we're right on the ridge.

146:05:07 Schmitt: Yeah. Yeah.

146:05:09 Parker: Okay; and we're picking...

146:05:11 Cernan: We're at 106, 3....

146:05:12 Parker: ...on a Rover pan, you guys...Copy that (bearing/range readout).

146:05:14 Cernan: 106, 3.2.

[The checklist location is 107/2.8.]

146:05:18 Schmitt: Okay, let's see.

146:05:19 Cernan: Tell me where you want that thing (the seismic charge) and we'll get a pan around it.

146:05:21 Schmitt: Okay, I tell you what. You see right ahead of you?

146:05:24 Cernan: Yeah.

146:05:25 Schmitt: (It) looks like a place you could spin a profile on.

146:05:28 Cernan: Yeah, I could do it. Right up in here.

146:05:31 Schmitt: And deploy the charge. Tell me where you're going.

146:05:35 Cernan: I'm going, right here; you could put it in that hole. No, you don't want to do that.

146:05:41 Schmitt: Oh, that's all right.

[Schmitt - "I don't think the antenna (on the charge) had to see the Central Station. There was a ground wave that would let you communicate. I think we had asked the Principal Investigator if there were any reasons - like coupling of the explosion - why we should avoid holes and he had said it didn't make any difference."]

146:05:42 Cernan: Just pick a spot and take your photos.

146:05:43 Schmitt: Okay, I've got them. Now, go just beyond there. Little bit more. That's good.

146:05:54 Cernan: Okay? Okay, Bob, we're at 106, 3.2.

146:05:58 Parker: Copy that. (Pause)

[Jack's photo of the charge location is AS17-133-20280.]

146:06:05 Schmitt: Okay. Pull out (the charge antenna); pin 1 is pulled and safe. Pin (pause) 2 is pulled and safe.

Pin...Boy, these are stiff this time around. (To himself)
 Push it in. Try again.
 146:06:25 Cernan: That's a big black box. Don't pull it too hard. (Pause)
 146:06:33 Schmitt: Aah. Stand by on pin 3, gang.
 146:06:35 Parker: Copying that. Remember to push it all the way back in, Jack, and start from scratch.
 146:06:40 Schmitt: I did; I did; I did. I remembered; I remembered.
 146:06:43 Parker: Good, good, good.

[Parker says that Jack had sometimes had trouble with the charges in training.]

146:06:46 Schmitt: But now I can't get to the...
 146:06:53 Cernan: Your hands are tired. Let me try it once.
 146:06:55 Schmitt: No, it's not that. It's just...It's coming. Got it! Pin 3 is out and safe.
 146:07:02 Parker: Copy that. (Pause)
 146:07:07 Cernan: And look at the orange flag. Zowie!

[Each of the charges has an orange strip attached to the tip of the antenna for photo-identification.]

[Schmitt - "The engineers were also afraid that we would come back along our track and run over one."]

146:07:12 Parker: That's what you guys were sampling at Station 4, I bet.
 146:07:17 Cernan: Huh? Yeah, it's about that orange, only not quite as bright. Same shade. Okay. Okay, let me turn my (Rover power) switch on. Hey, Bob...

[Public Affairs reports that they are only 12 minutes behind the nominal (EVA) timeline]

146:07:28 Schmitt: Wait a minute, wait a minute. Let me get that (charge) out a little more (away from the Rover).
 146:07:31 Cernan: Bob, there's no question but what that we're at Victory.
 146:07:36 Parker: Say again there, 17.
 146:07:37 Cernan: It's the first crater that looked like I thought it would.
 146:07:39 Parker: Okay.
 146:07:40 Cernan: (To Jack) Okay. You ready?
 146:07:44 Schmitt: Let me change my (camera) setting here.
 146:07:48 Cernan: Okay.
 146:07:49 Schmitt: Go ahead
 146:07:51 Cernan: Okay, let's get a nice Rover pan here.

[Gene will turn the Rover in a tight circle while Jack takes a sequence of photographs. The photos in the LRV pan are AS17-133-20281 to 20300. Frames 20291 and 20292 show their in-bound Rover tracks. Frames 20293 and 20294 show the

west arm of Victory; and frames 20296 and 20297 show the east arm.]

146:07:55 Schmitt: Okay, turn the other way first.

146:07:56 Cernan: Yeah. (Pause)

[As at the Scarp Gravimeter stop, Jack probably wants Gene to turn left.]

146:08:01 Schmitt: Take her slow.

146:08:02 Parker: And we'll get a Rover sample here before you guys leave, too, after the circular pan. (Static)

146:08:08 Schmitt: We will.

146:08:12 Cernan: Slow enough?

146:08:13 Schmitt: Yeah. (Pause) Look at the light mantle over there.

146:08:21 Cernan: You can sure see it now, can't you now?

146:08:23 Schmitt: Yeah. (Long Pause)

[The frame showing the light mantle and the Scarp is AS17-133-20289.]

146:08:38 Cernan: Getting your (camera) settings changed fast enough?

146:08:41 Schmitt: I got it; yeah. (Pause) Okay.

[Schmitt - "You had to change the f/stop. With the Sun directly behind you it was f/11. On either side of that it was f/8. And then f/5.6 back toward the Sun. The shutter speed was 1/250th of a second. When we had color film in one of the cameras - usually in Gene's camera - we were making the first use of a brand new Kodak Ektachrome film."]

146:08:47 Cernan: Okay, let's get our Rover sample.

146:08:50 Schmitt: Okay. (Pause)

146:09:01 Schmitt: (To Parker) And the Rover sample will be from the same locality. (Pause)

[Schmitt - "It had seemed to me for a long time that with the Rover we just weren't getting enough statistical coverage of the regolith across the area, and the Rover sampler was a way to get more samples. I don't remember how many Rover samples we got, although it wasn't as many as I'd intended to get."]

146:09:10 Cernan: Boy, it's just a couple of meters from the charge, isn't it?

146:09:12 Schmitt: Yeah. I hope I didn't put too much soil in there for you (to be able to close the bag). Wait a minute.

146:09:20 Cernan: Okay.

146:09:23 Schmitt: (To Parker) Rover sampler works just as advertised.

146:09:25 Parker: Copy that.

146:09:27 Schmitt: Not bad.

[Jack believes that, at some point during training, he had requested a tool he could use to get samples from the Rover. "It was pretty much considered my baby."]

146:09:30 Cernan: Bag 43 Yankee.

146:09:33 Parker: Copy; 43 Yankee. And how about a frame count now, Jack.

146:09:39 Schmitt: I will. Stand by. You're jumping the gun occasionally but not very often.

[Schmitt - "Bob sometimes forgot to anticipate when the crew was busy."]

146:09:50 Schmitt: (Having trouble reading the frame count indicator) One hundred and six.

146:09:52 Parker: Copy...

146:09:53 Cernan: It's in the bag (SCB), Jack. Okay?

146:09:54 Parker: ...106.

146:09:57 Cernan: Okay. I guess we're ready to leave here, huh?

146:10:00 Schmitt: Well, if they don't want us to stop here, I guess we leave.

146:10:02 Parker: Roger. We're ready for you guys to leave there...

146:10:03 Cernan: No, there's nothing else here now.

146:10:04 Parker: ...and we're pressing on toward station 5.

146:10:07 Schmitt: Okay...Gene?

146:10:11 Cernan: (Looking at checklist page LMP/CDR-22) Okay, and I want to go about (on a heading of) 120.

[They will drive about 1.9 kilometers on a heading of 120 to reach the southwest rim of Camelot.]

146:10:13 Schmitt: Gene.

146:10:14 Cernan: Yeah?

146:10:15 Schmitt: Gene, can you swing out there and give me one look down north into Victory?

146:10:18 Cernan: Yeah, I can do that. I've got to go by that way anyway. (Pause) North.

146:10:25 Schmitt: Well, you know, just swing around and point north so I can look in there.

[Because they can't twist the suits and have limited field-of-view, Jack is asking Gene to turn the Rover.

[Cernan - "Your helmet didn't move, so you had to turn your head. But the visor only let you look maybe 45 or 60 degrees to either side, so it was easier just to point the Rover."]

146:10:28 Cernan: Yeah.

146:10:29 Schmitt: I never got a good look at it.

146:10:32 Cernan: Well, it's a series of three craters. There's some boulders on the talus slope of the easternmost...eastern slope of the west...eastern slope of the southernmost crater, the one we're closest to. (Pause)

146:10:51 Cernan: Now, how does that look to you?

146:10:53 Schmitt: Well, it looks like...

146:10:55 Cernan: Okay, and there's the other...

146:10:57 Schmitt: I don't know what it looks like. The northwest end of the V has white...(correcting himself) light blocks on it - boulders - on the inner wall and right at the rim. And the northeast end of the V looks like it has somewhat darker rocks.

146:11:15 Cernan: Yeah.

146:11:16 Schmitt: Part of that is shadow, but I think they are darker. And they look like about the same as down here near the tip of the V.

146:11:22 Cernan: Got to be careful on that one, because there's one sloping away and one sloping towards us.

146:11:25 Schmitt: Yeah, I know. I've qualified it.

146:11:28 Cernan: Okay; we are rolling, by the way. And we're at 106 and...Well, we're still 3.1.

146:11:37 Parker: Yeah. Copy that. Thank you.

146:11:42 Schmitt: And the rim itself, though, of Victory is not blocky. There is some increase in fragment size, but that seems to be the result of some craters in the rim that have gotten below the debris that's covering it. I'd say that Victory's somewhat like Horatio in that it has blocky inner walls but essentially a normal block population on the rim.

146:12:09 Parker: Okay. And we've got a Rover sample going toward Station 5 (Camelot Crater) at about 103 and 2.5. (Pause)

[This is a change from the location given on checklist page LMP/CDR-25, a revision due to the fact that the LM is not at the planned landing spot. Evidently, the Backroom is interested in a particular geographic location for the sample.]

146:12:21 Cernan: Okay. 103 and 2.5.

146:12:24 Parker: Roger. And that'll be just a grid (sic) sample.

[Schmitt - "I think Bob may have been mis-using a term here. And that may be reflected in my next comment. A 'grid' sample would have been a series of samples on a map grid. So I'm not sure what he meant."]

146:12:32 Schmitt: They're none of them just grid samples, Bob. (Pause; Jack laughs as Gene turns to avoid a crater)

146:12:40 Cernan: You see, you can't tell how deep they are until you get up to them.

146:12:43 Schmitt: Yeah.

146:12:44 Cernan: That one I could have gone through.

146:12:46 Schmitt: Yeah. (Pause) Okay; Station 5 is Camelot. (Pause) Good old Camelot.

[Long Pause; Jack hums at length from the Lerner and Lowe song Camelot: "Where once it never rained 'til after sundown," etc. Photos taken during this part of the drive are AS17-133-20301 to 20318.]

146:13:21 Cernan: Look at the size of that one. That's another one of those (GLPBC's)...

146:13:23 Schmitt: Yeah.

146:13:24 Cernan: There's another one on the right. Lookit.

146:13:26 Schmitt: Some of them have...

146:13:30 Cernan: Well, that one doesn't have any fragments in the bottom of it.

146:13:31 Schmitt: No.

146:13:32 Cernan: Looks like someone walked across it.

146:13:34 Schmitt: Yeah. (Pause) I think that there's quite a variability in the thickness of the dark mantle in here. Did you...I didn't notice us crossing that one tongue of light mantle.

146:13:43 Cernan: No, I didn't either. We obviously did...

146:13:45 Schmitt: I think we did. Right at Victory, but it didn't show up.

146:13:48 Cernan: Looking into the Sun, you can't tell any difference anyway. (Pause)

146:13:56 Schmitt: However, I tell you, I certainly get the impression there is a mantle. I would say that...

146:14:03 Cernan: Oh, I think so.

146:14:05 Schmitt: I don't know what it is, but the dark mantle exists. (Pause) They're just...The craters...(Pause) These craters are just too big not to have thrown up blocks. And they're either subdued by the mantle or they haven't penetrated it.

146:14:28 Cernan: And a lot of these blocks...

146:14:30 Schmitt: And I think you probably have both. Excuse me, Gene.

146:14:32 Cernan: I'd say they've been subdued by the mantle. That really imposes an impression on me.

146:14:39 Schmitt: Yeah. There are those that appear that way; like Horatio, for example, or the big ones. But others, I think, are too young. They just don't penetrate. Particularly those that are big and have bright halos.

146:14:47 Cernan: Well, yeah; but the only ones that look fresh and not (big) enough to penetrate are these little ones with the glass in them.

146:14:52 Schmitt: Well, there's been some big fresh ones. We'll look for one.

146:14:57 Cernan: Now there's one with glass in it, probably.

146:15:00 Schmitt: Yeah. I think that's one...

146:15:01 Cernan: And without any blocks on it. That may not have penetrated.

146:15:05 Schmitt: Yeah. Yeah, that just has mostly the shock-indurated rock...instant rock.

[The academically-favored term is regolith breccia, soil fused into rock by an impact. AS17-133-20316 may be a photo of this crater.]

[Cernan - "We were having a little observational debate through here. Jack looked at things differently than I did because of his professional background but, on the other hand, I always thought my observations were as good as his. You describe what you see. Someone else might interpret what it is. I always felt I didn't have to tell them what it was; I had to tell them what I was looking at. If I had an impression of what it might be, I'd give them that impression. But I don't think we had time to come to any absolute conclusions nor was it expected of us. We were on the Rover and we were moving and we had to give good enough observations that a geologist could put them together and come up with a pretty fair description of what these craters were all about."]

146:15:13 Cernan: We're coming up to 103 at 2.6 now, so we need a sample up here.

146:15:17 Schmitt: Okay.

146:15:18 Cernan: Okay. 103, 2.5. Anywhere.

146:15:22 Parker: Roger. That's affirm.

146:15:23 Cernan: Okay, let me slowly go to the right here.

146:15:25 Schmitt: Okay. Right out in that little inter-crater area, right out in there is good. If you let me guide you a little, I might get a rock fragment. Whoa, whoa, whoa.

146:15:34 Cernan: (Garbled)

146:15:36 Schmitt: Yeah. That wasn't quite enough.

146:15:41 Cernan: Okay. Pick a place.

146:15:42 Schmitt: Move ahead about...Yeah, right...Just...No, that's good. Straight ahead. Straight ahead. Good, good, good, good, good, good, whoa! (Pause) Now we'll give it a try.

146:15:55 Cernan: Okay, 103, 2.5.

146:15:58 Parker: Copy that.

146:16:00 Cernan: And that battery is still at about 132.

146:16:02 Parker: Okay. Copy that. We're allowed to go to 140, tonight.

146:16:10 Cernan: I don't expect we'll make it (past 140). I think we'll get done before that. Save that for tomorrow. I'll tell you those batteries deserve any temperature they want today, after going up that...

146:16:21 Schmitt: That's the soil.

146:16:24 Cernan: ...that Scarp. (Pause) Okay. The soil is in 44 Yankee.

146:16:30 Parker: Copy; 44 Yankee. (Long Pause)

146:16:44 Schmitt: That block's too big. I can't get it. Too big!

146:16:49 Cernan: Okay. Get your picture?

146:16:51 Schmitt: No. (Pause) Okay, got mine. (Pause)

[The sample documentation photo is AS17-133-20319. Gene doesn't have any film left in his camera and will change magazines once they get to Camelot.]

146:17:01 Cernan: Okay. What's the...Well, we'll find Camelot.

146:17:04 Schmitt: And 125's the LMP frame count.

146:17:08 Parker: Copy that. And just press on the same heading you've been carrying there, Gene, and that will get you to Camelot.

146:17:17 Cernan: We want the southwestern edge, huh?

[LMP/CDR-26 shows the planned Station 5 location based on Apollo 15 photographs.]

146:17:20 Schmitt: Do you want to go where Station 5 is, Bob (that is, to the planned spot on the southwest rim)?

146:17:23 Parker: That's my understanding, Jack. So press on towards there unless I tell you otherwise.

146:17:29 Schmitt: Well, but you were talking about changing Station 5. I think Station 5 is a pretty good spot (as is).

146:17:34 Parker: Roger. And I think that's where we want to go. I'm just trying to verify that. You can go in that direction, though. I'll get with you if it's not.

146:17:42 Schmitt: Okay. (Pause) It's probably the most concentrated boulder field on Camelot.

146:17:48 Parker: Okay. You know where it is, and we think it's about 092 and 1.6.

[They will stop at 086/1.4.]

146:17:56 Cernan: 092 and 1.6. You know this country...

146:18:00 Parker: Roger. But you know where it is, so you'll find it when you get there.

146:18:02 Cernan: ...is rug...is undu..

146:18:04 Schmitt: It's different. (Pause) Wonder where Horatio is?

146:18:14 Cernan: Well, we're going to run into something in a minute if it's...It (Horatio)'s probably right over that rim on the right, Jack. Right off your right hand at 2 o'clock.

146:18:21 Schmitt: Right. I guess so. You know, it doesn't have boulders on it.

146:18:24 Cernan: It should be over there. That should be it right over that rim. You know, I see why Al (Shepard) and Ed (Mitchell) had trouble walking up Cone Crater (on Apollo 14). You could stand right on the edge of the rim of a crater and not know it's there.

146:18:36 Schmitt: Yup. (Pause)

[AS17-133-20320 to 20324 show this part of the traverse.]

146:18:48 Schmitt: (Thinking back to Shorty) Man, that was spectacular. It's color on the Moon! Whoohoo!
 146:18:51 Cernan: It was really orange! (To Parker) Could you see that color on the television? (Pause)
 146:18:58 Schmitt: No answer.
 146:19:00 Cernan: I'll bet they couldn't.
 146:19:02 Parker: No, we couldn't see it, Gene. (Garbled) guys...
 146:19:05 Cernan: (To Jack) Look at the Sculptured Hills. (Responding to Parker) Okay. I'm sure glad I went up to take that second pan (at Shorty) to see that stuff go radially down into the center of the crater at that contact.
 146:19:14 Schmitt: Yeah, that's good.
 146:19:17 Cernan: Hope that comes out.
 146:19:19 Schmitt: Doesn't make any difference. It's there (whether the picture) comes out or not. Okay. Sculptured...

[Schmitt - "That was the field geologist talking. When you're a field geologist and you say something's there and you put it on your map, you expect that people will trust you without a photograph. And Gene was thinking "Nobody'll believe us unless there's a picture of it."]

[Cernan - "A picture adds a lot to your description, particularly if you're in a hurry like we were at Shorty."]

146:19:26 Cernan: Okay. Look at...Look at up...up the (Wessex) Cleft over there. You can see definite change in albedo now between the North Massif and the Sculptured Hills. Lookit, right up the valley. Well, you can't see it...Let me...
 146:19:36 Schmitt: (Laughing) You're right.

[Jack's view may have been blocked by the high gain; or Gene may have turned the Rover.]

146:19:39 Cernan: You got to see this. See that?
 146:19:45 Schmitt: Yeah. But, again, that may be your photometric effects.
 146:19:50 Cernan: Yeah, one's an upslope and one's a downslope.
 146:19:52 Schmitt: Yeah. Yeah. Just about right; but it's supposed to be darker in the cleft you know. (Pause) I guess I've been on...(To Parker) LMP's back to Minimum.
 146:20:12 Parker: Roger. Thank you. (Pause)
 146:20:18 Schmitt: Whoa! Whoop, whoop, whoop!
 146:20:23 Cernan: I wish I had a movie picture of us driving.
 146:20:26 Schmitt: You're doing the driving.
 146:20:29 Parker: Who's going to take it?
 146:20:30 Cernan: That (movie) would be the classic of the century. (Responding to Parker) Well, there must be somebody out there. (Pause)
 146:20:40 Schmitt: Bob, the fragment population - we're at 099/2.0 - is still about the one-percent category of...And

it's hard to tell, going into the Sun, what kind of blocks you're dealing with. But my guess is - well, more than a guess - (is that) most of them look like they're slightly vesicular. And, in that regard, resemble the gabbros.

146:21:19 Parker: Okay, copy that.

146:21:21 Schmitt: There's a class of boulders that is flat topped and fairly-well rounded that is just about completely buried. Only the...Not more than (about) 5 centimeters of it projects above the surface. We've seen those off and on, both days. Remember, Geno?

146:21:43 Cernan: Yeah.

146:21:45 Schmitt: And they seem to be quite distinct. At least you notice them. Now, whether it's just a continuation of the mantling, I don't know. But most other boulders - the big ones - seem to project above the surface more than just that 5 or 10 centimeters. (Pause)

[At 113:23:22, about twenty minutes after the landing, Gene commented on partially-buried boulders he'd seen and tried to avoid during the final approach.]

146:22:09 Cernan: I tell you, the Sculptured Hills just have that wrinkled old-face feeling.

146:22:13 Schmitt: Yeah. There are blocks over there though, aren't there?

146:22:16 Cernan: There's blocks, but I don't see any concentrated outcrops...

146:22:18 Schmitt: No.

146:22:19 Cernan: ...or concentrated masses of blocks up on the slope anywhere...

146:22:23 Schmitt: Possibly...

146:22:24 Cernan: ...like you did on the Massif.

146:22:25 Schmitt: Possibly due...

146:22:26 Cernan: Oh. Do you think that's Camelot or not?

146:22:27 Schmitt: I think that might be Camelot.

[AS17-133-20325 to 20327 show the approach to Station 5. In 20325, boulders on the rim are visible in the glare of the Sun.]

146:22:29 Cernan: Look at that!

146:22:30 Schmitt: Nice shot.

146:22:32 Cernan: Look at that. Right on the southeastern ...

146:22:34 Schmitt: Now, wait a minute.

146:22:35 Cernan: ...(Correcting himself) southwestern rim.

146:22:36 Schmitt: Yeah, yeah.

146:22:37 Cernan: (Perhaps looking at LMP/CDR-22) Yeah, because Horatio's got to be on our right. Well, wait a minute, doggone it.

146:22:41 Schmitt: It's not Horatio, is it?

146:22:43 Cernan: Well, we're at 094, 1.7.

146:22:46 Parker: Stand by. (Pause)

[They are approaching the west rim of Camelot.]

146:22:52 Schmitt: No, I think that's Camelot. Horatio didn't...
 146:22:53 Cernan: That's too...That's too...
 146:22:54 Schmitt: ...have blocks that far up the rim.
 146:22:55 Cernan: ...Let me...Yeah, let me look in the bottom. I'll tell you. I remember.
 146:22:58 Schmitt: Yeah.
 146:23:00 Parker: That kind of sounds like Camelot to us.
 146:23:01 Schmitt: (Garbled) these blocks (garbled)...
 146:23:05 Cernan: Yeah. Yeah, that's it, Bob. We're coming right up at Station 5. Right at it.
 146:23:07 Parker: Okay.
 146:23:10 Schmitt: Only way to fly. (Pause) Okay. You going to park up on the rim so they can have a good (TV) panorama?
 146:23:19 Cernan: Yes, sir. I'd like to get a little on the other side of those blocks, if I can.
 146:23:24 Schmitt: Yeah, you better. Then they can look with the Sun on them (the rocks).

[They will park just east of a group of meter-sized boulders. By parking east of the blocks, they will give Houston a view of them in full sunlight.]

146:23:27 Cernan: Yeah. Because, otherwise, they can't see that other rim over there. (Pause)

[Gene also wants to give Houston a view of the blocks on the east wall of the crater.]

146:23:35 Cernan: Same heading. So, I'll be all right, there. Yeah. I'll get to the other side. Then they can look at these blocks and those across the way. I got to go around this block field, though. (Pause)
 146:23:49 Schmitt: I should hope so! (Pause) I missed seeing Druid (Crater). (Pause) There's Horatio back there! I can see Horatio now.
 146:24:04 Cernan: Okay.

[If they are seeing Horatio, Gene must be headed west or southwest as he turns to get around the boulder field.]

146:24:05 Schmitt: Looks just like it did before.
 146:24:07 Cernan: So, we came right where we were supposed to.
 146:24:10 Schmitt: All the blocks look very much the same in the wall of Horatio.
 146:24:15 Cernan: There's a path through...
 146:24:16 Schmitt: Watch it. Watch it! (Static) Okay.
 146:24:20 Cernan: Well, that's a test.

[They've run over a rock with the wire wheel.]

146:24:23 Schmitt: That was a good one.
 146:24:24 Cernan: That was a good test. Didn't let any air out of that tire, did it?
 146:24:29 Schmitt: No, I don't think so.
 146:24:32 Cernan: Talk about a block field!
 146:24:36 Schmitt: I think my guess of 30 percent (block coverage of the surface) was reasonably good before. Where are you going to park. Right over there?
 146:24:43 Cernan: I'll park right over here, so that they can look in it.
 146:24:45 Schmitt: Okay. (Static)
 146:24:49 Cernan: Okay. Yeah; I got to head 045, so I head right into those blocks. (Long Pause)
 146:25:08 Schmitt: You still got to turn, remember?
 146:25:09 Cernan: Yeah, that's why I want to leave myself a little room over there.
 146:25:12 Schmitt: Whoa.
 146:25:15 Cernan: Okay, Bob. We're stopped. 086 and 1.4.
 146:25:19 Parker: Okay. (Pause)
 146:25:25 Schmitt: Not very level for the gravimeter. What's their (tilt) limit?
 146:25:31 Cernan: I don't know, but it's taken a couple better than this. (Pause) Now, I've got to change film. (Pause)
 146:25:40 Cernan: Let me get things going here.
 146:25:43 Schmitt: I think I can get by this station without it.

[That is, Jack thinks he can complete the station without having to change film magazines.]

146:25:46 Cernan: How's our time, Bob?
 146:25:48 Parker: Stand by. We're talking about that now. Stand by. You've got 25 minutes at this station, guys. We've given you somewhat of an extension here. You're using up some of it back at the LM, but we've given you somewhat of an extension. You've got 25 minutes at this station. The primary priority will be subfloor documented samples, and then subfloor rake soil. (Pause) As you can imagine.
 146:26:26 Schmitt: Okay.

[Schmitt - "Basically there wasn't going to be anything but the subfloor to sample here. Camelot is about a 600-meter-diameter crater, so it should have penetrated maybe 150 meters into the subfloor."]

[The tasks planned for Station 5 are listed on LMP/CDR-27.]

146:26:28 Parker: As you get off, we'd also like to open the SEP and again get that to cool.

[TV on. Jack is at the gate.]

146:26:36 Schmitt: Okay. You wanted to turn it Off?
 146:26:39 Parker: That's affirm...
 146:26:40 Cernan: Turn it off.
 146:26:41 Parker: ...turn it Off, open, dust...
 146:26:42 Schmitt: You want it off?
 146:26:43 Parker: ...the same thing we've been doing to it
 all aft(ernoon)...(correcting himself) all evening.
 146:26:48 Schmitt: Well, it's midday here, Bob. (Pause)
 146:26:56 Cernan: Leave it open and I'll dust it, Jack.
 146:26:58 Schmitt: Okay. Oh, the (SEP) temperature; they'd
 like to know.

[Jack goes to the SEP receiver behind his seat.]

146:27:06 Schmitt: Temperature is still about 112.

[Gene goes to the gate. Fendell starts panning
 counterclockwise.]

146:27:08 Parker: Copy that.
 146:27:09 Cernan: You know, the thing I dread most? About
 closeout?
 146:27:15 Schmitt: What's that?
 146:27:16 Cernan: Is dusting you.
 146:27:17 Schmitt: Yeah, I'm not going to be able to do much
 (about it) today, I don't think.
 146:27:20 Cernan: Well, you know, we don't have nearly as
 much dust. Yesterday we were wallowing around in it. Today,
 we're...
 146:27:25 Schmitt: Who? Me! (Guffaws)
 146:27:27 Parker: Okay, and, Gene, if you're not off the
 Rover, how about the rest of the Rover readouts?

[Gene comes into view, going to Jack's seat.]

146:27:33 Cernan: Okay, Bob, I'm off, but I'll get them for
 you. I'm sorry. I look at them, and they all look good to
 me. And, you know, I keep forgetting to give them to you.
 146:27:44 Schmitt: Bob, I have 135 frames. I think I can
 finish the station, don't you?
 146:27:51 Parker: Yes, probably. (Long Pause)
 146:28:08 Cernan: You know that SEP isn't getting
 much...Well, it's getting a little (dust) on it, but those
 mirrors don't clean off as nice as the LCRU mirrors. (Pause)

[Fendell pans counter-clockwise past Jack, who is among
 the boulders west of the Rover.]

146:28:31 Schmitt: Okay, Bob. This looks just like our old
 friend, the pyroxene gabbro, with the shiny ilmenite
 platelets in the vugs and partially recrystallized vesicles.
 The textural variations are planar, and they're primarily -
 or, sub-planar - in the concentrations of vesicles. (Pause)

[Fendell pans clockwise to Jack; Gene crosses the field of view, carrying the brush to do the left battery covers. Fendell finds Jack making his way through a field of boulders up to 6 feet in size.]

146:29:12 Cernan: Jack, I'm going to put this brush under my seat. It's just getting too hard to get off that place up there (on the LCRU bracket)..
 146:29:17 Schmitt: Okay.

146:29:21 Cernan: Bob, what magazine?

146:29:24 Parker: Magazine Delta, (Apollo magazine 145).

146:29:27 Schmitt: Watch yourself through here, Geno.

[There are a great many rocks underfoot.]

146:29:30 Cernan: Yeah. (To Parker) Delta, huh?

146:29:33 Parker: That's affirm.

146:29:34 Cernan: Okay, Delta. (Searching through the film supply under his seat) Bravo. There's Delta.

146:29:43 Schmitt: Boy, this is certainly a uni(form) subfloor, (just) as we mapped it (pre-mission). It's certainly a uniform rock type. I'll tell you.

[Jack goes to the big boulder.]

146:29:56 Schmitt: The only variations are those grey zones which just seem to be either finer or (have an) absence of vesicles. Boy, I'm nose to nose with a piece of it right now. (Pause)

146:30:19 Cernan: Say, Bob, where can I get a new set of bags?

146:30:23 Parker: Okay, you want new bags...They'll be under Jack's seat.

146:30:26 Schmitt: Under my seat, there's some, Geno.

146:30:30 Cernan: Okay. Just loose?

[Jack looks toward the Rover.]

146:30:31 Schmitt: Yeah. (Pause) Here I am, folks, in the middle of a boulder field. Just minding my own business. (Pause)

[Jack examines several boulders around him, but without getting down to look at them closely.]

146:30:50 Schmitt: I don't know whether I mentioned it. The mineral texture appears to be subophitic to...(sort of) like a good diabase, although a little coarser. (Pause) But it's unquestionably organized (pause) with that variation in vesicle concentration.

[Jack moves a few feet south among the boulders.]

[Schmitt - "'Ophitic' - and 'subophitic' would be less strongly representative - is when the feldspar crystals are

approximately the same size as the pyroxene and are only partially included in them. It looks like a mat with feldspar and pyroxene intergrown. 'Diabase' is the type of basalt that has that texture. And what I meant in the last sentence is that the rock structure is organized, that it's not a random, uniform face in that the vesicles are in planar concentrations. There were some zones with more vesicles and some zones with fewer vesicles and they were organized in planar structures. Lava flows often show that.

"One characteristic of impact craters is that, when they form in layered rocks, they overturn the sequence and maintain it. You see that at Meteor Crater (Arizona) and other places where you can actually see the rim deposits. Nuclear explosion craters do the same thing. It's all ballistic and the layers just end up being overturned; so, as you walk away from the rim, you're walking upsection. That is, (as you walk away from the rim) you're going through the layers as if you were down in the bottom of the crater going up. And if there was going to be any variation, you would want to walk radial to the crater; not along the rim. Everywhere on the rim you'd find the same material from roughly the same layer."]

146:31:34 Cernan: Starting on frame 4, Bob.

146:31:36 Parker: Copy that, Gene.

146:31:44 Cernan: Jack, I've got to get new bags. I've only got one left, and you don't have any, I don't believe.

146:31:47 Schmitt: I don't have any. (Pause) Bob, I have the impression that these blocks are buried up here (and) that the mantle does exist, even on Camelot. There are a few blocks that are lying out on the...(It) looks like they're lying more less on the surface, but you can attribute those to craters that have disrupted the block field.

146:32:24 Parker: Okay; good observation, Jack.

[Fendell pans clockwise to look at boulders on the rim and down into the crater.]

146:32:25 Schmitt: The big ones seem to be projecting out of the...(Hears Parker) The big ones seem to be projecting out of the mantle.

146:32:34 Parker: Okay. Do you see any such mantle on...

146:32:36 Schmitt: Although I can't see how the mantle in here could...

146:32:40 Parker: ...on top of them.

146:32:44 Schmitt: It's not as...(Responding to Parker) No, I don't. What's there seems to be what could have been knocked up there (by local impacts).

146:32:50 Parker: Okay. Understand.

146:32:52 Schmitt: I see a place where I think we can skim some off the top of a rock, which I think we probably ought to do.

146:33:00 Parker: Okay.

146:33:01 Schmitt: But I don't have the impression of draping, so much as I have just of burial. And I have a feeling that the zap-pitting process just has cleaned these boulders off of anything that may have been on top of them, in excess of what's around them, right now.

146:33:22 Parker: Okay, you're talking about...

146:33:23 Schmitt: Also, like Horatio, the...(Hears Parker) Go ahead.

146:33:29 Parker: You're talking about mantle...(correcting himself) (a sequence of) blocks, then mantle, and then cleaned off by zap pits, in other words.

146:33:38 Schmitt: That's right. Most of the rocks seem...That seems to be what has happened all over the Moon that we've looked at (during Apollo). But the rocks are always cleaner than the surface, of course. The far rim of Camelot...You can see...(In) fact, everywhere but where we are and on the rim near(est) the LM, the rim seems to be completely covered (with mantle) or, at least, the blocks don't show through.

[Fendell returns to Jack, who hasn't moved since the Fendell left him.]

146:34:13 Schmitt: They (the boulders) show up in the wall but not at the rim. That's much like Horatio, but not to the extreme that we saw at Horatio. I'd say, at Camelot, the mantle is - oh, maybe, at the most...The rim thickness, if that's mantle, is on the order of a half of what we saw at Horatio.

[Schmitt - "What I was trying to say was that, at Camelot, the rim thickness of mantle (the apparent depth of regolith burying boulders) was about half of what we saw at Horatio. That's the problem with talking and observing simultaneously."]

146:34:34 Parker: Okay. Copy that.

146:34:35 Schmitt: The pan should let you measure that...Well, we didn't get a pan at Horatio, but we got some Rover shots of it. But you may be able to quantify that a little bit.

146:34:46 Parker: Okay.

[Jack's pan, taken at 146:49 from east of the Rover, consists of frames AS17-133-20339 to 20361. Jack is currently west of the Rover.]

146:34:52 Schmitt: (Turning toward the Rover) How you coming, Geno?

146:34:53 Cernan: Oh, I've got new bags. I've got new mags. I've got everything cleaned up and Mark, gravimeter.

146:35:00 Parker: Copy. Mark that.

146:35:04 Schmitt: Here's a nicely structured rock that we probably ought to work on here. Structured, again, in the vesicle concentration. And then I think we ought to try to get...Right over there, we can get mantle.

[Gene enters the picture, stops a little west of the Rover and looks around.]

146:35:23 Cernan: Hey, I'll tell you what impresses me about some of these rocks. There's a lot of...They may be zap pits...I guess you looked at them closer than I did, but there sure is a lot of lineation in some of that white material, Jack.

[Gene waves his forearm horizontally to indicate the orientation of the linearities he sees in the rock.]

146:35:34 Schmitt: But at what scale?

146:35:36 Cernan: Well, on a...on a...on a...on a visual-obvious scale.

146:35:40 Schmitt: Well, I mean the...Okay.

146:35:43 Cernan: I'll show you. If you don't...Let me see if it's up here. (Pause)

146:35:49 Schmitt: The crystal grains seem to be linear, but they are more or less random. Is that what you mean?

146:35:56 Cernan: No, they're linear, though. I can't...

146:35:58 Schmitt: Yeah.

146:35:00 Cernan: ...can't be really linear and random. There's some rocks here that are...

146:36:01 Schmitt: No, I mean...

146:36:02 Cernan: ...that are highly vesicular and there's others that are not.

[Jack leans on a three-foot rock.]

146:36:04 Schmitt: That's right.

146:36:05 Parker: Okay, and a reminder, 17...

146:36:07 Schmitt: Gene, if this is what you mean, it's...

146:36:08 Parker: ...you guys, that the primary priority is the blocks and then a rake soil of the white subfloor soil there. And you've only got 15 minutes before we want you driving back to the LM. Over.

146:36:22 Cernan: Okay. We'll get to work. Okay...

146:36:25 Schmitt: Let's sample this.

[Gene puts the gnomon down; Jack stands up.]

146:36:27 Cernan: Okay. Let me get these two first and then we'll go get that one, because there's two different kinds here...at least apparent kinds. One's a relatively new fracture.

146:36:32 Schmitt: Well...

146:36:34 Cernan: Boy, I tell you, watch when you back up. (Garbled) you already...

146:36:37 Schmitt: (Garbled) told you.
 146:36:38 Cernan: ...learned that. (Pause)

[Gene makes his way out of the boulder field to take cross-Suns from the south; Jack moves north out of the TV picture to take a cross-Sun from that direction. Gene's photos are AS17-145-22136 to 22138. Jack's is AS17-133-20328. Jack also takes a locator the the Rover, AS17-133-20329.]

[Schmitt - "I was trying to get Gene to work on a bigger boulder just to the right of where I was standing here. It was one I was looking at earlier; and he set up at a different boulder and I was afraid we were going to lose the opportunity to get the structures. This is one of the few times - that I remember, anyway - that he didn't follow the lead I was trying to get him to take on the sampling. Also, there were fractures and planes in the bigger boulder that he could have sampled without bending over."]

[Cernan - "Twenty years later, Jack's just got a better memory about some of the details of the sampling. If you had something on your mind at the time, the pictures and transcripts will tend to bring them back. And, if you didn't have them on your mind at the time, there's nothing to recall. But I do remember being in that boulder field and that you really did have to watch your step. We were hopping around between rocks and boulders and you could have tripped on even a foot-high boulder. And you definitely didn't want to fall on another rock or boulder. I won't say that it was 'precarious' but it certainly was a challenging traverse through there. It wasn't something you could train for, because there wasn't any way to really train for the one-sixth gravity. There was a training device called the Peter Pan rig (with harnesses for the simulation some aspects of on-sixth gravity) which was used early on; but I don't think I used it after Apollo 10. But, with a little common sense, you can adapt. I mean, you don't go in there dumb and blind. You know there are boulders and, by this time in the mission, you certainly knew how to get around in one-sixth gravity. If you jumped off the LM for the first time and, right away, had to walk around in this boulder field, you wouldn't have the aggressiveness - and caution - we had. You wouldn't be adapted yet to one-sixth gravity. You wouldn't know the most productive ways of getting around and you wouldn't know the pitfalls as well."]

146:36:42 Cernan: (To himself) I've already cycled film.
 146:36:44 Schmitt: We need to sample the structures, though, in this thing. We haven't really done that.
 146:36:48 Cernan: We'll try and get a(n) "around-the-corner"....
 146:36:50 Schmitt: And we've got to get...
 146:36:51 Cernan: ...picture.
 146:36:52 Schmitt: We need to get that stuff on the mantle, too. (Pause) I mean on the blocks.

[Gene gets the hammer out of his shin pocket.]

146:36:57 Cernan: Yup. Okay, we want to get an "around-the-corner" picture of one of those big ones, too. See if we can get the structure of it. Okay, you get your picture?

146:37:05 Schmitt: Yup. (Pause)

[Gene stands over the boulder and takes three low, nearly horizontal whacks at it.]

146:37:19 Cernan: Here's a piece right here.

146:37:20 Schmitt: Okay, can you hand me a bag, or I'll pick it up with a scoop, whichever you prefer. (Pause)

[Gene grabs the fragment with his tongs, then goes to Jack so that Jack can get a sample bag from him.]

146:37:29 Cernan: Get the bag? Let's see if we can fix your (sample) bag thing tonight. (Pause)

[Gene raises the tongs so that Jack can take the sample.]

146:37:41 Schmitt: Okay, I got it. (Pause) Okay, that looks like our old friend, the gabbro, all right. (Pause)

[Having examined the rock, Jack bags it. Gene dislodges another sample with three hammer blows.]

146:38:00 Cernan: How's that for a piece.

146:38:01 Schmitt: 462 is Gene's fairly freshly fractured rock.

[Once Jack finishes closing the first sample bag, Gene presents his SCB.]

146:38:07 Cernan: Okay, you can put it in the bag. (Pause)

146:38:16 Schmitt: Okay.

146:38:17 Cernan: Okay, here's another one right here.

146:38:20 Schmitt: That one?

146:38:21 Cernan: Yup. I can't squeeze these things (the tongs) anymore. Here they go. Got a bag?

146:38:28 Schmitt: Not yet. (Jack gets a bag) Okay. (Pause)

146:38:39 Cernan: You in there?

146:38:40 Schmitt: Ahh.! (Long Pause)

[Jack had taken the sample from the tongs but now can't open the sample bag. Gene takes the sample from him; Jack opens the bag; and Gene inserts the sample.]

146:38:52 Cernan: Okay.

146:38:53 Schmitt: (Bag number) 463. Is another of the same variety. Wish we'd started on that structured rock because we're going to run out of time. Let's go over there and get at least one off of it.

146:39:13 Cernan: Yeah, we'll get it.

146:39:14 Schmitt: Get the "after". (Pause) Whoops.

[Jack drops the scoop, then asks Gene if he's finished taking the picture.]

146:39:24 Schmitt: Got it?

146:39:26 Cernan: Got it. (Pause)

[Gene's after stereo pair is AS17-145-22139 and 22140. Notice how dirty Jack's legs are. Jack uses the "step on the scoop head" retrieval trick again and Gene may have caught him in the act in the first of these two stereo pictures. Gene gets the gnomon and they move away from the Rover a few feet to the chest-high, layered boulder.]

146:39:48 Schmitt: Okay, why don't we...

146:39:51 Cernan: What did you have picked out?

146:39:52 Schmitt: This in here with the layering in it.

[Looking at them standing close together at some distance from the Rover, Jack seems by far the dirtier.]

146:39:57 Parker: Okay, guys...

146:39:58 Schmitt: I'll get a...

146:39:59 Parker: ...looks like you'll be going in about 10 minutes.

146:40:00 Schmitt: ...flight line photo. (Responding to Parker) Yeah. (Pause) (To Gene) Why don't you get a flight line...

146:40:11 Cernan: I'm going to get that from here.

146:40:13 Schmitt: Sort of northeast. How you going to go?

146:40:15 Cernan: I'll come around from this end and go around to that side.

146:40:18 Schmitt: Okay, I'll go perpendicular to you more or less. (Long Pause)

[Gene takes a series of photos on an east-west line south of the boulder. His photos are AS17-145-22141 to 22152. Jack takes a similar series on a north-south line from the east. His photos are AS17-133-20330 to 20335.]

146:40:53 Cernan: Boy, that one right behind you is just vesicular, by comparison, to a high degree - like three times as much. Oh, I hope those bags weren't in the way of every one of those pictures. Okay. (Pause) Boy, I tell you there ought to be a lot of permanent shaded samples in here, Jack.

[Gene leans on the boulder from the south.]

146:41:17 Schmitt: Okay, I got the down-Sun. (Pause)

[Gene strikes the rock ten times with the hammer: three slow and deliberate strokes, then seven quick strokes. Jack turns and takes a "locator" of the Rover. This is AS17-133-20336.]

146:41:25 Cernan: Man! (Pause) That's a hard Moon.

(Pause) Just a little piece but that's...See...

146:41:41 Schmitt: How about this chunk down there, Gene?

146:41:42 Cernan: Where you looking?

146:41:43 Schmitt: That'd...

146:41:45 Cernan: I don't think that'll...That plate (shaped) piece?

146:41:47 Schmitt: Yeah.

[Jack points with the scoop to the lower east face.]

146:41:48 Cernan: I don't think that'll come off very easy.

146:41:50 Schmitt: Let's see your...

146:41:52 Cernan: I'll try...Here try it. You're over there.

[Gene hands Jack the hammer and takes the scoop.]

146:41:54 Cernan: You know I've worn the RTV off that hammer already.

146:41:57 Schmitt: Yeah, I saw that.

146:42:00 Parker: Roger, 17. Copy that.

[Cernan - "The rubber grip on the hammer was made of the same material as the glove finger tips."]

[Jack leans on the rock, takes a half swing and knocks the sample off.]

146:42:01 Cernan: There you go; beautiful call. Beautiful call. Beautiful call.

146:42:07 Schmitt: That's why...

146:42:08 Cernan: I wore the RTV...

146:42:09 Schmitt: That comes from 15 years as a trained hammer bearer.

[They trade hammer and scoop.]

146:42:18 Cernan: By golly, your geology training is coming in handy.

146:42:20 Schmitt: You learn where to hit rocks. (Pause)

[Jack gets the sample with the scoop.]

146:42:27 Cernan: Bob, 3...(correcting himself) Well, 464. Won't all go in there but...

146:42:34 Schmitt: That's all right, you can wrap it around it.

146:42:40 Cernan: I'll get it...No, I'll get it, babe.
It's in there.
146:42:43 Schmitt: Okay.

[Jack presents his SCB.]

146:42:49 Parker: Okay...
146:42:50 Cernan: Okay, let's...
146:42:51 Parker: ...Jack, and now...
146:42:52 Cernan: Bob, can we...
146:42:53 Parker: ...if you could get that rake soil and
maybe also get the soil off the top of one of those boulders
that you thought you saw.

[Jack hops toward the south. Gene takes an "after"
picture (AS17-145-22153) and then gets the scoop off of the
boulder where Jack left it.]

146:43:02 Schmitt: Yep. Whew. I've got to have Gene with
me since (I) can't carry sample bags.
146:43:09 Parker: Roger.
146:43:10 Schmitt: I probably can if I'm careful; but I keep
dropping them.
146:43:13 Cernan: (Looking at the boulders they've just
sampled) These rocks here have an awful lot...a much greater
density of the white minerals in them - or crystals - than
I've ever seen before, Jack. Where did we see these kind
before?
146:43:25 Schmitt: Well, when I looked at them right at
first, that's what I thought. But I think that the zap pits
are making the white stand out more. They're fooling you a
little bit.
146:43:33 Cernan: They might.
146:43:34 Schmitt: Because when I looked at it with the hand
lens, it looked like a fairly normal gabbro, like some of
those that have crystallized with the mare basalt.
146:43:42 Cernan: Where are you? You ready to take them
back...
146:43:43 Schmitt: I'm back over here. What I want is a
sample of this soil off one of these rocks.

[Gene picks up the gnomon and goes out of the TV picture
toward Jack.]

146:43:47 Cernan: Okay, let's get that now and then let's
get the rake sample. (Pause)
146:43:52 Schmitt: But it looks to me like it's soil that's
been thrown up there rather than...(Pause) This rock is
about 3 meters in diameter, but it's one of the flat-surfaced
rocks. It only stands about - at the most - one-third of a
meter high.
146:44:18 Parker: Copy that. (Pause)

[Fendell finds them working farther south, still among the boulders. The gnomon is on the flatish rock that Jack has just described. Gene is taking cross-Sun pictures from the north. These are AS17-145-22154 and 22155. Jack takes a down-Sun, AS17-133-20337, and a locator, 20338.]

146:44:25 Schmitt: But we can get up about a meter from the soil/rock interface and get soil off the rock, I think.

(Pause)

146:44:44 Cernan: Okay. See what you can do.

[Using the scoop, Jack skims some soil off the rock, at about knee height. After taking a picture of Jack doing the skimming (AS17-145-22156), Gene opens a bag.]

[Schmitt - "This type of sample would enable you to decide whether dark mantle had been laid down on top of the rocks or whether that material had all just been thrown up there from the regolith surrounding it."]

146:44:49 Schmitt: Whoops, oh, yeah; I got some soil.

146:44:51 Cernan: Don't kick up anything new.

146:44:53 Schmitt: No, that's all right.

146:44:56 Cernan: 455 is that bag number, Bob.

146:44:57 Parker: Copy that.

146:44:59 Schmitt: (Pouring the soil) Okay, this is soil from a half a meter in. It's about a centimeter deep and a half a meter in (from the outer edge of the top of the rock).

(Pause)

[Jack skims another scoopful.]

146:45:18 Cernan: Let's take that chip there that's lying on top with the next scoop.

146:45:21 Schmitt: (Pouring) I'm going to...

146:45:23 Cernan: Let's take the soil on that. No. I was taking...No. Okay, take that one then. Well, that's another bag. Put this...Before you pick that one up, pick that little chip up...

146:45:29 Schmitt: Well...I don't want to get the chips. I want the soil. Either that or a coherent rock.

[Jack collects a third scoopful of soil off the top of the rock.]

146:45:35 Cernan: Okay, there you go.

146:45:37 Schmitt: (Pouring) I think we better leave it at that.

146:45:43 Cernan: Okay, 465. Pick that other one up and I'll bag it real quick.

146:45:45 Parker: Copy that.

146:45:49 Cernan: That's the soil from on top the rock. And we're taking a piece of the rock itself, which looks pretty much like the other one, Bob. It might be a little bit more vesicular.

146:46:00 Parker: Okay, and that'll be in 466, right?

[Jack is now prying a fragment off the boulder with the scoop.]

146:46:06 Cernan: You're right again. Here we are and I'll be able to grab it with my hand. If I put this away.
(Pause) Okay. (Pause)

[Gene puts the soil sample in Jack's SCB. Jack raises the scoop high enough that Gene can grab the fragment and bag it.]

146:46:23 Schmitt: Okay, the soil came from a half a meter in from the soil boundary. We need to get a...Let me get over here and try to get one bag of soil that's away from the boulder.

[Jack moves about five feet south.]

146:46:36 Cernan: I'm going to get my "after" while I'm here.

[Gene moves north to take AS17-145-22157.]

146:46:38 Parker: Okay, 17...

146:46:40 Schmitt: (To Gene) Could you... (Hearing Parker) Could you...

146:46:41 Parker: Roger. And the present time, we drop the rake soil, we'd just like to get the kilogram of soil somewhere between the boulders - (in) as open (a location) as you can.

146:46:51 Schmitt: (Is) my scoop in that (picture)?

146:46:53 Cernan: It will be. (Garbled) Okay, it is now.

[This is AS17-145-22158.]

146:47:00 Schmitt: (Responding to Parker) Oh, you want a kilogram?

146:47:02 Parker: Roger.

146:47:03 Schmitt: From between the boulders?

146:47:04 Parker: Roger. That'll replace the rake soil sample we were going to get. And we'd like you moving in 3 minutes.

146:47:12 Cernan: (Joining Jack and responding to Parker) Okay.

146:47:14 Schmitt: Let's do it right here.

146:47:15 Cernan: Yeah, right there. Let me...

[Gene wants to put a sample bag in Jack's SCB.]

146:47:17 Schmitt: Oh, okay. (Pause) This will be a matched pair with our soil sample, too.

146:47:29 Parker: Roger.

146:47:32 Cernan: Okay, bag 467 is where your kilogram is coming from.

146:47:36 Parker: Roger. (Pause)

[Jack gets and pours a first scoopful of soil.]

146:47:49 Cernan: Another scoopful.

146:47:50 Schmitt: Yeah. (To Parker) I'm sampling down to about 5 centimeters.

146:47:56 Parker: Copy. (Pause)

[Jack gets a second scoopful.]

146:48:03 Schmitt: Get your hand down, please. I'm coming down to you.

146:48:06 Cernan: Oh, okay. (Pause)

[Gene has been holding the bag too high for easy pouring.]

146:48:12 Schmitt: Okay.

146:48:15 Cernan: That's full. That's 467.

146:48:18 Schmitt: Pinch her down tight or that will leak out. (Pause)

[Gene closes the sample bag and puts it in Jack's SCB.]

146:48:27 Cernan: Now let me get your big bag (SCB) tight.

146:48:30 Schmitt: Okay, let me try to get a... (Pause) You got a shot of where my scoop was, didn't you?

146:48:39 Cernan: Yeah. Let me get an "after" of it, though.

[Gene moves northeast to take the "after" but decides to do a pan, instead.]

146:48:44 Schmitt: Okay, Houston, we sampled about 3 meters southwest of the gnomon that was set up for the top-of-boulder soil sample. So it's a match pair, really, in that regard.

[Gene turns to the east to start his panorama. These photos are AS17-145-22159 to 22183. This is a superb pan.]

146:49:03 Schmitt: (To Gene) Don't forget your gnomon.

146:49:05 Cernan: I'm not. (Pause) Now I need to get a pan...

146:49:06 Schmitt: Are you getting a pan?

146:49:08 Cernan: I've already started it.

146:49:09 Schmitt: Okay, I'll go over near the Rover and get one. (Long Pause)

[Jack runs around the south edge of the boulder field, out onto open, flat, ground. He is moving very easily. Fendell pans to Gene who is still doing his pan.]

146:50:03 Cernan: Okay, I got the gnomon. (Pause) When do you want us to leave, Bob? (No answer; pause)

[Gene starts toward the Rover, coming directly east and picking his way between the boulders. Jack has started his pan and catches Gene making his way back to the Rover in AS17-133-20341. He is visible above the seat backs. The other photos in Jack's pan are AS17-133-20339 to 20361.]

146:50:20 Cernan: Jack, do you read me?

146:50:21 Schmitt: Yeah. (Pause) Hello, Houston.

[Gene turns south to get out in the open.]

146:50:24 Parker: Hello, 17. Loud and clear. We'd like you to leave immediately, if not sooner. (Pause)

[Gene switches from a running gait to a gallop.]

[Schmitt - "Gene doesn't seem to have picked up the rolling gait that you need to have in order to use a stride rather than a hop. And that may just be because he never did any cross-country skiing. It's a fairly natural motion, I think, for a cross-country skier."]

[Cernan - "Each individual adapts in a different way, but the results are basically the same. Some guys skip; some guys hop. And you pick a way of getting around that gives you the greatest comfort and mobility and productivity. I moved around in a half-dozen different ways and found I liked the old fifth-grade skip, because I could cover eight or ten feet in the air and come down - with stability - on both feet. Boomboom.and up again. That was my way of really moving across the surface without expending a lot of energy. And that's probably why, subconsciously, I went that way rather than wobbling from side to side. Subconsciously, you sought a way of getting around that gave you a sense of security and required the least amount of energy. And I got my energy out of my knees by springing up like that. You shouldn't say, rigidly, 'you have to do it in this fashion'. It's like a golf swing, to some degree. You'll find a number of good golfers with totally different swings.']

146:50:40 Cernan: (Singing) Hippity-hoppity, hippity-hoppity, hippity-hopping over hill and dale.

[Cernan - "I don't know where I got the song from, but it's got to be a thousand years old. Some cowboy singer or something. This was fun! My feet just got far enough apart for stability when I hit the ground and then I could spring up with both of them. I was doing a little bit of the cross-country stride in the beginning, but I wasn't doing it with

strides as big as Jack's, going way left and way right like he did. You were less balanced like that than when you were skipping, so I switched."]

[Gene now switches to a kangaroo or bunny hop. During our review of Station 6, it occurred to Gene that a tendon injury suffered about 5 to 6 weeks before the flight may have influenced his choice of gait. See his comments at 165:59:32.]

[Cernan - "In order to stop, I had to take a couple of steps to transition from the skip to a walk. It's like a horse that's in a gallop and slows down to a trot."]

146:50:53 Cernan: (Singing) Hippity-hopping along. (Pause)

[Gene's song seems to have been inspired by "Peter Cottontail", written by Steve Nelson and Jack Rollins in 1950. The most popular version of the song was recorded by Gene Autry, sometimes known as the Singing Cowboy. Neither Gene Cernan's lyric nor his "melody" bears much resemblance to the original but the relationship seems likely. Gene reaches the Rover and stows the gnomon. Fendell pans away clockwise.]

146:51:07 Cernan: Okay. My golly, this time goes fast!

146:51:10 Parker: That's affirm.

[Schmitt - "It would have been nice to have had more time at Camelot, just like everywhere else. We hadn't seen much variety in the boulders we looked at and it would have been nice to go as far down the rim inside of Camelot as it was prudent to walk and then work our way - both sampling and observing - all the way to the edge of the boulder field and really see if there is any mineralogical or compositional variation. One of the hopes for the long-term future might be that these mare have stratified mineral deposits in them like the Bushveldt in South Africa and other places. It would be a ready way to get metallic resources for use on the Moon: for example, for making the teeth for any bucket-wheel miner you might have so that you don't have to keep importing those; you could just replace the teeth with ones you make on the Moon. But we just didn't have that kind of time.

"Presumably, at the rim of Camelot we were sampling the deepest material that would have been thrown up out of Camelot. So maybe it was not unexpected that what we saw was fairly uniform; it would have cooled more slowly, probably, than other material we might have found. I don't think a rake sample would have added much because, again, we were dealing with pretty uniform stuff and it was just a question of what might have been thrown in there from somewhere else. And the other rake samples were already giving us that information."]

[Cernan - "It would have been nice to have more time. Time was your greatest asset because you're there at all; and it's your greatest enemy because you don't have enough of it.

I would have liked to have walked down into that crater, too, and have spent some time down in the bottom. I think it could have been very interesting. It would have been a good walk out! But it would have been interesting."]

146:51:12 Parker: Okay, and when you leave here...
 146:51:13 Cernan: Where did it (the time) go?
 146:51:14 Parker: ...17, remember that we want to pick up...
 146:51:16 Cernan: I'm giving you (gravimeter) readings.
 146:51:17 Parker: ...EP number 8. (Responding to Gene) Roger. We're ready.
 146:51:19 Schmitt: (To Gene) Go.
 146:51:23 Cernan: 06...(Correcting himself) 670, 031, and 401. 670, 031, and, 401.
 146:51:30 Parker: Copy that. And when we leave we want to take EP number 8 with us, guys. We'd like the SEP turned back on and the blankets closed. (Pause) Okay, Jack, I guess that's your option, you may...
 146:51:46 Schmitt: Let me fix your...
 146:51:48 Parker: ...stop and take the charge off when you get to the distance or, if it's only a short one, you might like carrying it in your lap.
 146:51:55 Cernan: Jack, I can hold it in my left arm on the seat.
 146:51:57 Schmitt: No, I'll get it! I'll get it!
 146:51:59 Cernan: Okay, you want the SEP on?
 146:52:00 Parker: That's affirm.
 146:52:03 Cernan: Okay, both DSEA (Data Storage and Electronics Assembly) and the other switch. You want the blankets open?
 146:52:10 Parker: No, closed.
 146:52:14 Cernan: Closed. Well, closed is...What happened to the Velcro on that other side? (Pause) I thought they mounted that thing so that...
 146:52:23 Schmitt: It came off, Gene. It stuck to the Velcro.
 146:52:26 Cernan: That thing that, (garbled). Okay, you (Houston) got the TG(E reading). We'll get EP-8. The (TV) camera's going (off).
 146:52:36 Schmitt: We made a mistake earlier and it's too late to rectify it in carrying these charges.

[Schmitt - "It was a mistake when I carried the charges for long distances, primarily the charge I'd carried on the traverse to Station 1 and the one I'd carried from Shorty to Victory. And, what couldn't be rectified was that my hands were already tired."]

146:52:42 Cernan: Oh, I don't know...
 146:52:43 Parker: Negative, Jack...
 146:52:44 Schmitt: We did. I wouldn't want...

[TV off.]

146:52:45 Parker: If you don't have it off, we could stop and get off and get it, if you want to? But this is a short distance. You might want to carry this one.

146:53:00 Schmitt: That's right, that's right. I say the mistake was made earlier. There's no problem now.

[Cernan - "Jack was a little testy here. He was probably a little tired. And your hands do get tired from holding the camera and holding the bags."]

146:53:03 Cernan: (Reading CDR-29) Okay, traverse to LM, low gain 100.

[Gene will be driving on an average heading of about 090 to get back to the LM, and will use a low-gain antenna pointing of 100 on the indicator. LMP/CDR-28 is a map of this part of the traverse]

146:53:06 Schmitt: Did you turn this (SEP receiver) on?

146:53:08 Cernan: It's all on, all squared away.

146:53:09 Schmitt: Okay.

146:53:10 Cernan: Push that thing (probably the SEP cover) down and it'll stay. (Garbled). Well, sometimes it will. Okay.

146:53:16 Parker: And how about a frame callout before you get back on, guys.

146:53:19 Cernan: Got it.

146:53:23 Schmitt: Yeah, I need some new... (Responding to Parker) Do you want me to get it (a new magazine) here? (Pause)

146:53:33 Cernan: CDR's at fifty.

146:53:34 Parker: Copy that.

146:53:35 Schmitt: A hundred and seventy.

146:53:36 Parker: Copy one seven zero.

146:53:37 Schmitt: LMP's 170.

146:53:41 Parker: And, Jack, it'd be my opinion, since you're just going back over the same path, that you came up this morning, it's probably not necessary.

146:53:49 Schmitt: Okay, I'll use it until it runs out.

146:53:50 Parker: Okay.

146:53:52 Cernan: I've got a lot of film anyway.

146:53:53 Schmitt: (To Gene) But when you leave me at...Okay.

146:53:55 Parker: Yeah, we'll let Gene take some of the photos near the bomb, or near the charge, perhaps. (Pause)

146:54:07 Cernan: Just jump up again and get your bottom... Yeah, there you go. You got to come this way quite a bit.

146:54:13 Schmitt: Yeah. (Garbled) slope.

[Gene never did give a complete set of Rover readouts; but he parked the Rover with some noticeable pitch and roll. See his remark about Rover tilt at 146:25:25.]

[Schmitt - "It must have been tilted towards me - it usually was - and that made it tougher to get on."]

146:54:17 Cernan: Your seat's rising with you, for some reason. There it is, I guess. You're all right. (Pause)
Up closer to you. (Pause)

[Jack is getting his seat belt on.]

146:54:42 Schmitt: Okay.
146:54:43 Cernan: Okay?
146:54:46 Schmitt: Let's go. (Long Pause)

[Cernan - (Tongue in cheek) "I always parked the Rover sloping towards Jack. It didn't make it tougher; it made it easier. It was lower to him and he didn't have to jump as high to get in. All he had to do was lean uphill. That was a Commander's prerogative. I particularly liked to drive on slopes with him on the downhill side."]

146:55:16 Cernan: Okay, the switch is coming On. (Pause)
Okay. (Reading checklist page CDR-29) Traverse to LM: 12 minutes, 085/1.4. That's...Man, that (Rover indicator) says 086/1.4 to the LM, and my checklist (says) 085/1.4. We must have landed where they wanted us to!

[The checklist location of Station 5 is 088/1.2. They parked very close to the planned spot and the 086/1.4 reading is the actual location relative to the SEP transmitter. Gene is looking at checklist page CDR-29, which indicates a planned drive of 1.4 kilometers drive to the LM - including some extra distance to get around the southern rim of Camelot - on an initial heading of 085. He is mistaking these numbers for the planned range and bearing to the SEP which, again, are 088/1.2.]

146:55:39 Schmitt: Just about.
146:55:42 Cernan: Hey, Bob?
146:55:43 Parker: Roger.
146:55:45 Cernan: You know where we landed yet?
146:55:46 Parker: Well, we think so. We've been transecting (garbled) positions tonight.

[Houston has been using Rover navigation readings at known sites, such as this southwest rim of Camelot, to estimate the landing spot.]

146:55:54 Cernan: It must be...
146:55:56 Schmitt: It must be pretty close.
146:55:59 Cernan: You bet your life! (Obviously pleased with himself) I'm reading 085/1.4, and that's what my checklist said.
146:56:03 Parker: Roger. (Pause)

[Again, Gene is misreading his checklist.]

146:56:10 Schmitt: Okay, Bob; I guess my impression - and it's purely pure interpretation right at this stage - is that Camelot is mantled by whatever has formed the dark mantle.

146:56:26 Parker: Copy that.

[Schmitt - "In the final analysis, of course, it turned out that the dark mantle - the orange and black soils that we found at Shorty - were deposited from fire fountains well before - like three and a half billion years before - either Camelot or Horatio were formed. And what gave the impression of younger age is exactly what had fooled the mappers; and that is that the dark regolith is so loose and moves so much that craters don't last very long in it. It doesn't retain small craters as long as other types of regolith do, so you get a false impression of youthfulness. And when you hit it, it spreads around and produces pretty much the same effects that you'd get from true mantling."]

146:56:30 Schmitt: It does not seem to be mantled to the degree that Horatio is.

146:56:34 Parker: Okay, copy that, too. (Pause)

[It is also possible that, because Camelot is younger than Horatio, it may have thrown ejecta out over Horatio, helping to obscure any blocks on the rim or walls.]

146:56:48 Parker: And give us a mark when you're going.

146:56:54 Schmitt: Oh, I'm sorry...

146:56:55 Cernan: Bob...

146:56:56 Parker: And we don't have...

146:56:58 Schmitt: We've been going about a minute.

[Gene probably started to move at 146:55:39.]

146:57:00 Parker: Okay, copy that. And we don't have battery temperatures there, if you could quickly give them to us.

146:57:05 Cernan: Okay, I never did give you that. It's 110 and 136.

146:57:11 Parker: Copy that, good enough. Thank you. (Pause)

146:57:17 Cernan: Never did get that for you.

146:57:19 Parker: That's okay.

146:57:20 Schmitt: But I tell you, the inner wall of Camelot to the east is certainly blocky.

[They are driving along the south rim of Camelot looking at the east, inner wall of the crater. Jack's photos of the east rim and associated ejecta are AS17-133-20363 and 20364.]

146:57:30 Parker: Well, there were a few blocks where you guys were, too.

146:57:31 Cernan: (Garbled) mantle, too, Jack.
146:57:32 Schmitt: Yeah, well, I don't know, you could see the other wall, too. It's...
146:57:35 Cernan: Hey, here's some Rover tracks!
146:57:44 Schmitt: (Melodramatically) Hey, somebody's been here before.
146:57:48 Parker: Okay, and, 17, what we're looking for is deploying charge number eight at (bearing) zero eight two and zero decimal four on the range.
146:58:02 Schmitt: Okay.
146:58:08 Cernan: Okay, we're at 083 and 1.1. We're just about abeam the eastern rim of Camelot. And there is Challenger!
146:58:19 Schmitt: Hey, hello, Challenger. You can even see the ALSEP.
146:58:26 Cernan: I think I'll go this way. (Jack laughs as Gene avoids a crater; Pause.)
146:58:41 Schmitt: Gee, it seems like a short day. (Laughs)
146:58:44 Cernan: Well, I'll tell you, the time went fast.
146:58:49 Schmitt: (To Parker) Okay, you've heard about this country (on the outbound trip to Station 2). (Pause) Hey, looking over there, though, there's no...We're about, oh, 50 meters from boulders in Camelot. And their appearance from this distance is the same as what we sampled at (Station) 5. I think we've pretty well identified the subfloor, Bob.
146:59:10 Parker: Okay, sounds like we have and sounds like from the very deepest - even from the bottom of Camelot - it looks like it's about the same.
146:59:19 Schmitt: It sure does. (Brief static) I can't say I understand it. But that's the way it appears right now.
146:59:28 Parker: You can't say what, Jack? (Pause) Okay, understand that.
146:59:33 Schmitt: I can't say that I understand.
146:59:37 Parker: Copy.
146:59:39 Schmitt: Whatever filled this valley, it certainly was different than the Massifs. I think we've proved that. And, it presumably. At least everything I see indicates that it was an igneous extrusion of some kind. Either that, or the whole valley's been tilted and we're looking at some strange cross section - planar, more or less, relative to the other mountains - of a crystalline body that was formed at depth. But I don't think that's likely.
147:00:19 Parker: Okay. (Pause)
147:00:29 Cernan: Man; we've covered 19.3 kilometers, Jack.
147:00:32 Schmitt: Is that what we planned to cover?
147:00:33 Parker: That's outstanding.
147:00:34 Cernan: (To Jack) I don't know. What did we plan to cover, Bob?
147:00:37 Parker: Stand by. But we've been everywhere we've planned to go, so, we must have gone just about as far as we've planned to go.

147:00:44 Cernan: Yeah, but it's a straight line. I don't know what the wander factor was, but I'm sure it was pretty high.

147:00:51 Parker: 17.6, they're telling me. So we went a little bit out of our way.

[In driving around craters, Gene has added 1.7 kilometers (or about 10 percent) to the straight-line, station-to-station distance.]

[Cernan - "Adding a kilometer and a half or more to our projected travel distance from station to station is not too surprising. I call it the wander factor. When you're driving around, you've got to drive around craters; when you're driving up the scarp, you've got to take particular routes which are accessible and secure; and, when you're driving into the Sun, you've got to be extremely careful and you go around things you might not, otherwise, go around because you can't see them all that well. So it's not that surprising at all."]

147:00:58 Cernan: Well, it's all mileage.

147:01:00 Schmitt: 0.7 and what was the bearing? 083?

[Jack is asking about the place where they will deploy the charge.]

147:01:03 Cernan: 082, I think, but we want oh-point-four.

[Gene's "oh-point-four" isn't very clear.]

147:01:08 Parker: Zero decimal four. Zero decimal four, guys...you...

147:01:14 Cernan: Oh, zero decimal four.

147:01:17 Schmitt: Yeah, that's the range.

147:01:19 Cernan: Yeah, that's what I said: 0.4.

147:01:20 Schmitt: But you want to bear north, don't you, a little?

147:01:22 Cernan: Yeah, I want...What'd you say, 082, didn't you, Bob?

147:01:25 Parker: That's affirm. That'll be close enough. It's probably be right on your track, there.

147:01:31 Cernan: Okay. Well, I don't make a habit of following myself. I like to cover new ground.

147:01:35 Parker: Okay, copy that.

147:01:36 Schmitt: Watch out for that new ground there. Looks like in the...Look at the Italian flag!

[This is a pennant affixed to the antenna on charge they deployed at the start of the traverse - at 083/0.5. Neither Jack nor Gene remembers why they called it "the Italian Flag". Like the flags on all the charges, it was international orange in color.]

147:01:41 Cernan: Hey, there is one there. I saw the box before I saw the flag. (Pause) No, I didn't, I saw the flag first, I've got to admit it.

147:01:49 Schmitt: Come on now!

147:01:51 Cernan: I got to admit it, I saw the flag first.

147:01:53 Schmitt: The boss said you saw the flag first.

[Schmitt - "During the design phase there was probably some discussion over whether one really needed the flags. And the reference to the "Boss" may mean that Shepard or Slayton finally ruled that there had to be flags. I think that Gene did see the box first; and then we corrected the record, facetiously, so that it was consistent with what the Boss said we had to see first, namely the flag. Of course, I'm guessing and making this up, because I don't remember this incident."]

[Gene doesn't remember the incident either, but suggests that the "Italian Flag" may have had something to do with Rocco Petrone, the Apollo Program Director at the time. Neither Shepard nor Slayton, nor Joe Allen was able to offer any insight. Parker agrees with Cernan that there may be a connection with Petrone. He remembers that, because of sensitivities about the Vietnam war, Petrone had insisted that the charges not be called 'bombs'.]

147:01:55 Cernan: I'm 082 and I'm 0.5. I'll just head right in towards the LM. Man, I want to stay away from ALSEP, I see the big boulder (Geophone Rock), so I'll...

147:02:03 Schmitt: Okay.

147:02:04 Cernan: I'm going to go around...

147:02:05 Schmitt: 0.5. Okay, you'll have to swing (to the) right after we deploy, probably.

147:02:09 Cernan: Yeah. (Pause)

[See Gene's comment at 141:36:27 about having to turn right to avoid the charges. Photo AS17-133-20367 is taken toward the north, perhaps as Gene maneuvers so that Jack can deploy the charge.]

147:02:14 Schmitt: Whee! (Pause)

147:02:23 Cernan: Did we ever get any glass out of the bottom of those craters?

147:02:25 Schmitt: No, we haven't, we've got to try to do that before we leave. (Pause) There haven't been any good...

[This chance remark probably triggers Jack's decision to get a glass sample as described at 147:19:46.]

147:02:31 Parker: Yeah, sometime you'll have time to do that, I guess, guys. I'm not sure when... (Pause)

147:02:40 Schmitt: (Zero point) four! Okay.

147:02:47 Cernan: Okay, 08...Well, she just went to 1. Okay, 081/0.4.

[Jack has been watching the indicator and, since the digit just changed, they are about 350 meters from the SEP transmitter - plus or minus a residual nav system error of about 50 meters or so. The actual distance is 440 meters, an indication of the superb performance of the navigation system over a closed, 30 kilometer course.]

147:02:46 Schmitt: Okay, let's put it in that little depression there. See right ahead of us to the right?
 147:02:50 Cernan: Okay.
 147:02:51 Schmitt: Can you...
 147:02:52 Cernan: Got your pictures?
 147:02:53 Schmitt: I'm getting them. (Pause) Okay. Now just swing into that depression and I'll put it there. (Pause) Beautiful. Whoa, whoa. Okay, charge number 8.
 147:03:12 Cernan: You didn't get a (locator) picture to the LM then, did you?
 147:03:14 Schmitt: Yeah, I did. I got several of them.

[These picture are included in the series AS17-133-20368 to 20373 which Jack has taken prior to the charge deployment.]

147:03:16 Cernan: Well, we don't have to take any more, do we?
 147:03:19 Schmitt: No. (Pause) Okay, antenna is deployed. Pin 1 is pulled and Safe. And, let me check that. It's dusty. Yeah, it's Safe. Pin 2 is pulled and Safe. Pin 3, pulled and Safe.
 147:03:39 Parker: Copy that.
 147:03:41 Schmitt: I guess as long as it didn't go off, it's safe.
 147:03:45 Cernan: Ooh, don't bang it. (They both laugh) I don't care what they say, that's a charge. (Pause) You're having great luck with those.
 147:03:57 Schmitt: (Garbled). Okay, the LM was in the approach shot, I believe. Let me...Go ahead and turn around.
 147:04:06 Cernan: Yeah, I got to go around anyway. (Pause) This way I can get a running shot of (static). (Garbled) right in the middle of it. Let me get them both in it.
 147:04:17 Schmitt: Okay, I ran out of film, too.
 147:04:18 Cernan: Oh, boy.
 147:04:19 Schmitt: Now that's pretty well located.
 147:04:20 Cernan: (Garbled).
 147:04:21 Schmitt: When you come around, take a picture of the LM on your camera.
 147:04:23 Cernan: I will. I'll take it right out the front looking right at the thing.

[Gene is taking a picture of the charge with the LM in the background. This is AS17-145-22184 and Jack's last two pictures are AS17-133-20374 and 20375.]

147:04:26 Schmitt: Yeah, and give them a frame count.
(Pause)

147:04:35 Cernan: Five-six. (Pause) Bob, I've got the "locator" of the charge and the LM all in the same order here, and I'm one more than what I just gave you. I can't look at it now.

147:04:48 Parker: Okay, one more than what you gave me at Station 5 (which was frame 50). Understand.

147:04:55 Schmitt: Okay, Bob. You want me to go to the gravimeter now?

[Here, Jack is referring to the LSG, the gravity-wave detector.]

147:04:57 Parker: Roger. And if you guys will start out, we'll drive you by the ALSEP, Jack, and if you'll get out at the ALSEP, we'll have you take a look at the surface gravimeter and Gene can press on home to the LM.

147:05:15 Schmitt: Okay.

147:05:17 Cernan: Jack, I'm going to drive you in this way, and then I'll drive all the way back around that one geophone.

[Gene probably is driving in toward the Central Station from the southwest, coming between the south and west geophone lines. Then, on his way to the LM, he will have to go all the way back out and around the south geophone line to avoid running over it.]

147:05:21 Schmitt: Okay. Shall I...

147:05:24 Parker: (Garbled) to the north, you could drive in toward the heat flow, towards that big rock, if you can see that.

147:05:30 Cernan: Yeah, well, okay; that's as good as anything.

147:05:34 Schmitt: Bob, you want me to get some ALSEP pictures?

147:05:38 Parker: Negative. (Pause) Okay, and Jack, you can stand by...

147:05:46 Schmitt: I got a (warning) flag.

147:05:48 Parker: ...for a feedwater dump (means "flag") very shortly. Okay, (PLSS) Feedwater, go to Aux(illiary), please.

147:05:52 Schmitt: I just got it. (Pause)

147:06:00 Cernan: Man, look at that mess of cable. I hope that thing (the ALSEP)'s working, Bob.

147:06:04 Parker: Every...Well, a lot of it's working. We've just got to try and see if we can't level this thing (the LSG) tonight. When you get off there, Jack, I'll talk to you a bit about procedures for that. And in the meanwhile, it's my understanding...

147:06:15 Schmitt: Okay; that's good, Gene...

147:06:16 Parker: ...that the second UHT is not in the immediate vicinity, where it's accessible, is that right?

147:06:23 Schmitt: No, it is, I can get it.

[They have two Universal Handling Tools. They are using one as the handle for the LRV Sampler; Gene tossed the other one in the general direction of the Central Station at the end of the ALSEP deployment.]

147:06:24 Parker: Okay; if you can...

147:06:26 Cernan: Okay, and watch my heat flow (cables) over there, don't trip over them (as happened) on Apollo 16). (Pause)

147:06:38 Schmitt: Okay, I'm going to take a pair of tongs.

[There are two pairs of tongs. Gene is wearing one, attached to his yo-yo, and the other is almost certainly stowed in the tool rack on the back of the Rover.]

147:06:39 Cernan: Do you have any film at all?

147:06:40 Schmitt: No, I want your camera.

147:06:41 Cernan: You want my camera? (Pause)

[As Gene confirms at 147:07:38, Jack is taking Gene's tongs and camera so that, as Jack relates at 147:20:13, he can collect a sample of glass on his way back to the LM.]

147:06:52 Parker: Okay, Jack, you won't need (a camera)...We aren't planning on taking the ALSEP photos right now.

147:07:00 Schmitt: Okay.

147:07:04 Parker: Okay. And, Jack, we're not sure you went to Aux on your water yet.

147:07:04 Cernan: (Garbled; pause)

147:07:11 Schmitt: (Responding to Parker) I thought I did.

147:07:12 Parker: Okay, it's coming up, now, we see it coming, Jack, don't worry.

147:07:14 Schmitt: Gene, can you... (Responding to Parker) Okay. (Pause)

147:07:20 Cernan: You got what you want?

147:07:23 Schmitt: Let me take a set of tongs in case I drop something.

[Again, Jack is planning to get a glass sample but isn't telling Houston.]

147:07:26 Cernan: Can you reach them?

147:07:27 Schmitt: Yeah. (Pause)

[Schmitt - "I may have been pulling out the Gene's yo-yo and taking the tongs off so that he didn't have to fool with it. It would have been easier that way."]

[This would suggest that Jack moved around to Gene's side of the Rover. Alternatively, he could have stayed at his side of the Rover while Gene removed the tongs from his yo-yo and handed them across. Gene's "can you reach them?" suggests the latter.]

147:07:35 Cernan: You got everything you need?
 147:07:37 Schmitt: Yep.
 147:07:38 Cernan: (To Parker) Okay, Jack's got my camera and tongs, and I'm on my way.
 147:07:43 Parker: Okay, copy that.
 147:07:50 Schmitt: Okay, Bob, I got a tone again.
 147:07:52 Parker: Okay, what's it say? Probably just your water (garbled) been building up...
 147:08:00 Schmitt: I can't read my gages. (Pause)

[Jack probably has moved away from the Rover by now, on his way to get the UHT.]

147:08:07 Cernan: Want me to take...
 147:08:09 Schmitt: Well, we better take a look. Okay, I'm coming over there (to the Rover).

[Gene will look for a warning flag on Jack's RCU.]

147:08:13 Cernan: I think I just got my water tone, Bob.
 147:08:15 Parker: Okay, that's right, also.
 147:08:20 Cernan: Okay, AUX water's On.
 147:08:23 Schmitt: We got our tones yesterday. Can you see anything?
 147:08:27 Cernan: Well, not unless...Let me see, let me brush your...Bend over.

[Gene hasn't dismounted and Jack is probably standing beside him.]

147:08:31 Cernan: You don't have a brush to brush off (because it is under Gene's seat). Okay, no flags. (Pause)
 Now, wait a minute. Okay. You got no...
 147:08:39 Schmitt: Huh?
 147:08:40 Cernan: You got no flags.
 147:08:41 Schmitt: Okay.
 147:08:42 Parker: You look good to us, Jack.
 147:08:43 Cernan: Once more. A good look.
 147:08:44 Parker: Jack, you look good to us.
 147:08:45 Cernan: No flags. All right, no flags, Jack.
 147:08:48 Parker: Okay, and, Gene, I think you need to go to Aux...
 147:08:50 Cernan: (To Jack) Okay.
 147:08:51 Parker: ...if you didn't.
 147:08:53 Cernan: Yeah, I just did, Bob, and my water flag cleared.
 147:08:55 Parker: Okay, copy that...
 147:08:58 Cernan: No, it didn't. Not yet.
 147:09:00 Parker: Yeah, it's probably still coming up.

[Schmitt - "When you switched to the Aux tank, it took a little while for either the flow of water or the water

pressure - whichever the sensor worked on - to build up enough to get rid of the flag."]

147:09:01 Cernan: Okay, Jack, just be careful of the cables. (Pause)
 147:09:09 Schmitt: Okay, you want me to get a UHT, huh?
 147:09:11 Cernan: It's right over there by the...
 147:09:12 Schmitt: Yeah, I know where it is...
 147:09:13 Parker: If it's quite close, but if it's not, don't bother, I think we can probably try this by hand.
 147:09:20 Cernan: No, it's there, Bob; he'll get it.
 147:09:21 Parker: Okay.
 147:09:27 Cernan: (Looking at CDR-30) You got a (parking) heading for me at the Rover (means the LM)? Is 017 good?
 147:09:31 Parker: 018. 018.
 147:09:36 Cernan: Okay.
 147:09:37 Schmitt: (To Parker) You don't want me to kick the LEAM yet, huh?
 147:09:41 Parker: Negative. (Long Pause)

[Schmitt - "I was joking, of course; and I think this refers to some time in training when I accidentally kicked it."]

[Parker agrees that this is a training reference.]

147:09:54 Schmitt: Okay, Bob, I've got a UHT.
 147:09:57 Parker: Okay, when you go back to the LSG, Jack, we first of all would like a reading on where the bubble is in the circle, (that is) whether it's in the center. And what we're going to have to have, unfortunately, is to have the bubble centered in the inner circle (pause) because this is, apparently, a requirement, even though we didn't train to it. Apparently it's something that's come up, and it's going to have to be within the inner circle of the bubble. So, the first thing we need to do is, when you go up there, is to see whether the bubble is in the center of the circle. (Pause)
 147:10:39 Schmitt: Okay, Bob. (Pause) That bubble is centered!
 147:10:45 Parker: Okay. Okay, the next thing we want you to do is put the UHT in the socket there, and move the...
 147:10:51 Schmitt: Hey, Bob.
 147:10:52 Parker: ...LSG from side to side...
 147:10:53 Schmitt: Bob...
 147:10:54 Parker: ...do not pick it up. Okay, go ahead, Jack.
 147:10:58 Schmitt: I did not have to touch it, it is centered.
 147:11:01 Parker: Okay, but now they're worried that it's stuck like your gimbal thing was last night (on the Central Station antenna).

[Parker is referring to the "sticky level bubble" Jack encountered on the Central Station at 119:38:02 and again at

119:55:35 and following. In that case, surface tension had kept the bubble stuck to the outside of its dome.]

147:11:06 Parker: And, also, the thing is that maybe something's hung up inside and, by moving it, we can jostle it free. They do not want it picked up, but they'd like to have UHT put in there and sort of have the instrument rocked from side to side to again see the bubble move. And once that is done, to then press it down into the ground and again realign it and put the bubble within the inner circle. Over. They would also like to see if the gimbal is free.

[Schmitt - "They wanted me to press the legs into the surface. I suspect that, by this time, Joe Weber was absolutely panicked about his experiment. And there was a tendency, if I remember correctly, for me to think that they were convinced that I hadn't deployed it right, instead of suspecting that the instrument was faulty. Clearly, Bob was on our side and believed we'd done it right."]

147:11:33 Schmitt: How much do you want me to rock it? How far should I let the bubble travel?

147:11:42 Parker: Basically, we just want to see it move. (If) you go out to the outer circle, that's plenty. (Pause) And, again, you (garbled).

147:11:55 Schmitt: There's only one circle. Okay.

147:11:58 Parker: Oh, I mean the outer rim of it.

147:12:04 Schmitt: Okay, I did that. It's still centered and gimbal is swinging.

[Schmitt - "I could see the gimbal by looking through the top of the instrument. I don't know why I said 'gimbal' because I was probably looking at the balance beam."]

147:12:07 Parker: Okay, we copy the gimbal is swinging and we copy you moved the bubble out to the edge of the bubble level and come back into the inner circle.

147:12:17 Schmitt: That's right. (Pause)

147:12:23 Cernan: (Puffing rather heavily as he leans forward) Okay, Bob, I'm reading 089, 20.1, 002, 92, 88. Volts are 65 and 66. Batteries are 114 (degrees) and 138. Rear motors are off-scale low. Forward left is off scale low and right is 210 degrees.

[Schmitt - "Getting off the Rover shouldn't have made Gene breathe heavily. He may have gotten off and leaned way over to read the console. That might have cramped him a little bit and made him spit his words out."]

[Gene is reading a bearing of 089 to the SEP and a range of 150 to 250 meters. The actual values are about 080 and 150, indicating a very small residual error.]

147:12:57 Parker: Copy that. What's the first battery temperature there, Gene?

147:13:02 Cernan: First battery temperature is 114.
 147:13:07 Parker: (Unenthusiastically passing up the request) Okay, Jack. They apparently don't believe you when you said you aligned it last night and they're concerned the shade is not on 20 degrees. (Pause)

[Schmitt - "There was a sunshade on the LSG that shadowed the hole in the top of the instrument that let it cool by radiating to the sky. Twenty degrees refers to our latitude and I guess I had to get the LSG leveled and then tilt the shade at the proper angle. It's amazing how you don't remember doing any of that. I remember going back to fix it, but not the actual deployment."]

147:13:12 Parker: Copy 114 on that battery temperature, Gene.
 147:13:16 Schmitt: It (the sunshade)'s on 20, Bob.
 147:13:21 Parker: Okay. Okay; in that case, I guess you're free to come home.
 147:13:28 Schmitt: Well, what is basically the problem with it?
 147:13:33 Parker: They haven't been able to level it for some reason, and they were afraid that the thing wasn't level. They were hoping also maybe by moving it that you might jostle it a bit and it would come to level, but I think we'll just have to think about it some more. Their first presumption - the easiest solution - was to have it unlevelled, which case we could fix it this way. But I guess that's not the case. We'll have to see what happens overnight. Give us a chance to follow the tradition of coming back to the ALSEP tomorrow.
 147:14:00 Schmitt: Well, do you want me to change it's level a little bit...put it off level a little and see if you can work it.

[Schmitt - "They were moving weights on the balance beam and my question was, could we do something to change the relative gravitational force on either side of the fulcrum to make it work. But I don't think they could have ever convinced themselves that it was a design problem in time to do something like that."]

147:14:06 Parker: I don't think so, Jack. That doesn't sound very good to me.
 147:14:14 Schmitt: Well, it might be some air (or error?) in the level bubble or something.
 147:14:16 Parker: Why don't you just leave it there if it's centered with the level bubble within the inner circle there. That's the requirements as far as we can tell, and we'll just have to leave it overnight again. And why don't you come on back to the LM. (Pause)
 147:14:42 Parker: Okay, Gene, are you at the Rover?
 147:14:46 Cernan: Yes, sir. I'm parked.
 147:14:47 Parker: Okay...

147:14:49 Cernan: Gave you my readings.
 147:14:50 Parker: Okay. You gave me your readings and when you get done, let me know, because the first thing we want to do is work on the SEP (receiver) a little bit.
 147:15:00 Cernan: Okay. Stand by. (Pause) (You've) got TV. (Pause) Okay. What do you want to do to the SEP?

[TV on.]

147:15:19 Parker: Okay, Geno. When you go back to the SEP now - and let's do this first and get it out of the way - you can probably do this anyway while Jack's coming home. When you open the blankets, remember that at the back of the SEP there was a piece of Velcro on the case and a piece of Velcro just inside the rear hinge on the covers, and this is what you sort of peel back when you go to remove the back end there so you can get the DSEA out? You remember that piece of tape there?
 147:15:48 Schmitt: Yeah. That came off.

[Gene is dusting the right-side battery covers as per CDR-31. Normally, he and Jack would have taken care of the SCB's before the dusting but, since Jack is out at the ALSEP, Gene is taking care of the tasks that don't require Jack's presence. Fendell pans away.]

147:15:50 Parker: Okay.
 147:15:51 Schmitt: That came off.
 147:15:52 Parker: Okay. This is on the side away from you as you stand facing it. Right?
 147:15:57 Schmitt: Oh, no. That's the side...Go ahead, Gene, I'm sorry.

[The SEP receiver rides on the Rover just behind Jack's seat, protected from sunlight and dust by a thermal bag. The receiver - like the TV camera and the LCRU - has a mirror on its top surface which allows the unit to cool. The top of the thermal bag consists of a pair of flaps held down by strips of Velcro attached to the undersides of the flaps and to the front of the bag. As indicated in the accompanying illustration and in this exchange between Parker and the crew, there are also pieces of Velcro holding the back of the bag closed and pieces of Velcro designed to hold the covers open. At 123:17:10 at the end of the first EVA, Jack noticed that the Velcro pads glued to the front of the bag had debonded, allowing the cover to flap open. At the start of EVA-2, Jack suggested taping the cover but no decision was made to do so. Gene has been trying to keep the mirror clean but, even after cleaning, enough dust remains adhered that the SEP temperature is unacceptably high. Houston will have him tape the cover at 164:01:01. Because the LCRU and the TV camera are still working well, one obvious conclusion is that the SEP equipment is too sensitive to heat. One note of interest about this failure is the fact that, on Apollo 16,

there was an adhesive failure on a Velcro patch on a padded sample bag, albeit a failure involving a different adhesive. No corrective action was taken because the padded bags were not going to be flown again; however, it does not appear that the failure modes of other adhesives were re-examined.]

147:16:02 Cernan: Okay, go ahead.

147:16:03 Parker: Gene, if you stand facing it, in the back - away from you - there's a strip of Velcro on the case and there's another strip of Velcro on the blanket itself and this is the Velcro you have to tear off or to unhook, as it were, when you come to tear the blankets down to get the DSEA off. Remember that piece?

147:16:25 Cernan: Yeah, but that's on the side away from me. I'm on the LMP's side and that's on the other side.

147:16:29 Parker: Right. That's on the other side of the top. And what we're interested in, number 1, is that piece of Velcro still mated or when you open the blankets to cool it, does that Velcro come open? Over.

147:16:47 Cernan: Well, that's the Velcro that's so full of dust it comes open, Bob.

[Gene is referring to the Velcro which holds the covers open, not to the piece Parker is referring to that holds the back of the bag closed.]

147:16:50 Parker: Okay, and so what happens...

147:16:52 Cernan: Trying to stay...It's hooked; it'll stay.

147:16:56 Parker: Okay. Well, the feeling...

147:16:57 Cernan: I don't know if you can see that but it's...Well, you can't (because of the) back seat...

147:17:02 Parker: Okay, well, feeling is that...

147:17:03 Cernan: Bob, I swung the covers and they will stay open about 150 degrees. (Pause)

[Fendell finds Gene leaning over the SEP.]

147:17:14 Parker: (Trying to figure out what Gene's saying) I...Stand by a minute. What you're saying is that the cover actually stands up a little bit in space.

147:17:25 Cernan: Now, if you want the cover open, I can open it and normally it should swing 180 degrees, (that is) parallel with the top of the SEP.

147:17:33 Parker: Okay, but does that Velcro in back stay mated?

147:17:34 Cernan: Well, the Velcro holds (and), the way that we've been opening it, it holds. (Hearing Parker) Yes, it's being mated and probably it holds the covers open 150 degrees!

[Gene is uncharacteristically annoyed.]

147:17:48 Parker: No. That's okay. What the concern originally was, was that when this...

147:17:50 Cernan: The Velcro...
 147:17:51 Parker: ...happened, the sunlight was getting down in the back there and warming up the back of the SEP. That's apparently not the case. Over.
 147:18:02 Cernan: No, that's not the case. The Velcro that came off is the Velcro that keeps the covers closed.
 147:18:07 Parker: Okay. We were concerned about both pieces of Velcro since the one had come off.
 147:18:14 Cernan: No. The other one is still on and it still holds and the back part of the SEP - where the DSEA is - is in the shade.

[Gene dusts the SEP cover with the big brush.]

147:18:22 Parker: Okay. I copy that. Okay. While we're talking about this - and I'll get back with you - turn the DSEA and the receiver both to Off, please. (Pause) And read me a temperature, please.
 147:18:35 Cernan: 112 degrees.
 147:18:37 Parker: Copy that. And I mark them both off, right?
 147:18:43 Cernan: Yes. (Pause) Bob, I just dusted it as clean as it'll get.
 147:18:50 Parker: Okay. Thank you. (Long Pause)

[Gene finishes dusting the SEP, then dusts the TCU. Fendell pans away counter-clockwise.]

147:19:46 Schmitt: Hey, Bob, ...
 147:19:47 Parker: Go ahead.
 147:19:48 Schmitt: ...I cheated on you.
 147:19:50 Parker: I was sure you would. What'd you do?
 147:19:53 Schmitt: I just sampled the glass in the bottom of a crater. I documented it by shooting the LM across the crater at infinity and then shooting the crater with stereo at 11 feet and then a cross-Sun pair at 7; and then I sampled it.
 147:20:13 Parker: Okay.

[Jack borrowed Gene's camera when he got off the Rover at the LSG at 147:06:40. The locator to the LM is AS17-145-22185. Note that this crater is down in the swale between the LM and the ALSEP. Jack's up-Sun stereo pair is 22186 and 22187; and his cross-Sun stereo pair is 22188 and 22189. He also shot a cross-Sun stereo pair of afters, which are 22190 and 22191.]

[Schmitt - "There's a little bell ringing in my head that I'd taken Gene's camera and tongs (at 147:06:41) just so that I could sample one of the glass-lined craters. That's probably why I didn't pay any attention to Parker when he told me to leave the camera with Gene."]

147:20:14 Schmitt: Then I took a cross-Sun pair at 7 "after".

147:20:16 Parker: (Punning) I guess now "gnomon is a LM".

[Schmitt - "Throughout training, I had used the pun 'gnomon is not an island', and Parker was one-upping me here."]

147:20:20 Schmitt: It (the glass sample)'s very fragile.
(Hearing Parker) That's right. It's very fragile, and I double bagged it. I don't know whether we can keep it or not.

147:20:30 Parker: Okay. We'll hope.

147:20:31 Schmitt: You may think about how to preserve it.

147:20:33 Parker: Okay. (Pause)

[Gene goes to dust the left side battery covers.]

147:20:42 Schmitt: While you're thinking, I'll put it on my (Rover) floor pan, I guess. (Pause) Okay. What do I have to do here?

147:20:50 Cernan: Get this bag (SCB) off me to start.

147:20:52 Schmitt: Get that bag off you to start with.

(Pause) Be careful of that sample there. (Pause)

21:03 Cernan: Those are the cleanest battery covers in existence on a Rover right now, I tell you. (Pause)

147:21:09 Cernan: (Noticing that Fendell is tilting the TV down to look) Oh, you don't believe me. Look at that!

147:21:11 Schmitt: What?

147:21:12 Cernan: They don't believe me.

147:21:15 Schmitt: Excuse me. Move forward just a little. And I'll get your bag. Here you go.

147:21:20 Cernan: (Noticing that the TV is still pointed down) Now you're stuck down there, aren't you?

[Fendell tilts the TV up.]

147:21:23 Cernan: No you're not. Seems like you (would think) I may be going nuts talking to that moving machine (the TV) over there. (Pause)

[There is laughter in Houston.]

147:21:36 Schmitt: Boy, we don't need any hooks; I'll tell you.

147:21:38 Cernan: I know it.

[Jack is having trouble removing Gene's SCB.]

147:21:39 Schmitt: Can you stoop just a little bit?

147:21:41 Cernan: Yeah, all that stuff is getting...There (garbled).

147:21:43 Schmitt: (Garbled) get your hook back.

147:21:45 Cernan: Yeah, hook my harness back up so we don't forget that.

147:21:50 Schmitt: Velcro's closed. Okay.

[Jack goes to the gate.]

147:21:55 Cernan: You know, (as) you look at those little sparklies in the soil we're walking on and they change colors on you.

147:21:59 Schmitt: Yep.

22:00 Cernan: Greens to purples.

147:22:02 Schmitt: Iridescent. Iridescent sparklies.

147:22:06 Cernan: Okay. I'll come over, and I'll unload your stuff.

[Gene moves toward the front of the Rover. Fendell pans clockwise to follow him.]

147:22:08 Schmitt: Okay. Now, we got more samples than we've got sense, I think. Let's see here (consulting checklist), you're taking care of the SEP.

147:22:21 Cernan: Yeah, don't...That's all right.

147:22:24 Schmitt: Okay.

147:22:25 Cernan: Hey, Bob; the covers are open on the SEP.

147:22:27 Parker: Roger. Copy that.

147:22:32 Cernan: Oh, why did I do that?

[Gene is doing something at the front of the Rover, then moves away. Fendell continues to pan clockwise.]

147:22:34 Schmitt: Hey, Bob, you think that glass sample would be better off in the SRC?

147:22:39 Parker: We're still talking about that. (Pause)

147:22:46 Cernan: Wait a minute. Your core cap assembly is empty. (Probably throwing it away) Up and away it goes!

(Pause) And that's all closed. Let me check your bag.

(Pause) Okay. Now, Bob, you've got to tell us which one of these (SCB's) you want in the SCB (means SRC) and which one you want just taken in because we got our numbers all confused.

[They're not wearing the SCB's called for in the checklist.]

147:23:17 Parker: Okay. Go ahead. What we would like to do here...

147:23:20 Cernan: (To Jack) Got it.

147:23:21 Parker: ...on the closeout, guys. Let me read this to you first of all. In the SRC, we'd like the following stuff along with...Let's see...Stand by. (Pause)

147:23:44 Cernan: (To Jack) Is this (SCB) 9 or 6?

[Fendell passes Jack at his seat, Gene at the gate, and then pans up to Earth.]

147:23:45 Parker: Okay, guys. We're going to follow an Apollo 16 mode and put stuff in (the SRC) loose, because

they'd like to segregate stuff in the following way. We'd like to put the long can and four core tubes in the SRC. I guess it's going to take a while just carrying stuff back and forth (between the Rover and the MESA). But they'd probably like to get this in because of the volatile stuff. They'd like to get the long can and three core tubes in the SRC; (that's priority) number 1. And then we'd like to get all the SCB-4 samples in the same SRC. Over.

[The reference to "volatiles" means that the backroom is considering the possibility that the Station 4 orange soil is a product of recent volcanism. In essence, they want all of the Station 4 samples in the SRC in case volcanic gases remain adhered. Presumably, the Station 3 drive tubes - which will also go in the SRC, will provide a control. SCB 4 is the one Jack donned at Station 2 and was wearing at Shorty. Because Jack was sampling and Gene was bagging, the Shorty trench samples are in SCB-4.]

147:24:23 Schmitt: (To Gene) Oh, wait a minute. Wait a minute.
 147:24:24 Cernan: (To Parker) Yeah. You want...
 147:24:25 Schmitt: Okay.
 147:24:26 Cernan: ...three plus the long can; that's four cores all together.
 147:24:29 Parker: Right. Put those in the SRC...
 147:24:30 Cernan: All samples from 4.
 147:24:32 Parker: All the samples from SCB-4.
 147:24:34 Cernan: Okay. (Pause)
 147:24:37 Schmitt: (To Gene) These are 4. You want to get the core tubes in first, though.
 147:24:40 Cernan: Yeah. I want to put these in. If you'd give me the...Yeah, I only got two hands. I'll come back by the time you dig them out. (Pause)
 147:24:54 Parker: Okay, and then, 17, do you guys remember where the trench samples - the three trench soil samples - which bag (SCB) those were put in? (The one's) from Station 4? Over.
 147:25:10 Cernan: Yeah, let's see. I'm the only one who had (sample) bags, so I bagged them and put them in whatever bag Jack had (that is, SCB 4). I think.
 147:25:17 Schmitt: Yeah.

[Fendell returns to Jack at his seat. Gene is behind him, out of sight, at the MESA.]

147:25:18 Parker: Okay, then that'll be SCB-4. So we'd like those in SCB 4...those are the ones that will go in the rock box and that's in agreement with what we want to do.
 147:25:30 Cernan: Okay, give me those other two cores, if you've got them, Jack.
 147:25:33 Schmitt: Okay.
 147:25:34 Cernan: Long can. (Long Pause)

147:25:51 Schmitt: The long can. Here's a...Oh. Got it?
It's slippery.
147:25:58 Cernan: Yeah, and we need one more core.
147:26:01 Schmitt: One more core.
147:26:03 Cernan: Okay.
147:26:05 Schmitt: (Is) that right, now? Three core tubes
and a long can?
147:26:07 Cernan: Yep, got them all.
147:26:09 Parker: And then...Roger that. And then all the
samples in SCB-4. We won't bother to try and sort them out,
and then beyond that we'll fill them up with samples from
SCB-5. Over.

[Jack takes SCB-5 to the MESA.]

147:26:23 Cernan: Which one's that? That's 5. Let me get
4, first.
147:26:26 Schmitt: Here, hold this. I'll get it.
147:26:27 Cernan: Well, it's on the gate right there, just
hanging. I just put it there. (Pause)
147:26:34 Schmitt: (Going to the gate) Four is the one I
had on there at Shorty? Or you had on at Shorty?
147:26:41 Cernan: Well, you had it on. I don't know, but
they should have that logged. I don't remember who had it
on.
147:26:48 Schmitt: Well, now wait a minute. I took the
trench. You held the bags.
147:26:51 Cernan: And I put them in you.
147:26:52 Schmitt: You put them on me. Did I have 4 on at
Shorty?
147:26:55 Parker: Yes!!
147:26:56 Schmitt: That's what they said.
147:26:57 Parker: That's affirm. That's why we want SCB-4
dumped into the thing (the SRC). But it's a dirty bag, so we
just want to dump the samples in.

[Jack goes to his seat. He is wearing Gene's tongs on a
yo-yo, which he seems to have been wearing as a contingency,
even though he hadn't planned on using it.]

[Cernan - "The yo-yo was about an inch or two high, a
rectangular box, and it had a little strap that went under
something (usually a hose) and came back around and snapped
on itself. I wore mine all the time, so Jack must have been
wearing one, too."]

147:27:07 Schmitt: Okay. Okay; and you want 5 to fill it
up. (No answer; pause) Okay, Bob...(Pause)
147:27:27 Parker: Okay. And, Jack, it probably would
protect the glass a bit better if you put it in the SRC
gently with the other rocks there. Particularly if you don't
fill the SRC too full. But, again, we'll be putting SCB (5)
samples in there to more or less flesh it out if there's not
too many SCB-4 samples.

[Jack pours samples out of an SCB into his footpan. He then grabs the tongs and picks up an unbagged rock that he may have just dropped. He puts the rock in an unseen SCB on his seat.]

147:27:51 Schmitt: Leave a space for a sample, I guess, Gene.

147:27:56 Cernan: Well, you'd better give it to me. There's not much space. It's going fast.

147:28:01 Schmitt: You're really...Well, can you leave one...

147:28:06 Cernan: Where is the sample?

147:28:08 Schmitt: Well, it's over here.

147:28:09 Cernan: I'll get it.

147:28:11 Schmitt: No, I'll bring it to you. I just...(Pause)

[Jack takes the glass sample to the MESA.]

147:28:18 Schmitt: Is there some way to...

147:28:20 Cernan: Just set it in there. (Pause) I'll set it. I'll be delicate with it. Take this bag back.

147:28:31 Schmitt: Okay. It's in the right-hand back corner of the SRC.

147:28:35 Parker: Okay. Copy that.

[Schmitt - "I must have known - and this changes what I've said before about the observation of glass in craters on other missions - because I talked to the people doing remnant magnetism and asked them if they didn't want an oriented sample of glass in order to see if there had been any modern magnetic fields. And I don't remember their having any enthusiasm for it; but, in my mind, that was a reasonably important sample to get. And that's probably why I was manipulating things to get a sample and all the documentary photographs and why I had some concern over protecting it."]

147:28:37 Schmitt: You're just about full. You got some (samples) left in there (SCB-5)?

147:28:40 Cernan: I'll get some small ones and some big ones, too.

[Jack takes SCB-4 to the Rover. Fendell stays with Gene at the MESA.]

147:28:43 Schmitt: Don't fill it too full.

147:28:44 Cernan: No. (Pause) Hey, we got some big rock samples.

147:28:54 Schmitt: Okay, Bob. SCB-6 and SC...Wait a minute. What's in (SCB) 6?

147:29:00 Parker: Six? Probably nothing. But tell us...

147:29:02 Schmitt: Well, there's samples in 6.

[Gene is taking sample bags out of the SCB and is putting them in the SRC, the rock box.]

147:29:03 Parker: Okay. You should also have SCB-8 under your seat with samples in it.

147:29:06 Schmitt: This is what I sampled at...

147:29:10 Parker: At Station 3, maybe.

147:29:12 Schmitt: Six has the samples from...(Hearing Parker) Yes.

147:29:18 Parker: Okay. Let's take up SCB-8...

147:29:20 Cernan: We have more samples today than Carter...

[Schmitt - "There was a brand of pills called Carter's Little Liver Pills, and there was an expression "You've got more of such-and-such than Carter has pills."]

147:29:21 Parker: And let's take up SCB-6; and why don't you dump out the Rover samples into SCB-6?

147:29:33 Schmitt: Well, one reason not to take 6 is I don't know if I can get it off (the Rover)!

[Gene discards the SRC seal protector.]

147:29:39 Parker: Okay. And let's save SCB-4 because I think you may need that tomorrow.

[Schmitt - "Parker thought he'd seen Gene throw SCB-4 to his left, not having noticed that I'd taken SCB-4 back to the Rover."]

147:29:51 Schmitt: Four is on the rack, empty.

147:29:53 Parker: Okay. How about SCB-5? Is that only partially emptied, or is it totally emptied?

147:30:01 Cernan: No, it's about half full, Bob.

147:30:03 Parker: Okay. We'll take that up with us.

[Jack, who has been at the gate, goes to his seat carrying an SCB.]

147:30:08 Schmitt: Bob, I've already...Let me tell you what I've done. I've got SCB-8 full.

147:30:17 Parker: Okay. Copy that.

147:30:19 Schmitt: Let's take it up.

147:30:20 Parker: Roger. On that.

147:30:26 Schmitt: It's got Rover samples in it.

147:30:28 Parker: Okay.

147:30:31 Schmitt: But I can't get them all. They won't all be in there.

147:30:34 Parker: Okay; eight.

147:30:37 Cernan: (Closing the SRC) Okay. Bob, the seal (on the box) was clean. It was clear, and I got your four cores...(correcting himself) three cores, plus a long can. I got Jack's glass. I got SCB-4 and a couple of samples out of SCB-5.

147:30:55 Parker: Copy that. Sounds great.

[Jack now picks up samples from his footpan and puts them in SCB-6.]

147:31:01 Cernan: Okay. Now where was I? You got me all out of whack, here.

147:31:06 Parker: That's affirm.

147:31:08 Cernan: "Core cap dispenser." Okay, you're "clean" (and the) cosmic ray is done.

[During the EVA 1 Rover preps (checklist page LMP-12), Jack had the option of deploying the cosmic ray experiment if he had time - and did so at 118:34:41. For the EVA-2 closeout, Gene's checklist page CDR-30 indicates cosmic ray deployment unless Jack had already done it.]

147:31:12 Cernan: SCB-5...Yeah, okay. Now, Jack, we've got SCB-5 that's half full. What have you got over there?

147:31:16 Schmitt: Bring it over here, and I'll put it into 6. Six is a little more than half full.

147:31:25 Cernan: Well, this is a little less than half full. Okay.

147:31:27 Cernan: That ought to make one full bag. And these are big rocks so they'll come out easy. Where's that big, big rock we got? That's in one of those bags, too. Picked up a big rock.

[Gene may be referring to the large sample collected at Station 5 at 146:42.]

147:31:38 Schmitt: Here...

147:31:39 Cernan: Here let me see if I can't dump it.
(Pause)

[Gene, at the Rover, dumps the contents of SCB-5 into SCB-6.]

147:31:49 Cernan: How's that for a lunar dump? Huh?

147:31:53 Schmitt: Perfect. (Pause)

147:31:59 Cernan: (Going to the gate) I want to see if I can't dust (the bag latches on the gate)...Did you lock this one over here?...No.

147:32:02 Schmitt: Hey, don't lock those...

147:32:04 Cernan: No, I'm going to see if I can dust them and make them work easier.

147:32:06 Schmitt: Boy, I'll tell you...I really had to pull. I pulled harder than I like to in a pressure suit.

[Cernan - "The latches were starting to stick, so I was just going to dust them to see if that would help. Jack's comment, it seems to me, was that, in a pressure suit, you can sometimes apply more force than you would normally intend to. You're not outfitted to be a brain surgeon with tweezers. So the tendency to grab hold of something and pull harder than you might want to was a real danger; and what Jack was saying was that he didn't want to pull the latches off."]

[Schmitt - "You're putting pressure on the suit bladder whenever you open something, and you want to be careful. I think this is what scared a lot of us about what Scott and Irwin were doing on 15 when they were trying to get the deep core out. They got away with it; except Scott wrenched his shoulder. He's a moose anyway, but that shows you how much force they were putting on it."]

[Cernan - "Until this very moment, reading Jack's comment, it never crossed my mind that you could hurt the suit. I never had any concern about it. I had experience with suits going back to my Gemini IX EVA and the only problem was that you didn't have the feel. You could squeeze too hard or pull too quickly because you didn't have the feel - the sensitivity - in your arms and hands of whatever you were holding on to. But as far as heavy movements, like trying to get core samples out of the ground, and putting stress on the bladder, I'd never heard of that."]

147:32:10 Cernan: See if I can...

147:32:15 Schmitt: (Closing SCB-6) Okay, Bob. SCB-8 and 6 are going up.
 147:32:20 Parker: Okay, and I understand 5 will be...
 147:32:21 Schmitt: Or will go up.
 147:32:22 Parker: ...on the gate.
 147:32:26 Cernan: Yes, sir, Bob. It'll be there.
 147:32:29 Schmitt: (Stowing the empty SCB) And 7 under the LMP's seat.
 147:32:31 Cernan: 4 and 5 will be on the gate. You know, here's a problem for you tonight. You got any way of freeing up these gate hinges that lock the bags on? I'm dusting them, but they're not going to lock, any of them. They're frozen tight, just about.
 147:32:49 Parker: Okay. Copy that. We'll talk about it.

[Jack takes SCB's 6 and 8 to the ladder so that he can put them on the LM footpad. One of them is partially open. As he pulls the SCB's out of his Rover footpan, he turns to his right so that he doesn't have to lift the bags very high.]

[Schmitt - I can't tell you why I was going sideways here, unless it was just the way I got started. A little overshoot on my rotation."]

[Cernan - "When I was working around the MESA, there were a lot of times when I wanted, for example, to move five feet to the left, that I did not turn left and start walking straight on. I'd just slither sideways. Those were not planned maneuvers. You just do what that computer up in your head tell you to do that's most productive, safe, responsive way to make a move."]

147:32:51 Cernan: If you do get them locked, you may never get them off.
 147:32:57 Parker: Okay. We'll give them something to work on overnight.

[Houston never had any suggestions about the locks.]

147:33:01 Cernan: Okay, I'm dusting them right now. But I still can't free them up.
 147:33:10 Schmitt: Man those are heavy bags.
 147:33:11 Parker: Jack, have you got the top of the bag closed?
 147:33:12 Cernan: (Garbled) bags.
 147:33:17 Schmitt: (Returning to the Rover) Yeah, what do you need?
 147:33:19 Parker: Okay. No. John (Young) thought maybe they were still open. He was worried.

[Cernan - "Parker got out of this one by saying "John thought that they might still be open"; and Jack came back very nicely. If Parker had said "Jack, I thought maybe you had left them open", I guarantee you that Jack would have come back with some remark to Parker. That's just the way it

went. Those guys could go after each other in a very sarcastic manner sometimes."]

147:33:24 Schmitt: Oh, no, I latched them. I'll check them again before I go up.

147:33:28 Cernan: (Garbled under Parker)

147:33:28 Parker: Okay, and we got no FSR's (football-sized rocks) underneath the seat. We understand. Roger.

147:33:35 Schmitt: No. I just checked and they're all in the bags. And the Rover sample bag is empty.

[Jack stows the maps under his seat.]

147:33:48 Parker: Copy that.

147:33:50 Schmitt: Not nothing left.

[Jack takes the Rover sample bag (an SCB) from the hook on the accessory staff where it normally hangs and shows his TV audience just how empty it is.]

147:33:52 Cernan: Bob, neither one of these bag latches are going to latch on the back. I dusted them, but...

147:33:58 Parker: Okay,...

147:33:59 Cernan: ...they're not going to work. I can't free them up...

147:34:02 Parker: ...we'll talk about it tonight...

147:34:05 Schmitt: We'll use the seat.

[That is, they can put samples under the seats.]

147:34:06 Parker: ...Don't worry about it now.

147:34:07 Cernan: Yeah, we can probably use the seat.

We've got a little more room than we had. Okay. Let me get something else done.

147:34:14 Schmitt: (Taking a packet of sample bags from under his seat) I wonder if I ought to take a sample bag holder up there to see if I can fix that. To see if it fixes.

[Jack takes the sample bags out of the holder.]

147:34:20 Parker: Roger, Jack. I'd suggest that.

147:34:22 Schmitt: Probably ought to, huh?

[Jack opens his shin pocket, puts bag holder in the pocket, and closes the pocket cover.]

147:34:28 Cernan: Okay. (Reading CDR-32) (The SEP) receiver's been dusted and blankets are open; power is Off and Off. Okay. I'm going to take the TGE (Traverse Gravimeter Experiment) off (the Rover) now - or dust it and then take it off - and then just leave it there. Hey, congratulate Jose (John Young) on that fender will you?

Because I think he just saved us an awful lot of problems.
He and whoever else worked on it.

[Jack puts the sample bags under his seat.]

147:34:54 Parker: He mumbled something very humbly about a thousand guys.

147:35:00 Cernan: Well, tell him that's going to be my "bring home" present to him: a picture of his fender.

[Cernan - "I brought the whole fender home!"]

[The replacement fender is on display at the National Air & Space Museum in Washington, D.C.]

147:35:11 Schmitt: Okay, Bob. Unused gear - which you have an inventory on - is under the LMP's seat. (Pause)

[Jack closes the seat.]

147:35:33 Schmitt: Okay. Where am I (in the checklist)?

[He is on checklist page LMP-29.]

147:35:36 Cernan: (Taking the gravimeter to the ladder) I'm bringing the TGE over here, but I'm not pushing it yet.

147:35:40 Parker: Okay. Copy that.

147:35:42 Schmitt: (Going to the MESA, looking at LMP-30) Cosmic ray's deployed! (Pause)

[As is discussed at 118:35:03, deployment of the cosmic ray could have come then or now. Having had a spare moment after the flag deployment, Jack set out the cosmic ray experiment at that point in EVA 1.]

147:35:50 Schmitt: Man, I got the sorest hands in the world, right now.

147:35:53 Parker: How about on the Moon?

147:35:56 Schmitt: (Carrying the ETB to the Rover) Bum, bum, bum, baa.

147:35:58 Cernan: Nothing's in the big bag, is it?

147:36:00 Schmitt: (Responding to Parker) I just can't compete with you astronomers.

[Bob Parker was a member of the Astronomy Department faculty at the University of Wisconsin before joining the astronaut corps.]

147:36:03 Parker: Just keep trying.

147:36:04 Cernan: Nothing's in the bag, is it? Big bag?

147:36:07 Schmitt: Nothing's in the big bag.

147:36:09 Cernan: Okay.

147:36:11 Schmitt: Unless there's one rock in there that disappeared yesterday. I don't know what happened to it.
(Pause)

[Jack is referring to a rock he collected east of the LM during the Rover preps at 118:31:10. Shortly there after, he put it in the big bag but then, at 123:40:07, couldn't find it.]

147:36:18 Schmitt: Hey, we forgot the polarizing filter work!

[Gene returns to the Rover.]

147:36:21 Cernan: Nah, I saw it on the checklist, and I mentioned it to Bob, and he didn't come back with anything. And there was a...(Pause)

[Gene called out the polarization filter when he checked under his seat at 141:20:35 when he checked under his seat to make sure (as per checklist) that Jack had transferred the filter from the ETB during the Rover preps. They were to have taken pictures at Shorty with the filter on Jack's camera but the activity was dropped without remark because of the discovery of the orange soil.]

147:36:26 Cernan: (Consulting CDR-32) Okay. I guess I'm going to go ahead and...

147:36:30 Schmitt: Put those (unused sample bags) under that seat, please.

147:36:33 Cernan: (At Schmitt's seat) Yeah, there's only one left.

147:36:35 Schmitt: One? No, there's three or four...

147:36:36 Cernan: There's three left.

147:36:37 Schmitt: Just put them under there. Who knows, we may need them at the rate we're going.

147:36:40 Parker: Okay. And, Jack, while you're unloading there,...

147:36:42 Cernan: (Garbled) pull those (Rover circuit) breakers.

[This item is on CDR-31. the fact that they are getting everything done - albeit in almost random order - is a testament to this crew's thoroughness and to their training. They know what needs to be done and why and know how to use the checklist as an effective tool. On Apollo 12, Pete Conrad had some occasional difficulties because he relied too much on his memory and, at the other extreme, one can imagine people using a checklist as a crutch, as a means of covering up inadequate preparation. Here, Cernan and Schmitt are using the checklists - and Houston - to help them make sure that everything gets done, but aren't getting flustered or confused because they are having to do things out of order.]

147:36:44 Parker: ...on the 500 millimeter you might squeeze off a few shots of the North and South Massif there, if there's any lineations visible.

147:36:56 Schmitt: Okay. I'll give it a try. Why, are we ahead of time?
 147:37:03 Parker: No, we're working right on time.
 147:37:08 Schmitt: Okay.
 147:37:09 Cernan: Why don't you give it to me while you're packing the ETB, Jack; I'll do it.
 147:37:12 Schmitt: Am I behind you, now (in the checklist)?
 147:37:14 Cernan: Yeah, I'm going to start inventorying the Rover and pulling the breakers so...(Pause)

[Gene gets the 500-mm camera. Jack is on LMP-30 and Gene is waiting to finish the last few items on CDR-31.]

147:37:24 Schmitt: Man, we are so far off nominal on what bags (SCB's we've used)... (Laughs) I sort of didn't think. The checklist is going to have to be updated, I guess.
 147:37:33 Parker: Totally. (Pause)

[Gene raises the 500-mm camera to his face plate so that he can use the boresight mounted on the lens barrel as he photographs the South Massif. The pictures in this sequence are AS17-144-22080 to 22104. 22090 is a good picture of the most notable outcrop.]

[Cernan - "The boresight was just like a little magnifying glass and you could see rainbow-rings inside of it as you looked through it."]

147:37:52 Schmitt: Oh, I should call (and tell Houston what I'm putting in the ETB). Mag Charlie.
 147:37:56 Parker: Copy that.
 147:37:58 Schmitt: Mag Kilo.
 147:37:59 Parker: Copy.
 147:38:00 Schmitt: Mag Bravo. (Pause) Mag Golf. (Pause) Mag India.
 147:38:21 Parker: Copy all those. And tell Gene that we can confirm that his lens cover's off.

[As can be seen in the TV, the lens cap is hanging free, attached to the barrel of the lens with a strap. After finishing a sequence of South Massif photos, Gene's turns his attention to the North Massif, taking a right to left sequence starting just west of Wessex Cleft. He actually does three sequences of the summit area and then finishes up with a sequence across the face of the mountain, starting to the left of the large boulder track. AS17-144-22105 to 22132 are his North Massif pictures. 22129 shows the boulder track.]

147:38:32 Schmitt: Okay. (To Gene) They confirm that your lens cover's off.

[Needless to say, Gene can hear Parker perfectly well. The humor here is exceedingly dry.]

147:38:36 Schmitt: (To Parker) The scissors are in (the ETB).
 147:38:38 Parker: Copy that.
 147:38:43 Schmitt: Lens brushes. (Pause)
 147:38:49 Cernan: (Facing east) I hope this is the right setting. It is.
 147:38:53 Schmitt: (Laughs) Hey, try f/5.6 directly down-Sun... (correcting himself) or, up-Sun, at (the) Sculptured Hills there in the distance. (Pause) See where I mean?
 147:39:14 Cernan: Yeah, I'll get it.

[Schmitt - "I may have been trying to get Gene to take an over-exposed picture into the shadowed areas on the Sculptured Hills."]

147:39:18 Schmitt: Okay, Bob. (To himself) What else do I need here? Let's see. 500, mag R. (To Gene) (I) need mag R as soon as you're through.
 147:39:27 Parker: Yeah. I think we've got enough of those now, Gene.
 147:39:32 Parker: (To Jack) You got the maps?
 147:39:35 Schmitt: Yep, got them.
 147:39:42 Cernan: Some of these (photos) won't overlap, Bob, because I'm hurrying.
 147:39:45 Schmitt: Don't smear them.

[Many of the Apollo 16 500-mm pictures were badly smeared.]

147:39:46 Parker: Don't hurry and smear them.

[Gene finishes with the 500 and puts the lens cap back on.]

147:39:47 Cernan: They're not smeared, but I just didn't overlap some of them. (Hearing Parker) Okay. Everyone agrees to that. Don't hurry and smear them. (Jack laughs) I'll get those others, Jack, tomorrow.
 147:40:00 Parker: Okay. You got the maps in there, too, Jack?
 147:40:02 Cernan: Frame count, Bob, is...
 147:40:05 Schmitt: (Answering Parker) Yes.
 147:40:07 Cernan: Frame count is 152 on the 500.
 147:40:09 Parker: Copy that.
 147:40:13 Schmitt: (Laughing) (To Gene) Let go of it (the 500). There.
 147:40:16 Cernan: Okay.
 147:40:17 Schmitt: Dynamic. Did you cycle it twice?
 147:40:19 Cernan: No; cycle it twice.

[Jack will expose two more frames before removing the film magazine and inserting the dark slide.]

147:40:21 Parker: Do you have the maps there, Jack?

147:40:23 Cernan: (To Jack) Okay. I guess I'll go in and pull some Rover breakers.
 147:40:26 Parker: Okay. And...Roger. Copy that.
 147:40:33 Cernan: (Leaning in-board over the Rover) Oh, boy. Pulling breakers is not going to be much fun.

[Cernan - "Whether you're working in a pressurized suit or working in shirtsleeves, if I had to pick between zero gravity, one-sixth gravity, or full Earth gravity, in every case I'd pick one-sixth. Sometimes you'd have trouble getting as much leverage as you can on Earth; but, otherwise, one-sixth gravity makes things easier. The pressure suit, on the other hand, is a big inhibitant, particularly in restricting your dexterity. You can make the big movement and turn around and get from here to there with a step or a hop. But the things that get to you and the things that get frustrating are the little things that you can't do with you're fingers, things that you can't do with your hands. In a pressure suit, particularly from your elbows on down, you're a big, clumsy ox. You had the blue RTV on the fingers of the glove and, to pull the breakers, you had to force your fingers in there to get some fingertip dexterity and control through those gloves. It was just a very difficult thing to do. These were little, round, aircraft-type breakers rather than household breakers. The top of the breaker was no bigger across than the top of a pen - a half centimeter across. It was a little cylindrical breaker with a lip on it. We built them with a little more room so that you could grab onto them but, when they were pushed in they were only about a centimeter tall. They had to be set pretty tight, and it was hard to get a grip. And, besides, our hands were tired by this time. "]

147:40:40 Schmitt: You want me to...You want the scissors or something (to use in pulling the breakers)?

[Cernan - "These were surgical scissors with the rounded point, and they were the most common instrument in spaceflight."]

147:40:43 Cernan: No. (Pause) Oh, boy. (Pause) Oh, boy.
 147:40:55 Schmitt: Mag Romeo.

[This is the magazine off the 500-mm camera, which Jack is now putting in the ETB.]

147:40:59 Parker: Copy that. You got the maps, Jack?
 147:41:02 Schmitt: (Laughing) You ask me that one more time Parker, and I'm going to get mad at ya.
 147:41:12 Cernan: Oh, I got to...Whew! What have you got over there? You got the scissors handy?
 147:41:19 Schmitt: Yeah, you want them?

147:41:21 Cernan: I got three of four breakers. Let me try this other one one more time. (Pause) Okay. I got it - with the old fingers.

147:41:36 Parker: Okay. Copy that. All four of them out, Gene.

147:41:38 Cernan: Okay; (circuit breakers) Alpha, Bravo... (Responding to Parker) Yes, sir. Alpha, Bravo, Charlie, Delta are Open. I'll get the LCRU power.

147:41:46 Parker: Okay. And, Gene, when you leave the (TV) camera, a reminder to face it away from the Sun and tilt it down.

[Houston wants to minimize the area exposed to the Sun and get maximum cooling through the rest period. Gene is on CDR-31.]

147:41:57 Cernan: Okay. (Pause)

[Gene points the TV camera in a generally westward direction and down toward the Rover seats.]

147:42:06 Parker: Hey, Gene. That's not quite away from the Sun. Really it ought to be, you know, down-Sun.

[TV off.]

147:42:11 Cernan: I'll (static). I'll get it, Bob. (Long Pause) Bob, are you reading?

147:42:31 Parker: Roger. Loud and clear. (Pause)

147:42:38 Schmitt: I read you, Gene.

147:42:39 Cernan: Yeah. See, I just turned LCRU power off; they got to go through the LM.

147:42:43 Parker: That's right.

147:42:46 Cernan: Bob, do you read?

147:42:47 Parker: Loud and clear. (Pause)

147:42:54 Schmitt: Is this gravimeter working?

147:42:55 Cernan: No, it's not. I didn't push it yet. Hello, Houston, come on. Otherwise, I'll turn this power back on.

147:43:02 Parker: Read you loud and clear, Gene. Do you read Houston?

147:43:05 Cernan: Well, let me turn it on and talk to them.

[Cernan - "From the tone of voice, you can hear that we were pretty tired. 'God damn it, let's get on with the show and stop screwing around.' You can hear the fatigue in our voices."]

147:43:07 Parker: We read you loud and clear, Gene.

147:43:13 Cernan: Well, I just turned the LCRU back on. Are you reading us through the LM, now?

147:43:16 Parker: Yeah, we came through the LM that time.

147:43:21 Cernan: Okay. I'm turning it off and the camera is pointed down and it's pointed effectively to the west. Down-Sun.

147:43:27 Parker: Okay. Copy that. Very good. Thank you.

147:43:29 Cernan: LCRU Power's going Off. (Pause) Okay, LCRU Power is Off. (Reading) Battery covers. Open battery covers. They're all dusted already.

147:43:49 Parker: Copy that. (Pause) 17, you read Houston?

147:44:04 Cernan: Uh-oh, I got to work on one battery. (Pause)

147:44:15 Parker: 17, you read Houston? (No answer; pause) 17, you read Houston? Over. (Pause)

147:44:34 Schmitt: Hey, Bob?

147:44:35 Parker: Roger, 17. Do you read?

147:44:40 Schmitt: Still there? (Pause)

147:44:46 Cernan: Well, they're supposed to be going through the LM.

147:44:47 Parker: 17, do you read Houston? (No answer)

147:44:49 Schmitt: Got something fouled up. (Pause) Maybe we got the switches wrong, or something, up there (in the LM cabin.) Don't think so, though.

147:44:58 Cernan: No.

147:45:00 Schmitt: They talked to us first.

147:45:03 Cernan: Let me give them a call. (Pause)

147:45:08 Parker: 17, do you read Houston? Over.

147:45:09 Cernan: Bob, you want to try again. We're on the LCRU! (Hearing Parker) Yeah, we read you, but I'm on the LCRU again. We're not reading you through the LM!

147:45:15 Parker: Yeah, I don't understand that. Stand by. (Brief pause) Press on with the rest of the closeout.

147:45:21 Cernan: Well, I'll leave you on the LCRU, here. (Responding to Parker) Yeah, we're pressing on. Okay. For the first time, I've got to dust the center battery cover. All the others are good.

147:45:31 Parker: Okay. Roger, 17. Do you read Houston now?

147:45:34 Cernan: Well, yeah, but I'm on the LCRU. I don't know.

147:45:39 Parker: No, now they say we're going back to the LM again. Press on with the closeout.

[TV on.]

147:45:46 Cernan: Okay, Bob. I'm going to go turn the LCRU power Off. And for the first time, I've got to dust the center radiator on the batteries.

147:45:55 Parker: Okay. Copy that.

147:45:56 Cernan: Up until this time, they've all been real clean.

147:46:01 Parker: Copy that.

147:46:05 Cernan: Okay. Give me a short count. And in the interim I'm going to turn the LCRU Power, Off.

147:46:09 Parker: Okay. Roger. 1-2-3, 3-2-1.

[TV off.]

147:46:15 Parker: Okay, 17, do you read Houston? Over.
 147:46:17 Cernan: Okay. We've got you.
 147:46:18 Parker: Okay; very good.
 147:46:19 Cernan: Yeah. We got you, Bob.
 147:46:20 Parker: Okay. We've got about two-zero (20) minutes before we have to be inside the LM there, fellows. Let's hustle on.
 147:46:29 Schmitt: (Joking) Oh, I think we'll just sort of take it easy, Bob. (Pause) Okay. The MESA's tidied.
 147:46:37 Parker: Thank you.
 147:46:38 Schmitt: I've got the (PLSS LiOH) canisters; pins are green.
 147:46:41 Parker: Copy that.
 147:46:42 Schmitt: The LM (lithium hydroxide) canister's in the pocket (on the EVA pallet).
 147:46:44 Parker: Very good.
 147:46:53 Schmitt: And, let's see. (Looking at the bottom of LMP-30) I think I'm ready to dust. Could I help you?
 147:46:57 Cernan: No, I'm leaving here right now.
 147:46:59 Parker: Okay. And, Gene, as you go by, how about giving us the SEP temperature readings.
 147:47:46:55 Schmitt: (Garbled) I got to take these bags up.
 147:47:00 Cernan: (Hearing Parker) Oh, me. I will. (Long Pause)
 147:47:48 Parker: 17, Houston. It's awfully quiet.
 147:47:55 Cernan: Okay, Bob. Here's your reading. About one hundred and...About 108 to (1)10 degrees.
 147:48:10 Parker: Okay. Copy that. (Pause) Okay. We'll leave it there, as is, overnight. Thank you.
 147:48:18 Cernan: And I'll give her one good little smack with the brush. And it's as clean as it'll ever come.
 147:48:24 Parker: Okay. Thank you.
 147:48:31 Cernan: Jack, you might just as well go cold water. There's no more use for it now, if you're warm.
 147:48:35 Schmitt: No, I'm not warm I'm just... Want to hand me that other SCB there? (Pause)
 147:48:44 Cernan: Oh, man!

[They both laugh. Apparently, Jack has decided to take one or more of the SCB's up to the porch.]

147:48:47 Cernan: Oh! The cover's open on this one.
 147:48:50 Schmitt: You wonder why it's hard to get up the ladder.

[It's hard to get up the ladder because he's carrying a heavy SCB.]

147:48:53 Cernan: Don't hold it by the cover.

147:48:55 Schmitt: (To himself) What do I want these tongs on for?
 147:48:57 Cernan: Give them to me. I'll take them down.
 147:49:00 Schmitt: Just noticed them.
 147:49:02 Cernan: Don't want them (up to the cabin). Okay.
 147:49:05 Schmitt: Thank you.
 147:49:06 Cernan: Don't take it by the cover. The (SCB) cover's going to come open. Take it by this.
 147:49:10 Schmitt: Wait a minute.
 147:49:11 Cernan: Got it?
 147:49:12 Schmitt: I got it.
 147:49:13 Cernan: Okay. (Pause) Probably got tongs on for the same reason I've got them on. (Long Pause)

[Schmitt - "What would explain the two sets of tongs is that I had Gene's from when he let me off at the ALSEP and, sometime during the closeout, he took the others off the gate for some purpose. And it could be he just did it to have them in case he dropped something."]

147:49:59 Parker: And, 17, we're ready for a grav measurement.
 147:50:06 Cernan: Yes, sir, Bob. Just cleaning up the Rover. Getting our tongs out of the way (and back on the gate).
 147:50:10 Parker: Okay.
 147:50:12 Cernan: And for your information, at this heading (of 017), the western-most battery cover, like I talked about yesterday, is just starting to cover the radiators.

[The Sun moves very slowly in the lunar sky, and shadows move only about 12 degrees in 24 hours.]

147:50:29 Parker: Okay; cover that...(Correcting himself) Copy that.
 147:50:36 Cernan: Oh, hum-de-dum-de-dum! You know, I think it's another good day's work.
 147:50:40 Schmitt: Uh-huh.
 147:50:41 Cernan: Okay. I dusted all that.
 147:50:45 Schmitt: I just knocked as hard as I could, on my feet, several times.
 147:50:52 Cernan: What you're going to say is you want me to brush you, huh? Let me keep this (gravimeter) out of the way so it doesn't get dusty.
 147:50:57 Schmitt: Okay. (Pause)
 147:51:09 Cernan: Wonder if our bouncing around that gravimeter is going to disturb it like this.

[At 147:59:32, Gene will give Parker a gravimeter reading. On every other occasion, Gene gave Parker a mark when he started the measurement, but not this time. The preceding statement suggests that, at this point, he has already punched the Grav button.]

147:51:13 Schmitt: Shouldn't.
 147:51:14 Cernan: Got to do...Well...
 147:51:15 Schmitt: Want me down (off the ladder)?
 147:51:16 Cernan: You got to do me first.
 147:51:17 Schmitt: Yeah. (Jumping down the ladder) Plink.
 147:51:21 Cernan: You're not nearly as dusty as you were yesterday; you're just dirty, that's all.
 147:51:24 Schmitt: Well.
 147:51:25 Cernan: I think I can get everything off my shoes by banging, if you'll just get my arms. I didn't really fall in much today, except maybe my left arm. But...
 147:51:34 Schmitt: I tell you, (if) we saw some of the things I think we saw today, we both fell in. (Laughs)

[Schmitt - "This is a play on words. I meant that finding the orange soil was a lucky break."]

147:51:40 Cernan: Don't. Ow!
 147:51:41 Schmitt: What? I hurt you?
 147:51:43 Cernan: Yeah, you're hitting.
 147:51:45 Schmitt: Well, you're right. Sorry. (Laughing)
 I don't have much control.

[Jack is trying to brush Gene because, because of the stiffness of the suit and his general tiredness, what he is actually doing is hitting Gene.]

147:51:49 Cernan: (Laughing) I know it. That's the way mine (his arm) feels. (Pause)
 147:51:55 Schmitt: That's dirty. Under there. (Pause) I'm glad they can't see this. (Pause)

[Schmitt - "I was referring to the 'intimate' nature of this part of the dusting operation."]

147:52:11 Cernan: Oh, I stand out here and I look at that flag, and I look at the Rover, and I look at those massifs. It's still hard to believe.
 147:52:18 Schmitt: What did we deserve to do...(correcting himself) do to deserve being out here, huh? (Pause) Okay. That's not very good. Let me get some (of the dust on) your PLSS, here. Keep...Go forward just a little.
 147:52:37 Cernan: This way?
 147:52:38 Schmitt: There you go. (I) think your sharp (Rover) turns are...

[Schmitt - "I suspect that what I started to say was that he'd been throwing dust on our suits when he made sharp turns."]

147:52:43 Cernan: Hey, that fender is really a classic.
 147:52:47 Schmitt: (Punning) One might say it's a "young" fender, (because we) just put it on.

147:52:56 Cernan: Do we need...Do we really need those clamps?

147:52:59 Schmitt: No.

[Gene is referring to the lamps clamps from the LM cabin that they used to fasten the new fender to the Rover. He is wondering if he'll need to take one or both up to the cabin after EVA-3.]

147:53:03 Cernan: I can't think of anything we need them for. That light...but you can tie that light somewhere...

147:53:07 Schmitt: We don't...Well...

147:53:08 Cernan: I might bring one back (in the LM, just in case).

147:53:09 Schmitt: Yeah. We ought to leave one in tribute. To Dr. Young. (Pause)

147:53:24 Cernan: Oh, that orange soil was something.

147:53:27 Schmitt: Huh?

147:53:28 Cernan: And the way it went radially down that crater. (Pause) Let me turn, and then take another look, and then I'll...Then you get up there.

147:53:35 Schmitt: You got quite a bit (of dust) around your hoses here.

147:53:38 Cernan: My hoses?

147:53:39 Schmitt: Okay, and I don't know what I can do about it, Geno.

147:53:41 Cernan: Oh, just give it a swat (garbled) front, too..

147:53:42 Schmitt: Well, I got it the best I could. Let me get the top of your LCRU there.

[Jack means Gene's RCU.]

147:53:49 Cernan: Mine's pretty good.

147:53:50 Schmitt: (Correcting himself) Or, RCU.

147:53:51 Cernan: Yeah, mine's good. Okay. Let me get to your front.

147:53:55 Schmitt: No, I didn't get your other arm here.

147:53:56 Cernan: Oh, okay.

147:53:58 Schmitt: I don't know that I can.

147:53:59 Cernan: It's the inside arm. I don't have anything on it.

[That is, Gene's right arm which, being in-board on the Rover, doesn't get sprayed with as much dust.]

147:54:02 Schmitt: No, that's right. You don't. It isn't. It's about the same.

147:54:04 Cernan: When you fall out, you fall out on your other arm.

[Gene is referring to his fall at the end of the Scarp Gravimeter stop as he tried to mount the Rover.]

147:54:07 Schmitt: There is some on that leg there.
 147:54:09 Cernan: Okay. (Pause)
 147:54:13 Schmitt: Don't know what I'm going to do about it.
 (Pause) I think we're just going to have to make do.

[Cernan - "Dusting was a major process. By now, we've already spent 5 minutes dusting."]

147:54:25 Cernan: Let me see what I can do with you.
 (Pause) Just look at me. (Pause) What is this rock, right here, by the pad!
 147:54:32 Schmitt: I don't know...I.
 147:54:34 Cernan: Did I just turn your comm? Do you still hear me?
 147:54:37 Schmitt: Yeah. I've just been intending to mention that (rock) several times. Anybody that lands on a rock ought to have their head examined. Put their ladder (strut right on a rock)...
 147:54:47 Cernan: Boy, where have you been again today?
 147:54:48 Schmitt: Oh, I played some games there around Station 3. (Pause) I'm sorry.

[Jack fell several times at Station 3, now known as Ballet Crater because of his performance.]

147:54:55 Cernan: Boy, oh, boy!
 147:54:57 Schmitt: Wasn't intentional.
 147:54:58 Cernan: Whoo.
 147:54:59 Schmitt: But (a) lot of your turns...
 147:55:01 Cernan: Hold your arm up. Hold your arm up.
 147:55:02 Schmitt: Lot of your turns threw dust...
 147:55:06 Cernan: Yeah, I noticed that. (Chuckles)
 147:55:08 Schmitt: ...on me.
 147:55:09 Cernan: God dang that rock! If I was strong enough, I'd move it. Hey, I am strong enough. That's one we ought to bring home!
 147:55:17 Schmitt: Well, if we can't fill up the LM with anything else.
 147:55:20 Cernan: That's about the size of the SRC. Stand up on the pad. (Pause) Oh, shoot! First time that's happened.

[Cernan - " (Laughing) I just read this and said to myself, 'Now what's the worst thing that could happen.' It's dropping the brush in the dust. So I'm sure that that's what happened. It's just like with the hammer. You've got to hold on tight. And when you brushed, you had to brush hard. Your hands are tired, so you drop it. I'm positive I dropped the brush."]

147:55:34 Schmitt: Here, hold on to me. (Long Pause)

[Jack is offering himself for Gene to hold onto as he bends to retrieve the brush.]

[Schmitt - "I can remember that, by the time I finished trying to dust Gene, that was it for my hands. My fingers and forearms were so fatigued that it was really hard to do anything useful in the dusting operation, because you just couldn't stroke without losing your grip on the brush. There was some pain under your nails because they had lifted off the quick, but mainly you were just fatigued and holding that brush was just the last straw. Gene didn't talk about it as much as I did; but sometimes, in listening to this, you get the impression that his hands were just as sore. That's probably why Gene dropped the brush. And the fatigue was the reason why I switched to just banging on his suit with the brush: it was easier hitting him than trying to brush. And that's when he complained. I can't believe that he felt it; but, apparently, he did."]

147:55:56 Cernan: You know, by rights, that (dropping the brush) should have happened more. (Pause) I want to get around back and then I want you to get up on the ladder some (so I can dust your legs.) Oh, man, let me get the back of your PLSS. What did you bump against? I guess that's from the Rover seat.

147:56:10 Schmitt: I think it is.

147:56:12 Cernan: No, I mean you got a couple abrasions right on through the...

147:56:14 Schmitt: So do you. I wasn't going to mention them (and risk alarming anybody in Houston).

147:56:17 Cernan: Well, these are only a pin-hole thick, but... (Pause)

147:56:27 Schmitt: All I can say is it's better than walking.

[Among its many advantages, the Rover delivers two relatively rested astronauts to each of the geology station. The only fatigue that the Rover ride didn't help with very much was the forearm and finger fatigue, particularly for Jack when he had to carry one of the charges.]

147:56:30 Cernan: Oh, man, I'll tell you, we covered over 20 kilometers today, babe. How'd you like to walk up and down those hills and ditches at 20 kilometers? Okay. Can you... Turn towards me. I want to get the front of your legs one time. (Laughs) Come back.

147:56:51 Parker: Okay. And, 17, Houston. How's the dusting coming?

147:56:53 Schmitt: Man, you've had your day of dusting, haven't you?

147:56:57 Cernan: (Answering Parker) Well, we're almost there. I'm going to send the LMP in in about a minute.

147:57:04 Parker: Okay. We're getting to a point where we need...

147:57:06 Cernan: Oh, I tell you, I've spent more hours on the dustbrush...

147:57:07 Parker: ...where we need to be inside in less than 10 minutes, with the thing (the hatch) closed up.

147:57:11 Cernan: Yes, sir. We're on our way, Bob.

[Cernan - "This didn't mean that lightning was going to strike in ten minutes. If there was something to do and I had to stay out there ten or fifteen minutes longer, I still would have been very comfortable. I knew our margins were very, very conservative and I never had a concern about running out of consumables or having to scramble to get in. It wasn't like the margins we had for fuel to land the LM which you could eat up very quickly. Sometimes we were pushed up against Houston's limits on consumables but, in reality, it was never even close."]

147:57:15 Cernan: (To Jack) That takes care of it. Knock (the dust off of) your feet off, Jack. Knock your feet off on the ladder.

147:57:21 Schmitt: Okay.

[They've spent 6 1/2 minutes dusting, and will still take a lot of dust into the cabin.]

147:57:22 Parker: And don't forget the antennas, guys.

[Parker is referring to the antennas on the top of the OPS's which need to be put in the stow position before they crawl through the hatch. On Apollo 15, Scott and Irwin forgot to stow Irwin's antenna, which then broke off.]

147:57:24 Schmitt: Okay. I need the pallet.

[This is the EVA pallet which contains replacement batteries, replacement LiOH canisters, and food. Jack is now at the top of LMP-32.]

147:57:28 Cernan: (Responding to Parker) Oh, Bob, you're a beauty.

147:57:29 Schmitt: How did you think of that?

147:57:30 Parker: John (Young) suggested it.

147:57:36 Schmitt: John who? (Laughs)

147:57:38 Cernan: He strikes again. (To Jack) You'd (have) broke yours off sure, because I wouldn't have seen it as you went up (pause) unless I took inventory with my book, which I'll do here in a minute. (Consulting checklist page CDR-31) Open battery covers, taken care of; dusted LCRU; blankets open 100 percent. They've been open 100 percent all day.

147:58:01 Schmitt: Okay.

147:58:06 Cernan: If I can just get up here.

147:58:07 Schmitt: Oh, shoot. I forgot a snap up there (on the antenna tie-down).

147:58:10 Cernan: Now, let's make sure we got all of those. I don't want to get hung up on anything.

147:58:12 Schmitt: Yeah. I mean I forgot to put the antenna under the snap...under the other thing. (Pause)
 147:58:30 Cernan: Wait a minute, get the snap. (Pause)
 Okay. (Did you) get it? (Long Pause)
 147:59:00 Schmitt: Okay. You're set.
 147:59:03 Cernan: Okay. Go on up, Jack, and I'm going to read the gravimeter.
 147:59:06 Schmitt: I need that pallet before I go.
 147:59:10 Cernan: Okay.
 147:59:12 Parker: Okay, and, Gene, we don't think you've punched the Grav reading yet.
 147:59:19 Cernan: Yes, I did, Bob. I'm going to read it for you in a minute.
 147:59:22 Parker: Okay.
 147:59:24 Schmitt: Okay. (Pause)
 147:59:32 Cernan: The reading is 670, 023, 501; that's 670, 023, 501.

[This measurement is listed in the Apollo 17 Preliminary Science report, albeit without a starting time. Because the experimenters took this to be a valid measurement, we can conclude that Gene pushed the Grav button without giving Parker a mark. At 147:42:54 Gene noted that he hadn't started the gravimeter measurement and, between then and now, there is only one statement (at 147:51:09) which can be interpreted to indicate that a measurement had been initiated.]

147:59:40 Parker: Okay. We got that. Go to Standby. Open the cover and dust the (TGE) radiator if it needs it. Or dust the radiator, period.
 147:59:52 Cernan: It's dusted already; I took care of that. And I'm in Standby.
 147:59:57 Parker: Okay. Copy that.
 147:59:59 Cernan: Okay. Final check. (Reviewing CDR-31) LRV. Blankets open 100; battery covers, open; samples off. We checked under both seats. Equipment stowed. (Pause, reviewing CDR-32) Okay. You're all clean to go in. Okay. Dust SEP, blankets open; verify Power, Off; Recorder, Off. TGE, that's read; that's dusted. Tidy the MESA blankets. They're okay. (Pause) Okay, and I've got this (rock) box to bring up when I go. Okay, let's see. (Probably stepping out of the LM shadow) Oh, man, that (Sun)'s bright...Stow PLSS antenna; brush to ladder hook, EVA pallet to LMP. You got it. The pins are green; and (Grav) reading; Standby; open TGE thermal cover lid and dust. That's done. (Turning to SDR-33) Final check: we got the pallet, ETB is on the hook, you inventoried the S-IVB's (sic; he means SCB's), Mr. Parker, and I guess you're happy we got them all.
 148:00:56 Parker: Roger.

[The S-IVB is the top stage of the Saturn V that boosted them out of Earth orbit for the trip to the Moon.]

148:00:57 Cernan: SRC-2 is in my hand. The big bag is not required.

148:01:00 Parker: Roger that. (Pause) And we're ready to call you all in as you go through the hatch.

148:01:05 Cernan: Okay. Jack's going in with the... (Hearing Parker) Okay, Jack's halfway through it now, and I'm going on up the ladder.

148:01:14 Parker: Okay. Copy that. (Pause)

[Four minutes have elapsed since Parker told them they had ten minutes to get the hatch closed.]

[Schmitt - "It seems from listening to the tapes that we never showed any concern whatsoever about ten minutes to go or any other limitation on getting in; and I suspect it's not only that we had certain things we had to get done but, also, we assumed - and which was correct, I think - that there were significant margins in the oxygen and coolant supply."]

[They have only used about 75% of their oxygen and battery power and 80% percent of their feedwater. On the first EVA, they went to 90% of their feedwater and will do so again on the third EVA. At 90%, they still have 45 minutes of cooling water left.]

148:01:21 Cernan: Oh, my; oh me! (To Jack) How you coming?

148:01:27 Schmitt: Just about there. (Pause)

[Carrying the rock box, Gene only has one hand free to grab the ladder as he jumps up to the first rung.]

148:01:32 Cernan: Ohhhh! That's a nice one-handed first step. "Godspeed the crew of Apollo 17". I'm going to keep reading that. I like that message. (Calling to Parker) How's Captain America, speaking of Apollo 17?

148:01:53 Parker: Captain America is sound asleep. Just about to come around to AOS (Acquisition of Signal when the Command Module emerges from behind the Moon on the current orbit). We think he's sound asleep.

148:02:00 Cernan: Hey, how does that always happen? That happened yesterday. (Pause)

148:02:12 Parker: He got up before noon this morning, too.

[Gene and Jack got up on this day at 1:30 p.m., Houston time - a fashionably decadent hour.]

148:02:17 Cernan: Oh, okay. (Pause) Just take it easy, Jack, it'll... Here you go...

148:02:31 Schmitt: Pip pin didn't work.

[This is a release pin on the EVA pallet.]

148:02:35 Cernan: Lot of things don't work when your hands get tired; that's the problem. Wasn't a bad day. How long we been out, Bob. Of course, we're still out.

[The EVA won't be over until cabin pressure reaches 3.5 psi.]

148:02:43 Parker: 7 (hours) plus 27 (minutes), so far.
 148:02:48 Cernan: 7 plus 27?!
 148:02:50 Schmitt: (Garbled)
 148:02:50 Parker: How does that grab you? (Pause) Well, we're getting anxious to get you in and get the hatch closed.
 148:03:00 Schmitt: (Garbled under Parker) Well, we understand that.
 148:03:02 Cernan: Jack's unloading the pallet and as soon as it comes out, I'll shove this stuff (the SRC and the two SCB's) in, and we'll be gone. (Pause)
 148:03:15 Schmitt: Just takes a certain amount of time.
 148:03:16 Parker: Okay, Gene. Are the three SCB's inside the hatch already?
 148:03:24 Cernan: Bob, I don't think any of them are inside. Let's see...
 148:03:28 Schmitt: No.
 148:03:29 Cernan: ...I've got 8 here and 6 here and we emptied the contents of 4 into the...
 148:03:39 Parker: Roger.
 148:03:40 Cernan: ...SRC, and we emptied the contents of 5 into one of these other two bags. So we've only got two of them here, plus the SRC.
 148:03:46 Parker: Roger that.
 148:03:47 Cernan: Five went into six.
 148:03:48 Parker: Roger that.
 148:03:52 Cernan: And we've got two of them hanging on the tail of the Rover. And I don't know what it is under Jack's seat right now.
 148:03:57 Schmitt: Seven is under my seat.
 148:03:58 Parker: We copy that. Don't worry about it.
 148:04:05 Schmitt: One more (PLSS) battery (to get off the pallet), Geno, and it's yours.
 148:04:07 Cernan: Okay. (Pause)
 148:04:16 Schmitt: You always used to stand and watch me do this, anyway.
 148:04:23 Cernan: Yeah, but we had some long EVA's at the Cape but... (Pause)

[Schmitt - "In training, when we went through these procedures, Gene didn't have anything to do. Somebody else handed me the pallet and I went through it, dutifully, simulating unloading and stowing material off the pallet. And, once or twice, we probably did it with the real hardware in the real LM, just to make sure it worked."]

148:04:31 Schmitt: There you go.

[Jack is pushing the empty pallet out through the hatch with his foot.]

148:04:32 Cernan: Okay. Just be careful of the...Let me get up there a little farther. Careful of that hatch. Getting to look like a regular garbage dump down there.

[Gene has tossed the pallet down to the surface.]

148:04:47 Cernan: Okay. Ready (for an SCB)? (Pause)
 Sorry, babe.
 148:04:58 Schmitt: It's all right.

[Gene may not have pushed the SCB far enough through the hatch for Jack to get it easily. Alternatively, it may have been tipped over.]

[Schmitt - "It was hard to lean down to get the things Gene's was handing in."]

148:05:03 Cernan: Now, this one (an SCB)'s going to come open if we're not careful. Let me see if I've got one more step to go up. No I think that's the last one. I'll just hold it here until you get it. (Pause) I could shove that in if I push it with the SRC. Jack, the cap'll come open. Be careful. (Pause) Okay. Here's that big silver box. (Pause)

148:05:41 Schmitt: Can you push on that (box) a little bit?

148:05:43 Cernan: Yup.

148:05:46 Schmitt: Okay. (Long Pause) Okay.

148:06:13 Cernan: Okay, Bob, you've got the two SCB's - (To Jack) I'll push it in - (the) SRC, and there goes the ETB.

[Schmitt - "I may have stuck the SCB's and the rock box on their storage rails to make room for Gene. Either that or I stuck them on the engine cover."]

[Cernan - "I'll bet a million dollars that he wasn't stowing those things in the rack until we got into soft suits. It took too much time. The hatch had to go quite a ways open for me to get in so there wasn't much room under his feet, so I've got to believe that he stowed them on the engine cover."]

148:06:23 Parker: Copy that. Now how about a CDR?

148:06:27 Cernan: There's only one thing left...(Hearing Parker) That's right, that's the only thing left out here.

148:06:32 Schmitt: Are you on a checklist?

148:06:34 Cernan: No, I'm not even on my checklist, but I guess...Yeah, I am; it says "Ingress". Let me knock some more dust off. (Pause)

148:06:46 Schmitt: Okay. Let me get behind the door.

[As he had at the end of EVA 1, Jack had the hatch fully open while he was getting the SCB's and other gear stowed. Now, in order to let Gene get in, he has to stand on Gene's side of the spacecraft and swing the hatch closed far enough that he can get over to his side of the spacecraft. He will

then open the door against his legs so that Gene can crawl in.]

148:06:49 Cernan: Well, I'm going to take what dust I got in with me. Ohhhh! (Long Pause)
 148:07:08 Schmitt: Push. There you go. (Pause) Keep your buttons close (to the floor). You're good. (Pause) Beautiful. Just float in. Hanging up a little on the purse, but that's all right. There you go. (Pause)
 148:07:41 Cernan: (Standing up) Ohh!
 148:07:43 Schmitt: That's my arm I'm getting in the way, there. Let me get out of the way.

[There is very little room in the LM for two suited astronauts.]

148:07:47 Cernan: Let me just check that (hatch) seal (for dust) before we close that. Okay. Can you get your arm up? Okay. There's no big rocks in it (the hatch seal), that I can see. Lots of dust on the floor.
 148:08:06 Schmitt: Yeah, I think it's okay. Okay, the hatch is partially closed...
 148:08:11 Cernan: Let me get it. I think it (the checklist) says to lock it, doesn't it?
 148:08:14 Schmitt: Well, we're supposed to close our water first.

[They will now use the Post-EVA cue card. The items listed there are also listed on Surface 5-1.]

148:08:16 Cernan: Okay. (Reading) "Forward Hatch, Close and Lock; dump valves both Auto, okay; Primary Water, Closed." Let me see if I can't get my (garbled) here.
 148:08:26 Schmitt: Here, why don't I get yours and you get mine.

[That is, turn each other's feedwater off.]

148:08:29 Cernan: Okay. I just got mine. And if you'll turn, I'll get yours.
 148:08:34 Schmitt: (Softly) You'll have to do that.
 148:08:36 Cernan: You'll have to put your right arm high; pick it up high.

[The PLSS controls are on the right, front corner. There are actually three controls, each with a very different shape so that they can be distinguished by feel. The outer control is a two bladed nylon lever that controls the PLSS feedwater diverter valve and, therefore, the amount of cooling. Inboard of the diverter valve are two other levers, one to turn on the primary feed and the other to turn on the Aux tank. One is a flat blade and the other is a rod.]

148:08:43 Schmitt: Oh, wait a minute.

148:08:45 Cernan: No, I can't reach you, Jack, unless you turn...
 148:08:47 Schmitt: Don't move yet; don't turn around.
 148:08:48 Cernan: Okay.

[Cernan - "It was just incredible in there with two guys in pressurized suits, plus all the stuff on the engine cover. It was just very difficult even to reach behind him."]

148:08:49 Schmitt: Move over to the corner. (Pause) Okay.
 148:09:00 Cernan: (Make) sure I got the right ones. Far right, far left, secure oxygen. Okay. Your water's Off.
 148:09:08 Schmitt: Okay. Water's off. (Pause)
 148:09:13 Cernan: Now, stay there and I'll lock the hatch.
 148:09:15 Schmitt: I've got to get into position to do the other good things (that is, close circuit breakers on the panel on the right side of the cabin and reset ECS valves behind his station). You go ahead. Do you have enough room or do I need to turn?
 148:09:23 Cernan: No, let me get down there. (Pause) No, I can't...
 148:09:36 Schmitt: Okay. Let me turn back (and face inboard); get out of your way. Got it?
 148:09:44 Cernan: Okay. Hatch is closed and locked.
 148:09:45 Parker: Okay. And remember, I think it's the overhead valve that you have (garbled) Open.
 148:09:52 Schmitt: That's right.
 148:09:53 Cernan: Yeah, you'll have to move over, Jack, so I can reach it.
 148:09:58 Parker: And you ought to verify both, I guess.
 148:10:00 Cernan: (To Jack) You're going to have to wait, then.

[They hear Parker but don't respond.]

148:10:03 Schmitt: Can you reach it now?
 148:10:05 Cernan: Okay. No, you got to swing left...
 148:10:08 Schmitt: Well, I'll have to...
 148:10:09 Cernan: ...(correcting himself) (swing to Jack's) right.
 148:10:11 Schmitt: I'll have to turn around, then. (Pause) How's that? Any better?
 148:10:21 Cernan: Nope, you've got to...
 148:10:22 Schmitt: Okay, for some reason I can't put my PLSS toward you.
 148:10:25 Cernan: No, you can't. Just face front, if you can, and move as far forward as you can.

[That way, Gene might be able to lift his arm behind Jack's PLSS and reach the valve.]

148:10:27 Schmitt: Well, if I get my...I'm going to have to go all the way around, I guess.
 148:10:32 Cernan: Well, just...

148:10:34 Schmitt: Look, I've got to get the PLSS against the circuit breaker (panel)...

148:10:35 Cernan: Wait. I've got you just where I want you. Now stay right there, and shift your weight as far to the right (probably forward) as you can. (Pause)

148:10:42 Cernan: Okay, it's Auto...

148:10:43 Schmitt: Okay.

148:10:44 Cernan: ...and (pause) it's locked. Okay?

148:10:52 Schmitt: All right.

148:10:53 Cernan: Now, (reading) Cabin Repress (valve), Auto. (Pause) Can't get it. I'll have to turn left, here.

148:11:02 Schmitt: Huh?

[Gene is facing inboard and needs to turn left and face more forward so that he can get his arm down behind Jack to get the valve.]

148:11:03 Cernan: Okay. Let me turn left.

148:11:04 Schmitt: No, I can get it.

148:11:05 Cernan: Okay. Cabin Repress, Auto.

148:11:07 Schmitt: It's Auto.

148:11:09 Cernan: And at (panel) 16, Cabin Repress breaker, Closed.

148:11:12 Schmitt: Closed.

148:11:14 Cernan: Master Alarm and Cabin Warning Lights. Cabin's coming up, Bob, 0.5 (psi).

148:11:19 Parker: Copy that. (Pause)

[The sound of the cabin filling with oxygen can be heard.]

148:11:26 Schmitt: I've still got 15 percent oxygen (left in the PLSS).

148:11:31 Cernan: Okay. Cabin pressure's increasing. Go "Pressure Reg's A and B, Cabin." (Pause)

148:11:40 Schmitt: A's Cabin.

148:11:42 Cernan: Okay. And your PLSS O2 (oxygen), Off, at cabin (pressure) greater (than) 2.5 (psi). It's there now. And you're probably getting (a) soft suit. (Pause)

148:12:05 Cernan: Mine's Off.

148:12:06 Schmitt: Mine's Off.

148:12:08 Cernan: Okay, cabin's up to 3.5. (Pause)

Cabin's up to 4.0. (Pause)

[The EVA is over after 7 hours, 37 minutes, 22 seconds.]

148:12:24 Cernan: Okay. Next thing, Jack, you can start verifying your white dots are out.

148:12:27 Schmitt: Okay.

[They are verifying that all of the LM circuit breakers marked in the checklist with white dots are in the open position.]

148:12:31 Cernan: And you can use your purge valve to depress, if you have to.

[That is, he can remove the purge valve to depressurize if the regulator hasn't done the job.]

148:12:35 Schmitt: Well, I don't think I have to. Okay; white dots.

148:12:40 Cernan: Wait a minute. White dot's plus, for you, EVA decals.

[Some of the switches are marked with "EVA" decals to indicate the proper settings.]

148:12:44 Cernan: Okay, I'm good here, here, here.

148:12:54 Parker: And, 17, congratulations. That was two EVA's and a half (worth of achievement).

148:13:03 Cernan: Thank you, Robert, but until I get my helmet and gloves off, I won't say anything. Okay, Jack. On 16, ECS Suit Fan 2, Closed.

148:13:10 Schmitt: Closed.

[They are turning on a pair of fans which circulate oxygen through the ECS Suit Circuit.]

148:13:12 Cernan: Suit Fan Delta-P, Closed.

148:13:13 Schmitt: Closed.

[And, now, they are turning on a sensor which responds to the pressure difference across the fans.]

148:13:14 Cernan: Okay. Master Alarm just came on. Okay. And the Heaters (in the) Mesa, Open. You can Open your MESA Heaters (circuit breaker). We're getting a Master Alarm, Houston.. I don't know why.

148:13:28 Schmitt: I think that's the...

148:13:29 Cernan: You did get Suit Fan number 2?

148:13:33 Schmitt: ...Suit Fan Delta-P (sensor).

148:13:34 Cernan: Okay. You've got Suit Fan number 2 and Delta-P. Okay ...

148:13:39 Schmitt: MESA (heater) circuit breaker is Open.

148:13:40 Cernan: Okay. That's why it (the alarm) came on; (because the fan isn't up to speed). ECS Caution/Water Sep(arator) component light should go out after that fan comes up. You can doff your glove.

148:13:47 Parker: Roger. We think that's what happened.

148:13:49 Cernan: Okay. (Long Pause)

[Schmitt - "Gene doesn't sound as tired as after the first EVA, but he's eager to get the gloves off. I'm sure I was tired, in part because our last stop, at Camelot, was a little tougher, physically, than some of the others because of walking through the boulders."]

148:14:09 Cernan: Well, I never thought I'd wear my EV cover gloves through two EVA's.

[Cernan - "These were like golf gloves with no fingers. We wore them to protect the suit gloves against abrasion. They really took a beating. They weren't falling apart, but they were pretty well worn."]

[They will take the gloves off during Rover preps on EVA-3. Gene will put his in his thigh pocket and will bring them back to Earth. They are currently in the collection of the Kansas Cosmosphere in Hutchinson, Kansas.]

148:14:12 Schmitt: Oh, I forgot all about them.

148:14:14 Cernan: No, I didn't. I thought about taking them off until I started chipping those boulders. And I'm glad I wore them.

148:14:20 Schmitt: Yeah, I think it's a good idea.

148:14:22 Cernan: As hard as it is on your hands, these cover gloves are just ripped to a nub. Glad it's not my gloves. (Long Pause)

[Schmitt - "I think we had planned to take the cover gloves off after the ALSEP deployment because that was supposedly the major wear. But, it would seem to me that it would have been imprudent to take them off given the way they were wearing. We were pretty active - we were doing lots of stuff - and, every time you gripped something, you were abrading the cover glove with that soil. Gene's wore more quickly than mine because of the brushing and the hammering. Of course, the cover gloves made your hand's bulky. It's just like being out on the snow. The more you put on your fingers, the less mobility you have with them. The fingers are separated and the extra layers cramp you when you try to bend them. The cover gloves probably contributed to our fatigue, and they certainly affected dexterity."]

148:14:42 Schmitt: (You) might consider taking them off tomorrow.

148:14:47 Parker: Roger, 17. Your talking about your cover gloves?

148:14:53 Cernan: Yeah. We're still wearing them, Bob. And, I swore (before the flight that) I'd take them off after the drill, but I used a bit of real-time common sense.

148:15:02 Parker: Okay.

148:15:04 Schmitt: Okay. Gloves are off. LMP's gloves are off. Need some help?

148:15:12 Cernan: Yeah, a bit. (Pause)

148:15:19 Schmitt: I think you just about got it.

148:15:20 Cernan: No, you went the other way.

148:15:22 Schmitt: Did I go the wrong way? Yeah, I did. (Pause) What's wrong with that one?

148:15:33 Cernan: I don't know.

[Schmitt - "It's hard to tell what was going on here, although it may have had to do with lock rings on Gene's gloves. As I recall, you pressed in on the ring and then turned. It was easy to do for yourself - when your hands weren't tired - but then you had to reverse your mind when you were doing it for somebody else, like tying somebody else's necktie."]

[Cernan - "I think there were arrows on the rings. And I do think that that is what we were doing: helping each other because it was cumbersome to unlock your own glove with a gloved hand. Once you got one off, the other one was a piece of cake to get off with your bare hand. By helping the other guy, rather than have him stretch and try to get the ring between his thumb and finger, you could take two hands and push in on the locks with your thumbs and turn the ring."]

148:15:35 Schmitt: Shouldn't have done that.

148:15:37 Cernan: Hey...Let me get this. (Pause) I had them then.

148:15:42 Schmitt: Yeah, I'm sorry.

148:15:45 Cernan: Well, you get that one, and I'll get these two. Get that one. I'll get this one. (Pause) (Garbled). Hold that thing.

148:16:06 Schmitt: Okay. Let me try this one, now. (Long Pause) It wants to go.

148:16:43 Cernan: Let me try that. Yeah, that one (garbled).

148:16:48 Schmitt: Got it?

148:16:49 Cernan: Yeah.

148:16:50 Schmitt: It's usually easier when you do it yourself. The angle's wrong.

[Schmitt - "Boy, this is a classic of a discussion between two people who are looking at what they're doing and not communicating with anybody else. Maybe this was the glove lock rings."]

[In February 1994, I examined an Apollo suit being prepared for public display at the Johnson Space Center in Houston. Operation of the wrist ring requires pushing, simultaneously, a pair of tabs toward the glove fingers and then, while holding the tabs in place, rotating the wrist ring to unlock it. The tabs are separated by about 2 or 3 inches and, at least on an old, worn suit - John Young's Command Module Pilot suit from Apollo 10 - that hadn't been lubricated in a long time, the wrist rings were quite difficult to unlock, even with bare hands. New, well lubricated wrist rings are, according to the dialog, easy for a trained, rested person to operate. However, here, we have two tired astronauts who are also having to contend with equipment that has probably become at least a little fouled with dust.]

148:16:54 Cernan: Oh, boy! (Pause)

148:17:02 Schmitt: (The wrist ring is) starting to get a little stiff.

148:17:03 Cernan: Oh, they came off. Now, they came off. (Relieved to have the gloves off) Oh, ho, ho, ho.

[Cernan - "By the time the mission was all over, my hands were nothing but blisters. The skin on my knuckles was gone. Inside the glove, all the knuckle points were constantly scrapping and, although they hurt, I guess I didn't let it bother me when we were on the surface. You're hands are so vital to everything you do that the gloves were custom fit; but we still ran into these problems. We got down to blue-collar work and you couldn't design everything for the convenience of the astronaut. On the Shuttle, I think, a lot of the equipment they're using in the Payload Bay EVA's are big things that you can hold on to. They don't have Rover breakers to pull, and sample bags to twist, and core caps to put on, and drills to run, and cores to jack out of the ground. If you went through the kind of things we did, your hands would probably get tired even if you didn't have gloves, if you didn't have to work against the pressure of the suit, if your knuckles didn't rub on the inside of the glove, if you didn't have to work with all of the layers covering your hand and your fingers, if you didn't have to work with your fingertips covered with RTV. Even if you took all of that away, if you look at all the work we did during those three EVA's, you would probably end up with your hands fairly tired anyway. How long can you grip a hammer and beat on a core tube and chip rocks even without gloves?"]

148:17:09 Cernan: Okay. Doff helmets, with visors. (Pause) Here; I'll get yours for you. Turn my way, if you can. (Pause)

148:17:26 Schmitt: I know how you feel.

148:17:28 Cernan: I don't know how they're so wet. I don't know whether it's...They're just soaking wet. (Pause) Everything is just twice as hard.

[Gene's hands are probably wet.]

148:17:50 Schmitt: Now comes the old hay fever, again.

[Jack is anticipating having a reaction to lunar dust as he did after EVA 1.]

148:17:54 Cernan: That one (visor) up and that one down. (Pause) "Stow (helmets) in BRA". Let's get mine off, though. (Pause)

148:18:14 Cernan: (Garbled) velcroed... Well, these things are off. Oh, man. Does that (dust) smell, doesn't it? You sure can pick that up.

[Cernan - "There was a definite smell of spent gunpowder. I'll never forget that."]

148:18:23 Schmitt: Okay. You got yours?
 148:18:24 Cernan: I've got mine. (Pause) Okay, Bob. Now, (chuckles) helmets and gloves are off.
 148:18:35 Schmitt: (Cabin) pressure looks good, still. (Long Pause)
 148:19:02 Cernan: Hello, Houston. Do you read?
 148:19:03 Parker: Roger, 17. Read you loud and clear, Challenger.
 148:19:10 Cernan: Very good, Robert. The helmets and gloves are off.
 148:19:13 Parker: Absolutely outstanding crew, there.
 148:19:15 Schmitt: Why don't you go home and get some sleep, Bob?
 148:19:16 Parker: Absolutely outstanding. I can't say more than that. And I mean it from the bottom of my heart (pause) or the bottom of my soul or something, my conscience.
 148:19:25 Schmitt: Thank you, Bob. Well, it's all (of) ours.

[Schmitt - "I meant that it was the achievement of the whole Apollo team."]

148:19:30 Cernan: Bob, it's all your good training and help...
 148:19:34 Parker: 7 (hours) plus 37 (minutes), from 3.5 (psi) to 3.5.
 148:19:42 Schmitt: As mission scientist, you're totally responsible.
 148:19:45 Parker: And the backup crew (Young and Duke) says that you are even better than outstanding.
 148:19:48 Schmitt: Remember, it's in your contract. (Hearing Parker; laughs) Well, thank you. We enjoyed it.
 148:19:58 Parker: Hey, I'll turn you over to Little Joe (Allen), here...
 148:20:00 Cernan: Ohhh, boy!
 148:20:01 Parker: ...while I go talk to some people.
 148:20:05 Schmitt: Thanks again, Bob. We...
 148:20:05 Parker: We've got a 9 and 1/2 hour EVA scheduled for you tomorrow. We're planning to spend 2 and 1/2 hours extra over there at Station 4.
 148:20:15 Cernan: (Laughing) I hope those gloves that you've got packed in the back have got something in them (that is, a cold beer). (Laughing) Oh, let's read the checklist. See if we can go to bed on time tonight.
 148:20:28 Schmitt: Oh, man.
 148:20:29 Parker: Okay. That might be a change.
 148:20:30 Schmitt: I feel better than I did last night, as a matter of fact.
 148:20:32 Cernan: (To Jack) Turn that light on.
 148:20:33 Parker: I'm going to turn you over to Joe.
 148:20:35 Cernan: That (light) didn't do very much good.
 148:20:36 Parker: See you guys tomorrow.

148:20:38 Cernan: (To himself) Okay. "Verify safety on dump valve." Yes.
 148:20:41 Schmitt: Okay, Bob. Get some sleep, huh?
 148:20:43 Cernan: (To himself) Yeah, I verified them both.
 148:20:44 Schmitt: (To Parker) Sorry to be touchy, occasionally.

[Schmitt - "I was referring to the times when I was annoyed with Parker, such as at Station 3."]

148:20:46 Cernan: (To Jack) "Descent Water Valve, Open."
 148:20:51 Schmitt: Okay. (Pause) Water Valve's Open.
 148:20:55 Cernan: Okay. Then you can take your purge valve off. (Pause) There's a little dust in that (purge valve fitting) tonight. Little stiffer. Wiped that out again. (Reading) "Remove purge valves, stow in purse. Disconnect OPS hoses."
 148:21:17 Schmitt: Oh, man! That is dusty.
 148:21:18 Cernan: Yeah, let me disconnect yours; you disconnect mine. It's easier with the...
 148:21:24 Schmitt: I think I can get...What did you say?
 148:21:25 Cernan: ...OPS hoses.
 148:21:26 Schmitt: Oh, yeah.
 148:21:27 Cernan: Or whatever it said.
 148:21:28 Schmitt: Yeah.
 148:21:29 Cernan: Disconnect OPS hose.
 148:21:34 Schmitt: Is that what it said?
 148:21:35 Cernan: Yeah. (Pause) Maneuver my fingers in here a little bit better. (Pause)
 148:21:48 Cernan: They are all showing a little bit of stickiness.
 148:21:51 Schmitt: Glad we're in this (means "doing this") in pairs.
 148:21:54 Cernan: (Laughing) Well, just everything's, you know, harder to...
 148:22:01 Schmitt: Okay. There, you're disconnected.
 148:22:02 Cernan: PGA diverter valve, horizontal.
 148:22:04 Schmitt: Okay. Horizontal.

[With the this diverter valve in the horizontal position, they are getting air flow into the suit torso and helmet. During the EVA, they had it in the vertical position and only got flow into the helmet. In either case, the oxygen then flows through the suit cavity to outflow vents at the wrists and in the feet and, finally, through closed ducts to the outflow connector mounted over the stomach. flow into the torso helps dry the suit by keeping some flow going despite the helmets and gloves being off.]]

148:22:09 Schmitt: (Now on Surface 5-2) And Suit Isol(ation Valves), both to Suit Flow.
 148:22:12 Cernan: All right...We don't have the LM hoses on. So don't...Put mine to Suit Flow to get some air in here.

148:22:20 Schmitt: Yeah. Start filtering the dust.

[Schmitt - "We were setting up the LM oxygen flow and, even though we weren't connected to the LM hoses, the system would start to filter dust out of the air."]

148:22:27 Cernan: PLSS pump, Off; and fan, Off.

148:22:29 Schmitt: Okay.

148:22:32 Cernan: Man, that's hot. Feel that.

[Gene may be talking about his RCU because that is where the switches for the pump and fan are located. See the discussion at 148:25:00.]

148:22:36 Schmitt: (It was) out in the Sun.

148:22:38 Cernan: Yeah.

148:22:40 Schmitt: Pump's Off. Fan's Off.

148:22:42 Cernan: Okay.

148:22:46 Schmitt: "Disconnect PLSS H2O from PGA." Okay.

[The PGA or "Pressure Garment Assembly" is the combination of suit, PLSS, and visor assembly.]

148:22:49 Cernan: And connect LM water. That's what we want.

148:22:53 Schmitt: (Garbled). The P(ressure) and O(xygen) flags.

148:22:57 Cernan: Yeah. (Garbled) LM water hose, here.

148:23:04 Schmitt: I'm sorry that's so complex, there.

148:23:07 Cernan: Oh, that's perfectly fine.

148:23:08 Schmitt: But it was easier to start.

148:23:10 Cernan: It had to be. (The dust) smells like someone's been firing a carbine in here. (Pause)

148:23:18 Cernan: Why don't you stay there and push in that...

148:23:19 Schmitt: I will

148:23:20 Cernan: ...pump breaker...When you get it. (Pause)

148:23:26 Cernan: Hey, Little Joe? Are you there?

148:23:31 Allen: 17, this is Houston. And...

148:23:33 Cernan: Little Joe, are you there?

148:23:35 Allen: Roger. How do you read Houston? Over.

148:23:40 Cernan: Joe, we're reading you loud and clear. We're on the left-hand column (of the post-EVA card) and we're both going PLSS mode to O, and we'll be off the air for a skosh.

[They are still on the lefthand column of Surface 5-2.]

148:24:48 Allen: Roger, Geno. I've been following you real close, and you two are mighty smooth. Boy, was that nice today.

148:24:57 Cernan: Thank you.

148:24:59 Schmitt: (To Gene) Feel how hot that is.

148:25:00 Cernan: Yeah, the whole thing.

[Comm Break]

[After turning off the PLSS by going to Mode O, they hook up the LM comm circuit before recharging the PLSS oxygen tanks and then doffing the backpacks. Because of the short interval between Gene's comment about "going PLSS Mode to O" and Jack's remark about a hot piece of equipment, the most likely candidate, again, would seem to be the chest-mounted RCU.]

148:27:42 Schmitt: Okay, Joe. LMP's PLSS is getting 02.

148:27:45 Allen: Thank you.

[Long Comm Break. They are recharging Jack's PLSS for EVA 3 and are on the righthand column of Surface 5-2.]

[Schmitt - "We were recharging the PLSS's mostly just to get them out of the way. And, if you had a problem, then you'd know it right away. That's always a good philosophy: try to identify your problems early. Then they'd have all night to work it."]

148:31:45 Schmitt: Joe, 02 is off.

148:31:48 Allen: Roger.

[Comm Break. Next, they will recharge Gene's PLSS.]

148:32:57 Cernan: Hey, Joe. This is Gene.

148:33:00 Allen: Go ahead.

148:33:05 Cernan: Hey, Challenger has been holding at about 5.5 (psi) ever since we got in here. Are you all happy with that? (Pause)

148:33:18 Allen: Looks good to us, Geno. We have been watching it and everyone is happy down here.

148:33:26 Cernan: Okay. Well, this morning, when we were getting ready, we saw it at 5.5 and part of that (Gene's concern) is that it's been at 5.0 all of the time. Just so we are not venting anything (into the cabin), that's all.

(Long Pause)

148:34:00 Allen: Geno, we hear you on that and we'll be watching it. (Long Pause)

[The nominal cabin pressure is 5.0 psi and Gene's question is whether or not there is some valve open that should be closed. Eventually, they will trace the increased pressure to a slow leak in Pressure Regulator A. There will be more discussion of this leak through the evening and into Day 3.]

148:34:13 Schmitt: Joe, we're about 2 minutes into the CDR's (PLSS) 02 charge.

148:34:19 Allen: Thank you.

[Comm Break. Jack does not sound as congested as he did after EVA 1.]

148:35:48 Schmitt: Joe, LMP has 96 percent on his (oxygen) gage.

148:35:55 Allen: Thank you, Jack. We copy that. (Long Pause)

148:36:52 Allen: Geno, with regard to your observation made to us a few moments ago, I guess we will ask for the Cabin Return (Valve) to the Auto position and your Suit Diverter Valve to Cabin, please. We are about two-tenths of a psi from Cabin Relief. Over.

[They are resetting the diverter valve so that oxygen can flow from the suit circuit into the cabin.]

148:37:14 Cernan: Okay, we're getting that now. (Long Pause)

[If the cabin pressure exceeds 5.83 psi, a relief valve will dump the excess out of the spacecraft. As long as the valve works, there is no danger to the crew or the LM but, obviously, they would rather not waste oxygen.]

148:37:57 Cernan: Joe, CDR is reading 94 percent on the O2 charge.

148:38:03 Allen: Thank you.

[Long Comm Break. having finished Gene's PLSS recharge, they are disconnecting and removing the RCU's and OPS's and then the PLSS's. Before stowing the OPS's, they will report the pressures as check to make sure they have not changed significantly since the start of the EVA. These activities are listed on Surface 5-3.]

148:44:47 Schmitt: Okay, Joe. LMP's OPS pressure is 6300 (psi).

148:44:51 Allen: Thank you.

[Comm Break]

148:47:57 Schmitt: Commander's OPS pressure is 6100.

148:48:01 Allen: Copy, 6100.

[Comm Break. Next they will change the PLSS batteries and LiOH canisters. these activities are listed in the righthand column of Surface 5-3.]

148:49:02 Schmitt: Say, Joe, our cabin pressure is rising even higher, now. About 5.7.

148:49:08 Allen: We copy that.

148:49:12 Schmitt: Joe, we had the commander's hoses stowed, but in Suit Flow. That might have done it. Is that right?

148:49:20 Allen: Sounds very plausible, Jack. We'll look at it a little more here.

[Long Comm Break. Jack is speculating that oxygen from the Suit Circuit is being added to the cabin through Gene's hose without returning to the Suit Circuit. However, it is normal procedure to have both Suit Isolation Valves in Suit Flow at this point. The Cabin Gas Return Valve is currently in the Egress position and no oxygen would be flowing from the cabin to the suit circuit through that valve; cabin gas should be flowing back into the suit circuit through the return hoses; and, finally, with pressure regulators A & B both set to Cabin, there shouldn't be any oxygen being added to the suit circuit. the following dialog was accumulated during a change-of-shift press briefing and times are not available.]

148:53:14 Allen: Challenger, this is Houston. Requesting you move your Demand Reg's A and B to Egress, please.
(Pause)

Schmitt: They're (now) Egress.

[Houston wants Jack to turn off oxygen flow from the tanks in the descent stage to the cabin. They are testing the possibility that one or the other of the pressure regulators is adding small amounts of oxygen to the cabin even with the pressure substantially higher than 4.8 psi, the normal cutoff point.]

Allen: Okay. (Long Pause) 17, Houston. We noted down here that your Suit Diverters went to Egress and we want the demand Reg's to the Egress position, please.

Schmitt: That's right, but the Suit Gas Diverter extends when you go to Egress.

Allen: You're right, again.

[Whenever either of the regulators is set to Egress, a sensor activates a solenoid which puts the diverter valve in Egress as well. The diverter valve has a push/pull control and Egress is the extended ("pull") position.]

Schmitt: Houston, do you figure we're relieving?

Allen: Jack, we don't think so. It looks like you're pretty steady at between 5.5 and 5.6. We're watching it very closely, however.

Schmitt: Okay, you know when we had that problem this morning, I hope the backflow did not hurt something when I had the LMP's hoses stowed and the Isol valve in Suit Flow.

[During the EVA preps, Jack had apparently stowed his hoses in such a way that oxygen could not flow out of them and into the cabin, thereby creating some back pressure.]

Allen: Jack, just for your information, we saw about the same thing last night. The only difference was the pressure didn't climb quite so high. So, we think that, whatever it is, it really doesn't involve the small problem you had this morning.

Schmitt: Okay, Joe.

[Comm Break]

148:59:35 Cernan: Okay, Joe. We got the commander's PLSS back in the recharge station. We got a new battery in it - odd numbers - and a new (LiOH) canister in it and we are working on Jack's right now.

Allen: Okay, Gene. Sounds good.

[The recharge station is on the left bulkhead next to Gene's shoulder. However, they aren't doing any recharging at this time but, instead, are just getting Gene's PLSS out of the way.]

[Cernan - "The odd numbered batteries were the Commander's and the even numbers were the LMP's. That way you could keep them straight. When you took a bad battery out, you'd put the new ones in the order 1,3,5 and 2,4,6 and you'd know you had the right battery at the right time.

[Comm Break]

149:02:44 Allen: 17, Houston.

Schmitt: Go ahead, Joe.

Allen: We are still watching your cabin pressure down here. Could you check for us, please, if the PLSS (oxygen) fill valve is securely closed?

Schmitt: Yes, it was closed.

Allen: Okay.

[If the PLSS fill valve were open, it could be adding oxygen to the cabin.]

Schmitt: Joe, do you want me to check out the regulators?

Allen: Stand by.

149:03:49 Schmitt: Houston, Challenger. Do you want me to check the...(Hearing Allen) Okay. ED BATs are 37.2.

Allen: Copy that.

Schmitt: PCM's going High. (Pause) Let me know when you're ready for the battery management.

[Jack still doesn't sound as tired or congested as he did at the end of EVA 1. He remarked on this at 148:20:30.]

Allen: Roger.

[Comm Break. They are now on Surface 5-4.]

149:05:31 Allen: 17, Houston. Standby on the battery management for a few minutes, please. And, in the meantime, could you check the low pressure PLSS fill valve, Closed, please? Over.

Schmitt: Joe, I checked that. It's closed.

Allen: Thank you.

[Comm Break]

Schmitt: Houston, Challenger.

Allen: Go ahead.

Schmitt: Does your telemetry and our gage come off the same telemetry...(correcting himself) same transducer on that?

Allen: That's affirm. It does. (Pause) And, Challenger, we've got a communications problem at one of the (terrestrial receiving) sites and are going to ask you to go to panel 12 and turn the Power Amplifier to Primary, please.

149:08:27 Schmitt: Okay, it's Primary.

[Comm Break]

Allen: And, Challenger, we're ready for battery management, at your convenience.

Schmitt: Okay, stand by.

[Comm Break. Jack may be just finishing changing batteries and the LiOH canister on his PLSS. Once that is done, he will lay his PLSS on the floor between them. After the battery management, he and Gene will weigh and stow the samples.]

149:12:03 Cernan: Hey, Joe?

Allen: Go ahead.

Cernan: Okay, this is Geno. I just dug a rock out of my pocket. No one back there probably remembers, but when we were at Shorty (at 145:39:00), fumbling around, trying to get everything done, I said there was a piece of very shiny, black, glass-like-looking material that reminded me of obsidian. Well, it's not. It looks like a very fine-grained, grey rock. But, it's a fractured piece; and I've picked up fractures of about three or four vesicle faces on it. The vesicle faces are very shiny and that's what reflected and caught my eye. I think the unique part about it is...Jack may want to say something else about it...the unique part about it is that I picked it up (at) Shorty. Undocumented, halfway between the Rover and where we were sampling that orange stuff. And it will be in bag 12 Echo.

Allen: Okay, Geno. Copy, 12 Echo. And, I was assured by the folks here when I came in...

Cernan: That'll go in ...

Allen: ...that you did indeed have a shiny sample of some kind in your pocket and would probably find it later on.

So, they called that one. Could you turn off the Power Amplifier...

Cernan: Okay, we'll put in it (the sample) in SCB-8.

Allen: Okay, go ahead.

149:13:34 Cernan: (Responding to Allen's instruction about the Power Amplifier) Okay, it's off and we will put that rock in that sample bag and put in SCB-8.

Schmitt: Joe, this rock looks very much like (Apollo 12 sample) 12008. It's a fine-grained, very coarsely-vesicular grey rock. Probably basaltic.

[Sample 12008 was collected at the end of the first Apollo 12 EVA. It is a fine-grained basalt with a notable ilmenite content.]

[Cernan - "It's amazing - like somebody remembering license plate numbers!"]

[Schmitt - "(Laughing) I had the sample numbers memorized in those days! I had worked very closely with the Apollo 11 samples; and, with two or three other people, I had done an introduction to the Apollo 11 Science Conference. My main contribution was to look at all of the basaltic samples and, particularly, study the minerals that lined the vesicles. And, after Apollo 12 came back, I extended that study. Bob Sutton and I gave a talk at the Apollo 12 conference in 1971 but, unfortunately, that paper has never been finished or published. We did something that had never been done before; and that was to try to relate the positions of the samples to the depth for which they were derived by the various impacts that formed craters in the vicinity of the Apollo 12 landing site. The 12 crew did an excellent job of sampling; they got a good distribution of samples. It was the only place where I think we had a chance to really look at the layering within the upper portion of the mare basalts. I need to finish that paper."]

Allen: (Amused) Okay, Jack. Real fine. We want Low Bit Rate. Power Amplifier, Off, and Low Bit Rate. And we can maybe label that one 17008. How does that sound?

Cernan: No, you got to label that Gene's Rock. I was going to tell you those other things, but I thought I'd let Jack.

Allen: (Laughing) Okay, thank you..

Schmitt: The vesicles, if I may project the size of them, probably were up to 4 or 5 centimeters in diameter. They're irregular in shape, but they're clearly vesicles and it looks like they are lined with either glass or very fine-grained crystals. They're very shiny.

Allen: Roger.

[Cernan - (Tongue-in-cheek) "I want to thank Jack for supporting all my geologic observations about Gene's Rock, which looks very much like the Apollo 12 rock 12008."]

Schmitt: And for our next act...

149:15:48 Allen: Jack, we're going to ask, for your next act, that you check for us both PLSS valves, Off, and both OPS valves, Off. Over. (Long Pause)

149:16:51 Schmitt: Joe, they're both verified Off.

Allen: Okay, Jack. We understand that all four valves are verified Off.

Schmitt: That's affirm, Joe.

Allen: Okay, thank you. I'm sure that you realize that we're still showing that pressure increasing very, very slowly and are pretty well convinced that nothing is leaking in from the outside. So, we are looking around on the inside here.

Cernan: Joe, is our oxygen consumption abnormal at this point?

Allen: No, not at all, Geno. Everything looks pretty normal, except this slow creep in the cabin pressure.

Schmitt: Well, I guess the possibility is a creeping Reg(ulator) or a (faulty) transducer, is that right?

Allen: Yeah, either that or it maybe we're just watching some of the effects of the thermal shock that your tanks took from the repress itself. We're not worried about it at all, but we are still watching it.

[Comm Break. One possible cause of the pressure increase is the heat load added by the warm suits, PLSS's, samples, and sample containers. Twenty years after the fact, Jack wonders if Allen may have been referring to the LM oxygen tanks, perhaps a temperature increase in the tanks resulting from the sudden outflow during repressurization. This does seem to be Allen's reference, but the speculation doesn't sound very plausible.]

Schmitt: Joe, you might make a note that my two S-E-P area samples went into bag (SCB) 8 also.

Allen: Roger, Jack. That's noted.

[Usually, Jack and Gene pronounce the acronym as a single word: "Sep". This may be the only instance where Jack spells the acronym.]

Cernan: Joe, got some numbers, if you'd like them?

Allen: Go ahead.

Cernan: SRC is 41.5. Bag 6 is 24, bag 8 is 35.

Allen: Copy, 41.5; and 24 in bag 6; 35 for bag 8.

Cernan: That's it. (Pause)

[These are aggregate weights of the containers and the samples in them, measured in terrestrial pounds. The empty SRC weighs 14.7 pounds, each of the empty SCB's 1.7 pounds, and each of the individual sample bags a negligible 1/50 of a pound. In addition to bagged samples, the SRC also contains the long can - empty weight, one pound - and four core stems which, empty, collectively weigh 2.6 pounds. The Mission Report gives a net weight of about 75 pounds of samples for

this EVA, a figure in good agreement with the 78 pounds estimated here. Gene and Jack collected about 31 pounds of samples during the first EVA and will collect about 137 pounds during the final traverse. The weights are being taken so that the flight engineers will have a good reading of the LM weight and, if necessary, can adjust stowage of the rock containers to control the center-of-mass in preparation for lift-off.]

[Schmitt - "They wanted to make sure we didn't get over our margins so that we wouldn't have to use the RCS (Reaction Control System) to complete the rendezvous."]

Schmitt: Joe, how many samples did we get today?

Allen: Standby.

Schmitt: Don't start a big investigation. I'm just curious.

Allen: (Making a mis-identification) Let me ask around, Gene. We will see in a minute.

Allen: 17, we think you have 54 samples from this EVA, plus some cores.

Schmitt: Thank you, Joe. Just curious.

Allen: That's not half bad.

[Gene and Jack will collect a total of 243 pounds of samples, compared with 210 pounds by the Apollo 16 crew, 170 by Apollo 15 crew, and a combined total of 215 pounds returned by the Apollo 11, 12, and 14 crews.]

149:21:56 Cernan: And, Joe, we're on (page) 5-5 and I am going to start doffing (his suit).

[Prior to removing the suits, they turned on a heater for the urine dump line and, then, emptied the urine collection bags.]

Allen: Okay, Geno. Copy 5-5, and before you get started there, would you put both Demand Reg's to Closed, please? As we continue to watch this pressure.

149:22:19 Schmitt: Okay, Joe. Demand Reg A, going Closed. (Pause) Demand Reg B going Closed. (Pause)

Allen: Thank you. And we verify 'em both Closed.

[Schmitt - "By closing the regulators we stopped the flow of make-up oxygen into the cabin. The air in the cabin still circulated and, as you breathed down the oxygen and scrubbed out the carbon dioxide, you had a gradual decrease in pressure."]

[Long Comm Break. They have started to get Gene out of his suit.]

149:27:54 Allen: 17, this is Houston. We'd like the Suit Diverter (Valve) back to Cabin, please?

149:28:16 Schmitt: Cabin.

[They are letting oxygen from the suit circuit flow into the cabin through the diverter valve again. this will tell them if the source of the extra oxygen is in the suit circuit.]

149:28:20 Allen: Okay.

[Comm Break]

149:31:46 Allen: Gene and Jack, you'll be interested to hear that the cabin pres(sure) is dropping down, very slowly now. So, we think we have a tiny leak in one of the (two) cabin demand regulators, and we'll run a check (to see which one is leaking) after you get squared away there a little better. (Pause)

149:32:15 Schmitt: Okay, Joe. We'll be at your beck and call.

149:32:26 Allen: I'll only smile at that.

[Very Long Comm Break. Jack's sinuses sound a little clogged. During this period they are probably cleaning the zippers and other fittings on Gene's suit as per checklist page 5-5. Once they are done, they will stow the suit on the engine cover, neck ring aft, and will put the suit legs in jettison bags to try to control the dust. Once that is done, they will reconnect the air hoses to the suit to help dry it out.]

149:47:51 Schmitt: Houston, Challenger.

149:47:54 Allen: Go ahead.

149:47:59 Schmitt: Joe, we're going to air out the suits. We're going to go to Suit Flow on the Commander's Isol valve now.

149:48:11 Allen: All righty.

149:48:16 Schmitt: Say again.

149:48:21 Allen: That sounds good.

[Schmitt - "When you took it off, the inside of the suit was damp but there wasn't water sloshing around."]

[Long Comm Break. Gene and Jack are two hours behind the nominal time line. Now they will get Jack out of his suit and, then, clean and stow it.]

149:57:02 Schmitt: Joe, I guess you guys are tired of looking at my heart beat. So, I'm gonna turn the Biomed off as I get out of my suit.

149:57:12 Allen: Okay, Jack. (Long Pause)

149:57:49 Cernan: Hey, Joe. This is Geno. How do you read me (on LM comm)?

149:57:51 Allen: Geno, you're five-by(-five).

[Cernan - This is just pilot's talk. 'Five-by-five' just means that you're reading loud and clear."]

149:57:56 Cernan: Okay, we're going to get Jack out of his suit. I'll be monitoring (mostly for comm from Houston).

[Schmitt - "There wasn't much Gene could do but unzip me. So he just stood back out of the way while I wiggled to extract myself. It didn't take very long as long as the inside of the suit was reasonably dry and, because the zipper was on the front, you could get out by yourself if necessary."]

149:58:03 Allen: Roger. (Long Pause) From the way the two of you worked today, I'd think you could just about turn him upside down and pour him out. (Pause)

149:58:30 Cernan: Yeah...If he'd fit through that little hole in the end of his wrist. (Pause)

149:58:41 Schmitt: Joe, the day they can pour me out of anything, they'll call me "Slim". Talk to you later.

149:58:49 Allen: (Laughing) Okay. (Pause) Among other things.

149:58:55 Cernan: Remember those nice white suits? (Pause)

149:59:06 Allen: The Clean Room will never be the same again.

149:59:13 Cernan: You'd never believe it.

[Very Long Comm Break]

[Cernan - "I think you've really got to start out clean. There weren't any special 'clean-room' precautions like you utilize when you're making computer chips or something like that. People wore coveralls and they wore coverings on their shoes so that they wouldn't drag in dirt, but it wasn't burdensome in any way. You went in in your street clothes to suit up. You just wanted to start out with a clean suit, with clean wrist bands and all your seals working. 'Start with a whole airplane. Don't leave town with only part of an airplane, because you may lose another part of it on the way.' We proved that we could put the suits on, take them off, and put them on again - repeatedly and in a very constrained and not very clean environment. We tried to dry them out and we tried to wipe wrist rings off. We tried to make sure that the quick-disconnects on the oxygen hoses were clean. We proved that we could do it because we had no other choice. That's the way it was designed. But I don't know that, the way we were treating them, we could have gone for ten EVA's and not have trouble with them. I'm sure we probably would have had trouble, as a matter of fact. With all that dust, you're going to have seals start leaking. You've already heard us talk about how hard it was to turn the wrist rings because dust was getting in them; and, if you used them a little bit more, they were going to quit working altogether. If you're talking about a lunar base, I'm sure that, after ten outings, the suits are going to have to be put on a rack to be cleaned up and oiled and a few other

things. At some point you're going to have to go through a refurbishment cycle and, if you're going out every day, you'll certainly want to have a couple of suits so that, while the technicians are cleaning up one, you've got another to use. We didn't push the hardware to that limit, but I'm sure we would have run into some problems if we had.

"That was one of our major concerns: care and treatment of the suits. The worst thing in the world would be to be on the lunar surface and not be able to go out because your suit has a leak in it. So we were awfully, awfully careful with those things. There weren't four guys to help you and keep you cleaned and brushed and oiled. Rather than having the suits hanging on a rack, they were laying in a bundle on the engine cover; so you took care of them the best way you could."]

150:18:34 Allen: Challenger, this is Houston.
 150:18:39 Cernan: Go ahead, Houston. Challenger here.
 150:18:42 Allen: Geno, we're going to start to investigate which of your demand regulators is leaking and we're going to ask you to put Demand Reg Alpha to Cabin now. And, as we watch it, please do not make any urine dumps. Over.

[Although the urine is dumped into a sump in the descent stage, opening the dump valve would influence the cabin pressure at least a little and Houston wants to watch what will probably be small variations in pressure in response to the regulators.]

150:19:03 Cernan: Okay, we will not make any urine dumps and we'll go to Cabin now. (Pause) Okay, Alpha's in Cabin. And we'll be ready for your debriefing here in about 5 minutes.
 150:19:21 Allen: Okay, Geno. And, it's going to be a short one.

[Long Comm Break. Having gotten Jack out of his suit, they then got out of their Liquid Cooled Garments and into their Constant Wear Garments or, longjohns. They are now on Surface 5-6.]

150:27:17 Schmitt: Okay, Houston. We're going Downvoice, Backup.
 150:27:22 Allen: Standby on that. (Pause)
 150:27:29 Cernan: And, okay; we are ready for your EVA-2 debriefing. (Pause)
 150:27:48 Allen: Okay, 17. To begin with, we want you to delete that step going to Downvoice, Backup. And I've got a surface block data to read up to you. A few minor changes in your Lunar Surface Checklist. And a couple of very quick questions for the debriefing when you're ready. Over.
 150:28:17 Schmitt: Go ahead, in the stated order.
 150:28:23 Allen: Roger. Moving right along now to the surface block data. Lift-off times : T-33, 152 plus 30 plus

01; T-34, 154 plus 28 plus 33; T-35, 156 plus 27 plus 05; T-36, 158 plus 25 plus 37; T-37, 160 plus 24 plus 09. Over.

[These are optimum lift-off times for upcoming orbits of the Command Module, beginning with orbit 33.]

150:29:26 Schmitt: Okay, Joe. Starting with 33. 152:30:01, 154:28:33, 156:27:05, 158:25:37, 160:24:09. And what's our present rev?

150:29:51 Allen: Rev 32, Jack. (Pause)

[Ron Evans, in the Command Module America, is roughly over the landing site, about halfway through orbit 32. Orbit 33 will start over the middle of the Farside at about 151:37.]

150:30:06 Cernan: Hey, Joe, for pantry purposes, what day is this? (Pause)

150:30:16 Allen: We've checked around the room here and the consensus is that it's (about 3:30 a.m. Central Standard Time) Wednesday morning. Over.

150:30:28 Cernan: Oh, okay. I really wanted to know whether it was irradiated ham or frankfurter morning, and I guess we can work that out. (Pause)

[Schmitt - "The trail-food-like packages of freeze-dried or dehydrated food were connected together and, as you pulled them out of the storage compartment, you were supposedly getting that day's pre-planned meal. Now, that was the case in the Command Module and, in the Lunar Module, it probably wasn't that organized and we just had large packages with the mission day indicated: LMP Day 5 or something like that."]

150:30:52 Allen: Roger, Gene. Apparently, the Surgeon is happy with either of those days. And we want you to turn, right now, to (page) 5-7 in the checklist and perform that one particular step, at 150 hours, which will prevent the computer clock from overflowing. And that's the "Proceed, Verb 37 Enter, 06 Enter, Proceed" step. We'll stand by for that. Give us a mark as you start it. Over.

150:31:34 Schmitt: Okay, we're starting. Proceed (pause), Verb 37 Enter (Pause)

[Jack reads the steps while Gene, who is off comm, enters them into the computer.]

150:32:00 Cernan: Okay, Joe. You don't want me to go on the Verb... You're not going to give us an update, huh?

150:32:07 Allen: No update required. That was just to prevent an overflow. And then I'm ready for the quick changes in the Lunar Surface Checklist when you are. (Long Pause)

[Cernan - "I think our computer-based inertial navigation system was the state-of-the art. It ended up in 747's flying across the Pond (the Pacific Ocean). We'd write the software for the different missions and it would take hours and hours in the simulator to wring out all the bugs in it before you would have a level of confidence in it that it could be declared operational. It's obsolete equipment today but, as far as I know, there was nothing comparable at the time in military or commercial aviation."]

150:32:45 Schmitt: Okay, Joe, go ahead.

150:32:50 Allen: Okay. Begin by putting the Demand Reg Bravo to Cabin position and leave the Demand Reg Alpha in the Cabin position where it now is. And I'll continue on with the changes in the checklist here. Page 5-6, left-hand side, where it reads "Configure ETB." The fourth line down that starts out "Four B&W mags," they should read, "Hotel, India, Juliet, and Romeo in LCG compartment." Then going up to the right-hand side under "Stow in ETB," change the line "One B&W mag Romeo" to read "One B&W mag Kilo." Over.

[At some point prior to the start of EVA-3, Jack takes a series of photographs out his window. These are AS17-140-21352 to 21358. 21354 is the best in the series showing the Rover and the replacement fender. In 21355, note the darkened Rover tracks near the ALSEp and how the tracks disappear into the swale.]

150:34:15 Schmitt: Okay, Joe. I changed the mags in the "Empty" from Kilo to Romeo and the mag in "Stow" from Romeo to Kilo.

150:34:30 Allen: Okay, that sounds like the thing to do. And a note on your demand regulators. We're showing that the demand regulator Alpha has good integrity and we're now in the process of checking demand regulator Bravo. I've got a couple of fairly quick questions here when you're ready for those.

150:34:54 Schmitt: Okay, Joe. Go ahead with your questions; and integrity is certainly what we need around here, right?

(Pause)

150:35:11 Allen: Okay. Jack, a question for you to begin with. Is your gold (electroplated) visor sticking halfway down? Apparently, that's based on a discussion earlier. Over. (Pause)

150:35:36 Cernan: Yeah. Apparently his visor is sticking. (Pause) (To Jack) Which one?

150:35:36 Cernan: The gold visor? No, he said his sunshade is sticking halfway down, but his gold visor's not.

[Schmitt - "I was working a lot with my gold visor halfway down, just so I could see better. And they got confused when Gene or I made a comment some other place that the sunshade wouldn't come all the way down."]

150:35:45 Allen: Okay, that answers the question. We couldn't tell from the TV whether it was the visor or the sunshade. That's fine. We also heard some discussion about possible wear in the seats of the suits when you were dusting each other off. We want to know if you could see any hint of the aluminum layers showing through in the suits. Over.

[Joe is referring to comments made at 147:55:56 when Gene was dusting Jack's PLSS.]

150:36:13 Cernan: No, Joe. Not to worry. It's just a few scars on the PLSS thermal blanket in back where you probably rub the seat when you get in. Nothing on the suits.

150:36:24 Allen: Okay, Geno. Now two real quick geology questions that will help us do the planning for your EVA tomorrow. The first one has to do with Station 4. And you called out some material on the rim (of) the crater at Station 4 which looked like "bedded spatter". And we're wondering if that resembled things that you'd seen in Hawaii? Over.

150:37:00 Schmitt: Hey, Joe, I think they misheard. I think I may have said "shattered" and you might have thought "spattered". No, I didn't - neither one of us - intended to leave that impression. The big rock we sampled looked like intensely-shattered gabbro, such as we've had around the LM. Probably more significantly, the rocks - one of which Gene picked up - (were) the fine-grained, coarsely-vesicular basalts. And we didn't have any time to really examine the interrelationships of those rock types there, but those were the two fragment types we saw.

[The phrase that Jack used at 145:25:00 to describe the Station 4 boulder was "intensely fractured". A search of the Station 4 dialog reveals nothing resembling "bedded spatter" or, as another possibility, "bedded strata".]

[Schmitt - "If we had seen 'bedded spatter' or some other clearly volcanic-looking material, they would have sent us back to Station 4. If there was any indication at all that it was a volcanic cone, we would have gone back there."]

150:37:44 Allen: Okay, Jack. That's quite clear to us now. Also a question about Station 4...

150:37:51 Schmitt: Joe...Joe.

150:37:53 Allen: Okay, go ahead.

150:38:04 Schmitt: The bottom of that crater, now, had material that was extremely disorganized in its aspect and, really, we didn't have time to examine it in detail in order to decide why it was disorganized. It did not necessarily look (in texture) like the boulder that we sampled at the rim.

[At 145:23:48, Jack described the rocks in the bottom of the crater in the following words: "The central peak, if you will, or central mound, is very blocky and jagged. And the

impression I have of the other mounds in the bottom is that they look like slump masses that may have come off the side."]

150:38:34 Allen: Okay, Jack. Understand that. A question about the boulder you sampled at the rim. Would you compare the basalt in this boulder - which you may have called a gabbro, I'm not sure, in any case a basalt - to samples which you collected at Camelot and at ALSEP. Over.

150:39:01 Schmitt: Well, my impression was that they were the same rock types.

[Jack sounds like his sinuses may be a bit clogged.]

150:39:06 Allen: Okay, that's our impression, too. Thank you. That's it for us on the questions. And for information, we're showing your cabin pressure is holding fairly steady even with both those demand regs on.

150:39:26 Cernan: Okay. Keep watching it for us, would you, and let us know. I expect one of them is probably leaking pretty slow.

150:39:33 Allen: Yeah; no worry about that, Gene. We're looking at it real close.

150:39:44 Cernan: How's (Command Module) America looking to you?

150:39:47 Allen: It is just as clean as a whistle.

150:39:58 Cernan: It may not be when we get back there, judging from the looks of us. (Pause) That's good to hear, though. It's a good bird. So is this one. (Pause)

150:40:20 Schmitt: Joe, is there any...You got any more debriefing questions?

150:40:25 Allen: Negative, Jack. And we're interested that you move right along so we can get you turned in there and get some rest.

150:40:37 Schmitt: We're moving. We're eating now, and we feel the same way, I think. (Long Pause)

[Schmitt - "Almost certainly, I was surprised - and I think I recall it now - that they didn't want to ask more questions about EVA 2. More than likely, there were lots of questions; but the Flight Director was saying 'We've got to get them back on the time line and get them to sleep.' We did a lot of geology debriefing when we got home but, unfortunately, we can't find the tapes or a transcript. I sat with Lee Silver and probably Muhlberger and Swann and others and recorded a lot of extra debrief."]

[Tapes and a transcript of the post-mission geology debriefing were found for us in early 1994 at the Lunar and Planetary Institute in Houston by Carol Albyn.]

150:41:12 Allen: Troops, enjoy your meal there. And at your convenience, you can go ahead with the (PLSS) feedwater recharge. We want you to hold off on the oxygen recharge until we watch these regs for about another 10 minutes. And

give us a mark if you do start the water recharge, please.
Over.

150:41:36 Cernan: Okay. (Pause)

150:41:46 Allen: And if there are any ways we can cut corners on the time here, it'll be helping us, because we're still looking at being down a couple of hours nearly.

150:42:01 Cernan: Okay, Joe. We're working at it as fast as we can. (Pause) Best place in the world to make it up is tomorrow night.

[Schmitt - "After EVA 3, you were getting ready to go home, you'd done what you'd come to do so why worry about getting your full eight-hour rest period? You don't need eight hours of rest anyway; five was plenty, I think, for both of us. Plus, we were going to spend three days in orbit after rendezvous, so there wasn't going to be any hurry. So I think Gene was just trying to discourage them from even thinking about shortening the EVA."]

150:42:19 Allen: Right, Geno, and, actually, we're going to pick up a good one shortly, because we're coming up to a pad in the time line. So, as long as we don't waste too much time, we're doing pretty well.

[That is, there is an hour's worth of unallocated time in the schedule. this is the item on Surface 5-7 called "MCC-H Conference"]]

150:42:34 Cernan: Okay; be assured we're not. There's just a certain amount of housekeeping we have to do. But, very seriously, day after tomorrow is a very short day, and I think we ought to look at making up any time. I'm a hold-faster on sleep periods but tomorrow('s rest period) is the one that I think is flexible.

150:42:56 Allen: Roger. We hear you.

[Cernan - "We had five and a half hours to get prepared from the time we woke up to the time of lift-off and that was an enormous amount of time. We could have pushed the third night's sleep back and gotten up an hour later. And, if we did shorten the sleep, once we got back in the Command Module we could make it up."]

[As things will turn out, they will have a 7-hour rest period after a full, 7-hour, 15-minute EVA.]

[Cernan - "I've said that I thought sleeping on the Moon was a big waste of time. We needed physical rest, we needed to get out of our suits, but I really wish we'd had more time to absorb what was going on. There's no human being who can consciously take in all of an experience like that while it is occurring. Subconsciously, you do retain things that you weren't aware of at the time and it takes a while for those to come out. You have to be careful that you don't develop a convenient memory and have things come out the way you might like to have them come out or in a way that makes you look

like you had all the right answers beforehand. It's a very dangerous trap that you can fall into. So I wish we'd had more time to absorb things. But we had no choice; we had to rest and, as crew commander I had to maintain some discipline in our relationship with the ground. We knew we had some padding in the schedule, we knew we could go out a little longer, we knew we could sleep a little less; but the eight hours was important because, although we really only slept about four hours, we needed to think and talk and rest."]

[Long Comm Break]

150:46:12 Schmitt: Hey, Joe. This is Jack. We're eating here. Won't be too long at it, but if you've got any significant news or anything, why don't you give it to us?
(Long Pause)

150:46:46 Allen: Jack, I don't know if it's significant news, but at least I know you'll be interested. Both your demand regs look good now. We show no evidence of a leak there and it may have been that just recycling them reseated them and solved whatever problem we had. You can go ahead with the 02 (top-off) recharge on the PLSS and the water recharge at your convenience. And let me poll the room here for other news items. Over.

[Comm Break]

150:48:21 Schmitt: Okay, Joe, we're starting an 02 charge of the CDR's PLSS; (that is, recharge for) ten minutes.

150:48:26 Allen: Okay.

[Long Comm Break. The PLSS recharge was scheduled to start at 149:30. Evidently, they have decided to do the recharging tasks while they eat. They are now on Surface 5-7.]

150:53:29 Allen: Challenger, this is Houston.

150:53:36 Schmitt: Go ahead, Joe.

150:53:42 Allen: Roger. This is a news report to eat by. I'll combine an orbital science report with a sports report, an unusual combination here. I'll start out with a sports report on Monday Night Football, which you may not have heard yet. Joe Namath tried mightily to lead the New York Jets into the American Football League playoffs, but the Oakland Raiders grounded the Jets in a fourth quarter 24 to 16 blitz. Namath passed for more than 400 yards but, in spite of it, New York scored only one touchdown.

150:54:20 Allen: Moving along to the successes of Captain America, I'll run down different items in the SIM bay here, beginning with the UV spectrometer. In general, the data has been excellent. We're getting indications that the hydrogen atmosphere of the Moon is much less than expected. In fact, I don't think we're detecting any, but rather setting a limit on the amount of hydrogen around the Moon. There was an

Aerobee launch...(correcting himself) or, an attempt at an Aerobee launch from White Sands on Monday to calibrate solar UV radiation, but this launch failed because an instrument viewing port in the rocket failed to open. A second launch - let's see - was scheduled, I think, for today, and I don't know whether that was successful or not. (Pause) I guess it'll be launched later today. The infrared scanning radiometer is performing beautifully. Indications are that subsolar-point surface temperatures are higher than we've detected from our Earth-based observations before. We're seeing many thermal anomalies, particularly in (Mare) Procellarum - in the Procellarum area west of Copernicus. And we're seeing also a few unusual cold spots, which apparently are indicating areas of very fine soil with a few or no blocks in and on the soil. The lunar sounder data is beautiful, and the power monitor signals we find correlate with the surface features. And the HF (high-frequency radio) data indicates to us that we are detecting a variety of layers in the mare areas. (Long Pause)

150:56:52 Schmitt: Joe, this is Jack. Do you know where specifically they're seeing the hot spots west of Copernicus?
 150:57:02 Allen: Jack, I don't have it on the page in front of me here. We're going to check into it and I'll get back to you in a second.

[Comm Break]

150:58:42 Allen: Jack, this is Houston. With regard to your questions on the hot spots, apparently they've not yet indexed these warmer sources that they're detecting to the CSM ephemeris, and so they don't know exactly what they correspond to as far as the surface features themselves go. So I can't help you on that right now.

[Houston knows the times at which the hot spots were seen from the Command Module instruments; but geographical identification will require knowing exactly where the spacecraft was in its orbit at each of the observation times.]

150:59:14 Schmitt: Okay, Joe. Just curious.

[Comm Break]

151:01:04 Allen: Gene and Jack, TELEMU handed me some numbers which I think you will be interested in. From the EVA-2 EMU summary, the elapsed EVA time was 7 hours plus 37 minutes plus 22 seconds for a new outdoor record under international rules. The rest of the sheet looks free from problems in a comforting way. Let's see, average metabolic rates: for you, Geno, 855 (BTU per hour); and, Jack, you're running at around 920. And that's relative to pre-mission (estimated) averages of around 850. And you have a grand total EVA time now of 14 hours 49 minutes and 35 seconds.

[The previous single EVA records had been 7:12 and 7:23 set during the second EVA's on Apollos 15 and 16, respectively.]

151:02:19 Cernan: Very interesting numbers, Joe. Do you have any idea how the metabolic rate compared to yesterday?
 151:02:25 Allen: Good question. Let me ask on that one.
 (Pause) Yesterday you were running at 1045 and 1090. So you're down considerably from your work rates of yesterday, which is good news. Maybe you're learning how to do it more easily or something like that.

[Schmitt - "Because we spent at least a couple of hours on the Rover on this second EVA, clearly we didn't stress ourselves as much as during the first day. And we were more familiarized, so there was less emotional stress than on the first EVA, if there had been any at all. And I'll tell you, I never remember feeling anxious about anything except about the timeline and being able to get things done."]

151:02:57 Cernan: Yeah, but we spent a lot of time riding today and a lot of time working yesterday.
 151:03:03 Allen: That's true. I guess that's not taken into consideration of the average here. It's certainly true. We can ask for the metabolic rate of the Rover. I bet that is pretty impressive for today.

[Schmitt - "Joe was joking here. He was going to ask how hard the Rover worked. That's the way Joe thinks."]

[The energy saved by riding the Rover is shown dramatically by the following table of activity averages. The table is derived from the Apollo 17 Mission Report.]

Activity (BTU/hr)	Average Metabolic Rates	
	Gene's Average	Jack's Average
Riding	479	447
Geology Stations	1036	1189
ALSEP Deployment	1129	1104
Rover Deployment & other Overhead	1200	1130
All Activities	946	950

[Jack notes that, even though he spent a lot of time leveling equipment versus Gene's efforts with the drill, he also spent time laying out the geophone lines. He offers his relatively low ALSEP average in support of his contention that running with the cross-country stride didn't consume much energy.]

[Cernan - "Our rates weren't all that different.
 (Laughing) Of course, I had to expend a lot of my energy getting Jack all squared away, so you'd probably want to take

about ten percent off of my average and add it to his. I had to get his valves turned off, shove him in the hatch, help him on the Rover, pick him up when he fell. So, realistically, we've got to take that into account. (Somewhat more seriously) My rate while we were driving was about ten percent higher than Jack's and maybe that had to do with the fact that you're not a casual driver on the Rover - you're involved all the time. And I've got to believe that that shows up as an expenditure of BTU's."]

151:03:18 Cernan: Well, don't get me wrong. Driving that Rover is soft; but, I'll tell you, it keeps your attention.

151:03:29 Allen: I'm sure it does.

151:03:31 Schmitt: It keeps the passenger's attention, too!

151:03:32 Allen: I'm sure it does. We noted some comments when you were rolling along today; and reading between the lines from time to time. (Pause)

151:03:59 Cernan: Actually, Joe, for good long spans of the run up to Station 2, except when we had to pick our way up the Hole-in-the-Wall, I was running full bore at anywhere from, I guess, what'd I say, 10 to 12 to 15 clicks. I didn't hit 15 going up (to Station 2) very much. Coming down I did, but it's really a "standby for a turn and watch where you're going" type of run. Because the small craters, of course, are the ones that can really jolt you. But the trouble is, you can never see what's just over the next ridge, and the next ridge may be 20 meters away and you just can't see it until you're there, and you don't know whether it's a dish crater or whether it's a pit crater.

151:04:56 Allen: Roger, Gene. We copy that.

[At 10 kilometers per hour, they would cover 20 meters in 7 seconds. Note Gene's statement of 15 kph versus his claim of 17 1/2 or 18 kph at 144:21:31.]

151:04:58 Schmitt: Joe, that des...

151:05:00 Allen: Go ahead.

151:05:03 Schmitt: That description fits the geology up in there (on the Scarp), because we weren't seeing blocky rimmed craters and otherwise you would have been able to tell more easily about the old versus new craters, which would be the ones you could either go through or not go through, respectively.

151:05:22 Allen: Roger. (Pause)

[The avalanche that produced the light mantle had covered the Scarp to considerable depth with fine material and, unlike out on the valley floor, there were very few blocks of any size near the rims of even the freshest craters. Therefore, when they were approaching a crater, unless they could actually see the interior, there was no ready way to distinguish the deep, fresh craters - which they wanted to drive around - from the shallow, aged craters they could usually drive through.]

151:05:33 Cernan: That's a super machine to drive though, Joe, I'll tell you. If you had enough time you could really learn to take it all the way. But you don't really do that, just the second time around.

151:05:51 Allen: Geno, was it spraying dirt at you today? Could you notice that you still missed the real fender and that the patched fender wasn't quite doing what maybe it could?

151:06:08 Cernan: No, sir, I don't think we missed it at all.

151:06:15 Schmitt: Fact is, we're recommending a design change, Joe.

151:06:25 Allen: That'll be for next year's models.

151:06:32 Schmitt: That's right.

[Long Comm Break as they finish eating, get the debris out of the way, and refill their in-suit drink bags.]

151:10:20 Schmitt: Hey, Joe. Is it all right to use the waste management system to make a urine dump)?

151:10:28 Allen: Rog. We're happy with those demand regs now. And you can proceed on with that (urine dump) and including all the PLSS recharges that you'll need to do as well.

[Comm Break]

151:13:23 Cernan: Joe, we're filling my PLSS with water now. You might check on the (change in the) water quantity (in the descent stage tanks during the fill).

151:13:29 Allen: Roger. Thank you.

[Long Comm Break]

151:23:11 Cernan: Joe, that should take care of my PLSS for tonight.

[Next, they will recharge Jack's PLSS.]

151:23:17 Allen: Okay, Gene. Thank you. Out of curiosity, have you packed, or are you packing, the ETB now (for EVA 3)?

151:23:27 Cernan: Yeah. Jack's doing it right now.

151:23:29 Allen: Okay; we've got a last minute change. We show that your mag Bravo is at about 77 frames, and we'd like for you to leave it in the ETB - it is already in the ETB - and take it out with you tomorrow. We can shoot up the remaining frames if we run out of film otherwise.

151:23:55 Cernan: Okay; fine. That goes along with our thinking. (Long Pause)

[Magazine Bravo - number 134 the overall Apollo catalog - is the one Gene used during the first EVA.]

151:24:28 Allen: You know, apparently you made some comment earlier in the day about being bothered by comm noise during your egress from Challenger. Did that go away right away, or did it just cease to bother you? What was the story on that?

151:24:49 Cernan: I don't remember. So, it must have gone away, because the comm was great.

151:24:56 Allen: Okay; that's what we kind of assumed.
(Long Pause)

151:25:24 Cernan: Okay; we're charging Jack's PLSS with oxygen. (Pause)

151:25:33 Allen: Sounds good.

[Very Long Comm Break]

151:39:44 Cernan: (Sounding tired) Houston, Challenger. The 02 fill is complete on the LMP's PLSS, and we're working on the water.

151:39:56 Allen: Roger.

[Comm Break]

151:42:19 Allen: Challenger, for your information, we're coming up on (a) comm handover in about a minute and a half.

151:42:33 Cernan: Okay.

[Long Comm Break]

[Cernan - "I sound a little tired. It was the end of a long day. During these long periods of silence we were probably eating something, packing things away, and cleaning up a little bit. Sort of relaxing a little bit and doing our own thing; letting them know, every once in a while, where we were. And they were leaving us alone to get things prepared for our rest period. It was good. You need that kind of time."]

151:47:33 Cernan: Hello, Houston; Challenger. The LMP's PLSS is charged.

151:47:36 Allen: We copy it. (Long Pause)

[They are at about 150 hours in the time line and have gained, at most, about ten minutes.]

151:47:52 Cernan: Joe, how's the weather gotten down there? Any better?

151:47:55 Allen: Geno, the weather is better. We were really socked in yesterday. That front's moved on through the Houston area, and it is cold and clear tonight, I suspect. It's been a while since we've been out, but they are calling for it to go down right near freezing.

151:48:21 Cernan: Okay. Thank you.

[Very Long Comm Break]

[Schmitt - "This was one of the few chances you had to reflect a little bit. This was just a gradual wind-down from the long day. While we were filling the PLSS's and doing the other things, Gene and I chatted, mostly about what'd we'd done rather than what we'd seen. And often, I think, we were speculating about the kind of things the ground might recommend. I wish we'd talked more with the ground about the geology, but I also understand the Flight Director's position."]

152:16:12 Schmitt: (Sounding quite stuffy) Hey, Joe; Challenger.

152:16:17 Allen: Go ahead.

152:16:22 Schmitt: (Have) they succeeded in leveling the gravimeter (the LSG), yet? (Pause)

152:16:33 Allen: Jack, we'll check it, update our information on that. My understanding at the moment is that they've not; but they're thinking that the unit's just too cold and they're in the process of warming it up by dumping heat into it by running some of the equipment around it and in it, and they've by no means given up hope for that unit.

152:17:02 Schmitt: I figure that means that my fooling around with it didn't help 'em.

152:17:07 Allen: Apparently, it didn't do too much for them, but what it did do was convince them that it's probably somehow locked up because its temperature's not right yet. And they're not worrying about whether it's level or not level now. They're confident that it's been set up okay, and now they're just biding their time to bring that temperature up. We'll get some more words to you sometime tomorrow on it as you make your traditional visit to the ALSEP site again, probably. How are you coming along with your sleep prep?

152:17:44 Schmitt: We're just about there, Joe. We picked up some time somewhere in here. Couldn't be much more than an hour behind.

152:17:56 Allen: No, that's just about right. You're looking pretty good on that.

[Deke Slayton joins the conversation.]

152:18:02 Slayton: If you get to sleep in the next 5 minutes, you're one hour behind.

152:18:08 Cernan: Yes, sir; I'm putting my hammock up now, as a matter of fact.

[They are now on Surface 5-8. The rest period was scheduled to start at 151:25.]

[Schmitt - "Gene got his hammock up first and got in it, then I put mine up and got in it. There wasn't much spare space. The suits were on the engine cover under Gene's hammock and, as I recall, the helmets and visor assemblies were way at the back, sort of under the suits."]

152:18:16 Schmitt: What's he (Slayton) doing up so late?
 152:18:22 Slayton: Well, somebody's got to sit up and keep you guys honest. (Pause) I think we're getting more sleep down here than you are. (Pause)
 152:18:44 Schmitt: (Garbled).
 152:18:47 Allen: I might add that not only do we have to stay up late, we have to get up mighty early to keep you honest, too.
 152:18:58 Schmitt: Okay; you going to let us sleep 8 hours or what?
 152:19:03 Allen: That's affirm, Jack. We're looking good on the time, and not only will you get, we hope, 8 hours of good sleep, but you'll have a full EVA tomorrow. So, it's not costing us anything there.
 152:19:21 Cernan: Sounds great, Joe. I fully expect it won't be much longer now. (Long Pause)
 152:19:48 Allen: And, Gene, just for rough planning purposes, we'll start to figure your sleep period starting around 152:30. And we'll be looking at your getting up around 8 hours from that time.
 152:19:11 Cernan: Okay, Joe; I'll buy that. (Pause)
 152:19:21 Allen: Might add, also, that there are a lot of us looking forward to that third EVA tomorrow. It's going to be the last one on the lunar surface for some time.
 152:19:37 Cernan: I tell you, if it's anywhere near what the first two were like, we're looking forward to it, also. (Long Pause)
 152:20:00 Allen: Gene and Jack, we're still marveling at the beautiful television pictures that we're getting from your TV camera there. It's fun, in fact, to watch the tracks that you're leaving behind in the lunar soil, both footprints and Rover tracks. And some of us are down here now reflecting on what sort of mark or track will - someday - disturb the tracks that you leave behind there tomorrow.
 152:20:39 Cernan: That's an interesting thought, Joe, but I think we all know that somewhere, someday, someone will be here to disturb those tracks.
 152:20:53 Allen: No doubt about it, Geno.
 152:20:55 Schmitt: Don't be too pessimistic, Joe. I think it's going to happen.
 152:21:00 Allen: Oh, there's no doubt about that. But it's fun to think about what sort of device will ultimately disturb your tracks.
 152:21:13 Schmitt: Well, that device may look something like your little boy.
 152:21:19 Allen: Ah; he'd make short work of them. (Long Pause)

[Joe's son, David Christopher Allen, was a very active four year old at the time of the mission.]

152:21:32 Cernan: Joe, I'll tell you it's also a pretty philosophical thought to think that you're riding around out

here on what is really undisturbed everything, you know. If there was someone here, way back when sometime, they didn't leave much sign of their whereabouts, but that's an interesting thought, too, as you drive around and all of a sudden cross your own Rover tracks and figure out those are the only ones that have maybe have ever been here.

152:22:06 Allen: Very true.

152:22:09 Cernan: And with that, I'm rolling out my hammock. (Long Pause)

152:23:11 Cernan: Okay, Joe. I'm waving goodnight to you. I'm rolling up my overhead (Rendezvous) window cover. (Pause)

152:23:24 Allen: Okay, Gene and Jack. We'll say good night to you from down here, unless there's some other way we can help you.

152:23:38 Cernan: No, sir. If there is, we'll give you a call, though. (Long Pause)

152:23:51 Allen: Just want to end by saying what a terrific job you did today, and we're really looking forward to tomorrow. Have a good 8-hours rest.

152:24:05 Cernan: Thank you, Joe.

152:24:09 Schmitt: Tomorrow we answer all the unanswered questions. Right?

152:24:15 Allen: If not more.

[Cernan - "It was easy to get philosophical. I've said before that I've always felt that sleep was one of the greatest wastes of the short time we had on the Moon. You're only there for 75 hours and you sure don't want to waste twenty four of it sleeping or resting. You'd like to be doing something that would allow you to go further in learning and exploring. And, yet, you had to rest if you were going to take advantage of your physical and mental capabilities the next day. Each EVA you became more tired and you began to sleep. When I slept, I slept pretty good. I don't know, maybe I got three or four good hours of sleep. So a lot of the time you'd just lay there and think. Just before you'd gone to bed, you'd look out the window and see the flag and the Massif and the Earth. There you were, a quarter of a million miles from Earth, laying in a hammock in a little tin can. 'Here I am; I'm really on the Moon. What should I be doing that I'm not doing? How can I take advantage of this? Is it real? Is it a dream?' I've always said that looking back at Earth was a link with reality from a place that was almost like a dream. During the rest of the mission you get caught up with all the things that you've got to do: checking out the PLSS, checking out the LM, doing the geology, driving. You get so caught up with what you're doing that you could be almost anywhere. So you've got to take time out sometime during the mission to think about where you are and what you're doing. You could do a little of that during the EVA's themselves. While Jack was dusting me off I could take a look around at the Massifs and the flag

1 4 0 2 3 9 3 0

and the Rover and it was a pretty big chunk to shallow. So
it was easy to get philosophical."}

160:25:04 Fullerton: (Music: Texas Aggie War Hymn, "E Pluribus Gigum")

[Pregnant Pause. Flight Director Gerry Griffin is an alumnus of Texas A&M University.]

160:26:34 Cernan: I want you to say it first. (Pause)

[Cernan - "This was probably the first time I'd heard the Aggie War Hymn in my life and it really didn't impress me all that much. You can tell that in my tone of voice. So when I said 'I want you to say it first,' I meant 'Whatever you're going to say, let's get it done and over with.' I wish I knew what Jack thought of that."]

160:26:40 Fullerton: Hello there, Challenger. The Gold Team Flight Director picked out the morning selection, and he said that if you can find some maroon dirt (the Aggie colors are maroon and white), today, instead of orange, you'll probably get a lot more cooperation out of him. (Pause)

[Cernan - "Gerry went to Texas A&M and he's a big Aggie (supporter). Now maroon is an Aggie color, but orange happens to be a (University of) Texas color. A&M and Texas are always at odds. If we had found blue dirt, it would have been better than finding orange dirt. That's a big deal around Houston."]

[Schmitt - "There were a lot of Aggies in the Control Room, but Gerry Griffin was the head Aggie."]

160:27:01 Cernan: I figured the Gold Team might do that. You know, I've woke up to a lot of pleasant thoughts, but never to an Aggie before. (Pause) Hey, Gordo, don't forget I'm a Boilermaker.

[That is, Gene is an alumnus of Purdue University and would like some appropriate wake-up music before the mission is over. Purdue is an engineering school and, hence, the students and alumni refer to themselves as "Boilermakers". A "Boilermaker" is also a drink consisting of a shot of whiskey followed by a beer chaser.]

160:27:20 Fullerton: Roger. (Pause)

160:27:26 Cernan: (Sounding a bit groggy) I feel like one right now. (Pause)

[Gene's reference is to the morning-after feeling following a few too many boilermakers.]

[Cernan - "Sometimes you're asleep and it's the wakeup call that gets you up; and other times you're up and taking care of things without bothering the ground. Here, we'd had a couple of hard days on the Moon and had one day to go. The adrenaline probably started pumping a little while later; but I would expect that a little bit of the edge had worn off."]

We were pretty tired, physically, at the end of each one of those days, and you don't get the best rest in the world in a situation like that. You rest and you sleep; but you lay there half the time asking yourself if there isn't something else you could do instead of try to sleep. It was enough sleep to keep you going, but I don't know how good a rest it was. I probably had my comm helmet hanging up next to my hammock and, when Gordo called, sat up Indian style. One sixth gee gave you some facility to move around, even in those tight quarters."]

160:27:35 Cernan: Tell the Gold Team Flight Director we'll find just about anything he wants today.

160:27:40 Fullerton: Okay; I'll do that. The Challenger looks as good as ever. No problems at all through the night.

160:27:50 Cernan: That's outstanding. How's America?

160:27:54 Fullerton: It's in the same shape. Just clicking along. Ron's been up for a few hours now and (is) really gathering up the data.

160:28:05 Cernan: Outstanding, Gordo. (Pause)

160:28:19 Fullerton: Challenger, the name of the game today is to stay with the EVA prep time line (see Surface 5-8). We're not going to talk much to you, except to bug you a little and stay on your back to keep with the time line, if at all possible. We'd like to get out on time. Over.

160:28:40 Cernan: Okay, Gordo. That's been our motive all along, and we will stay with it. As of right now, we're one hour behind. Is that correct?

160:28:50 Fullerton: That's affirmative. Although, if you stay on the normal time line, that's fine with us. We don't need to gain any, but we just don't want to lose any from where we're starting now.

160:29:03 Cernan: Yeah. Understand. Understand. (Pause) (Yawning; to Jack) Good. How are you this morning?

[Long Comm Break. The planned wake-up time was 159:25 and the planned start of the EVA was 162:40. Houston woke them up at 160:25 - and hour late - and they will start the EVA at 163:32 - only 52 minutes behind. Because of pads built into the time line leading up to launch on Day 4, they will start this third EVA in great shape.]

160:34:52 Schmitt: Houston, Challenger.

160:34:54 Fullerton: Go ahead, Challenger. (Pause)

160:35:03 Schmitt: Okay, Gordy. Crew status is good, in case you hadn't noticed. We haven't kept an itemized accounting of the food... (there) weren't enough blanks on the paper to do that. But we have ate... (correcting himself) have eaten, pardon me. We have eaten just about everything in the various meals. I guess the shrimp was the only thing we didn't really eat. And we've been drinking a lot of water and all the juices and tea and stuff, so I think we're in pretty good shape there. Commander had a Seconal last night, and he slept 3 good and 3 intermittent hours. LMP had no

medication and had 6 good hours of sleep. If you've got some lift-off time data, well, I'll copy it.

[Fullerton reads the following list of lift-off times slowly and very carefully.]

160:36:00 Fullerton: That's affirm. Okay; start with Rev 38. Time is 162:22:52. Rev 39 is 164:21:24; 166:19:55; 168:18:27; 170:16:59; 172:15:31. That should have been rev 43 (the last one), and read back starting with rev 38.

160:37:03 Schmitt: (Read back much quicker) Okay; rev 38: 162:22:52; 164:21:24; 166:19:55; 168:18:27; 170:16:59; 172:15:31. And what is our present rev?

160:37:21 Fullerton: That's a good question. Let's see here. (Pause) We're working on rev 37. (Pause) Ron just went by you about ten minutes ago on rev 37.

[The crew first entered lunar orbit by firing the Command Module engines over the lunar Farside. Evans has completed a bit more than half of the current revolution. Gene and Jack are about to start eating breakfast. Forty-five minutes are allotted in the flight plan for each of the meals. Long Comm Break.]

160:41:32 Cernan: Gordy, we're pressing on, but if you've got any good words, like news and what have you, while we are, we'd appreciate it.

160:41:40 Fullerton: Okay. There hasn't been a lot of news, but I'll read you what we've got. Former President Truman is still holding on. His heartbeat, breathing, and temperature all became unstable yesterday, but then he improved again. A Methodist minister in Kansas City said, "He's a rugged guy who's hanging in there and he's going to make it." The headlines were full of reports of the find of orange dirt and the rest of your adventures yesterday. Internationally, the U.S. and North Vietnam held intensified secret peace talks, and Henry Kissinger prepared to return to Washington, probably this afternoon, I understand, after a final session with Le Duc Tho. The French press said a compromise was in the works on the withdrawal of North Vietnamese troops from the South.

The Houston Rockets lost to Buffalo up in Buffalo last night, but the hockey team, the Aeros, took a 6 to 4 win over the Alberta Oilers. Really, that's about it on the news, except maybe for the weather, which finally broke. A cold front cleared out the drizzly rain last night, and for the first time since you've launched - that I can remember anyway - we've been able to look up and see the Moon, directly. It's a pretty sight as always. That's not much of a report, but that's about all we have. Over.

160:43:32 Cernan: Okay; thank you. What's the date today?

160:43:36 Fullerton: It's Wednesday - let's see - Wednesday, the 13th of December.

160:43:46 Cernan: Thank you.

160:43:48 Fullerton: Right now, it's about 1:35 in the afternoon (Central Standard Time). (Pause)
160:44:00 Cernan: Okay; just took a quick peek up there. I can't really see too much of the North American continent. South America looks pretty good. And it might be my eyeballs rather than the clouds up there, but it looks like most of the clouds are up into the north-central part of the southeastern United States.
160:44:24 Fullerton: I have a satellite picture here, and that's about the way it looks.

[Schmitt - "I remember that Gene was looking at the Earth through the rendezvous window. You couldn't see it out the front unless you got down and most of the time we were standing. The suits were on the engine cover, so you'd just stand and lean. In one-sixth gee it was no big deal to stand forever."]

[Cernan - "There wasn't much room to sit anywhere, except on the suits, and that was one thing we didn't want to do (because of the danger of getting dust into the zippers and rings.)"]

160:44:32 Cernan: Well, it's sunny and pleasant in the valley of Taurus-Littrow. (Pause) And, Gordo, what is our Sun angle going out today?

160:44:50 Fullerton: I'll get you an answer on that. Couple of questions. First of all, the Surgeon would like Biomed Right.

[That is, the Surgeon wants to look at Jack's biomedical data.]

160:44:56 Fullerton: And they were wondering how your hands feel this morning?

160:45:07 Cernan: Hands are in good shape, Gordo. No problem.

[Schmitt - "I doubt if anybody on the Moon would have told the doctors if there was a problem, just to make sure that there would be no glitches on getting out for the third EVA. Our hands and fingers were sore from the lifted fingernails. If you touched them, they were very sensitive. I don't recall that there was continuous ache. I think it was only when you hit your nails on something. I wore thin nylon liners in my gloves to try to protect my fingernails. Without the liners, I was uncomfortable with my sweaty hand against the rubber. We didn't have the water cooling out into the fingers - just up to the wrist. You're hands didn't get hot, but you did perspire."]

[Cernan - "As I've said, I don't remember my fingernails giving me as much of a problem as blisters on my knuckles. I've got such a fat hand. But I do remember that the lunar dust penetrated well down into the quick. It took three, four, five, six weeks for the lunar dust to grow out. So the

dust was able to get in there; I just don't remember any pain from the fingernails being lifted off. My main recollection is of my knuckles being rubbed raw."]

160:45:11 Fullerton: Okay; that sounds good. (Pause)
Sun is getting up there; about 33 degrees now. (Long Pause)

[Cernan - "If you go from the extremes of the first EVA to the third EVA, I can tell you that when I was working with my hands out in the Sun, I could feel the heat penetrate during that third EVA that I could not feel during the first EVA. Sun angle did have a significant effect. I don't know if the data show that we used more cooling in our PLSS's during that third EVA."]

[Gene's feedwater consumption rates for the three EVA's were 1.572, 1.339, and 1.566 pounds per hour. Jack's figures were 1.508, 1.326, and 1.589 lb/hr. The dominant factor determining the differences from day to day is the work load, rather than the Sun angle. On the first day, they spent most of their time deploying the ALSEP and, consequently, worked fairly hard. On the second day, they spent a considerable amount of time on the Rover and got plenty of rest between the geology stops. On this third day, they will spend much of their time doing geology on the slopes of the North Massif and the Sculptured Hills. The work will be challenging and they will have briefer drives between the stops.]

160:46:18 Cernan: Okay; we'll go Biomed Left (Fullerton asked for Biomed Right), and both PLSS's have been topped off. (Pause)

[They have completed the last task on Surface 5-8. Just after the second EVA, they filled the PLSS's with oxygen and then had let them settle before giving them a top-off charge just before going to sleep. Now they are doing a second top-off charge to ensure the longest possible EVA. Not surprisingly, this procedure was added to the checklist for Apollo 15, the first mission to attempt a seven hour EVA. Note that there is no water top-off, suggesting that they are confident that there wasn't a significant volume of gas added to the water tank during the filling procedure.]

160:46:35 Schmitt: Gordy, the LMP isn't hooked up right now. He will be shortly. So stand by on the biomed.

160:46:42 Fullerton: Okay. (Pause) Say I have a few words on the Command Module trajectory that might be of interest, although it doesn't affect your procedures any. (Pause as Fullerton waits for an expression of interest)

160:46:59 Schmitt: Go ahead.

160:47:00 Fullerton: Okay. The command module orbit somehow is missing all the mascons. And it's not degrading into a circular (orbit) like we thought it would. It's just

staying where it was, about a 70 by 50 (nautical miles high and low point above the lunar surface).

[Schmitt - "The Lunar Orbiter team discovered mascons in the Doppler tracking data. They found that the lunar gravitational field is not uniform; and, specifically, that there are concentrations of mass under the most circular - i.e., the youngest - of the large basins and mass deficiencies under the rims of those basins like Serenitatis, Nectaris, Crisium, Imbrium, Orientale. The computer model that fits is one that has the mantle of the Moon - at about 60 kilometers depth - slightly raised under the basins and with a bit of a deficiency around them. It's like an incipient water splash. The rebound from the impact that formed the basin has caused the mantle beneath the center of the impact to rise slightly. Plus, the effect of that little rise is accented by the flat plate of dense material represented by the lunar mare. As I remember, the lunar mare has density of about 3.4 grams per cubic centimeter, whereas the surrounding highlands have a compacted density of about 2.9. So it's a significant contrast. One of the more interesting aspects of it is that the old, irregular mare basins don't have mascons. And that suggests that between the formation of the old, irregular basins and the young, circular basins, something fundamental changed in the lunar crust. It became stronger - a lot stronger - so that, in the younger basins, there was no compensation for (or relaxation as a result of) these density differences as apparently there was early on. And the change presumably occurred over a fairly short period of time around 3.9 billion years ago when most of the young, circular basins formed. There's a lot of controversy raging about whether all of the 45 to 50 basins formed at just about the same time. I'm of the belief that that can't have happened, in part, because you have this very distinct strengthening of the crust beneath the mascon basins."]

[The net effect of the mascons is generally a circularization of an elliptical orbit and an overall loss of orbital energy. Indeed, because of the effects of mascons, no object can stay in lunar orbit for more than a few months without engine burns to episodically increase orbital energy.]

[Schmitt - "The flight dynamics people anticipated that, because of the micro accelerations and decelerations associated with the mascons along the path of the Command Module, you would get a perturbation of the orbit. So, after Ron dropped us off, he had a burn that put him into an orbit which, upon perturbation, would become a 60-mile circular orbit by the time we were ready to launch. They thought they could predict how the mascons would perturb the orbit - clever people, these Americans - but the mascons wouldn't cooperate. Their gravitational model was not sufficient to make those predictions. The main reason (for the inadequacies of the model) was that they couldn't track

spacecraft as they orbited over the Farside and, consequently, they didn't have any information about Farside mascons. One of my reasons in proposing a Farside landing on Apollo 17 - when I tried to persuade NASA to let us land in Tsiolkovsky - was that you'd have to put together a communications system; and that would allow you to track the Farside orbits and gain additional knowledge about the Farside mascons. I suspect that there aren't very many. Tsiolkovsky is probably one of the few, because there just aren't many young, fresh, circular basins on the Farside. I suspect they've all compensated except for Tsiolkovsky and one or two others.

"After the crew was finalized in the fall of '71, for the second time I tried to persuade Chris Kraft and others that we ought to consider a Farside landing. I had brought it up before - after Apollo 13 - as the culmination of the last four missions going to the places where everybody always wanted to go: Tycho, Orientale, the North Pole, and the Farside. I had fun trying to justify that mission to people. But everybody was so wrapped up in proving that they could survive the Apollo 13 failure and get Apollo 14 landed, that it didn't get much play. I worked it for a while, anticipating that just one more landing wouldn't help the politics of the space program very much. I wanted to build up to some sort of crescendo that would not only provide good science but would provide public interest. When I brought it up again in August or September of 1971, I went so far with the Lunar Mafia - the group of people at JSC who thought up these 'dumb' things to do on their own time - as to work out how to do it. Some of the guys in Flight Control were able to track down a couple of on-the-shelf Tiros satellites that could act as communications satellites. The plan was to place those, with a single Titan launch, at the Farside libration point. There's a libration point about 30,000 miles behind the Moon where things will stay, at least for a while, if you put them there. Except in very weird circumstances, satellites at the libration point would give you a direct link with Earth; and the two satellites gave you redundancy. It was a great plan. TRW quoted a price of about \$80 million and I had added a \$20 million contingency. And we had other plans. In one, as you went around the Moon in the Command Module, you'd drop off a bunch of small communications relay satellites, rather like the current Iridium scheme. (Laughing) But, finally, Chris called me in and said 'Shut up; quit talking about this. We're not going to spend a hundred million dollars to put a communications satellite behind the Moon for the last mission.' I'm not sure where the numbers came from, but the marginally cost of building the hardware for an Apollo mission was about \$250 million and I was told that operational costs - to run the centers and the tracking stations, etc - were about the same number."]

[Cernan - "Aside from the cost and the probability of having to delay the flight, management simply wasn't going to

take the risk of sending us to the back side of the Moon. It would have been a challenge and would have been worthwhile doing, but we still had a lot to learn about the front side. I was involved in discussions at the level of Chris Kraft and George Low and it quickly became obvious that it wasn't going to happen. Jack used to go on crusades like this and get other people involved and go into the details of how to do it and what it was going to cost. And that was good. But Jack used to have the habit of pushing people and pushing people without knowing - politically or diplomatically - when to quit. And, finally, Chris got fed up."]

160:47:12 Fullerton: So what we're planning on is an extra little maneuver about one hour prior to the normal plane change, which will lower the Command Module altitude at the plane change node to 60 (miles). This will be about a 11-feet-per-second RCS (Reaction Control System) burn. And then Ron will do the plane change at the normal time, but it'll be little bigger than we had planned. I think the last hack was about 365 feet per second for plane change. And we've checked the consumables. That puts the RCS right on the preflight line. He's been running about 4 or 5 percent above it. That will use up that pad there (the extra fuel), put him back to nominal on RCS, and on the SPS (Service Propulsion System, the main engine), that puts you right down on the CSM rescue redline; so, really no problem. In good shape, consumablewise. Over.

160:48:38 Cernan: Okay. Sounds like a good rendezvous posture.

[Very Long Comm Break as they finish their meal]

[Because the Moon slowly rotates about its own axis while it orbits the Earth, it rotates under the plane of the Command Module orbit which stays fixed in space. Consequently, each time the Command Module makes it's closest approach to the landing site, the distance increases. In doing a plane change, Evans will apply a carefully calculated amount of lateral thrust at a particular point in his orbit such that his new orbital plane will pass directly over the landing site at the expected time of liftoff.]

[Schmitt - "The normal rendezvous procedure was for the LM to be active and rendezvous with the CSM. And a CSM rescue would have been the case of where, for some reason, all the LM could do was get to orbit; and then it would have been a CSM-active rendezvous which would, of course, have taken lots more CSM fuel.]

[Cernan - "The LM had to get into some minimum, sustainable orbit. For a normal launch time, most likely it would have been a fuel problem that would have forced a Command Module rescue. For example, if your ascent engine shut down early and you got close to orbit and you had to expend most of your RCS fuel to get into that sustained orbit then, obviously, you would have done it. You would have used

all the fuel you had to get into orbit; and then you'd rely on the Command Module to come get you. I always felt that a Command Module rescue was a remote possibility, although one that you had to maintain a fuel reserve for. The reason I say that it was a remote possibility is that, in most cases, you would have done the rendezvous even without the radar. The Command Module had a Doppler device and other systems to give us information and there was manually- and computer-derived information. The LM was a much better rendezvous vehicle than the CSM and, unless there was fuel problem, there was little chance of having to do a Command Module rescue. And, even in the case of a fuel problem, the chances of you getting just high enough that, if the ascent engine shut down early, you had enough RCS fuel to add the amount of velocity to get a sustained orbit were small. You had to get into an orbit that wouldn't decay in five or six revs. And if you only got into an orbit that would decay in one or two revs, it would have been all over. The rescue was a time consuming process. Now, for an emergency situation - which I always thought would have to have been a fairly catastrophic situation - it would have been a manual launch because of the inertial navigation system being powered down. You couldn't sit on an emergency on the lunar surface, but you could sit on an emergency once you got into orbit, because the Command Module did have that capability to come down and get you.

"Of course, there were other reasons why we might have had to leave the lunar surface early. We could have been perfect but there could have been a problem with the Command Module which said 'guys, the Command Module's going to have to go home pretty quick, so you'd better get your ass off the lunar surface and get back there or he's going to go home without you. God forbid there had been an Apollo 13-type problem while the Lunar Module was on the surface, because I don't think any of us would have gotten home. But there might have been some other kind of problem in the Command Module: Ron could have gotten sick, a fuel cell could have gone out, you could have lost redundancy in your ability to start the Service Propulsion engine. And I guarantee you that, if you lose the redundancy to fire that engine, the ground is not going to allow you to stay there for three days. There going to take you off the surface, you're going to rendezvous, and your going to come home. So it wasn't just a potential problem on the surface that we had to be prepared for; it was the other spacecraft as well. And that's always going to be the case with lunar travel. You've got to look at the entire system, not just at yourself. The suits, the backpacks, the amount of fuel you're using. One effects the other. If we'd blown one of our suits for some reason, had gotten in safely, and had gotten back to orbit but with only one good suit, we would have blown Ron Evans' EVA. With only two good suits, you couldn't depressurize the Command Module and all of that data that Ron had up there (in the SIM Bay) would have been lost. It wouldn't have been an

emergency situation, per se, but it is typical of how interdependent the two spacecraft were."]

[Jack's next call indicates that they are ready to start Surface 5-9. They have picked up about 4 minutes.]

161:21:31 Schmitt: Okay, Houston. You got any updates to the EVA cuff checklists? (Pause)

161:21:41 Fullerton: No, I don't think there is, Jack. Although I do have a write-in for the Lunar Surface Checklist, and one that you really don't need to write in on the prep card. Over.

161:21:58 Schmitt: Go ahead.

161:22:00 Fullerton: Okay. Page 5-10 on the Lunar Surface Checklist. The reason for this change is to prevent cabin pressure from increasing. It got up to 5.7 yesterday. And it will also prevent Water Sep spindown like happened yesterday, if you happen to have the return hose blocked against the wall outlet there. The change is to write in on the upper left corner of 5-10, just prior to "Suit Isol(ation Valve), Actuator Override (to) Suit Disconnect." Write in "Pressure Reg's A and B to Egress." And then down five lines, where it says "Cabin Gas Return (Valve), Egress," change it to "Cabin Gas Return (valve), Auto; Verify." Over.

[Normally, they would have the pressure regulators in the Auto position in order to maintain cabin pressure. Because of the slow leak seen for a while the previous night, Houston is asking them to turn the regulators off and use the Suit Circuit to add oxygen to the cabin as necessary. After they put the Suit Isolation Valve to Suit Disconnect, they will attach oxygen hoses to the suits and reposition the Suit Isolation Valve to Suit Flow. Oxygen will then flow from the Suit Circuit into the suits and then, through the open neck ring, into the cabin. By positioning the Cabin Gas Return Valve to Auto, any resulting pressure differential will open the valve and let oxygen flow from the cabin back into the Suit Circuit. Prior to performing the suit integrity check, they will put the Cabin Gas Return Valve back in Egress.]

161:23:08 Schmitt: Okay, Gordy. At the top of the page, "Reg(ulator)'s A and B to Egress," and then five lines down, "Cabin Gas Return (Valve), Auto. Verify."

161:23:18 Fullerton: That's right. And the only other change I have has to do with matching - just like yesterday - matching the purge valves to the OPS's to maximize the OPS capability. And we can just call you when you get to that point. Or if you want to write it down, you need 211 and Geno needs 208.

161:23:45 Schmitt: Okay. We've got that.

161:23:48 Fullerton: Okay. That's all. (Long Pause)

161:24:03 Schmitt: Okay, Gordy. I guess we play the cuff checklist just as planned, with the exception of the bag numbers which have changed...the collection bag (SCB) numbers. I have more or less repaired the sample bag holder

on my camera. It's taped on there pretty well with good tape - believe it or not - off the food bags. I don't know that we have any other outstanding hardware problems.

[Schmitt - "What comes to mind is that the bags for each meal were stacked together and taped. So what I was probably using was that tape. It was tape on plastic or whatever those bags were made of; so, when you pulled the tape off it was still good. Boy! I'd forgotten that that was what I used. But it certainly was better than grey (duct) tape because it was thinner. And the grey tape may have still been out in the Rover, anyway. Actually, I'm surprised that the ground hadn't come up with a fix, because that was a major deficiency in that second EVA."]

161:24:40 Schmitt: I think in terms of sampling, Gene and I will try to shift the emphasis in the mantle area to fragments that are different from the gabbros (coarse-grained basalt) that we've sampled fairly well, I think, up to now, that presumably are subfloor materials. You might pass that word on and see if they agree with us.

[Bob Parker joins the conversation.]

161:25:05 Parker: Okay, Jack. We copy that. (Pause) And, Jack, if you guys are at a convenient place to sit and listen while you're doing some of your stuff, let me read up the planning for EVA 3 and the summary of what we think we have so far.

161:25:25 Schmitt: Go ahead.

[Their next tasks are to prepare their equipment for suit donning. They are on Surface 5-9.]

161:25:27 Parker: Okay. I'll read here from this thing just verbatim. It says, "EVA 3 continues to follow essentially the nominal pre-mission plan. Main objectives continue to be the North Massif - Station 6/7 - Sculptured Hills, and Van Serg Crater. In view of the extensive observations of the dark mantle and plains subfloor unit on EVA 1 and 2 - particularly, therefore, Station 5 - the relative priority of Station 10 is reduced, so that Station 10 becomes a flexible station, who's time allotment is a reserve, possibly providing more time at the earlier stations if desired. However, mantle and block sampling at Station 10 are still important objectives." Walkback constraints are not nearly as tight as they were yesterday, guys, and so we can be more flexible in reshuffling station times if we need. We probably won't be coming up against oxygen walkbacks like we did at Station 4. "Closeout time at the LM has been increased by 20 minutes to make the closeout less rushed and to allow for potential ALSEP troubleshooting. It is currently planned to take this time from Station 6/7. But if 6/7 requires more time when we get there, we can borrow it

from one of the other stations;" I guess, in particular, Station 10 probably.

161:26:38 Parker: The initial activity...Remember, we're going to have to take explosive package 5 with us, and we'll stick it under the LMP seat, and I'll remind you in real time when we get down on the ground on that one. And number 5 - the 3 pounder - will be deployed at Station 10, and again I'll remind you about that in real time, so you don't have to bother to write it in on your checklist.

161:26:59 Parker: Planned traverse proceeds as normal. We're expecting to spend about an hour and twenty minutes at Station(s) 6 and 7; and the suggestion is that we may end up wanting to spend that totally at the split boulder at Station 6. But, of course, the option still exists to visit more than one place and sample other boulders if it seems feasible and attractive and desirable." They're suggesting additional 500-millimeter photographs, especially if it seems that we can use those to document tracks and sources of the sampled boulders; for instance, at Station(s) 6 and 7.

161:27:32 Parker: We are continuing to hold the nominal 47 minutes at Station 8 - that is, 8A - and we still think that's as good a place as any to sample the Sculptured Hills. Station 9 is still a nominal 30 minutes, but in view of the similarities to Station 4, we're anticipating a possible desirability to remove time from Station 10 to enlarge Station 9, but that will have to be a real-time decision, based upon what we find at Station 9."

161:28:02 Parker: Station 10 continues nominal. We're still interested in sampling the blocks and also interested in trenching to try and see if we can say something about the dark mantle/light area relationship and, perhaps, (we will do) the nominal coring. We're going to deploy EP-5 there; and, other than that, they (the planned EVA and the one the Backroom now wants Jack and Gene to do) are basically the same. If we have the time during that closeout...and you'll note we have enlarged the closeout, somewhat, at the LM, based on our experience the last two nights, particularly for dusting. But also, if time permits, in that time we might try and use up the extra double core, if there is one, in the dark mantle near the LM or do some trenching near the LM. But that's only if time permits at the very end, depending upon how the consumables run out.

161:28:56 Parker: They want to call attention to two particular things here. One, since you guys really haven't gotten any very big rocks so far, they're recommending, they say here, and I quote: "The value of large individual samples has been demonstrated. We recommend that several football-sized samples of a uniform igneous rock be collected at Station 9 or 10." I'll pass that on as that. Another point of interest is the 1-to 20-millimeter size section of the regolith, the dark mantle, the lithology. Then, any observations or collections you can make pertinent to that would be of interest in trying to determine the relationship

of the dark mantle to the subfloor units - the gabbro - underneath.

[Schmitt - "The surface of the dark mantle at the 17 site looks young relative to the age that was actually measured because it such fine-grained material. When you get an impact you may get a little of the regolith breccia - that we used to call 'instant rock' - but, for the most part, you're just distributing fine-grained materials - the Dunkirk Effect. You form a crater and then the crater subdues immediately because of the slumping of the fine-grained material. In World War I, when the Germans tried to bomb the British Expeditionary Force that was evacuated from Dunkirk, the sand absorbed the effects of their bombs. Unless they got a direct hit on somebody, very few people got hurt. If the British had tried to evacuate from a rocky coastline, they never would have made it. I just coined the name: the Dunkirk Effect. I don't know why I thought of it; but, basically, the impacts in the mantle were hitting into a great big sandpile and, unless they were really big ones and were getting down to the underlying basalt and threw up some rocks, the craters were not going to look fresh in the terms that we think of when they hit hard rock. The age of a surface is based on the number of craters that you see and, in this dark mantle, craters three to five times the thickness of the mantle tend to disappear very fast and not even be counted. So you count fewer craters of a given size. If you could do it accurately, you'd probably see a knee in the curve. In the large crater fraction, the counts would match the old age. And then there would begin to be a fall off as you got smaller and smaller."]

161:29:40 Parker: Two short questions which I'll ask, which I hope you can answer in just a very few words. One of them is a yes-and-no answer. One, they can't find the geophone photos specifically called out in the transcript. There is apparently a little bit of garble at that point, and the people in the Backroom will be very happy if you could say once and for all, Jack, that, yes, you did get the geophone photos. Over.

161:30:04 Schmitt: Yes.

[Cernan - "This is typical of Parker and Schmitt. Jack would normally elaborate and this abrupt "Yes" was his way of getting back at Parker."]

161:30:05 Parker: Roger. And the second one concerns the 1/4-pound charge which we deployed on the way in last night. Two questions on that. It appears to us from your voice transcript - we weren't fast enough on it at the time - that that may be deployed closer to the ALSEP than the one you deployed on the way out. And we'd like an impression on that. And, number 2, you mentioned that you placed it in a depression. We'd like some feeling for that depression in

terms of how much of a danger that bomb...(correcting himself) "charge" might play to the ALSEP when it goes off. If it's in a depression of any sort, that's probably pretty well protecting the ALSEP. Any comment on those two questions? Over.

161:30:48 Schmitt: Well, (on) the second one, it's not in a major depression. But it is maybe a...It's a little dish, maybe a third of a meter deep. I imagine it will help a little bit. That's why we picked it. Just a second. (Pause) I'm not sure we understand your first question very much.

161:31:10 Parker: Okay. We have a feeling that when you...

161:31:12 Cernan: Bob, don't you have the mileages?

161:31:14 Parker: Roger. But there's again some confusion on that.

161:31:16 Cernan: Can't you pinpoint that?

161:31:18 Parker: Yeah, and those mileages also seem to indicate that...We had that callout; remember, you drove back by and you said you saw the flag (on the charge deployed at the star of the outbound drive), and then you said you actually saw the charge itself first. And it was some time after that you said you deployed the charge. And we have the opinion from both that and the mileage that you probably deployed the second charge closer to the ALSEP than the first one. Do you have any sort of a feel for that?

[On the outbound leg of the EVA 2 traverse, they passed south of the ALSEP just before the range clicked to 0.4 kilometers - a range of about 350 meters from the SEP transmitter - and placed the first charge (EP-4) prior to the click to 0.6 km (a range of about 550 meters) at a bearing position of 083. On the inbound leg, they spotted the "Italian flag" on EP-4 at a time of 147:01:36 and they placed the second charge (EP-8) at 147:03:19 just after the range indicator clicked down to 0.4 (a range of 350 meters) at a bearing of 081. The dialog then suggests that they approached the ALSEP from the southwest. This is the information available to Houston at the moment. Analysis of the locator photographs indicate that the second package (EP-8) was placed about 300 meters from the LM and 440 meters from the SEP transmitter. The first package (EP-4) is 550 meters from the SEP transmitter. Therefore, they deployed the second package closer to the ALSEP - about 140 meters versus 225 - and a bit further south.]

161:31:45 Cernan: (Skeptical) Ah, yeah; I remember saying that. But that's when I did a big 360, and Jack was out of film; and I just lined up to take that picture with the LM in the background. And when I said, "Hey, I saw the charge first," I was really...Don't take that comment too strong...

161:32:05 Parker: Okay. Copy that.

161:32:06 Cernan: ...as far as the position of it. Bob, we're looking for them out there now, as a matter of fact. We can't see them from here.

161:32:14 Parker: Okay. We'll let it go at that. And that's all the questions and comments we have on today's

traverse. We'll have a few real-time things on the surface, which I won't bother you with (now). A possible fix to the Surface Electrical Properties (flapping dust cover) and a possible trip back to the surface gravimeter, which is still having its problems. But I'll talk with you guys in real time on those when you get on the surface, rather than bothering you with them now.

161:32:39 Cernan: Hey, Bob. How far should that last charge be from the ALSEP?

161:32:43 Parker: They want it about 300 to 400 meters. (Long Pause) And, Gene, you gave 0.2 for range (to the SEP transmitter) when...

161:33:23 Cernan: Bob, I (garbled)... (Listens)

161:33:24 Parker: ...you got back to the LM. And I guess the question would be: Did you ever go through zero on the way back to the LM? If you were at 0.2, and we think 092 was the bearing, then the LM is right where it thought it was, and we were just a little confused by our distances. They don't quite hold together.

161:33:47 Cernan: No, I don't think I ever went through zero, because I initiated at the SEP.

[The SEP transmitter is east of the LM. Clearly, it is Houston that is confused.]

161:33:52 Parker: Okay.

161:33:53 Cernan: And, nah, I didn't go through zero.

161:33:54 Parker: Okay.

161:33:55 Cernan: I'm positive.

161:33:57 Parker: We copy that. Okay. We'll work on that.

34:00 Cernan: This is something to think about. It's not that far out there. You know, if there is any question about that thing damaging the ALSEP...It's just hard for us to recall how close they were. And we sort of thought you had them pinpointed for us. But, if you want it 3 to 400 meters, you might think about a late drive out there, just to make sure (garbled under Parker) ALSEP

161:34:22 Parker: No. We thought about that. We don't want to do that. No, we don't want to do that. So we'll take care of it. Don't worry about it now. That's all we have. Press on with the prep.

161:34:31 Schmitt: Hey, Bob; this is Jack. I can see the charge with the binocular (means "monocular"). It's out almost behind a rock that's between us and the LM, but I can see it. (Chuckles) I mean, a rock between it and the LM. I can't give you any idea, though, how far it is.

161:34:57 Parker: Okay.

161:34:59 Cernan: (To Jack) No, it's the one off to the left. (Pause) It's the (garbled)...

[Gene is correct. From their perspective, the charge on the left is EP-8, the one they emplaced at the end of the EVA. It is closer to the LM than EP-4, which they deployed at the start of EVA 2.]

161:35:03 Schmitt: Hey, Bob. Let me say again, I think we ought to emphasize the exotic looking fragments on the dark mantle. And we ought to try to make sure that we look at a variety of rocks from the North Massif. I think we saw the major rock types on the South Massif yesterday, but we really didn't spend a lot of time ranging along the front there to verify that completely. The other comment (is) on the 1- to 20-millimeter size fraction. There isn't an awful lot of that in the dark mantle. That's one of the striking things about it. In that size range there just isn't very much except chips of what appear to be - (based on) a comparable albedo, anyway, - of the subfloor gabbro.

161:35:57 Parker: Okay. Copy that. And...

161:36:01 Schmitt: But we'll keep our eyes open.

161:36:01 Parker: ...I'll talk with the back room about Stations 6 and 7. We'll get with you on that when you get there. And press on.

[Comm Break]

[Schmitt - "We hadn't planned to range along the base of the South Massif and didn't. And, in retrospect, we didn't do so badly in getting a fair variety at Station 2. Each of the three or four rocks we looked at in some detail was different. What we didn't get was which one was most representative. "]

161:37:38 Schmitt: Houston, Challenger. I was Biomed Right there for about 10 minutes, in case you're curious.

161:37:47 Fullerton: Okay, Jack. And it looked good.

[Comm Break]

161:39:21 Cernan: Okay, Bob. I've got them both (that is, the charges west of the ALSEP). And the last one we deployed, which I think is the easternmost one (correct), is definitely further out than the first one we deployed (incorrect). And, you know, to judge distance is awful hard, but looking at Jack's geophones...(To Jack) What's your...(Pause) (To Parker) I got to give you at least 300 meters, Bob.

[As indicated at 161:31:18, the second package (EP-8) is about 140 meters from the geophone module. The first package (EP-4) is farther west and is about 225 meters from the geophone module. If Gene's 300 meters refers to the distance of the second package to the geophone module, his distance estimate is way off.]

161:40:04 Fullerton: Okay, Geno. Bob's in the back room. I'm sure they're listening, and we got that.

161:40:11 Cernan: Yeah, I've got both of them with the monocular now. And the second one, the last one we deployed, is quite a bit farther out than the first one.
161:40:22 Fullerton: Okay. I think that's what they want to hear. (Long Pause)
161:40:54 Cernan: Gordo, I guess it's half again or maybe even twice as far away as the first one we deployed. So we're going to forget it.
161:41:03 Fullerton: Okay, Geno. That sounds good. (Pause)
161:41:11 Cernan: And, Gordo, I'm going off the air also here for about 10 minutes. It'll speed things up a little bit.
161:41:17 Fullerton: Okay. Fine.

[Very Long Comm Break. They are getting out of the Constant Wear Garments, into the Liquid Cooled Garments, and then the suits.]

[Cernan - "During these long comm breaks we were just busy doing things. You could always listen but, unless you were on VOX, it was sometimes inconvenient to key the switch to tell what you were doing. It was more efficient to just get it done. You know they're there and that you can talk to them if you need to."]

161:52:50 Cernan: Houston, Challenger. CDR's now back on. (Pause)
161:52:54 Fullerton: Okay, CDR. You're loud and clear.

[Long Comm Break. It appears that they are working partly in parallel, rather than getting Jack into his suit first and then Gene.]

161:57:42 Schmitt: Okay, Houston. This is the LMP from Challenger. How do you read?
161:57:47 Fullerton: Jack, you are loud and clear.

[Very Long Comm Break. By the end of this break, they are both in their suits. While Jack does the battery management, Gene may be getting unneeded items stowed and out of the way.]

162:25:58 Schmitt: Okay, Houston. I'm ready for battery management, and the ED Batts are 37.2 (volts). And I'm going to Power Amp, Primary, and TM (Telemetry), High (bit rate). (Long Pause)
162:26:28 Schmitt: Hello, Houston. How do you read Challenger?
162:26:30 Parker: Okay. We have high bit rate now. You're Go on the battery management.
162:26:38 Schmitt: Okay.

[Comm Break]

162:28:13 Parker: (Watching telemetry on the batteries)
 Okay. We've got that. We're ready for Power Amp, Off, and
 PCM (Pulse Code Modulation), Low (bit rate).

[Comm Break]

162:29:48 Cernan: Bob, CDR's PRD (Personal Radiation
 Dosimeter) is 17043. 17043.
 162:29:58 Parker: Copy that, Gene. (Long Pause)
 162:30:44 Cernan: And Jack's is 24138.
 162:30:49 Parker: Roger. Copy that.

[Comm Break. They are now on Surface 6-2.]

162:33:36 Schmitt: Okay, Houston. CDR's OPS is 5900 (psi);
 LMP's is 6100.
 162:33:43 Parker: Okay. Copy that. Very good.

[Long Comm Break. By now, they've checked the OPS
 pressures, have donned their watches and wrist mirrors, and
 have gotten the helmets, gloves, and LEVA's out into easy
 reach so that, once they have the PLSS's on, they can get at
 the other gear without having to do much turning or bending.]

162:40:58 Cernan: Gordy, the forward hatch is unlocked.
 162:41:01 Parker: Copy that.
 162:41:07 Cernan: I'm sorry, Bob, (for not having noticed
 the change in CapCom).

[Long Comm Break. They have just finished the lefthand
 column of Surface 6-2. First, they will get Jack into his
 PLSS and then Gene into his.]

162:49:31 Cernan: Bob, CDR is starting on with the PLSS
 donning. (Pause)
 162:49:44 Parker: We copy that, Geno. And we copy the
 forward hatch unlocked, right?
 162:49:53 Cernan: Yeah. Sure do.

[Cernan - "My PLSS was stowed on the port bulkhead at my
 left shoulder with the (U.S.) flag outboard so that I could
 just back into it. I'm almost positive that Jack's was
 stowed on the floor by the hatch with the flag up and the
 surface that interfaces against the body down against the
 deck. There were some interim stowage bags hanging in front
 of the Commander's PLSS which we just threw in the back to
 get them out of the way."]

[Long Comm Break; static. At the end of PLSS donning,
 they put on their RCU's and connect the PLSS control cables
 to it. These steps are on Surface 6-3.]

162:53:36 Parker: Challenger, Houston. We've lost down-link from you guys. We've got a very weak signal. You might check your configuration up there, please. (Pause)
 Challenger, Houston in the blind. We've lost down-link from you. Please check your comm configuration. Over.
 162:54:06 Cernan: (Faint) Roger, Bob. We're checking.
 (Long Pause)
 162:54:41 Parker: (Static clears) Okay, Challenger. We have you back loud and clear.
 162:54:50 Schmitt: Okay, Houston. That's...(Listens) Okay. It looks like I might have hit the Yaw knob on the steerable (antenna) with the PLSS.
 162:54:54 Parker: Okay. Copy that. (Long Pause)

[Cernan - "He had a signal strength meter and control knobs for pitch and yaw so that he could tweak up the signal. He must have hit one of the knobs."]

162:55:11 Parker: Okay. And, Jack, if you want to check those again for (steerable antenna pointing) numbers, it's Pitch of one-four and Yaw of eight. Zero-eight.
 162:55:29 Schmitt: Bob, that doesn't jibe with what my needles say. I've got a two-zero and five-zero.
 162:55:43 Parker: Leave them there. We'll check with you.
 162:55:48 Schmitt: That's minus five-zero.

[Comm Break]

162:58:20 Parker: And, Jack, this is Houston. What's your Signal Strength meter reading there on your high gain, next time you get around to it?
 162:58:30 Schmitt: We're at 3.8. It's not quite as good as it was. We had about 3.9, I think.
 162:58:35 Parker: Okay. Ed (Fendell) thinks maybe you're on a sidelobe, and he's suggesting a Pitch of fourteen - one-four - and a Yaw of plus eight. Over.
 162:58:46 Schmitt: Okay. I'll try it.

[Cernan - "On the surface, our antenna pointing didn't change but, throughout the flight when we changed attitudes, they would give us pitch and yaw for the (high-gain) steerable. This was true in the Command Module, too. If we were behind the Moon, they'd have given us a pitch and yaw so that when we came around the limb, we'd pick them up immediately."]

[Comm Break; static]

163:00:27 Schmitt: (Static clears) Bob, I'm in Auto right now, and it's holding at 3.8 with those numbers that I gave you. I can't...If I go to the numbers that Ed suggests, I get down to about point three (0.3) and it won't lock up in Auto.

163:00:40 Parker: Okay, we noticed that. Let's just leave her there, please. (Pause) Go to Slew, please.

[Schmitt - "All through this prep, it sounds like we had a pretty good rest. Compared with how we sounded at the end of the second EVA, it had obviously done us some good. Geno may not sound as rested as he has at other times, but I sound pretty normal."]

[Cernan - (Tongue in cheek) "Once you experience the responsibility of command, you realize that you never get as much sleep as the crew does. The crew's welfare comes first, before your own personal comfort."]

[Comm Break. By the end of this break, they have both PLSS's on and both RCU's connected and are about to start the comm check with each other and with Houston. As they come back on comm, they are doing the last two lines on Surface Checklist page 6-3. Recall that they aren't actually using the Surface Checklist but, rather, cue cards which they have mounted on the panel at the front of the spacecraft. The cue cards contain the same steps as do the pages in the Surface checklist.]

163:03:04 Cernan: (To Jack) VOX Sens(itivity setting) at Max. A, T/R; and B is Receive. On (circuit breaker panel) 16, your breaker open and connect to PLSS comm. (Pause) Okay, connect the PLSS comm and then put your breaker in. (Long Pause) (Garbled) (Pause)

163:04:09 Cernan: Okay. (On) your PLSS comm, Audio breaker, Closed. Okay, PLSS PTT Main right, verify, and go Mode (switch) A.

163:04:21 Schmitt: Okay.

163:04:22 Cernan: Okay, I got you. You'll get the tones (on), vent flag, press flag, and 0 flag.

163:04:26 Schmitt: Okay.

163:04:27 Cernan: Call Houston and give them your 02 reading.

163:04:30 Schmitt: Okay, Houston. This is the LMP on Mode A and my oxygen is nine-four (that is, 94 percent).

163:04:42 Parker: Copy that, Jack, you're loud and clear.

[Jack is unable to hear Houston in this configuration.]

163:04:47 Schmitt: Okay. I'm getting a little bit of a squeal on the initiation of my transmission.

163:04:52 Cernan: Yeah. I hear that too, but it's loud and clear here. Okay, I'm going mine open. (Pause)

163:05:03 Parker: And LMP PLSS data looks good down here. (Long Pause)

163:06:01 Cernan: (Hearing the PLSS warning tone) Yeah. There's the tone. There's a press flag and a vent flag.

[The flags indicate that the suit is unpressurized and that the sublimator is not in operation. They also show that the warning system is working.]

163:06:05 Schmitt: And you're...
 163:06:06 Cernan: And 02.
 163:06:08 Schmitt: (Garbled) you're loud and clear.
 163:06:10 Cernan: Okay. Okay, I cannot hear Houston but, Houston, this is CDR with 91 percent.
 163:06:18 Parker: Roger, CDR. And, LMP, we read the CDR loud and clear. We have good LMP medical data.

[Now, it is Gene who can not hear Houston. They are near the top of the righthand column of Surface 6-4.]

163:06:27 Schmitt: (To Gene) Okay, you're loud and clear and they got good data on me.
 163:06:30 Cernan: Okay, you go B and I'll go A.
 163:06:34 Schmitt: Okay, going to B.
 163:06:38 Cernan: Okay, how do you read me?
 163:06:39 Schmitt: You're loud and clear. Houston, this is the LMP in Bravo. How do you read?
 163:06:44 Parker: Roger. We read the LMP loud and clear.
 163:06:49 Cernan: Okay, Bob. And how me?
 163:06:50 Parker: Read you loud and clear also, Gene. And we have good medical data on you, Gene.
 163:06:56 Cernan: Okay, Jack, let's go AR.
 163:06:58 Schmitt: Okay, going to AR.
 163:07:01 Cernan: Okay, Houston, how do you read CDR?
 163:07:03 Parker: Loud and clear on AR.
 163:07:09 Schmitt: And the LMP?
 163:07:10 Parker: Also loud and clear on AR.
 163:07:14 Cernan: Okay, Jack, Squelch VHF B, full decrease.
 163:07:18 Schmitt: Decrease.

[They have finished the comm check and are about to start the ECS reconfiguration steps on Surface 6-5.]

163:07:19 Cernan: Okay. On (circuit breaker panel) 16, our LCG Pump (circuit breaker) is Closed.
 163:07:21 Schmitt: Yup.

[They are circulating LM water through the LCG's.]

163:07:22 Cernan: On 16, Cabin Repress (circuit breaker), Closed, verify.
 163:07:24 Schmitt: It's verified.
 163:07:25 Cernan: Suit Fan Delta-P, Open, and Suit Fan number 2, Opened.

[They are shutting off the fans in the Suit Circuit and a sensor that detects a pressure difference across the fans when they are in operation.]

163:07:29 Schmitt: Open and Open.
 163:07:30 Cernan: Okay, (because the fans are off), we should get a (caution) light in about one minute. Stand by for that. Okay, Suit Gas Diverter (valve) to Pull - these are "verify" - Pull-Egress.
 163:07:38 Schmitt: Okay, Pull-Egress.
 163:07:39 Cernan: Cabin Gas Return (valve), Egress.
 163:07:40 Schmitt: Okay, Houston. You want us to go by the checklist now on the ECS system?

[Jack is remembering the troubles they had before the rest period with a small leak in one of the Demand Regulators. After testing, Houston had them open and close the valve in an effort to get it to reseal. It did and the leak disappeared. This is a good example of the attention that he and Gene paid to details that Houston sometimes forgot. There is nothing like being the person on the spot to focus one's attention.]

163:07:47 Parker: Stand by. (Pause) Roger. As per the checklist.
 163:07:53 Schmitt: Say again. You didn't come through.
 163:07:55 Parker: Roger. As per the checklist.
 163:07:55 Schmitt: Okay, Egress on Cabin Gas Return (Valve).
 163:08:00 Cernan: Okay, that's Suit Gas Diverter (Valve), Egress; Cabin Gas Return (Valve), Egress.
 163:08:03 Schmitt: Egress and Egress.

[Here, they are isolating the ECS Suit Circuit from the cabin.]

163:08:04 Cernan: And Suit Circuit Relief (valve), Auto.
 163:08:05 Schmitt: Auto.

[The relief valve will open only if the Suit Circuit pressure exceeds 4.3 psi, dumping the excess oxygen into the cabin and, thereby, out the hatch and/or one of the dump valves. they are about to being the righthand column of Surface 6-5.]

163:08:07 Cernan: Okay, OPS connect; you're first. Suit Isolation (Valve), Actuator Override in (the) Suit Disconnect (position).
 163:08:11 Schmitt: Okay, that's done.
 163:08:13 Cernan: Your hoses are stowed?
 163:08:14 Schmitt: They're stowed.
 163:08:15 Cernan: Okay, connect your OPS hose, and I'll get you (purge valve) number 211.
 163:08:19 Schmitt: Let me turn around so I don't...
 163:08:20 Cernan: Okay.
 163:08:21 Schmitt: That'll do it. Keep hooking this water hose here.
 163:08:24 Cernan: (Purge valve) 211 is yours. 208 is mine. (Pause)

163:08:35 Cernan: Okay, the (purge valve connector) pin is in. It's closed, you're in Low Flow. Believe it or not, it still works.

[Schmitt - "There were two settings on the valves. Low Flow was for make-up and High Flow was for use if you had a hole in the suit."]

163:08:43 Schmitt: You want any more (drinking water)?

163:08:44 Cernan: Yeah, I do. (Pause)

163:08:57 Schmitt: Okay, are you through with it?

[Cernan - "It isn't in the check list but, while I was putting in his purge valve, he might have taken the water gun to get a drink, just to saturate himself." See, also, the confirming statement at 163:11:51.]

163:08:58 Cernan: I think so. (Pause) (Garbled) right now. (Garbled)

163:09:08 Cernan: I can get down there, if you can't, Jack.

[Cernan - "I don't know if he dropped the water gun or I dropped one of his hoses."]

163:09:09 Schmitt: (Garbled). I can reach it. (Pause)

163:09:18 Cernan: I'll get it; I can reach it. (Pause)

Okay, let's get your OPS hose. (Pause) OPS hose. OPS hose, it's way down here. That's your water hose. Here's your OPS hose. (Pause) Now, let's get the dust cover on it. The OPS hose is going in. I verify its locked and the lock-lock is in. Cover's up, and we'll take another look at them. Okay. (Pause)

163:09:56 Schmitt: Okay, we got the Master Alarm. Water Sep(arator warning light). (Garbled) pre-amps. Sluggish one.

[At 163:07:25 they'd turned off the fan in the ECS suit circuit and here, two minutes later, the Caution-and-Warning System is confirming that the centrifugal water separator has spun down and is no long operating. As with other instances, this is primarily a test of the warning system.]

[Cernan - "Maybe someone would think, 'Master Alarm! Emergency liftoff'! But, with all these reconfigurations, we'd get them periodically."]

163:10:08 Cernan: But it's in and it's locked and locked, and you're on...Okay, that's high, that's...You're on Low Flow. Pin is in and everything's locked. Okay. (Reading) Retrieve Purge Valve, close, lock, (garbled). Install Purge Valve. (PGA) Diverter Valve, Vertical."

163:10:29 Schmitt: Okay.

[With the PGA Diverter Valve in the vertical (Closed) position, all of the oxygen flows into the suit at an upward

pointing vent at the back of the neck. With the Diverter in the horizontal (Open) position, some of the oxygen would enter the suit through vents in the chest cavity.]

163:10:30 Cernan: Okay, you want to...

163:10:31 Schmitt: Vertical.

[They are now finished with Jack's purge valve, his OPS hose, and his PGA diverter valve. They will now repeat the procedure for Gene.]

163:10:31 Cernan: ...pick up my OPS hose. (Pause)

163:10:32 Schmitt: It's your OPS hose time. (Garbled)...

163:10:40 Cernan: Put it on top. I put yours on top. That's probably as good as anything. I'm not sure it makes any difference.

[They are talking about hose routing under Gene's right arm.]

163:10:45 Schmitt: Okay, you're over and locked; and dust cover...Verified.

163:10:55 Cernan: Okay.

163:10:56 Schmitt: And the comm? (Garbled) Here it is. That one's locked, verified.

163:11:00 Cernan: Here's the purge valve; and it's number 208, I hope.

163:11:06 Schmitt: No, you wanted 211.

163:11:07 Cernan: No. I wanted 208. I want 208 and you want 211.

163:11:12 Schmitt: No. I'm sorry. That's what I copied down.

163:11:15 Parker: Roger. 211 for the LMP

163:11:15 Cernan: Verify that, will you, Bob?

163:11:17 Parker: 211 for the LMP.

163:11:18 Cernan: That's right. That's...(Listens)

163:11:23 Schmitt: Okay. That's what he's got. Somehow I copied the wrong one.

163:11:24 Cernan: Okay, give me 208. Same thing we had yesterday.

163:11:26 Schmitt: Well, I didn't remember from yesterday, and that's what I thought Gordy said. Okay. That's in, locked, verified.

163:11:40 Cernan: On Low?

163:11:42 Schmitt: On Low and the pin's in.

163:11:45 Cernan: Okay.

163:11:47 Schmitt: Let me check this one. Good. Locked.

163:11:48 Cernan: Okay.

163:11:49 Schmitt: All right.

163:11:51 Cernan: Okay. We just had our drink. You can turn (the) Descent Water (valve), Off.

163:11:55 Schmitt: Okay, Descent Water is Off.

163:11:56 Cernan: And my hand lub(ricant) is all prepared.

163:11:59 Cernan: You get the scissors in the ETB? I think we finished up with that.

163:12:04 Schmitt: They're in there.

163:12:05 Cernan: Okay. Position mikes.

163:12:08 Schmitt: Okay.

163:12:09 Cernan: Okay. Here we go again, let's take a look at it. (Reading) "PLSS Fan (switch) will come On. Don helmets and LEVA's. Drink bag, position. Lower LEVA protective visor, and secure tool harness straps." Let's verify the following, then we'll go ahead and put your PLSS Fan, On, and get your helmet, and you can put mine on.

[The tool harness straps attached to the outside of the LEVA on either side of the helmet. The attachment on the right side of Gene's helmet is visible in AS17-140-21390 taken early in this EVA and, also, in the formal, flag-and-earth portrait AS17-134-20387 taken at 118:26:18.]

[Cernan - "I think that these straps were attached there so that we could do a quick release in case we had to get in (the cabin) in a hurry."]

[Next, they do steps at the top of 6-6 - verifying all their suit connections - before completing the helmet donning at the bottom of 6-5.]

163:12:27 Schmitt: Okay, going through one more time. Your electrical connector and it's locked. And your OPS is locked, covered. You don't have (cooling) water yet. Exhaust is locked, covered. Inlet is locked and covered. Purge is locked and (in) LOW (Flow).

163:12:50 Cernan: Okay. And vertical on the (PGA) Diverter Valve.

163:12:52 Schmitt: That's right.

163:12:55 Cernan: Okay, let me take a check (of Jack's connectors). Comm is locked and covered. OPS is locked (pause) and covered. PLSS exhaust is locked and covered. Inlet is locked and covered. You're vertical. Purge valve is locked and Low. Okay, let me get your helmet here.

163:13:24 Schmitt: Let's look at one thing here, Geno.

[For the next half minute or so, they are probably checking the sunshades of Jack's LEVA.]

163:13:26 Cernan: Let me put this up here. Get it out of the way, because that's half the battle. What do you want to look at?

163:13:34 Schmitt: That shade. (Garbled) mean to check it.

163:13:40 Cernan: That's what mine looks like. They're all stiff. Mine is a little stiff, too, it'll come, if you pull. If need be, I can pull it down for you.

163:13:48 Schmitt: Yeah. Okay.

163:13:49 Cernan: I can get that one up and out of the way. Okay. As soon as I get this (helmet) over your head, you can put your PLSS fan on. Okay, now, let's watch out for all your paraphernalia (food stick, drink bag, microphones)

there. (Pause) Can you pull that stuff away from there?
(Pause)

[To get something out of the way, Jack would have to use his teeth.]

163:14:21 Schmitt: Okay. (Long Pause as Gene gets Jack's helmet on)
163:14:45 Cernan: Well, not yet. Let me undo this.
(Pause)
163:14:55 Schmitt: (Garbled) problem?
163:14:56 Cernan: I just want to make sure I get my fingers on this thing, and make sure it's locked. (Pause) (Garbled) Do it.
163:15:10 Schmitt: That's it.
163:15:11 Cernan: There, that got it. (Pause) Okay, that should have it. Get your fan on here in a minute. Okay, you got your (PLSS) fan on?
163:15:32 Schmitt: Fan's On.

[The fan control is on the RCU.]

163:15:34 Cernan: Good. Okay, I want to verify it right now. Your helmet is locked. It's aligned. (Pause as he feels the neckring) It's aligned. It's locked.

[Cernan - "When you snapped your helmet in, there was an L-shaped lip and you wanted to make sure that overlapping piece was flush. So, when you felt all the way around, if it wasn't snapped in properly, you could feel it. If it wasn't flush, that would indicate that it had gotten in kattiwampus - that it may have locked the front but it didn't snap in and lock in the back. It was easier for us to feel each other's and it was very important to get the helmet on right. So we double verified it, just like we verified all those things. You don't want to go out with half a spacesuit. You don't want to have one little flaw, one little leak that might compromise your safety or your ability to get the job done."]

163:15:50 Cernan: Flaps are down in back. Your LEVA is locked. (Pause) Your fan's on, right?

[Cernan - "The LEVA didn't shift around very much, but it did have a little lock to keep it in place."]

163:15:59 Schmitt: Uh-huh.
163:16:00 Cernan: Okay, let's pick mine up. (Pause)
163:16:05 Schmitt: Okay. (Long Pause) Okay, you ready?
163:16:41 Cernan: Uh-huh. (Pause) See if you can feel that rim all the way around.
163:16:51 Schmitt: Wait a minute.
163:16:53 Cernan: What (are you doing)?
163:16:55 Schmitt: Well, let me...Either you...(Long Pause)
163:17:16 Parker: And, Geno, we don't see your fan on yet.

163:17:22 Cernan: It'll come on, Bob.
163:17:23 Schmitt: There, it's locked.
163:17:24 Cernan: Okay, are the engage marks marked?
163:17:26 Schmitt: Well, they are now.
163:17:27 Cernan: Okay.
163:17:28 Schmitt: That's in alignment only.
163:17:30 Cernan: Okay, Bob, my fan's on. (To Jack) It is locked? Look good to you?
163:17:34 Schmitt: Yeah. Fine.
163:17:36 Cernan: Okay. Get the LEVA locked. (Pause) The curtain down in the back?
163:17:45 Schmitt: Yeah. Velcro...(Pause) Okay. Looks good.
163:18:02 Cernan: (Finding his place on Surface 6-6) Okay, where are we here? Verify white dots plus EVA decals and then you can don your gloves.
163:18:05 Schmitt: Okay.

[They are going to verify that they haven't hit any circuit breakers or switches.]

163:18:07 Cernan: Okay. Why don't you turn that way and let me turn this way? Okay, Jack, I'm going to turn these lights off.
163:18:16 Schmitt: Okay.
163:18:14 Cernan: We don't need those.
163:18:17 Schmitt: Okay. EVA decals, white dots.
163:18:23 Cernan: Okay, Urine Line Heater's going to come off, and the breaker's out. Okay. (Pause)
163:18:37 Schmitt: Okay, I'm ready except for (turning off the) LCG pump.

[They are staying on LM water for cooling for as long as possible. Jack will turn off the LCG pump at 163:23:15. They won't turn on their PLSS cooling until the hatch is open at 163:25:31.]

163:18:41 Cernan: Okay, leave it on. We can don our gloves now.
163:18:42 Schmitt: Okay.

[Comm Break]

163:19:53 Schmitt: Okay, right glove's locked and verified. (Pause) Okay, and the wrist cover on there...On. Gauntlet's down. (Wrist) mirror's very dirty. Boy, do I need a shave. (Laughter)

[Cernan - "We each had a stainless steel mirror on a Velcro strap. Mine was on my right wrist. The mirror was as much a part of the spacesuit as the watch was. We wore mirrors from Gemini right on through the whole program. It was the only way you could see the connectors on the front of your suit and, as I remember, things were written backwards

so you could read them in the mirror. You could use the mirror to see things above you, behind you. We found it was invaluable in Gemini but they were afraid of glass so we had polished stainless steel mirrors. It was a square mirror, maybe three by three inches."]

[The strap on Gene's right wrist is visible in AS17-134-20380 taken at about 118:23:20. There appears to be a similar strap on Jack's right wrist in AS17-134-20425, part of Gene's Station 1 pan. The Apollo 17 packing list includes "wrist mirror" for each of them.]

163:20:32 Cernan: Okay. I got all mine down.

163:20:35 Schmitt: You all set?

163:20:36 Cernan: Well, I got my left hand. Got the left hand. Now, let's see what I can do with the right hand.

(Pause)

163:20:49 Schmitt: Almost tempted to take those cover gloves off today.

[The cover gloves are fingerless and are worn to protect the suit glove. Gene and Jack had planned to discard the cover gloves at the end of the first EVA but, because the cover gloves were getting worn, it seemed prudent to leave them on and postpone damage to the suit gloves for as long as possible.]

163:20:53 Cernan: I might take a look at that, too. I hate to argue with success, but I need that dexterity today.

(Pause) Bob, I don't know if you caught it yesterday, (but) a little interesting facet of the whole 2-EVA exercise was the fact that I've already worn a... (Comm drop out; pause)

163:21:33 Parker: Gene, you dropped out there right in the middle. (No answer; Long Pause)

163:21:47 Parker: Challenger, Houston. You dropped out there. (Long Pause)

163:22:10 Cernan: Okay, Bob. How do you read now?

163:22:12 Parker: Loud and clear, Gene.

163:22:15 Cernan: Okay, I hit the VOX switch on my audio panel.

163:22:16 Schmitt: You did!?

163:22:20 Cernan: Yeah, when I picked up my glove. Okay, Bob, the only thing I said - a little point of interest - I wore the RTV off the... Not all of it, but right through to bare metal on the hammer sometime in the previous 2 days. No problem; it just interests me.

[Cernan - "I used the hammer so much that, in some spots on the handle, I literally wore off the RTV coating. You can surmise anything you want from that: I was squeezing it to death; or I was holding it loose and it was slipping back and forth in my hand; or whatever."]

163:22:42 Parker: Okay, copy that. And copy that you still have you cover gloves on today, right?

163:22:48 Cernan: Yes, sir! I'll tell you, we have become very respectful of the dust.
 163:22:54 Parker: Copy that.
 163:22:55 Cernan: Oh, yeah, cover gloves, yeah...We've also got the wrist dust covers on, too.
 163:23:03 Parker: Roger. Strike a blow for Mason jar rings.
 163:23:04 Cernan: And what's left of the cover gloves.

[Like the RTV coating on the hammer handle, Gene's cover gloves are very worn. He and Jack will discard their cover gloves during the Rover preps on this EVA. at 163:48:11.]

163:23:08 Cernan: Okay, Jack, you on?
 163:23:12 Schmitt: I'm on.
 163:23:13 Cernan: And locked?
 163:23:14 Schmitt: And locked.
 163:23:15 Cernan: Well, I got my thing on; I want to make sure I'm locked again. (Pause) Yeah, I am. I took it off again. Well, I was. Talking and you just do things...Okay. (Reading cue card, same as Surface 6-6) "Don EV gloves...(skipping forward in the checklist) Cover (wrist rings)..." Okay. PGA biting? No. Okay. "LCG cold as required", and then "LCG Pump (circuit breaker), Open". I guess you can open it. (Pause) And disconnect the LM...
 163:23:42 Schmitt: Okay. LCG pump.
 163:23:45 Cernan: ...Water hose.
 163:23:46 Schmitt: And I got a tone but that's because I turned my oxygen on briefly.

[Here, Jack is putting a little pressure in his suit to keep it from collapsing around him because of breathe-down. Gene will put a little pressure in his suit at 163:24:54. The Apollo 12 crew had noted this problem in their post-mission technical debriefing and suggested this fix. Gene and Jack will fully inflate the suits for the pressure integrity check at 163:26:46.]

163:23:50 Cernan: Okay.
 163:23:52 Schmitt: Okay, Pump (breaker)'s Open. (I'll) turn around here and help you.
 163:23:55 Cernan: You can take the water off.
 163:23:58 Schmitt: Water's off. Or the pump's off. Okay, your (LM) water (hose)'s off.

[Next, Jack will connect Gene's PLSS water hose.]

163:24:06 Schmitt: Stick that (LM water hose) there for a minute. (Pause) Okay, hang on. Okay, you're in and locked. Locked over nicely. Okay.

[And, then, Gene connects Jack's PLSS water hose.]

163:24:26 Cernan: Okay. (Pause) You're off. I'll lay that (LM water hose) there. Where's your (PLSS) water? Here it is way over here. (Long Pause)

163:24:49 Cernan: Hold on. (Pause) Okay. And it locked, and your (dust) cover's on. I got to zap my PGA. Wait a minute, I'm biting here.

163:25:14 Schmitt: Okay. Well, let me try to stow this (LM water hose). (Pause)

163:25:32 Cernan: Okay. (Pause) "Verify your PLSS (feed)water's Min when you get a chance."

163:25:38 Schmitt: Okay, that's verified. Did that a minute ago.

163:25:41 Cernan: And mine's verified and your (PLSS LCG) pump on.

163:25:47 Schmitt: Okay, Pump's going On.

163:25:52 Cernan: Mine On. "Pressure Reg(ulators) A and B to Egress."

163:25:54 Schmitt: Okay, they are Egress.

163:25:57 Cernan: Okay, pressure integrity check. (Pause) Ready?

[They are now at the top of the righthand column of Surface 6-6.]

163:26:05 Schmitt: Let me (garbled).

163:26:06 Cernan: Okay. (Pause)

163:26:13 Schmitt: Awful lot of line there, isn't there?

163:26:15 Cernan: Uh-huh.

[Schmitt - "There were some gold-colored, yard-long lines connected to the utility lights and, since the clamps were outside on the fender, the lines may have been dangling. Or, I could have been referring to the LM hoses."]

163:26:18 Schmitt: Don't know exactly what to do with it. (Pause)

163:26:27 Cernan: (Garbled)

163:26:30 Schmitt: Okay. All right. You happy?

163:26:32 Cernan: Yep. "Pressure Regs A (and) B, to Egress."

163:26:35 Schmitt: They are Egress.

163:26:36 Cernan: Okay. Put your PLSS 02 water (means oxygen)...

163:26:40 Schmitt: No.

163:26:42 Cernan: ...On, now. Mark it.

163:26:43 Schmitt: PLSS 02, On?

163:26:45 Cernan: PLSS 02, On. Right?

163:26:46 Schmitt: Okay, it's on.

163:26:47 Cernan: Okay, and mine's on. We'll wait till it builds us up. Press flag should clear at 3.1 to 3.4 (psi), 02 flag'll clear at 3.7 of 4.0. (Pause) Okay, I'm coming up (in pressure). (Pause) Hope the old suit integrity is just as good as it has been. I don't see why not. (Long Pause)

[Schmitt - "I will always be surprised that the suits held up as well as they did to the abuse we gave them. Just think about what we were doing and the dust environment we exposed them to. We tried to clean the bearings and plug the holes (that is, the connectors) and things like that; and they really did well, just like everything else we had in the Apollo program did better than anybody ever expected it to. And I think that just goes back to the motivation of the people who were building it and testing it and flying it. It makes a lot of difference if people believe it's the most important thing they're going to do in their lives and they don't want to be responsible for screwing it up."]

163:27:48 Cernan: Coming up?
 163:27:50 Schmitt: Yep. (Pause) About 3.5 now.
 163:28:03 Cernan: Yeah, me too. (Pause) Okay, let me know when you are up.
 163:28:12 Schmitt: I think I'm up; I'm 3.8.

[Next, they will turn off the flow of oxygen into the suits so they can check for pressure integrity.]

163:28:13 Cernan: Okay, let's see if we can't get the... (Pause) Want me to get yours? I can.
 163:28:24 Schmitt: I got it
 163:28:26 Cernan: (Turning off his oxygen for the integrity check) Okay, mine's Off.
 163:28:27 Schmitt: Mine's Off.
 163:28:27 Cernan: Mark it. We wanted decay for 1 minute.
 163:28:32 Schmitt: Okay, I started at 3.83 (psi).
 163:28:35 Cernan: Okay. That's about exactly where I was. (Pause) Another 45 seconds to go.
 163:28:43 Schmitt: Okay.
 163:28:44 Cernan: So far, it looks as tight as it was yesterday. (Long Pause) Another 30 seconds. (Pause)
 163:29:11 Schmitt: Maybe lunar dust is a good sealant. (Pause)

[After getting out of their suits the night before, they cleaned and lubricated the zippers, seals and connectors as best they could. Under the conditions, it is not surprising that they weren't able to get everything completely clean. Consequently, there was still some dust in the connectors and mixed in with the lubricant. Jack is marveling that the suits aren't leaking more than they are.]

163:29:28 Cernan: Houston, CDR (garbled) 3.82 to (misreading) 2.70.
 163:29:32 Schmitt: 2.70? 3.70.
 163:29:34 Cernan: 3.70.
 163:29:35 Parker: Understand 3.70.
 163:29:37 Schmitt: Okay, LMP was (3.)83 to 70.
 163:29:49 Cernan: Okay, Jack. You can get your 02 on.
 163:29:52 Schmitt: It's on.

163:29:53 Cernan: Okay. Can you move to the left - a little bit to your left? I got to get in front here.

[Schmitt - "Gene was going to lean down to get the hatch. I was facing him and he wanted me to lean toward the rear of the spacecraft to maximize the room he'd have to get down. It was tough to get down there and get a hold of the hatch."]

[Cernan - "Once we had the suits up to 3.8, we moved around like tin soldiers. 'You move a little bit, and I'll move a little bit.' From this point on, where you've got two people with the pressurized suits and the PLSS's on and the hoses on, a guy moving six inches left or right or six inches fore or aft meant a great deal to the ability of the other guy to reach something."]

163:29:57 Parker: Okay, you're Go from here...

163:29:58 Cernan: Okay, let me turn this (cue card) over.

[They are in the middle of the righthand column of Surface 6-6.]

163:30:00 Parker: 17, you copy Go.

163:30:05 Cernan: Okay, stand by. (Pause) Okay, Heck of a time to have to turn the checklist over. Okay, we've got a Go for depress. On (circuit breaker panel) 16, Cabin Repress (breaker) , Open, and Cabin Repress Valve, Closed.

163:30:17 Schmitt: Okay.

[Jack is still facing Gene. The Cabin Repress valve is on his left and the circuit breaker panel is on the wall behind him.]

163:30:18 Cernan: (You need to get) the breaker open and the valve closed.

163:30:20 Schmitt: Okay, stand by. Can you give me a little room to...

163:30:24 Cernan: Let me...Okay, how's that?

[Jack needs to turn around to get the circuit breaker and Gene is probably leaning back to give him room to get around.]

[Cernan - "I can see in my mind Jack turning a little bit so that he could see the circuit breaker panel, and then his PLSS is hitting me right smack in the face."]

163:30:27 Schmitt: Okay. (Pause) Okay, Repress (circuit breaker) is Open.

163:30:34 Cernan: Okay. Now, why don't you face the wall over there and move in as close (to it as you can) and I'll get the overhead valve.

163:30:38 Schmitt: Wait a minute, I've got to close the (ECS) Repress valve. You got it all right. Okay, it's Closed and I'll get where I was yesterday.

163:30:47 Cernan: Okay.
 163:30:49 Schmitt: How's that? (Pause)

[Cernan - "Jack is getting as far over on his side (and as far forward) as he can, so that I can get back and up to get the overhead valve.]

163:30:55 Cernan: We'll find out in a minute.
 163:30:58 Schmitt: Okay.
 163:31:01 Cernan: I've got to get my PLSS...

[Gene is now turning to his right, putting his PLSS against the circuit breaker panel on the left wall so that he can reach up with his right arm.]

[Cernan - "The shoulder bearing really restricted your movements and I may have even been up on my tiptoes to get high enough. If we had been in a round room or a square room it might have been different. But we were in a room with all kinds of shapes and corners in our way. And we, ourselves, were very bulky and non-conforming shapes."]

163:31:02 Schmitt: Can you get it?
 163:31:07 Cernan: Well...
 163:31:09 Schmitt: Okay, wait a minute.
 163:31:13 Schmitt: I can turn with my back to the wall and you might have a little more...
 163:31:16 Cernan: Well, I think...I feel like I'm hooked on something. Wait. I can't turn either way. Stay where you are. (Pause) There. Okay. (Pause; straining to reach) Okay, the safety (pin on the overhead valve is pulled)...Oh, boy, I'm glad I'm not an inch shorter. Okay, coming down, Jack. You ready?
 163:31:45 Schmitt: Go ahead, to 3.5 (psi).
 163:31:48 Cernan: Okay, it's Open.
 163:31:49 Schmitt: Okay, 4.5 - 4 - Stand by. Mark.
 163:31:56 Cernan: Auto.
 163:31:57 Schmitt: Okay, at 3.5.
 163:31:59 Cernan: Can you read the checklist?
 163:32:02 Schmitt: Okay, I can. Okay. Open, Auto. 3.5. Cuff checklist...(Realizing his error) Ah. (Chuckles) (I mean that the) cuff gage does not drop below 4.6. It hasn't.
 163:32:15 Cernan: Mine's good.
 163:32:16 Schmitt: Have to put your (left?) hand down. I can't read it (the cue card).
 163:32:18 Cernan: Okay.
 163:32:19 Schmitt: "Cabin is holding at 3.5. And suit circuit is locked up at 4.5 and PGA is decaying greater than 4.5." (It's) 4.6. Okay. Okay, Bob, I'm starting my watch.
 163:32:43 Parker: We're Go.
 163:32:44 Schmitt: Okay. You can go to Open (on the overhead dump valve).
 163:32:51 Cernan: Okay, it's Open.
 163:32:53 Schmitt: Okay, and (suit) pressure is going up. And the next step is, when you can, open the forward hatch.

163:33:02 Cernan: Okay, my suit's relieving. (Pause)
 163:33:09 Schmitt: (Cabin pressure is) down to almost 1.5 now. (Pause)
 163:33:22 Schmitt: One psi. (Pause)
 163:33:35 Cernan: Okay, my relief valve just seated at 5.3. Okay, where are we?
 163:33:41 Schmitt: We're at point five (0.5 psi).
 163:33:44 Cernan: I guess the next thing is to open the hatch, huh?
 163:33:46 Schmitt: Yup. (Pause)
 163:33:53 Cernan: I've got to get down out of 5 (psi suit pressure), too, here before I can turn too well and open the hatch. I'm going to let it come down a little bit this time so I don't get down there unnecessarily.

[Cernan - "At five psi you might just as well have been in a block of concrete. Going down to 3.7 or 3.8 gave me a lot of flexibility that I didn't have at 5 to get down and open the hatch. When you went down to open the hatch, you're literally straining against the suit. So I didn't want to get down until my suit was down. And, also, there was no point in getting down to get it until the cabin was down enough that you could open it."]

163:34:03 Schmitt: Yeah. It's got a ways to go yet. (Pause) About point three now. (Pause) Point two.
 163:34:41 Cernan: I've got a tone and it's (a) water tone (because he hasn't yet turned on his PLSS feedwater). Okay, I'm going to go after that hatch. (Pause) Can you slip to the right as far as you can? (Pause)
 163:35:04 Schmitt: Got it.
 163:35:06 Cernan: Got to hold it (open) until the pressure decreases.
 163:35:10 Schmitt: (looking out his window) All sorts of junk going out there. Ice. (Pause)

[Schmitt - "One of the big issues for any kind of permanent lunar habitat is going to be dust control. And it just occurred to me that the design of the air/dust lock ought to be such that, when you depress to go out on an EVA, the air currents remove the dust you brought in the last time. Never thought of that before, and I've been dealing with this - along with a lot of other people - for a long time. I ought to patent that idea."]

163:35:19 Cernan: Okay, now. Okay. It's partially open.

[Cernan - "Once I was able to open the hatch against whatever residual pressure there was, if I didn't hold it open the pressure would slam it shut again. So I had to hold it open until the cabin relieved totally."]

163:35:21 Schmitt: Okay, get your (sublimator feed)water if you can.

163:35:26 Parker: Okay, Jack. We'd like you to close Reg(ulator) A, please.
 163:35:34 Schmitt: Oh, close Reg A, huh?
 163:35:38 Parker: That's affirm.

[The regulators are normally set in the Egress position during EVA's. Evidently, Houston is having second thoughts about this regulator, which was the one that experienced the slow leak before the rest period.]

163:35:39 Schmitt: Okay, stand by. That's not an easy task (because the valve's behind me). (Long Pause) Reg A is Closed. Gene, can you get my (PLSS feed)water?
 163:35:45 Cernan: Yeah. (Long Pause)
 163:36:15 Schmitt: Did you get in there?
 163:36:19 Cernan: Okay, it's Open.
 163:36:20 Schmitt: Okay. LMP's water is Open. You got yours?
 163:36:22 Cernan: Yeah, I got mine.
 163:36:24 Schmitt: (Burps) Excuse me.
 163:36:25 Cernan: Well, let's see.
 163:36:27 Schmitt: Okay, you got it open, so I need to turn around. See if I can back in and (get) out of the way of the door.
 163:36:36 Cernan: Say, Bob. What did you see in Reg A?
 163:36:40 Parker: Stand by, Gene. We're seeing high suit pressures, stand by.
 163:36:47 Schmitt: High suit pressure?

[Parker meant to say "high suit-loop pressures" and, hence, the confusion.]

163:36:50 Parker: Okay, and...
 163:36:51 Cernan: Yeah, I'm seeing about...
 163:36:52 Parker: Challenger, Gene, you're Go to go out, and once you get out, maybe Jack can turn around and work on those a bit better. We're seeing, I guess, the suit loop's a little high in pressure.
 163:37:02 Schmitt: Okay.
 163:37:05 Cernan: Okay, I'm looking at about 4.7 on the suit loop right now.
 163:37:10 Parker: Okay; we copy that.
 163:37:11 Cernan: Okay, Jack. (Pause)

[Gene is starting to turn around so that he can get down, put his feet out through the hatch and back out of the spacecraft.]

163:37:16 Schmitt: There you go. (Long Pause) (Garbled). (Pause) Okay, turn. (Long Pause)
 163:38:01 Cernan: Okay. What does it look like to you?
 163:38:03 Schmitt: Well, you're doing great; keep down. Just a little hang-up on the DSKY.
 163:38:11 Cernan: I gotta get my arm down there.

163:38:13 Schmitt: You need to go to your left a little to clear the purse and your harness. There we go.

[Schmitt - "There was a little bag called the 'purse' where we stowed the purge valves between EVA's."]

163:38:25 Cernan: Jack, you see this? This is one of those cards that...

163:38:27 Schmitt: Yeah, I saw that, Gene.

163:38:30 Cernan: I'll put it right there. (Garbled).

163:38:33 Schmitt: Can you come forward just a little?

163:38:35 Cernan: Forward?

163:38:36 Schmitt: That clip got away. Come towards...(Come back) in the cabin just a little. There.

163:38:42 Cernan: Okay?

163:38:43 Schmitt: Wait a minute. Okay. I got it. (Pause) Okay, you're in good shape. (Pause)

163:39:03 Cernan: Okay, I'm on the porch. Whoo! I'm still at 4.3!

[Cernan - "It was a strain getting out. It was easier for Jack because there was only one person and his suits had longer to come down. I'm still at 4.3, here, with a very stiff suit.]

163:39:04 Parker: Roger. We agree on that.

163:39:05 Cernan: Okay, I'm on the porch, Bob.

163:39:06 Parker: Copy that.

163:39:07 Schmitt: (To Parker) Okay, what do you want? What can I do for you, Bob?

[Here, Jack is not talking louder to Parker than he is to Gene.]

163:39:11 Parker: Standby Jack. We'll get a word to you in one minute. (Pause)

163:39:18 Cernan: Okay, Jack, in the...Well, I guess I ought to wait. (Pause) Get my L. E. C. ready for you. Okay. And everything looks normal on me, right now. Wait 'til I get pressure down a little bit. (Pause) Everything's normal, except a part of my nose itches I can't get to.

[Schmitt - "We had a piece of Velcro put on the inside of the helmet that we reached over and scratched our nose on. Everybody seemed to agree that you needed that. Also, the mention of the LEC reminds me of a lot of work we did - probably pre-Apollo 11 and probably Jack Small and myself, mostly - trying to devise some kind of a conveyor system to get stuff in and out of the cabin. There was some concern that it would be too difficult to carry stuff up and, at one point, we were actually trying to devise a loop one could use as a conveyor: attach something to it and then take it through a pulley. We got it so that you could do it but, in the final analysis, it was more trouble than it was worth."]

[The conveyor was actually used on Apollos 11 to 15.]

163:39:56 Schmitt: I'll give you the jett(ison) bag anyway, Geno, while they're thinking.

163:40:00 Cernan: I guess that's part of R&D (Research and Development). (Pause) Oh, yes, the jett bag. Santa Claus' bag again.

163:40:11 Parker: Okay, Jack. We'd like to have you stay in just a minute or so longer. We're trying to keep track here of the suit circuit pressure and see if it stabilizes or starts to drop. The one reg(ulator) has just has been intermittently leaking. We still haven't isolated it. And we think we've got it shut off, but we're still watching it. So bear with us just a minute or so.

163:40:33 Schmitt: I'm bearing, Bob.

[Before the rest period, Houston had run a series of checks on the Demand Regulators to see if one or the other of them had a slow leak that would explain a slow but steady rise in the cabin pressure. During the tests, the pressure build up stopped and, as Joe Allen told the crew at 150:46:46, apparently the leak had been cured by cycling the regulators.]

163:40:35 Cernan: Hey, what else...

163:40:36 Schmitt: I thought you isolated it last night. (To Gene) Okay. Let me give you the ETB.

163:40:42 Cernan: Yeah. (Pause) Give me that and I'll be on my way, working on the TGE (the traverse gravimeter). Okay, got it.

[Gene is on cuff checklist page CDR-4. After starting a gravimeter reading, he will change the LCRU battery, getting the new battery from under his seat, where he stowed it at the start of EVA-2.]

163:40:53 Parker: Okay, Jack, and how about taking the Suit Circuit Relief valve, cycle it just to Open and then back to Auto. (Pause)

163:41:06 Schmitt: Okay, Bob, stand by. (Pause) Suit Circuit Relief going Open, then Auto. (Pause) That's done.

163:41:23 Parker: Okay, we'll watch it for a minute here and let you know.

163:41:29 Cernan: Okay, Bob. I'm going down the ladder.

163:41:31 Parker: Roger, Geno. (Long Pause)

[Jack is probably verifying the circuit breakers and performing his other tasks on LMP-4.]

163:41:46 Cernan: Yup, still there, Jack. "Godspeed the crew of Apollo 17."

163:41:52 Schmitt: Good.

163:41:53 Parker: Amen there, Gene. Amen.

[Cernan - "It had become a little prayer at the start of those EVA's. I just shouted to the world, "God, bless us. Give us a shot at it." I'm beginning to think that there wasn't anything printed or written anywhere on that ladder. And if Jack doesn't recall it, it wasn't there. I think I just decided to say that when we started every EVA. Sort of like blessing the shrimp fleet."]

[The only sure way of knowing if the message was on the ladder or strut is to visit the expended Descent Stage at Taurus-Littrow. Gene first "reads" the message at the end of EVA 1 at 124:00:08. At the start of this EVA, Jack will take a color picture of the front of the LM and we have examined blowups of the hatch and ladder area. The blown-ups are quite grainy but there is nothing visible that looks anything like a note. A white spot just below the hatch is part of the normal LM hardware. At the end of this third day, Jack will take some pictures of Gene and the Apollo plaque, one of which shows considerable detail on the ladder and strut up as high as the second step below the porch. We have been unable to find anything that might be a message. The mystery remains.]

163:41:58 Cernan: Okay, Bob, I'm on the (foot)pad. And it's about 4:30 (on) a Wednesday afternoon, as I step out on to the plains of Taurus-Littrow. Beautiful valley. The first thing I'll do is I'll turn the TGE (Traverse Gravimeter) on, and I'll give you a reading.

163:42:18 Parker: Okay; we're ready.

163:42:20 Cernan: And I'm very much interested in my Rover battery (temperature).

163:42:24 Parker: And, Jack, you're Go for exit and looks like we've got it taken care of.

163:42:31 Schmitt: Okay, and I'm checking the circuit breakers. (Pause)

163:42:44 Cernan: It (the TGE)'s on and (I'm pushing the) Read (button). Bob, it reads 222, 262, 207; 222, 262, 207.

163:42:56 Parker: Okay, I copy that, Geno. (Pause)

163:43:07 Cernan: (To himself) Okay, get the visor down, Geno. Get the visor down...Holy Smoley. Think it'd be better to leave it up. Beautiful out here today, Bob! We can look to the east for a change - a little bit, anyway.

163:43:26 Parker: Okay, copy that, Gene.

163:43:28 Cernan: (Because of) the higher Sun angle. (Pause) Okay, I'll get the LCRU battery changed out.

163:43:36 Parker: Okay. And as you walk by there, if you walk by in the right side of the Rover, how about giving us a SEP temperature read-out, please. (Pause)

163:43:51 Cernan: SEP temperature is 103 degrees.

163:43:56 Parker: Copy, 103.

163:43:58 Cernan: 103, and the mirror is still clean.

163:44:00 Parker: Copy that. (Pause)

[The SEP temperature was 112 degrees Fahrenheit when Gene turned the unit off at 147:18:35.]

163:44:06 Cernan: Well, let's see if I can change this little baby now. Supposed to be simple. (Pause) Bob, we have no use for the old (LCRU) battery, right?

[Gene is asking if he can have some fun and see how far he can throw the battery.]

163:44:25 Parker: That's affirm. (Long Pause)

[Schmitt - "During Apollo, the answer to Gene's question was very simple: you weren't going to go back there any time soon. But at a lunar base, any used material will have to be inventoried, catalogued, and stored in some kind of recoverable way because the value of practically any material will, because of transportation costs, be very, very high - at least until the Moon is self-sufficient and is producing it's own stuff. And that won't be for a long time. You're just never going to know when you're going to want to get something and, with a good inventory system, you can always ask 'Do I have that or something like it for refurbishment or reuse.'"]

[There is some light static for a few minutes which ends when Gene turns on the LCRU.]

163:44:52 Schmitt: Okay. I'm on the porch and the hatch is closed.

163:45:03 Cernan: (To himself) Oh! Don't bump into that.

163:45:08 Schmitt: Are you talking to me or you?

163:45:10 Cernan: I'm talking to me. (Long Pause)

163:45:37 Schmitt: Okay, that sounds familiar and looks familiar - the old plains.

163:45:45 Cernan: The valley of the Taurus-Littrow.

163:45:53 Schmitt: Want me to get your antenna?

163:45:54 Cernan: Yes, let me get that...

163:45:56 Schmitt: I'll come over there.

163:45:57 Cernan: I'll get the TV on. I've already got the battery changed. (Pause)

163:46:16 Cernan: (Static ends) There's the Earth right in the middle of the antenna. Okay, verify Mode 3; I am in Mode 3; LCRU blankets are open 100 percent, battery covers I'm closing, the battery...Let me close it. Yeah, you can come and get my antenna.

163:46:33 Schmitt: Wait a minute. Let me set this down.

[TV on. Jack has probably brought the ETB over from the ladder. As per CDR-4, Gene probably left it hanging from the LEC.]

163:46:35 Cernan: Yeah, okay. (Pause)

163:46:46 Schmitt: Okay, stay there.

163:46:49 Cernan: I was just trying to.

163:46:55 Schmitt: Okay. (Long Pause) Okay, your antenna's up. Wait a minute. (Garbled) snap the snap.

[Fendell briefly picks up Jack at the gate, then pans clockwise.]

163:47:22 Cernan: Okay. (Pause)
 163:47:37 Schmitt: Didn't mean to do that.
 163:47:38 Cernan: (Chuckling) That's all right. I can't get close enough to you. There you are. (Pause) Lean a little more. (Pause) Antenna's up. Let me get the snap.
 163:47:55 Parker: And, 17, if you guys are interested, your shadows will be 8 feet long tonight.
 163:48:04 Schmitt: How many meters is that, Bob?
 163:48:07 Cernan: I'll draw it out...I'll step it out for ya. You can measure it. (Laughter)
 163:48:11 Schmitt: Well, I don't know. Should I take my gloves off? I mean my cover gloves.
 163:48:16 Cernan: Why don't you leave them on for a while and see where we're going. See what the boulder field looks like up there (at Station 6).
 163:48:21 Schmitt: Well, I know what it's going to look like.
 163:48:24 Cernan: No, you don't.
 163:48:25 Schmitt: The point is: my hands will be much better off without them.

[The cover gloves add bulk to the hands, lessen flexibility, and hasten fatigue.]

163:48:27 Cernan: Take them off, then. (Long Pause) Okay, battery covers are closed and tight. High gain is already oriented. Oh, they've even got TV, I guess.
 163:48:48 Parker: That's affirm.

[Gene can see the TV camera move as Fendell does his pan.]

163:48:52 Schmitt: (Garbled)

[Fendell finds Gene leaning across his seat, pushing in the circuit breakers on the instrument panel. Gene is at the bottom of CDR-4 and Jack is taking care of the tasks on LMP-5.]

163:48:54 Parker: And, Geno, when you push the Rover circuit breakers in, how about giving us a battery temperature reading on the Rover bats.
 163:49:00 Cernan: Tell them what my batteries are reading if I can.
 163:49:03 Schmitt: Well, let me see if I can do something else while I'm waiting.
 163:49:05 Cernan: No, I'm done, Jack. (Pause)
 163:49:12 Schmitt: I'll get the old SEP receiver.

[Jack goes to the SEP, behind his seat; Fendell follows him.]

163:49:14 Cernan: Well, Bob, battery 1 is 95 degrees and battery 2 is reading zero. So we got a gage failure. In fact, it's not reading zero; it's off scale low.

[Jack reaches back for his cooling control without having to do the double wave.]

163:49:34 Parker: Okay, copy that. That's a real cool-down, isn't it? Okay, Jack, if you're going to worry about the SEP, standby and don't do the SEP until after you worry with the ETB, and we'll get to you on that. When you get the ETB to the (CDR) seat, I'll talk to you about it.

[Gene goes to the gravimeter, which is on the ground near the LM ladder. Jack goes around the back of the Rover to Gene's seat.]

163:49:51 Schmitt: Okay, 102 is the temperature.
163:49:56 Parker: Okay; copy that.

[The temperature at the end of EVA 2 closeout - at 147:18:35 - was 112F. The unit turns itself off when the temperature is over 108F, so they will get a little data on the traverse to Station 6 before the unit heats up again.]

163:49:57 Cernan: Okay, Bob. Mark.
163:50:00 Parker: Mark.
163:50:02 Cernan: Mark gravimeter; it's flashing.
163:50:04 Parker: Copy that.

[Gene is now on CDR-5.]

163:50:09 Cernan: Okay, we'll take the big bag. I hope we can keep it on (the gate). (Pause)
163:50:18 Schmitt: Did you say (garbled under Parker)...
163:50:18 Parker: Okay. A couple of things on that, Geno. You might try tapping the thing (bag latch) to see if that loosens the dust. There's also the hook business on the inside of the pallet that you could hook it (the big bag) on. Caution: if you open the pallet, be careful not to knock the clamps off the fender. But you can also reach over the pallet to put the big bag on.

[Gene arrives at the Rover carrying both the dust brush and the big bag. The big bag has the same top cross-section as an SCB but is about twice as long and can be seen in AS17-143-21924, taken at about 169:13. Usually, Gene opens and closes only the gate, leaving the geopallet - to which the gate is attached - fixed in place. Apparently, there is a place to mount a bag on the forward surface of the geopallet, far enough inboard that Gene can't reach it from the side of

the Rover. Instead, Parker is suggesting that Gene open the pallet. Because the pallet pivots on the geopost at the right rear, Parker is urging that they watch to make sure the pallet assembly doesn't hit the replacement fender or the clamps holding it in place.]

163:50:42 Cernan: Okay, Bob. I brushed it and tapped it (the bag latch) yesterday. I'm not sure we're going to have much luck with them.

[Gene is referring to the bag latches on the back of the Rover gate.]

163:50:48 Parker: Say again there, Gene.

163:50:52 Cernan: (Trying to hang the big bag on the gate) I brushed them and tapped them yesterday.

163:50:56 Parker: Okay; copy that. You might want to put the big bag on the inside of the pallet there, if you can't operate them.

163:51:03 Cernan: Okay.

[Gene goes out of the TV picture toward the front of the Rover.]

163:51:08 Schmitt: Okay, mag Kilo goes on the 500; is that correct?

163:51:13 Parker: That's affirm.

[Fendell pans clockwise to Jack at Gene's seat; he is putting film magazines in the seatpan, taking them from the ETB.]

163:51:20 Schmitt: Okay, I've got Mary and Franny and Nancy (pause) and Donna (pause) and Bobbie and...

163:51:42 Cernan: (Now standing at Jack's right) Jack, I'm also going to keep this (the dust brush) in there (under the seat).

163:51:45 Schmitt: ...Karen.

[The magazines are marked with letters - MM, FF, and so on. At times through the mission - beginning at 118:15:29 - Jack has used girls names such as Franny for the magazines rather than the standard communications code words like Foxtrot. Parker has followed his lead but Gene won't join in the game until the end of Station 6.]

163:51:46 Cernan: Because it's too hard to get (the dust brush off the front end). We'll find a place for that in there.

[Gene is having trouble getting the brush in and out of the bracket on the top of the LCRU.]

163:51:52 Schmitt: (Not convinced that this is a good thing to do) Well...Okay.

[Schmitt - "I may have been thinking that we didn't want any more dust under the seat."]

163:51:54 Cernan: It's just too hard to get off the front end. Okay, let's see. "Big bag to gate, dustbrush to (LCRU)..." Let me get that big bag on the inside of the gate if I can. Inside the gate or the pallet, Bob?

163:52:07 Parker: Inside the pallet. My fault there.

163:52:11 Schmitt: (Showing Cernan his checklist) That says the pallet.

163:52:13 Cernan: (Going to the gate) Yeah.

163:52:14 Parker: And if you open the pallet, be careful of the clamp. Probably, if it's feasible, we suggest you reach across in front of the pallet. Reach across the pallet to do it instead of opening it because of the clamps on the fender.

163:52:32 Cernan: It's not feasible. It's not feasible to do that. I got to open it, plus our hook is over center. Let me get something to work on that with. (Pause) You know, Bob, how that pallet locking hook can be out of the little C-shaped release in there? It is.

163:52:58 Parker: Oh, boy.

163:53:02 Cernan: I noticed that yesterday. (Pause)

163:53:15 Parker: Jack. When you get done with the ETB, then you might save the grey tape out. We're going to use a little bit of that on the SEP when you get done. (Pause)

[Fendell takes a close-up look of Jack working in Gene's seatpan. In the background, Gene swings the geopallet open.]

163:53:44 Schmitt: When are you going to do that?

163:53:47 Parker: We'll turn the...

163:53:48 Schmitt: What am I supposed to do, stand...Well...

163:53:49 Parker: We'll turn both switches on when you're out at the SEP transmitter.

163:53:56 Schmitt: Well, the tape is in the CDR's seat, and it'll still be there.

163:53:59 Parker: No, we'd like to take the tape from the CDR's seat and use it on the SEP, right now.

163:54:06 Schmitt: Okay. (Pause) You want me to do it or Gene to do it?

[Jack removes the roll of tape and lowers Gene's seat.]

163:54:13 Parker: Why don't you do it since the tape is there. No, let's let Gene do it. Doesn't really matter. Whoever wants to.

[Jack takes the ETB to the MESA. Fendell follows him.]

163:54:25 Cernan: Okay, we'll get it. (Pause) Okay, Bob, the big bag is on the inside of the pallet.

163:54:41 Parker: Okay; we copy that.
 163:54:42 Cernan: I want it...Ooh! The...(Talking to himself) And I know why. (Pause)

[Gene goes to Jack's seat; Jack goes from the MESA to the gate. The next task listed on his checklist is a pan taken 30 feet out in front of the ladder.]

163:55:01 Cernan: This is the thing that's in the way, Jack. (To himself; discarding a thin, two-foot-long object) Get rid of this thing. We don't need it anyway. (To Parker) Okay, opening and closing of the pallet didn't interfere at all with those fenders.

163:55:12 Parker: Okay; copy that.

163:55:15 Schmitt: (To Gene) These aren't clamped now. Here's your tape.

163:55:18 Cernan: (Going to the gate) Okay. The big bag is on the inside (of the geopallet), though.

163:55:25 Schmitt: Yeah, but it's also in the way. Okay, I got it.

163:55:28 Cernan: Sure is. Wait a minute. Wait a minute. Don't close it.

163:55:31 Schmitt: Want me to get out of the way?

163:55:33 Cernan: I'll open it. See? It drags over that locking device.

[Jack works on the open pallet.]

163:55:40 Cernan: Okay, let me just see what we got to do here. (Pause) Okay. (Reading CDR-5) Big bag, dustbrush. (Pause) SCB-7 to gate, mount 20-bag dispenser on commander's camera, 20-bag dispenser to the LMP, core cap dispenser to the gate.

[Gene goes to Jack's seat.]

163:56:11 Parker: Okay. And, Jack, are you going out to take the pan now?

163:56:16 Schmitt: Well, as soon as I finish up here, I'll do that.

[Gene mounts a map on the holder to the right of the instrument panel. As per LMP-5, Jack put the map on the seat when he was unloading the ETB.]

163:56:20 Parker: Okay. And after you take the pan, we'd like you to retrieve the cosmic ray experiment. They're expecting a little solar storm, and before the rain gets on the cosmic ray experiment, they'd like to retrieve it. We'll leave it in the ETB during the traverse.

[If the solar flare is weak enough that the ETB offers adequate protection, the exposures experienced by the suited astronauts will be minimal.]

163:56:40 Schmitt: Okay, (I'll do it) after the pan. All right.
163:56:42 Parker: Roger. It will just be a nominal retrieval..
163:56:44 Schmitt: Okay, the gate's locked.
163:56:44 Parker: ...and we'll put it in the ETB. Copied the gate.
163:56:50 Schmitt: Okay. (Long Pause)

[Gene finishes mounting the map; Fendell pans clockwise to follow Jack will take a color pan with Gene's camera. These frames are AS17-140-21359 to 21380. 21362 shows darkened Rover tracks in the direction of the ALSEP. 21368 is a good picture of Gene at the Rover. In 21371 and 21372, note the jettison bags under the descent stage. 21374 is a good picture of Poppie.]

163:57:02 Cernan: Okay. (Long Pause) SCB-7; 20-bag dispenser goes on my camera when it gets back. Short can under the LMP's seat. Okay. Jack, I'll just go ahead and mount some of these bags on your camera while I'm here.
163:57:45 Schmitt: Okay. Thank you. (Pause)

[Fendell pans to Gene, who is mounting sample bags on Jack's camera.]

163:57:58 Parker: Okay. And, Gene, if you got time there with the camera...when you get done with the camera...how about getting some grey tape and we'll put you to work on SEP for about a minute.
163:58:12 Cernan: The SEP receiver?
163:58:13 Parker: That's affirm. (Pause) And if you get...
163:58:17 Cernan: Stand by. Let me finish with SCB-7 here.

[Gene reaches into Jack's seat pan for a core-cap dispenser.]

163:58:20 Parker: Okay. And did you get Jack's camera fixed last night? I didn't hear.
163:58:25 Cernan: (Going to the gate with the core caps) Yeah, we did. (Pause; returning to Jack's seat) Okay, there is already one (SCB) on the gate. Leave that one there. Okay, (reading quickly) SCB-7 to gate; 20-bag dispenser on commander's camera. We'll do it when he (Jack) gets back (with the camera); 20 bags on the LMP's camera; core cap dispenser to gate. There's one there, there's one under the seat. Short can's under the LMP's seat. (Pause, turning to CDR-6) Okay, I got to put that cap dispenser on him; I got to give him a rammer, a hammer. Hey, Bob, what bag do you want on the LMP? Do we have 8 here?

[Because of the mix up during the EVA 2 Geoprep, Jack wore SCB 8 during that EVA.]

163:59:12 Parker: Stand by. I think 8 went in (to the cabin after EVA2). Either 4 or 6. No, excuse me; either 5 or 4.

[Gene goes to the gate; Jack goes to the cosmic ray experiment, which is hanging beyond the ladder.]

163:59:23 Cernan: Okay. We'll put either 4 or 5 on there. Okay. I'll have to wait until he gets back. What do you want? Or let me give you TGE reading and get that out of the way and then I'll work on your SEP.

[Gene goes to the TGE at the LM ladder.]

163:59:34 Parker: Okay; copy that. (Pause)

163:59:47 Cernan: Okay. 670, 027, 001; that's 670, 027, 001.

163:59:57 Parker: Okay; copy that, Gene. Thank you. (Long Pause)

[Gene takes the TGE to the Rover and mounts it at the right rear, behind the SEP.]

164:00:16 Cernan: Fender wrinkled up in the Sun a little bit last night.

164:00:19 Schmitt: Okay, Mark it. The cosmic ray (experiment) is terminated.

164:00:22 Parker: Copy that.

164:00:27 Schmitt: And, Bob, I took two 5-foot stereo pairs of the (cosmic ray) configuration.

[These are AS17-21381 to 21384. The first two show the "Sun" component of the detector and the other two show the "Shade" component.]

164:00:35 Parker: Copy. And we'll stick it in the ETB and just hang it there.

164:00:44 Schmitt: Yep. And in case you're wondering, and so you don't confuse it with a rock, it's in (sample) bag 106.

164:00:54 Parker: Copy that.

[Jack goes to the MESA; Gene to the SEP receiver.]

164:00:57 Cernan: Okay. What do you want done to the SEP?

164:01:01 Parker: Okay. Take some grey tape over to the receiver, Gene. And with reference to the fact that there is some Velcro missing on the front there which hold the covers down, we'd like to tape the two covers together in the middle there - you know, where the two sides overlap in the middle

of the box. Tape those two together. A short piece about an inch long should do it if they are clean.

[Fendell examines the LM.]

164:01:28 Cernan: Well, I doubt if the tape will stick because it doesn't (stick) on dust, but I might be able to go over it with one piece to clean it and another piece to tape it.

[Schmitt - "You could dust the SEP mirrors, but you really couldn't get the dust out of the cover. So the tape wouldn't stick to the cover to hold it closed."]

164:01:35 Parker: Okay. And the question beyond that: is there Velcro to hold one of those flaps down or not?

164:01:43 Cernan: No.

164:01:45 Parker: Okay, so the Velcro is missing from both flaps, I take it.

164:01:50 Cernan: Yes.

164:01:51 Schmitt: Bob, what happened was that the tape (means "adhesive") that held the lower Velcro on there apparently came loose, and it stuck to the upper Velcro.

164:02:00 Parker: Okay. I understand that. In that case, we'd like to take a piece of tape and tape the cover down to keep it closed when it's supposed to be closed. The feeling is that if the cover flaps partly open, you may get specular reflection off the inside of the Mylar down onto the mirrors causing it to heat up during the drive when it's supposed to be closed.

164:02:23 Cernan: Okay, we'll give it a try.

[Fendell finds Gene at the SEP.]

164:02:25 Parker: Okay; thank you. (Pause) And, Jack, if you're done, you might go rescue EP number 5 from the (LM) footpad, and we'll put it under the LMP's seat.

164:02:44 Schmitt: Well, there are a lot of other things under there. Okay. I'll rescue it; we'll see where the best place to put it is.

164:02:50 Parker: Okay.

164:02:52 Schmitt: (At the gate, to Gene) Hey, I got bags on you. I got bags on your camera, Geno.

164:02:57 Cernan: Okay; thank you. (Pause)

164:03:05 Schmitt: Okay, we're going to put those two bags on the rear there on our PLSS's?

[Jack leaves the gate; Fendell pans up to find Earth.]

164:03:11 Parker: One of them will go...

164:03:12 Cernan: (Garbled) those two on.

164:03:13 Schmitt: Okay.

164:03:14 Parker: The one under the LMP's seat will go on the CDR, it's the one with all the stuff in it.

164:03:20 Cernan: Yeah, I got core tubes in 7 here, Jack.
 We'll put either one of those...
 164:03:23 Schmitt: Okay. So I can put the charge under my
 seat.
 164:03:30 Parker: That's affirm, I think, Jack; once you
 get SCB-7 out of there.
 164:03:34 Schmitt: Yep.
 164:03:38 Cernan: (Taping the SEP) I feel like a kid stuck
 in taffy. (Long Pause)
 164:04:00 Schmitt: Sure is strange not to see some fine-
 grained rocks out here. Seen a couple, but certainly not
 very many.
 164:04:07 Parker: Copy that. (Pause)
 164:04:18 Schmitt: That rock that you picked up at
 ra(ndom)...

[Schmitt - "I was thinking of the fine-grained,
 vesicular rock that Gene picked up at Shorty."]

164:04:23 Schmitt: (Noticing the TV pointing into the sky)
 What are you doing up there?
 164:04:26 Schmitt: (Realizing that the TV is pointed at
 Earth) Okay.
 164:04:30 Cernan: Bob, that'll hold it down. I hope it
 solves the problem.
 164:04:34 Parker: Roger. And so does Dr. Strangelove.
 (Long Pause)

[Schmitt - "The SEP P.I.'s name was really (David)
 Strangway, but Bob called him 'Strangelove'.]
 [Fendell pans down; Gene goes his seat.]

164:04:58 Cernan: Well, probably not any more than we would
 like to see it solved.

[Gene removes his right cover glove.]
 [Unseen by the TV camera, Gene puts his cover gloves in
 a pocket on his left thigh so that he can bring them back to
 Earth. At this writing in early 1994, they are on display at
 the Kansas Cosmosphere in Hutchinson, Kansas.]
 [Cernan - "They were pretty badly abraded, but not cut
 or torn."]

164:05:05 Schmitt: Bob...(Changing his mind) Nothing.
 (Pause) Gene, your bag's going to have two lowers and one
 upper (drive tube).

[Fendell pans up to find Earth again.]

164:05:17 Parker: Did you re-sort things there, Jack?
 164:05:23 Schmitt: What's that?
 164:05:24 Parker: Did you re-sort things in SCB-7? I was
 told...

164:05:26 Schmitt: Bag 7's got...(Stops to listen) Bob, I...(Pause) Go ahead.
 164:05:39 Parker: Okay. Our understanding was there were two uppers and one lower in bag 7, and two lowers under the LMP seat. Did you re-sort things there?
 164:05:48 Schmitt: How do you want them?
 164:05:51 Parker: It doesn't matter to us. I just wanted to make sure that we know what you are so we don't let you get away too far (from the Rover) with two uppers and a lower. Two lowers and an upper is certainly better than two uppers and a lower. As long as we know what it is.

[The lower drive tubes have a reinforced tip for driving into the ground. An extra upper would be far less useful than an extra lower, because a lower could be used to get a single core sample while an upper can only be used with a lower in getting a double core sample. the core tubes are marked with prominent L's and U's on the tops.]

164:06:04 Schmitt: Okay. It's two lowers and an upper.
 164:06:05 Parker: Got that.
 164:06:08 Schmitt: Two lowers and an upper.
 164:06:10 Cernan: Man, I'm confused. (To Jack) Okay. When you're ready, I'll configure you.
 164:06:13 Schmitt: Okay, here, let me get this on you first since I got...
 164:06:15 Cernan: Okay.

[Fendell pans down to find Gene and Jack still at the left side of the Rover. Gene is on CDR-6 and Jack is on LMP-7.]

164:06:20 Schmitt: And I'm going to ask you to turn a 180 degrees because you're up on a hill. I'll never be able to do it.

[Gene turns to face the Rover; Jack attaches SCB 7 to the left side of his PLSS.]

164:06:27 Cernan: How's that? I'm down in a hole now.
 164:06:29 Schmitt: That's beautiful. (Pause) Okay, just a minute. Can't get this fixed. (Long Pause) Tallest man on the Moon right now.

[Schmitt - "Gene is several inches taller than I am and reaching up to that level was tough in the suit."]

[An alternate interpretation is that, with Gene in a hole and Jack on a little rise, Jack is above Gene slightly and is laying claim to the title. Certainly, this would be in character. The TV camera angle makes this a difficult call.]

164:07:08 Schmitt: Okay, that's done.
 164:07:09 Cernan: Okay?

164:07:11 Schmitt: Just a second. Let me close the cover.
(Pause) Not a very good cover. Okay.

[Gene goes to the gate; Jack follows and presents his right side.]

164:07:18 Cernan: Okay, Bob, I'm going to put SCB-4 on Jack. (Pause)
164:07:26 Schmitt: Go ahead.
164:07:28 Parker: Say again there, Gene. SCB-6? (Gets corrected by somebody in Houston) SCB-4; copy.
164:07:35 Cernan: SCB-4 will go on Jack. Okay, Jack, I got to get these PLSS straps, too. Did you get mine?
164:07:42 Schmitt: Uh...
164:07:43 Cernan: The harness release straps?
164:07:45 Schmitt: Oh, no. Let's do that. I saw them as you go out, and then I forget about them.
164:07:48 Cernan: Yeah. Okay, yours is on over here. Probably a better time to do them, anyway, rather than when we go out. Okay, let me get the bag. I'll get the other one when I configure your other side. (Pause) Okay, you're on. Okay, want to get my PLSS straps? Then I'll be cleaned up, and then I finish your other side. (Pause)

[They are behind the gate; Jack is working on the right side of Gene's PLSS.]

[Schmitt - "All the equipment was on the back of the Rover, so that's where we stood. And, unfortunately, that meant that we did most of this Geoprep work out of sight. It's too bad we didn't think about that."]

164:08:29 Schmitt: Let me get the other one. (Pause)
Warmer out here today. (Pause) Heat treatment on the hands. Okay.

[They are thirty-six minutes into the EVA.]

164:08:45 Cernan: Okay, stay right where you are so I can get this. (Long Pause)

[Gene gets the rammer from the gate; Jack presents his left side.]

164:09:11 Cernan: Okay. Now come over here, and I'll get you a core-cap dispenser, which I left here. (Pause)

[They go to Jack's seat; Gene gets the core caps and stows them in a pocket on Jack's SCB.]

164:09:29 Cernan: Okay, (reading CDR-6) you got SCB-4; you got the cap; you got the rammer; I'll take the hammer. You got the...That's all you need. TGE is on the LRV. Okay, what charge you got there, Jack?

164:09:44 Schmitt: (At his seat) (Seismic charge number)
5's under my seat.

164:09:45 Cernan: Five, okay. You got 5 there; we got
(charges) 2 and 3 on the Rover; LCRU blankets are open 100
percent; battery covers are closed. I want to... (To Jack)
Push that battery cover over there down just to make sure it
goes down.

164:10:01 Schmitt: The warning flag is up.

[This is a flat, metal warning flag - painted with
diagonal white and red stripes - which pops up when one of
the battery temperatures exceeds 125 F or one of the drive
motors exceeds 400 F. The flag can be reset by pushing it
down and will not pop up again unless the other battery (or
one of the drive motors) exceeds it's temperature threshold.
Previously, the crew was told that Rover engineers at the
NASA Space Flight Center concluded that the batteries would
be no reason for concern at battery temperatures less than
140 F.]

164:10:03 Cernan: Yep. It's probably that...Already, huh?
Push it (the battery cover) on down over there.

164:10:07 Schmitt: Rover warning was up.

164:10:10 Cernan: Get one right there.

164:10:12 Schmitt: It (the battery cover)'s down.

164:10:13 Cernan: I'll take a look at that gage again, but
the gage on the high battery looked like it may have failed.
Okay, LCRU blankets are open, battery covers are closed and
pushed closed, dust LCRU...

164:10:26 Schmitt: (Carrying the scoop) I'm going to the
SEP (transmitter).

164:10:27 Parker: Okay, Jack.

164:10:28 Cernan: Wait a minute before you do. You got a
second? Just come over here by the left front wheel.
(Pause)

[Gene wants to take Jack's picture with the U.S. flag in
the background and then have Jack return the favor. Jack
returns to the Rover; Fendell pans counter-clockwise toward
the SEP transmitter site.]

164:10:41 Cernan: I know you got a second. Just a little
bit closer to the left front wheel, towards me. Oh, that's
good, anywhere in there. (Pause, taking Jack's picture)
Wait a minute.

[Gene's pictures of Jack are AS17-140-21385 to 21387.
21386 is the best of the three and shows Jack's checklist,
sample bags, and his LRV sampler.]

164:11:07 Cernan: Can you do that likewise (and take my
picture)? Or can you hold it with that other camera? It's
already set at 30 (feet focus).

[TV off. Gene is handing Jack the CDR camera so that the picture will be in color. He is asking if Jack can use the CDR camera while wearing his own.]

164:11:16 Schmitt: Okay.

164:11:18 Cernan: And you might want to take a couple...(Long Pause; static, even over Parker)

[Jack's pictures of Gene are AS17-140-21388 to 21391. 21390 is the best of the four and shows Gene's RCU, the "red apple" at the end of his purge valve release cable, his right thigh pocket, and his left calf pocket.]

164:11:48 Parker: 17, Houston. We think somebody lost their comm. Jack, it's probably Gene going to zero. (Pause)

164:12:01 Schmitt: (Static clears) You read us, Bob?

164:12:02 Parker: Roger. Read you now.

164:12:06 Cernan: Bob, do you read Gene?

164:12:08 Parker: (Making a mis-identification) Reading you, Jack. I haven't heard Gene yet.

164:12:14 Schmitt: Well, Gene's calling you.

164:12:17 Parker: You read me?

164:12:18 Cernan: How do you read me, Bob?

164:12:19 Parker: Okay, read you now.

164:12:23 Cernan: Okay, I didn't do anything. I just jiggled my Mode switch here. Okay, (reading CDR-6, again) we got 2 and 3 on the EP's (that is, EP's number 2 and 3), plus one under Jack's seat. LCRU blankets are opened 100 percent; battery covers are closed; dustbrush, I've got; TGE, I've got; mags and polarization filter is taken care of; and I'm ready to traverse to the SEP.

164:12:44 Parker: Roger. We understand TV stowed and you're taken care of in the comm. And you might give us a Rover read-out either now or when you get to the SEP.

164:12:55 Cernan: Okay; we'll see which is convenient.

[Gene is now on CDR-7. Jack has left for the SEP transmitter. He is on LMP-7.]

164:12:57 Parker: Yeah. (At the) SEP is probably more convenient while you're sitting there waiting for the nav to warm up or initialize - waiting for us to give you the reading.

164:13:08 Cernan: Okay, taking your TV. (Pause) Mode switch is 1.

164:13:26 Schmitt: Hey, Bob, are you watching LMP?

164:13:29 Cernan: Not any more he (Ed Fendell) isn't. I took the TV.

164:13:30 Schmitt: Okay. (Pause)

[Schmitt - "My guess is that I wanted them to record or time my running motion as I was going out to the SEP transmitter."]

164:13:37 Cernan: Bob, you still read?
164:13:38 Parker: Roger. Read you loud and clear. We aren't watching the LMP.
164:13:43 Cernan: Okay, I just wondered because I just took the TV. I just want to make sure we got comm here.
164:13:48 Parker: Yeah, we're reading you in Mode 1.

[At the end of EVA 2 at 147:42:11, Gene turned the LCRU off and lost comm with Houston. The problem was Houston's and, here, Gene is just making sure.]

164:13:53 Cernan: And, for your information, we've both got our cover gloves off.
164:13:59 Parker: Copy that. (Pause)

[Jack removed his cover gloves at about 163:48:27 and Gene took his off, on camera, at 164:04:58.]

164:14:08 Cernan: Okay, that's in, that's in, that's in. Should have dusted my checklist on the Rover. I can't read down there.

[Gene is trying to read a decal affixed to the console. It has a list of Rover start-up procedures.]

164:14:15 Schmitt: Bob, the old tape fix on the SEP (solar panel)'s still working.
164:14:19 Parker: Beautiful.
164:14:20 Schmitt: Both mirrors (means solar panels) have a little angular displacement, but not more than 5 degrees.
164:14:31 Parker: Sounds like that's the least of the SEP's problem, but we have hope. (Long Pause)

[During the SEP transmitter deployment at the end of EVA 1, Jack had found that the wire springs that normally hold the two side solar panels open and flat weren't going to do their job. He and Gene then used grey duct tape on the backs of the panels to hold them open. Here, Jack is reporting that, while the side panels aren't lying perfectly flat, the loss in electrical power will be negligible. Jack takes a stereo pair of the transmitter, AS17-141-21510 and 21511. Note the tape along the upper edge with both ends of the tape not adhering, probably because of dust picked up from Jack's glove fingers as he held the tape.]

164:15:01 Schmitt: (To Gene, who is orienting the Rover for a Navigation initialization) Okay, you're going to be over there, huh? (Pause) (To himself) I'll go over here. (Pause)
164:15:13 Cernan: (To himself) I don't believe this.
164:15:14 Schmitt: What's the problem?
164:15:16 Cernan: Oh, nothing. That roll indicator isn't worth a ding-dong. (It) says I'm rolled 10 degrees.

[Cernan - "It was pretty obvious to me that I wasn't rolled ten degrees, and I just ignored it, I guess."]

164:15:19 Cernan: Okay. (To Parker) Roll zero, pitch is zero; heading is 291; distance, 001; range, 000; amps hours are 90 and 85; volts are 65 (and) 65; Sun shaft device, by the way, is 0.

164:15:45 Parker: Copy that.

[The "Sun shaft device is the Sun-shadow instrument mounted on the console. With the shadow falling on the zero mark, Gene has the Rover pointed directly away from the Sun and, because the Sun's position at this moment is accurately known, Parker can give him an accurate heading so that he can correct any drift in the nav system. Note that Gene hasn't initialized the nav system since the start of EVA 2.]

164:15:46 Cernan: Batteries are 100 and off scale low, and motors are all off scale low. (Pause)

164:15:56 Parker: Okay, and, Gene, we'd like to torque (the heading indicator) to two-eight-seven. Two-eight-seven.

164:16:06 Cernan: Okay; in work. Let's see, 287. That's the heading from Cross City to Tyndall (Air Force Base). Okay, 27, 28; 287 right on the money.

164:16:21 Parker: Copy that, Geno. And...

[Cernan - "Cross City was a VOR station west of Gainesville Florida. Tyndall is near Panama City. We flew that way from Cape all the time. Patrick (Air Force Base near the Cape), Cross City, Tyndall, and whatever to Ellington (Air Force Base in Houston). That's why I remembered the heading. I used to have that flight plan engraved in my brain.]

164:16:24 Schmitt: Bob, 45...(Hears Parker)

164:16:26 Parker: Go.

164:16:29 Schmitt: Bob, 45 Yankee is a sample from near the SEP. (Pause)

164:16:41 Cernan: Boy, I tell you, Jack. That (transmission) was all cut out.

164:16:47 Schmitt: Oh, well. I got the sample anyway.

164:16:50 Parker: We copied 45 Yankee near the SEP. That's all we have. If you give us a frame count when you get done, and give us an approximate location for the Rover, at least crosswise from the Y (meaning from the intersection of the SEP transmitter wires), we'd appreciate it. And we also need SEP receiver power and DSEA both on. And we'd like the (SEP receiver) cover taped down when you get done, Jack. (Pause)

[Next, Gene will re-orient the Rover so that he is headed north and is within 5 meters of the north arm and 10 meters of the transmitter. He seems to have been west of the array when he did the nav initialization. If so, then he

will be driving into the Sun as he approaches the transmitter and will have some trouble seeing.]

164:17:22 Cernan: Okay, Jack, keep me honest on those reels.

[These are the cable reels for the SEP transmitter antenna wires. During deployment of the antenna array, Gene and Jack dropped the reels at the ends of the arms to serve as markers.]

164:17:26 Schmitt: Okay, you're okay now. Let me get over on the reel.

164:17:29 Cernan: I don't see...

164:17:32 Schmitt: See me? Come on. You're good.

164:17:35 Cernan: Oh, there's the SEP. Wait. Did I miss this other reel?

164:17:38 Schmitt: Yeah. There's the...I'm on the antenna.

164:17:43 Cernan: What about the one coming west?

164:17:45 Schmitt: That's what I...No, you're okay on the one west. You're way away from it.

164:17:49 Cernan: Okay. Going to look back. (Pause)

[Cernan - I had to physically look back. The mirror wouldn't have given me that kind of view.]

[The two ways of looking back are to turn the Rover or to raise up in the seat and turn the suit enough to be able to see. Gene doesn't think he turned the Rover at this point but, rather, raised himself up to look.]

164:17:57 Schmitt: You want to...Head towards the SEP. You're okay.

164:18:01 Cernan: Oh, I see it now. Okay.

164:18:02 Schmitt: Head towards it and then make your turn (to the north).

164:18:04 Cernan: I see it. I'll go over to it.

164:18:05 Schmitt: Matter of fact, turn on these tracks.

164:18:06 Cernan: Yeah. I'm in good shape. I see it. I see it. (Pause)

164:18:17 Schmitt: Bob, that 45 Yankee (sample) was a fine-grained basalt, I think. One of the few around here. That's why I picked it up.

164:18:27 Parker: Copy that. (Pause)

[The bag actually contains two samples: 70290 and 70295. The latter rock is, by far, the larger and, in the Preliminary Science Report, is described as a "dark matrix breccia".]

[Schmitt - "You would expect to see fine-grained basalts at the top of the subfloor because of the higher cooling rates; and the paucity of fine-grained samples probably was the result of our being in a cluster of fairly large craters - enough of them that the majority of material thrown out of them was the coarser-grained material from the interior of

the presumably thick flow where the cooling was slow. We ultimately found a few, but there just weren't very many. So, not only was the top of the flow the first to be pulverized (which, if all the fragments were ground down into regolith, would contribute to the lack of fine-grained samples), but they were further diluted by the excavation of these large craters that some people think were part of a ray from Tycho."]

164:18:37 Schmitt: (To Gene) Okay, you stopped?

164:18:38 Cernan: I'm stopped and I'm ready to go. (To Parker) I'm 2 meters to the west of the north line.

164:18:45 Parker: Copy that.

[Cernan - "This is a particularly good example of me talking louder to Parker than to Jack. It was a habit I had the entire time on the lunar surface. It was almost as if, because they were further away, I almost had to shout - that Earth was so far away that I wanted to make sure they could hear me. They probably didn't even need a radio to hear me.']

[Now that Gene is parked, he is zeroing the distance and range counters while Jack takes a picture of the transmitter and the Rover for use by the experimenters.]

[Jack's photos are AS17-141-21512 to 21517. 21513 is a good picture showing Gene on the Rover with the LM in the background.]

[Cernan - "21513 is an impressive picture to me. You've got the antennas pointed low over the South Massif to give you an idea how low to the horizon the Earth was. And I guess what really impresses me is that the Rover is so big in the forefront and yet, unless you have an appreciation for how big the LM is, you have no sense of how far away it is. You've got the SEP and the LM in the picture and, frankly, unless you know what you're looking at, you can't judge sizes very well. There are some boulders in the picture that appear to be farther away than the LM, so they must be really big.']

[Schmitt - "This picture is a pretty good illustration of how, even just this far behind the LM, the material kicked up by our feet is almost the same albedo as the undisturbed soil. This contrasts with what you can see ahead and to the left of the LM, which is an area which was significantly lightened. "]

164:18:49 Cernan: And I guess I'm certainly within 5 meters of the transmitter.

164:18:51 Schmitt: Yep. You're in good shape.

164:18:51 Parker: Okay, we'll get that in the photos. And Gene, how's the low gain oriented?

164:19:05 Cernan: It (the low-gain antenna)'s oriented 355 and my (Rover) heading is 352.

[The low-gain antenna has a pointing indicator which, when it matches the Rover heading, indicates that the antenna is pointed at Earth.]

164:19:09 Parker: Okay, copy that. (Pause)
 164:19:16 Schmitt: Okay, you want the (SEP) receiver on...
 164:19:20 Parker: Roger. Both...
 164:19:21 Schmitt: ...and taped down again, huh?
 164:19:22 Cernan: Yeah, (garbled).
 164:19:22 Parker: Roger. Both the receiver and the recorder on, both switches on and then tape the cover down.
 164:19:32 Schmitt: Okay, good luck. (Pause) I don't know if that tape is going to hold. Okay, On and On. (Pause)
 Okay, it's taped down more or less.
 164:19:54 Parker: Thank you.
 164:19:55 Schmitt: And then I guess I'm supposed to get on, huh?
 164:19:57 Parker: Roger on that.
 164:20:05 Cernan: Okay, Bob, Nav Reset is now Off and I'm all zeroed up.
 164:20:08 Parker: Okay. Copy that. And we're ready for you guys to roll.
 164:20:17 Cernan: (To Parker) Okay, what's the first range and bearing to the Rover sample, past Jones?

[A sketch traverse map is shown (identically) on LMP-8 and CDR-8. As with the prior traverses, Gene and Jack have identical checklist pages. The feature named "Jones" is a cluster of small craters about one kilometer south of the large crater Henry and slightly west. Jack named it for the Scottish-born naval hero of the American Revolution. Unlike other features names which are typed in the checklist maps, this one is written in by hand, although not by Jack.]

164:20:24 Parker: Okay, it will be 185 (on the heading) and 1.5 on the range.
 164:20:32 Cernan: Okay, 185 and 1.5. 185 and one-and-a-half. Okay. (Pause)

[Note that this sample location is not indicated on the checklist map. It is, however, listed in the traverse text on LMP/CDR-9. The location relative to the planned landing spot is 192/1.6 and the 7 degree difference in bearing is a result of Houston's estimate that SEP transmitter is 200 meters east of the planned location. The actual distance is 260 meters.]

164:20:44 Schmitt: Excuse me, Gene.
 164:20:45 Cernan: No problem. (Pause)

[Cernan (laughing as he thinks about it) - "This was probably the first time Jack said "Excuse me" since we got assigned to the crew! Record that for posterity. Obviously, old Twinkletoes, when he jumped on the Rover, probably almost

knocked me out (of the Rover). I'm sure that's what happened. But I got even. When I drove on the sides of hills, I always put him on the bottom side. Always! On every hairpin turn, we went around with him on the bottom side."]

164:20:54 Schmitt: Well, shoot. (Pause) I've forgotten how (to get on the Rover).

164:21:03 Cernan: Boy, that Challenger looks pretty from here, you know it.

164:21:04 Schmitt: Yep. (Pause) Okay, I'm on.

164:21:12 Cernan: Okay.

164:21:13 Schmitt: Did I want a charge? No.

164:21:15 Cernan: Nope.

164:21:16 Parker: No charge, Jack; no charge.

164:21:19 Schmitt: Okay. Got it. Got it.

164:21:22 Cernan: Okay. 185 and 1.5 and I'm going to head on about 012. We ought to go right through Jones. (Garbled) Jones.

164:21:28 Parker: Okay, and, Gene, remember the driving fairly slow - or fairly well controlled - the first 300 meters, and a "mark" at the end of the antenna. (Pause)

164:21:40 Cernan: Watch that, Jack, watch that antenna lead...Uh-oh. (Pause)

164:21:46 Schmitt: Keep going. (Pause)

164:21:51 Cernan: (What does it) look like to you?

164:21:52 Schmitt: Okay so far; keep going. Okay, let's do that again...

164:21:57 Cernan: Yep. But a little different.

[Cernan - "We were supposed to drive parallel to the antenna lead and I probably got too close to it and it was easy enough to do a 360 (degree turn and go back) and do it again.]

164:22:01 Cernan: I'll pick up that same spot, I can see right where I was. (Pause)

164:22:10 Parker: Okay. Give us another mark when you start up on that side.

164:22:16 Cernan: Okay. We'll give you a hack, Bob. (Pause)

164:22:19 Schmitt: Okay. (Pause) Ahh...You're a little...

164:22:30 Cernan: Yeah, I'm right on the track. Same tracks exactly.

164:22:31 Schmitt: Well, okay.

164:22:32 Cernan: That's exactly...I just came right over. Okay, we're starting Bob. Mark it.

164:22:36 Parker: Copy that. (Long Pause)

164:23:03 Cernan: We can't go too far in this heading. We've got a big hole up here.

164:23:08 Parker: Okay.

[This is the large, unnamed feature north of the SEP.]

164:23:09 Cernan: Like a big one. (Pause) Wonder if that's Rudolph?

[Gene is referring to a Poppie-sized crater on the northwest rim of the unnamed crater.]

164:23:16 Schmitt: Well, let's see, this is east...Looks awf(ul)...It's a double crater but it's much bigger than I thought Rudolph would be.

164:23:24 Parker: No, if you're where you think you are, you're east of Rudolph quite a ways.

164:23:35 Cernan: Gee, I think you ought to know where we are by now, Bob.

164:23:37 Parker: Roger that.

[It is a little curious that no one has yet told them that Houston thinks they landed just north of Poppie. Parker will, however, tell them in just a few moments.]

164:23:39 Schmitt: Maybe that's Lewis and Clark.

[Meriwether Lewis and William Clark explored the drainages of the Missouri and Columbia Rivers in the years immediately following the 1803 Louisiana Purchase. The pair of craters named for them is about a kilometer NW of the current Rover position.]

164:23:41 Parker: After you give me a mark there, I'll talk to you about it.

164:23:47 Cernan: I'm sorry, Bob. I guess you didn't hear it. We're passed the end of the antenna and we're headed northeast.

164:23:56 Parker: Okay, I...

164:23:58 Cernan: That screw you up?

164:23:58 Parker: Did you give me a mark when you started or a mark when you passed the antenna?

164:24:03 Cernan: I gave you a mark when I started and it took about 20 seconds to get to the end.

164:24:09 Parker: Okay, copy that.

164:24:13 Cernan: Is that good enough or do you want me to go back?

164:24:15 Parker: No. No. Press on. And, Jack, if you look at your contour map there, we think you are located right now at approximately where the P in SEP is, just below the P in "Poppy". (Note that the map has the crater name misspelled.) In which case you're probably driving through that little crater that's just to the northeast there.

164:24:34 Schmitt: Okay.

[Houston now has them accurately located. Parker is referring to the contour map on the back of the 1/25000 traverse map labeled "NE Sheet", meaning the northeast of four maps showing the area around the LM. If he is giving them a LM location, it is quite accurate. The "little

crater" is the unnamed, shallow feature north of the actual SEP location.]

164:24:35 Parker: That's probably the one you came upon.
 164:24:39 Cernan: Not very little, though. (Pause)
 164:24:50 Schmitt: Okay, Bob. Boy, I wish I could see a little bit better. (Pause) The major boulders still look like the pyroxene gabbro. The surface texture has not changed. There is a granule population, now that I look at it more closely with the shadows. (That is, now that they are driving north, he is noticing the larger granules on the surface because of the shadows they cast.) But I have a feeling that most of those are...They look like they're just very small clods. That should show up in some of the bulk samples we've taken. But, it is remarkable to me...the small number of fine-grain rocks. There's one at about halfway between the SEP and the LM that I'd like to pick up, it's a fairly good sized one. Maybe we can get it when we get back. It looks like a fine-grained basalt. (Pause) I may have sampled one in 45 Yankee there.

[Jack will collect the fine-grained rock between the SEP and the LM at 169:15:45. This is sample 70215 and, unlike the sample in 45 Yankee, it is a fine-grained basalt. Jack's photos taken during this first part of the traverse are AS17-141-21519 to 21541.]

164:26:02 Cernan: Well, I tell you, it's not exactly the greatest place to navigate through.
 164:26:06 Schmitt: I think you ought to bear left, don't you?
 164:26:07 Cernan: Yeah. That's where I'm going here. I just want to get across this...around these boulders.
 164:26:12 Schmitt: There's a crater we're just passing at 207/0.4 about 20 meters in diameter, with the pyroxene gabbro blocks on the rim, a few of them. It's not an exceptionally blocky rim crater, but we are in an area where the block population is up to about 5 percent (coverage of the surface), in contrast to most of the area we traversed yesterday.
 164:26:43 Cernan: I tell you, going is a little bit rough; there's a population of blocks as Jack said and an awful lot of small craters.
 164:26:51 Schmitt: Yeah, I was just going to add that the frequency of craters in the 10-meter size range is quite a bit higher than we were used to yesterday. (Pause) Oops, there's one.
 164:27:08 Cernan: Yep.
 164:27:09 Schmitt: Snuck up on you. (Pause) (To Parker) And they all - although not exceptionally blocky rim - they all have a slightly, maybe 2 or 3 or 5 percent more blocks in their walls and on their rim than does the normal terrain.
 164:27:32 Parker: Roger, Jack. Copy that.

164:27:35 Schmitt: Still no obvious structure within the dark mantling material itself.

164:27:44 Cernan: Bob, you said 185/1.5?

164:27:47 Parker: That's affirm.

[The checklist location of the sample stop is 192/1.6.]

164:27:49 Schmitt: What do you want? For the Rover (sample)?

164:27:51 Cernan: Yeah, for a sample.

164:27:55 Schmitt: Oh, they changed it on us. (Pause) Okay. Still seeing the little pit-bottom craters with the glass in them. I've forgotten the acronym already, Bob, I'm sorry. (Pause)

[Jack is referring to an exchange at 146:03:30 during the in-bound drive from Shorty, when Parker invented the acronym GLPBC for the glass-lined, pit-bottom craters.]

164:28:18 Schmitt: And you asked me for an LMP frame count awhile back and I believe it was 5. That was at the SEP.

164:28:24 Parker: That was after the SEP photos, right?

164:28:27 Schmitt: That's affirm. (Pause) Negative; that was before the SEP photos.

164:28:38 Parker: Copy that. (Pause)

164:28:43 Schmitt: Okay, Bob, looking up at the North Massif, we see the scattered, strewn field of boulders that generally seem to start, more or less, from a line of large boulders, which might indicate some structure. And those lines are roughly horizontal across the face that we're looking at. The boulder tracks are irregular in shape, obviously downhill, but you'll see in the pictures that they are (pause) curved in places. But they're all - that I see - tend to be aggregates of little craters where the boulder was obviously tumbling and bouncing a little bit. (Pause) We're out in (a) population of fragments now in the immediate area, at...Is that 188?

164:29:54 Cernan: 188/0.9.

[AS17-141-21533 is a representative photo showing the North Massif and, at least, the large boulder track.]

164:29:57 Schmitt: (The population's) generally about 1 percent between craters. But at the crater rims, it's up to about 5 percent.

164:30:03 Parker: Okay. Copy that, Jack. And how far down the North Massif...

164:30:06 Schmitt: And these craters...

164:30:07 Parker: ...is the line of boulders?

164:30:12 Schmitt: (Listens to Parker) Oh, there are several of them, Bob. What I'm talking about is about 100-meter-long lines where the boulder trains initiate. And there's one (that) looks like about halfway, maybe two-thirds of the way down in perspective. Another one that's probably about

halfway. They're just sort of scattered around on the Massif. (Pause) I think we're getting close to...Well, we couldn't be.

164:30:42 Cernan: I've got to move over here a little.

164:30:44 Schmitt: That must be Jones (Crater).

164:30:45 Cernan: Where are you looking?

164:30:46 Schmitt: Off to the right.

164:30:48 Cernan: Yeah, our heading that they're sending us down here, it really should put us to west of Jones. So that's about right. (Pause) A lot of static in the background today.

164:30:58 Parker: Yeah, I think we are talking to you guys through the LM right now; and how about a speed reading?

164:31:06 Cernan: Okay. We're at 12 clicks and we're full bore.

164:31:09 Parker: Copy that. (Long Pause)

164:31:22 Schmitt: Okay.

164:31:24 Cernan: 187/1.1.

164:31:28 Parker: Copy that. (Pause)

164:31:36 Schmitt: Bob, I wish I could give you more on that structure in there (that is, structure in the North Massif), but I think those lines of boulder sources are about all we can see right now. Talked about the lineaments yesterday and they're not nearly as obvious today in the higher Sun. Looking up Wessex Cleft, even with the Sun in the flat area there, it looks darker than the North Massif side. But again, the Sun angle may be fooling us, but I recall it was darker on the (overhead) photos.

164:32:16 Cernan: The old man wrinkled face on the...

164:32:18 Schmitt: Sculptured Hills.

164:32:19 Cernan: ...Sculptured Hills, though, is evident as soon as you come out of the Wessex Cleft.

164:32:22 Schmitt: Yeah. And they look like there are boulders up on the side of Sculptured Hills; except that they aren't nearly as big as those on the North Massif. The areas where the boulder source is look like they're made up of boulders no bigger than a meter maybe; whereas, the North Massif boulders are up to several meters. Those boulder sources all seem to be up within a third of the height of the Sculptured Hills, just east of the Wessex Cleft. Here is a boulder track that crossed the slope. See that, Geno?

164:33:05 Cernan: Yeah. Yeah. I sure do now!

164:33:08 Schmitt: It looks like it goes, rather than perpendicular to the contours, it probably is crossing them in a fairly straight line on an angle of 60 degrees, maybe.

164:33:18 Cernan: Back to the east.

164:33:19 Schmitt: Yeah, to the east. That one may be fairly near...

[The cross-slope track was made by the Station 6 boulder. There will be more discussion at 164:44:11. the Station 6 boulder is visible in AS17-141-21533 just above the near horizon above and slightly to the right of the fiducial mark that is the righthand neighbor of the central fiducial.

They are currently about 2 kilometers from the base of the mountain and, at that distance, the 10-degree separation of fiducials corresponds to 350 meters on the mountain. The station 6 boulder track is not visible in the digitized version of the photo used in this publication of the Journal.]

164:33:24 Cernan: Jack, see that big boulder with that big track? It looks like it's an elongated rolled-up boulder. Look at that.

[This boulder was photographed with the 500 mm camera from the LM during EVA 1. The photo is AS17-144-21991. The boulder also appears in AS17-141-21543. The boulder is below the fiducial mark in the upper right corner.]

164:33:30 Schmitt: Yes, it does. Looks like it may be broken now.

164:33:33 Cernan: Okay. Here we are: 1.5 and 185.

164:33:37 Parker: Okay; copy that.

[Cernan - "In listening to Jack's descriptions in here while I'm driving, he's doing an excellent job. For someone who can't remember a great deal about it - about the craters and boulders - it brings a very descriptive picture to my mind. Jack, being the geologist, was better equipped to describe this stuff. But, boy, as you can tell from some of the comments, driving takes your full concentration. Every once in a while I could make a comment about something; but, once you start looking around - and you're moving at 6 or 8 or 10 kilometers per hour - peripherally you don't have the contrast to see obstacles and holes and craters. They don't stand out. They blend into the countryside and you've got to be looking for them or you don't see them. So you learn very quickly that you don't go rubbernecking as you drive. Everywhere you go - and it doesn't just have to be while you're in a boulder field - there's a hole or a pit or a rock or something. And, to some degree that may limit my recall because I was narrowly focused on a path and on a direction and on a destination. Jack, on the other hand, could back off and look at the big picture. And that was a good situation. You had two people, with one looking at the big picture and one getting you there. And it explains why don't I remember Turning Point Rock when I do remember taking the pan at Tracy's Rock (at Station 6, see below). There, I remember how steep that hill was; I remember having to crawl up that hill; and I remember having to watch my footing as I was taking the pan. That, I remember. I was taking in the big picture then. But I don't have any impression of driving up to Turning Point Rock or to Tracy's Rock. I was probably intent on driving and I don't have any recollection about any of this until I got off the Rover. The only exception is that I do recall the boulder tracks because I could drive and take a moment to look at those."]

[The large boulder at Station 6 is known in the scientific literature as Split Boulder. For reasons explained at 165:28:58, others know it as Tracy's Rock.]

164:33:38 Schmitt: Okay, is this a Rover sample?
 164:33:40 Cernan: A Rover sample.
 164:33:41 Schmitt: Okay...
 164:33:42 Cernan: Tell me where you want it.
 164:33:43 Schmitt: ...see that little pit right over there about 30 feet ahead.
 164:33:44 Cernan: Yeah, I think so.
 164:33:48 Schmitt: Okay, I've got two pictures there.
 (Pause)

[Jack's photos of the approach to the sample area are AS17-141-21542 and 21543.]

164:33:55 Cernan: How's that?
 164:33:58 Schmitt: That's great. (Pause) Okay, this is a soil sample. (Pause; waiting for Gene to finish taking his "locator", then calling his attention to the waiting sample) Hey, Geno.

[The handle on the LRV sampler is too long for Jack to conveniently remove the cup so he will swing the cup end around in front of Gene so that Gene can remove the cup, seal it, and drop it in the SCB mounted on the accessory staff in front of them. Gene's locator is AS17-140-21392 and Jack's corresponding photo is AS17-141-21544.]

164:34:17 Cernan: Okay, and I just took a locator (probably a picture of the horizon, in this case); and CDR is on frame 41.
 164:34:23 Schmitt: Got it?
 164:34:24 Cernan: Ah, not yet.
 164:34:25 Parker: Copy that.
 164:34:26 Cernan: Got it now. Bag 46 Yankee.
 164:34:32 Parker: Copy that. (Pause)
 164:34:39 Cernan: Your bag (the SCB on the accessory staff) open?
 164:34:40 Schmitt: Yup.
 164:34:43 Cernan: Okay, it's in.
 164:34:45 Schmitt: We ought to tape that lead down if we can remember it next stop. It's in the way of (Jack's picture taking)...It's sticking up.

[Cernan - "We had the low-gain antenna lead velcroed to the staff and that may have come off.]

164:34:55 Cernan: Okay, I'll get it. That thing came off that piece of Velcro. I'll get it when I get back.
 164:35:00 Schmitt: Okay. And LMP's frame count (pause) is three-five.
 164:35:11 Cernan: Okay, Bob, I'd like a bearing and range.

164:35:14 Parker: Okay. Bearing and range for the large block, just beyond...Let's see; it's just beyond the crater Henry. The large block there near the break of the slope, which is our next aiming point. The bearing and range there is 188 and 2.8.

164:35:33 Cernan: 188 and 2.8. Roger.

164:35:36 Parker: Okay. And, Jack, what do you see in the way of boulders coming down the base of the Sculptured Hills, in terms of sampling opportunities at Station 8 and in terms of any boulder tracks that might lead down to boulders that might just possibly be accessible at Station 8?

164:35:54 Schmitt: Watch it, Gene. (To Parker) Boulder tracks are not obvious on Sculptured Hills at all. It looks like there are fragments over there that would have had their sources higher up the slope. I think we can get boulders there.

164:36:12 Parker: Okay; copy that. We'll see...

164:36:13 Schmitt: We'll have to get a little closer, Bob.

164:36:15 Parker: We'll find out in a couple of hours.

164:36:19 Schmitt: Yeah, I will give you a reading on that before long. I wouldn't eliminate Station 8 for the world - or the Moon - whatever's available today.

164:36:29 Cernan: Bob? What did you say? 188 (and) 2 point something.

164:36:32 Parker: 2.8.

164:36:35 Cernan: Okay, thank you. See that big boulder, Jack, with those tracks?

164:36:40 Schmitt: Yeah, it looks like...

164:36:41 Cernan: That's funny looking boulder.

164:36:43 Schmitt: It looks like it may have stopped rolling because it broke up. (Pause) Looks broken to me now.

(Pause)

164:36:52 Cernan: Boy, they've got the low gain right on 'em. But, I tell you, we still got static.

164:36:56 Schmitt: I don't have any, Gene. You may...

164:36:58 Cernan: Well, I sure do.

164:37:01 Schmitt: I don't like the sound of your bounces.

Okay, you've got yourself in some holes here. (Pause)

You've never...I've read you all along, though, so there's no problem. Okay, there's a big crater. I haven't recognized Jones yet. (Pause) Looks like you're getting up on the rim of Henry here.

164:37:27 Cernan: (Mulling it over) Well...No, Henry should be to...I should be well west of Henry, I think. I wouldn't be surprised if Henry isn't right over that little rise on the right.

[Jack's photos during this part of the traverse are AS17-141-21545 to 21548. In 21546, Turning Point Rock, which they are aiming for, is on the near horizon at the center of the frame.]

164:37:37 Schmitt: Bob, the surface structure hasn't changed ... (correcting himself) texture (hasn't changed). We're on a

little bit of a rise in here now and still about 1 percent of the surface...

164:37:48 Cernan: Here's Henry right there, Jack.

164:37:49 Schmitt: There's Henry!

[Jack's photo of Henry is AS17-141-21549. Turning Point Rock is just below the low-gain handle and the Station 6 boulder is above the TV camera. The next frame, 21550, shows Turning Point Rock above the TV, the large-track boulder above and to the left, and, to the right and slightly above Turning Point Rock, the Station 6 boulder.]

164:37:50 Parker: Okay, how about a range and bearing.

164:37:51 Schmitt: I thought you were close to Henry.

164:37:52 Cernan: Yeah. (Responding to Parker) 188/1.8.

164:37:56 Schmitt: And we're just southwest of Henry.

164:38:01 Parker: Okay. Copy that.

164:38:03 Schmitt: On the rim. Old Prince Henry the Navigator!

164:38:07 Cernan: (To himself) Watch that foot.

164:38:12 Schmitt: It's called a wheel, I think. (Pause) And Henry looks much like Horatio did. Has boulders on its inner wall (but) not as many. They look light colored: a light-albedo, gabbroic appearance. There may be some right down there, though, that are fine grained; they look a little greyer.

[Gene and Jack talk over each other for the next half dozen lines]

164:38:32 Cernan: Jack, there's our target...There's...Either one of...That's one right down there on (garbled) break in slope.

164:38:37 Schmitt: See the one we've got over has a boulder track. That's the one, that crossed slope.

164:38:41 Cernan: Yeah, if we could get up...

164:38:42 Schmitt: Can we get up there?

164:38:43 Cernan: It's awful high. We'll see.

164:38:45 Schmitt: That's the one. That's Station 6, and that was the...(naming the rock) the turning boulder.

164:38:50 Cernan: Yeah, that's it.

164:38:51 Schmitt: The one right there. (Pause)

164:38:54 Cernan: Station 6: we can probably get up there.

164:38:56 Schmitt: I think we can; it doesn't look too bad.

(To Parker) The break in slope, right now, doesn't show anything obvious, except that's where the boulders start.

164:39:07 Parker: Okay, we hope that's fairly obvious.

164:39:12 Schmitt: And on up the hill you have...(Stops to listen to Parker) But as I was saying, Henry just looks like a somewhat more mantled Horatio. (Laughs, then makes an aside) (This dialog is) getting to be ridiculous.

164:39:28 Cernan: Say, Bob, I'm navigating - headed northwest now - to get around the western rim of Henry.

164:39:32 Parker: Okay...

[AS17-141-21551 to 21553 are taken during this westward excursion.]

164:39:34 Schmitt: And on that west rim, we've got about 10 percent boulder cover.

164:39:43 Parker: Okay. And a reminder, Jack, to keep taking your Rover photos.

164:39:48 Schmitt: Yes, sir! And by "boulder", I generally mean "fragment", Bob, in this case. When I say 10 percent, I'm looking at stuff greater than about a centimeter in diameter. (Pause) I'll try to say "fragment" from now on and be more precise. (Pause) Okay. Here's a little area where there's...This is the one part of the rim of Henry I see that has fairly large fragments, or boulders, on them up to 2 or 3 meters. But, again, they all appear to be buried. There are very few - except small ones - sitting out on the surface.

164:40:32 Cernan: And, you know, the fragment population out here only goes out maybe 200 meters, I expect.

[Henry, like Camelot, is about 600 meters across. The blocks extend 200 meters beyond the rim.]

164:40:38 Schmitt: Okay. Now this (particular) concentration of boulders (we are driving past) is because of a 50-meter crater in the rim of Henry.

[AS17-141-21554 to 21556 show this ejecta and the next part of the traverse.]

164:40:45 Parker: Okay, that sounds like Locke (Crater).

[Locke is 100-meter crater on the northwest rim of Henry. At the moment, Gene and Jack are driving by a smaller crater about 200 meters south of Locke and right on the west rim crest of Henry. Jack's size estimate is quite good.]

164:40:47 Schmitt: I think that was one that we...(Hears Parker)

164:40:50 Cernan: Take a picture in here, Jack.

164:40:54 Schmitt: (Responding to Parker) No. Locke, I can see. (To Gene) I'm getting the picture.

[AS17-141-21557 shows Locke beyond the ejecta of the small crater they are passing.]

164:40:57 Cernan: Okay, that's not...Locke's right ahead of us.

164:41:00 Schmitt: This is one (of) about 50 meters (diameter) right on the rim crest of Henry, the due-west rim. Now Locke is just ahead of us. It also has boulders in its walls but has relatively few on the rim.

164:41:17 Parker: Okay. Copy that.

164:41:18 Schmitt: Characteristic of both Henry, Locke, and Horatio is essentially no change in the average frequency of boulders on the rim. The increase comes in the wall.

164:41:34 Cernan: We're at 184/2.3. We're just about between Henry and....

164:41:42 Schmitt: Locke.

164:41:44 Cernan: Locke. Yeah; right between them.

[AS17-141-21558 and 21559 are taken during the drive between Henry and Locke.]

164:41:46 Parker: Okay. I copy that. And you guys are heading for that big boulder, which must be just dead ahead of you there, about half a kilometer.

[Turning Point Rock is visible in overhead photographs taken from both the Apollo 15 and Apollo 17 Command Modules. It is about 400 meters NNE of Locke. The navigation readout there will give an excellent indication of LM location because of the very well-defined location of the rock and the fact that they haven't driven far enough for there to have been any substantial drift in the navigation system.]

164:41:54 Schmitt: Well, Gene's sort of headed for Station 6 now.

164:41:58 Cernan: I'm going to take a tour around that boulder and give them a fix on it.

164:42:00 Schmitt: Okay. Go ahead.

164:42:02 Parker: Yeah, and that would be a good mark to give us a range and bearing on, since it's a pretty discrete point.

164:42:08 Cernan: Yeah, we are.

164:42:09 Schmitt: Bob, the boulder concentrations in the wall of Henry have their upslope start (that is, upper limit) at about, oh, I would guess an average of 30 meters down from the rim crest. The rim crest of Henry is not very well defined, but it's there. And from that initiation of boulders, they stream down the slope to the break-in-slope down at the floor. Still no obvious change in the dark mantle, as we're just to the east of Locke now. (Pause) There's a 30-meter crater, fairly subdued but still quite deep... (That is, with a) subdued rim. Again, it looks as if it were mantled; (and it) has no significant increase in blocks on its rim. That crater, in any other place, would have been a very blocky-rim crater. It's maybe 30 meters (across) by 5 meters deep. Man, that is a big rock up there! (Pause)

164:43:30 Schmitt: Turning Point Rock is a split rock; (it) has (what) looks like a northwest-southeast overhang, with another block just this side of it, just to the south of that overhang. It's a pyramid shape in cross section - triangular shape in cross section - and it looks like it is pretty well fractured, although not pervasively like the rock at Shorty was.

[Jack's photos taken during the approach to Turning Point Rock are AS17-141-21560 to 21563. Gene's approach photos are AS17-140-21393 and 21395.]

164:44:06 Cernan: Okay, Jack, I know I can get up to Station 6.
 164:44:08 Schmitt: Yeah.
 164:44:09 Cernan: I can drive up there.
 164:44:11 Schmitt: Yeah. Now, Bob, Station 6 rock - one of them - is from that boulder track that runs obliquely across the contours.
 164:44:19 Parker: Okay. I copy that, Jack. Sounds like good news.
 164:44:23 Schmitt: And the pictures ought to pin down at least the (upper) end of the boulder track pretty well.
 164:44:32 Cernan: Boy, this is a big rock, Jack. Whew.
 164:44:35 Schmitt: As I saw it, the boulder track stopped about halfway up the slope of the North Massif. (To Gene) That (Turning Point Rock) is a big rock.

[Based on the length of it's shadow in the overhead photograph, Turning Point Rock is comparable to the LM in height - 23 feet or 7 meters - in close agreement with Gene's six-meter estimate below. AS17-141-21564 is taken as they go east of the boulder.]

164:44:42 Cernan: We're at Turning Point Rock. And it looks like it's - I don't know if it's mantled on top, but it's certainly filleted. There's a lot of the dark mantle up and on some of the shallower slopes of the boulder. And it's on a little mound itself, as if much of it might be covered up.
 164:44:57 Schmitt: Yup. Okay. It looks like a breccia from here.
 164:45:02 Cernan: Can you get a sample of it right here? You see these little chips?
 164:45:05 Schmitt: Yeah, I probably can.
 164:45:08 Cernan: Okay, Bob. I'm 3 meters from Turning Point Rock on the east side, and I'm reading 186 and 2.8.
 164:45:16 Parker: Roger. Copy that. Sensational.

[The checklist location is 192/2.9. See the discussion at 164:47:52. AS17-141-21565 is taken at about this point.]

164:45:17 Cernan: Ahh! (Garbled) that over.
 164:45:21 Schmitt: Okay. Can you drive up...
 164:45:24 Cernan: Yep.
 164:45:25 Schmitt: ...to the...right there. Let's see...No, I can get them. The thing is, I don't know what it is.
 164:45:31 Cernan: Well, but it's part of these fragments around here. (Pause) I guess Turning Point Rock is (visual measuring the rock) 1, 2, 3, 4, 5, 6...Six meters high

anyway. It's a...Well, I'd say it's a very rough, subrounded type of rock. By the face...Let me get this, Jack. Okay.

[Cernan - "That's big! I'm obviously impressed with how big it is. Jack says 'Gee, that's a big rock;' and all of a sudden I'm counting 'One, two, three...' All of a sudden I'm eighteen feet high! That's a big rock. And I hate to admit it, but I just cannot picture that rock in my mind. Now, the color pictures I took (AS17-140-21396 to 21398) do bring back some memories. And it may be that I remember because we'd stopped to take the pictures."]

164:45:57 Schmitt: There are two fragments in that sample.

164:46:01 Cernan: 47 Yankee.

164:46:02 Schmitt: Plus some dirt. And it (the sample location)'s about 4 meters from Turning Point Rock on the north side.

164:46:15 Parker: Okay. Copy that. And presume you got some good photos of the rock.

164:46:21 Schmitt: Yeah, I got a couple. (Pause) I hope they're good.

164:46:25 Cernan: Well, I'll tell you what I'm going to do here, real quick.

164:46:28 Schmitt: And my locator is...

164:46:29 Cernan: I'm going to do a...

164:46:31 Schmitt: ...(frame) 56.

164:46:32 Parker: Copy that.

[Jack's locator to the South Massif is AS17-141-21566.]

164:46:33 Cernan: Jack, let me spin around this little crater here to the left.

164:46:36 Schmitt: Bob, it's very coarsely vesicular; but. at first glance, it did not look like the pyroxene gabbro - although that rock (another rock nearby) does. It looks like it might be fragmental, although I'm suspicious that I'm looking at zap pits.

[Now, Gene starts to turn the Rover to give them a good view of Turning Point Rock.]

164:47:01 Schmitt: Oh, yeah.

164:47:05 Schmitt: (I'm) getting them (that is, the black&white pictures). I got them. (To Gene) Take one (that is, a color picture). That's a nice view.

[Jack's pictures of Turning Point Rock are AS17-141-21567 and 21568. This is where Gene takes AS17-140-21396 to 21398.]

164:47:12 Cernan: Man, we're on a little rise looking at this boulder. That's incredible. (Pause) Okay. We're on the roll, Bob.

164:47:18 Parker: Copy that.

164:47:20 Schmitt: (To Gene) You know that...(To Parker)
 Bob, my guess is, right now, is that Turning Point Rock is a
 big piece of subfloor gabbro.
 164:47:32 Parker: Okay. I gather you changed your opinion.
 164:47:34 Schmitt: What looked like fragments is just big
 spalls where the zap pits have cleaned off the rock.

[Schmitt - "From my description, it sounds like Turning
 Point Rock was the same kind of rock as the north half of the
 Split Boulder (at Station 6). That boulder was two kinds of
 rock: a vesicular breccia that had intruded a blue-grey
 breccia. My first instinct here was to call it a vesicular
 breccia (164:44:57 and 164:46:36), and then I backed off from
 that."]

[Jack discusses the relationship between Turning Point
 Rock and the Station 6 boulder in a comment after 165:35:52.]

164:47:52 Parker: Okay. I copy that. And, guys, you might
 be happy to know that we think we've finally found the LM,
 because we were calling that for 188 and 2.8, and you got
 there at 186 and 2.8.
 164:48:06 Cernan: That's not bad. (Pause)
 164:48:12 Schmitt: Okay.

[Because Turning Point Rock is almost due north of the
 landing site, the bearing gives a very good east-west
 position for the SEP transmitter. The two-degree difference
 in bearing is equivalent to a 100-meter east-west position
 difference at a 3-km range. In general, if the planned
 bearing and range at any particular place was Q_p and R_p ,
 respectively, and the actual values are Q_a and R_a , then the
 position differences between the planned SEP location and the
 actual location are

$$D_x = R_a \sin(Q_a) - R_p \sin(Q_p)$$

and

$$D_y = R_a \cos(Q_a) - R_p \cos(Q_p).$$

Here, a positive D_x indicates an eastward displacement of the
 actual SEP site and a positive D_y indicates a northward
 displacement. The following table lists estimated
 displacements for the reasonably-well-defined places visited
 during EVA's 2 and 3.

Location	R_p (km)	Q_p	R_a (km)	Q_a	D_x (km)	
Dy (km)						
Hole/Wall	5.5	80	5.7	81	0.21	-0.06
Station 2	7.2	68	7.6	71	0.51	-0.22
Station 3	5.6	87	6.0	87	0.40	+0.02
Station 4	4.1	101	4.4	102	0.28	-0.13
Victory	2.8	107	3.2	106	0.28	-0.06
Station 5	1.2	88	1.4	86	0.20	+0.06
Turning Point	2.9	192	2.8	186	0.31	+0.05
Station 6	3.2	198	3.1	192	0.34	+0.01
Station 9	2.3	235	2.2	230	0.20	-0.09
			Averages		0.30	-0.05

Readers interested in some of the details of the table should note that, while doing the nav initialization at the start of EVA-2, Gene read a heading of 283. With the sunshaft device properly zeroed, the heading should have been 282. Houston decided that the difference was too small to justify any heading correction. If there was an error of one degree, then all EVA-2 values of Qa would have to be increased by one degree and, for most of the EVA-2 stations, this would produce about a 100 meter increase in Dy and, for the over-all average, an increase of Dy to 10 meters north. However, it is not clear in the transcript whether Gene followed Houston's advice or, rather, torqued to the new heading. Similarly, we can't be certain that the Sunshaft was perfectly zeroed, etc. If nothing else, these considerations emphasize the potential uncertainties in position measurements made with the Apollo LRV navigation system. For present purposes, I note that the displacement of the actual SEP site from the planned site is 260 meters east and 60 meters north, compared with 300 meters east and 50 meters south for the table averages. These discrepancies are comparable with those observed by the Apollo 15 and 16 crews. As anticipated, the best estimates come from the closet stations: Victory, Station 5, Turning Point Rock, Station 6, and Station 9. The averages for those stations are 0.26 and -0.01. It is a bit surprising that the north-south result isn't a little better. In detail, the planned SEP site was 100 meters east of the planned landing point or 150 meters west and 50 meters north of the center of Poppie. From the overhead picture, we know that the LM is actually 100 meters north of Poppie; and, from images of the LM obtained from the SEP site and from the Rover bearing readouts, we know that the SEP transmitter is about 140 meters east and 60 meters north of the actual landing spot or 140 meters east and 120 meters north of the center of Poppie.]

[Cernan - "260 meters out of 250 thousand miles ain't bad! They ought to give you that much leeway."]

164:48:13 Cernan: It (the Station 6 boulder)'s the split one up there, Jack. I've had my eye on it. (Pause) Get some more pictures (garbled).

164:48:22 Schmitt: I've lost...

164:48:23 Cernan: There's some big boulders down here. Got it.

[Gene's photo is AS17-140-21399. Station 6 is the apparent pair of boulders beyond the large foreground boulder. Jack's takes a similar picture, AS17-141-21569 at about this time.]

164:48:26 Schmitt: I sort of lost track of Station 6.

164:48:34 Cernan: Nah. I got it. I've had my eye on that boulder. You can't see the track from here. I'll bet you can. I can see it now. We'll see it. We'll be looking

right up it; looking right up the old boulder track. (Pause)
 Man, I tell you, this navigating through here is not...
 164:48:55 Schmitt: Okay. We're in a region where, really,
 the general fragment population is no different. We're up
 off the break in slope, although you wouldn't notice it.

[They are now on the lower slopes of the North Massif,
 with presumably little or none of the gabbroic lava beneath
 them.]

164:49:08 Schmitt: But we are, quite a ways. But the
 fragment population is not much different than out on the
 plains. The big difference is that there are these scattered
 blocks that are from a meter to probably 10
 meters...(Correcting himself) No, 5 meters in diameter.
 Hard to say, maybe 8.

[Jack's photos taken during the approach to Station 6
 are AS17-141-21570 to 21574. In 21573, the Station 6
 boulders are at the left.]

164:49:26 Cernan: See that track coming down? We'll be
 looking right up that track.
 164:49:29 Schmitt: Yeah, yeah, you got it. I didn't realize
 you were (chuckling) that far upslope.
 164:49:31 Cernan: Yeah, we're way upslope!
 164:49:33 Schmitt: Yeah. You did it.
 164:49:36 Cernan: Not very uncomfortable for me on this
 side. (Laughing) How do you feel?
 164:49:38 Schmitt: Oh, I feel fine. I just...Until I looked
 down here and saw the slope we're on.
 164:49:41 Cernan: Yeah, I know it.

[They are angling upslope, with Jack's side down, as
 usual.]

[Cernan - "Here we have the responsibilities of command,
 again. Always watching out for your crew. And Jack deserved
 every minute of it. And I'll tell you one thing, I got
 myself on the downslope a couple of times and in one sixth
 gravity...I won't say it's uncomfortable; but the Rover is so
 free to move, so free to bounce, that it seemed if you so
 much leaned an arm out you'd tip over. The slopes got very
 noticeable. Now, on a 45 degree slope, sometimes, you'd
 think you were going straight up. I compare it to bombing
 runs. You could be in a 60 degree run and you'd absolutely
 know that you were going straight down at 90 degrees. You
 always tend to overestimate your angle. If you were looking
 for a 30 degrees bombing run, you might be at 15 and think
 you were at 30. And it was the same way here. A 15 or 20
 degree slope can be awfully steep when you're on it."]

164:49:45 Schmitt: And I can't see any obvious change in albedo, like we could see with the light mantle yesterday. (Pause) (To Gene) You got a...Don't...There you got her: a nice, nice place. Oh, oh, you don't want to go over that way.

164:50:01 Cernan: I can make it. I want to park right...

164:50:03 Schmitt: (Garbled)

164:50:04 Parker: And, 17, you want to park at a heading of 107; we're going to open the battery covers and let them cool at this station. So a heading of 107.

164:50:16 Cernan: (Pause) 107, huh? Okay. I'll get it up here. (Pause)

164:50:22 Schmitt: Hey, that's going to be moderately level right there (on the west side of the boulder).

164:50:24 Cernan: Yeah.

164:50:26 Schmitt: Trouble is, they (Houston)'re looking into the shady side of the block.

164:50:30 Cernan: Well, if I park on the other side, they won't be able to...I can go right upslope a little bit.

164:50:34 Schmitt: That's all right. We can work in there. No, that's all right.

[Schmitt - "I didn't know what I was going to see on the other side of the block at this point, so I told them that we could work in the shade. You got quite a bit of diffuse light, particularly on a down-Sun face because the Sun backscatters directly on it. You can see pretty well, as some of the photos show."]

164:50:35 Cernan: Yeah, I can't go up there. Let me just...This is going to have to be good. I can't go up there. (Pause)

164:50:49 Schmitt: Yeah, I think you're all right.

164:50:50 Cernan: That's not very level, but...

164:50:52 Schmitt: Oh, not too...Not too hard. Watch that turn. (Pause)

164:50:58 Cernan: That's not very level, but we're not going to get much more level than that.

164:51:01 Schmitt: No, that's good.

164:51:03 Cernan: Let me...They wanted 107. (Pause) That's the best I can do. That's not very level for the gravimeter, but...Let me see if I can get comm.

[There has been little apparent degradation of comm during this bit of maneuvering. Evidently, Houston has been reading them through the LM. They have now parked at Station 6. The Station 6 boulder is actually comprised of five large pieces. The two southernmost of these are about ten meters west of them. As indicated in the accompanying figure, a small gap separates these two fragments from the three others which are northeast of the Rover. The five boulders are fragments of a large rock which, long ago, tumbled down the North Massif. The story behind the alternate name of the boulder - Tracy's Rock - follows 165:28:58.]

164:51:19 Cernan: Hey, Bob, how do you read?
 164:51:21 Parker: Loud and clear, 17. How do you read?
 164:51:24 Cernan: Okay. We're parked on a heading of 107.
 (Jack is laughing) Are you happy with that?
 164:51:31 Parker: Roger. Sounds great.
 164:51:33 Schmitt: (Laughing) You parked on a slope, too.
 164:51:35 Cernan: There's no level...There's no level spot
 to park, here, though.
 164:51:40 Schmitt: You want some help getting off? (Laughs)

[Because of the slope, neither Gene - who has to get off
 the Rover on the uphill side - or Jack - who has to get off
 on the downhill side - is having an easy time dismounting.]

164:51:42 Cernan: (Laughing) I've got to go uphill!
 164:51:44 Schmitt: I just about ended up down at the bottom
 of the hill.
 164:51:46 Cernan: Okay; (static) 192, 3.8, 3.1; 88 and 80;
 (static ends) 108 and 0 on the batteries. The forward motors
 are 220 and about 270, and the rears are off-scale low and
 220.
 164:52:14 Schmitt: You want me to block the wheels? (Both
 laugh) You got the brake on, I hope.
 164:52:20 Cernan: You betcha! (Pause) I don't know if I
 can lean uphill enough (to get off)! (Hearty, playful
 Laughter) I can't. Holy Smoley! Boy, are we on a slope!
 164:52:35 Schmitt: You okay?
 164:52:36 Cernan: Yeah. Let me get this thing set again.
 164:52:38 Schmitt: I don't think you can get a (gravimeter
 reading)...
 164:52:40 Cernan: Boy, are we on a slope!

[Cernan - "Even the pan I took from up above Tracy's
 Rock doesn't really show you the slope; but the comments do.
 And we were parked cross slope, pointed roughly east, because
 they wanted us pointed 107. I had to get off uphill, and it
 was really pretty hard to get off. Jack said he almost
 rolled to the bottom of the hill. It was almost like parking
 in San Francisco, except we were parked side slope. Now,
 when we got back on, it was just the opposite: it was very
 difficult for him to get on and it was very easy for me. We
 might have wanted to park uphill or downhill, but we parked
 at their heading for battery cooling."]

[On Apollo 15, at Station 6a, Dave Scott and Jim Irwin
 also parked on a steep slope and, in that case, they decided
 to have Irwin stay with the Rover so that he could hold on to
 it in case it started to slip.]

[Cernan - "Working on hillsides wasn't something that
 you couldn't handle. Let's face it, you're on the Moon, it's
 a new environment, and all of a sudden you're on a hill. It
 wasn't something that you didn't expect. It's like you get
 on an airplane and you go to San Francisco and you sort of
 know what to expect. But you go and park on one of those

hills and you still say "Wow"! In one sense, we were trying to relate to the people who were listening what we were confronted with, because they couldn't see any of it."]

164:52:44 Schmitt: Okay. I'm going to stay out from between the rocks. It's a beautiful east-west split rock. It's even got a north overhang that we can work with. (Pause) And let me see what it (the boulder) is! We're right at station 6. You wouldn't believe it.

164:53:08 Cernan: I would. Oh, man, what a slope!

164:53:11 Schmitt: And this boulder's got its own little track! Right up the hill, cross contour. It's a chain-of-craters track, and it looks like it stops (static) off where it started. It starts in, what looks to be, a lighter-colored linear zone. Trying to give you perspective, it's probably only about a third of the way up the North Massif. (Pause)

[TV on.]

164:53:44 Cernan: Bob, are you reading us?

164:53:45 Parker: Read you loud and clear; and we've got a picture.

164:53:49 Cernan: Oh, man, I tell you, are we parked on a slope! I don't know whether your TGE's going to hack it.

164:53:57 Parker: Okay. It'll take up to 15 degrees.

164:53:59 Schmitt: Bob, this is a...

164:54:02 Cernan: (Working behind Jack's seat) Well, it's (the TGE) going to have it (that is, a slope of at least 15 degrees).

164:54:06 Schmitt: It's a coarsely vesicular, crystalline rock...finely crystalline. Looks like, probably, an anorthositic gabbro. (I'm) trying to see the zap pits for glass color; I don't have a good one yet. (Pause)

[Jack discusses the evolution in his thinking about this boulder in a comment following 165:35:52.]

164:54:31 Cernan: Say, Bob, you want both the (SEP) recorder and the other switch off? On the SEP.

164:54:36 Parker: Roger. Both of those off, and dusted. (Pause)

[Gene backs a step or two from the Rover and has to lean about 20 degrees into the hill to stay erect. Fendell pans the TV counterclockwise.]

164:54:44 Cernan: Oh, man, is it hard to get around here.

164:54:47 Schmitt: Bob, it looks like the glass is fairly light colored. It's not white. (Pause) Well, no; it's black. It's anorthositic gabbro, rather than gabbroic anorthosite (in composition), I think. Yeah, that's black glass in the pits.

[Schmitt - "I had worked out a rule of thumb that the glass color was indicative of composition. The glass in anorthosite - feldspar - was translucent white; and if you have any amount of mafic minerals at all, you're going to get darker color to black. I think that, right here, I'm mouthing off, getting my bearings, and don't really have things sorted out as yet."]

164:55:10 Parker: Okay. And, Gene, did you happen to notice the temperature on the SEP when you dusted it?

164:55:17 Cernan: I didn't dust it yet.

164:55:19 Parker: Copy that.

164:55:21 Schmitt: Bob, some of the vesicles are...They're flattened. All of them are flattened. There's a strong foliation of vesicles in the rock. Most of them are flattened, and they are up to 15 or 20 centimeters in diameter and about 5 to 6 centimeters thick ...or wide.

[Schmitt - "The flattened vesicles indicate that the rock was flowing while it was molten, but was still too stiff to allow the vesicles to take a spherical shape." See AS17-141-21629.]

164:55:50 Parker: Outstanding.

[Fendell pans by the boulders east of the Rover and finds Jack on the north side of the north boulder, dwarfed by it and standing in the shadow.]

164:55:56 Schmitt: And there's some beautiful north overhangs all around the block. Well, (laughs) on the north side of the block.

164:56:04 Parker: Okay. That's the best place to have north overhang; and I guess that means one of you guys might grab the SEC - the small can - before you leave the Rover.

[A north overhang offers a chance of sampling soil which has been continuously shielded from the Sun.]

164:56:15 Cernan: Okay, Bob. It's going to take me a while to dust. I tell you.

164:56:18 Schmitt: Okay,...

164:56:19 Cernan: Hard to get around here.

164:56:21 Parker: Roger on that.

164:56:23 Schmitt: Bob, let's get it straight. You want the north overhang sample in the SEC - or the short can? (Pause)

164:56:37 Parker: Miracle of miracles. They don't want the short can. I'm not sure I understand that, Jack, but they don't want the short can here, they say. (Pause) I guess they're looking for volcanics today (at Station 9).

164:56:49 Schmitt: Okay, we'll put them in bags.

164:56:51 Cernan: Oh, man...

164:56:52 Parker: They're looking for volcanics today, Jack.

164:56:55 Schmitt: Oh, they are, huh? We found those yesterday (at Station 4).

164:56:58 Parker: Well, they're hoping (to find volcanic material) again at Station 9 (and want to save the sealed "short can" for that possibility).

[Schmitt - "Because of Shorty, they were thinking that another fairly dark, fresh-looking crater (Van Serg) might have some volcanic material around it. Of course, when we got there, it was just another impact crater into a very thick regolith with some dark-mantle material in its wall. As I recall - and we'll see - we never used the short can there. I don't recall."]

[Jack is examining the west face of the north boulder.]

[Schmitt - "I was close to it to see better in the shadow, to keep my eyes out of the Sun."]

164:57:06 Schmitt: Now, that foliation I mentioned does not go all the way through the rock. There are variations in texture. One zone was strongly foliated. There's another; it almost looks like a large - it is - a large inclusion of nonvesicular rock within the vesicular rock. There may be some auto-brecciation involved in the formation of this thing. It really looks, mineralogically, like the light-colored (breccia) samples from the South Massif. But I tell you, that's only because it's light colored, and I...I can't give you anymore than that right now, until we get a fresh surface.

[Jack has moved around to examine the southwest face of the north boulder, which is in shadow because of an overhang. There is a spot of sunlight reflected onto the rock off of Jack's visor. He now moves south.]

164:57:59 Cernan: 110 degrees on the SEP and you want the cover closed, right?

164:58:04 Parker: Cover open, please. Cover open. Both (switches) off.

164:58:08 Cernan: Okay! Cover's open.

164:58:12 Parker: Okay. And did you get the batteries,...

164:58:14 Cernan: Oh, my golly.

164:58:15 Parker: ...the LRV battery covers open. We didn't copy that, Gene.

164:58:20 Cernan: No, I didn't copy that you wanted them open. I just got 107. I was about to ask you that.

164:58:24 Parker: Okay. We'd like them open. And, Jack, while I'm interrupting everybody here,...

164:58:27 Cernan: Oh, man!

164:58:27 Parker: ...how about a frame count, if convenient.

164:58:36 Schmitt: Well, shoot! Bob. I gave you one at the (Turning Point) rock. It's now 68.

164:58:41 Parker: Okay. Copy that.

164:58:46 Cernan: Man, I never...(Laughing) You can't believe how tough it is getting around this Rover, on this slope!!

[Jack moves to the west face again.]

164:58:56 Schmitt: I think I'll...

164:58:58 Cernan: Man, that...I think we're probably pitched 20 and rolled 20!

164:59:08 Schmitt: I think I'll get over here and get a pan while we're waiting to sample. (Pause)

[Gene is dusting the left-side battery covers; Jack moves north west of the Rover to take the pan.]

164:59:13 Cernan: Oh, I got to dust those radiators. I can't leave them like that. I tell you, this is not a very good place to dust them, though. Let me try one time. (A bit exasperated) Oh, boy!

[AS17-140-21400 is a photo of the dusty LCRU mirror which Gene takes at about this time.]

164:59:30 Schmitt: Be careful, Geno. Need some help?

164:59:32 Cernan: Nope. I need a little finesse, though. (Pause)

[Jack has some trouble moving uphill.]

164:59:40 Cernan: It's one thing to reach over here and do this on level ground. (Pause) I don't know if I can do that without falling on the battery.

164:59:54 Schmitt: Well, I found a place to stand where I can take a pan. (Pause)

[This is the "south pan" as marked on the Station 6 plan map. The pictures are AS17-141-21575 to 21603. 21592 and 21593 show the northernmost fragment from which, later during the stop, Gene will collect a dust sample. 21594 shows the fragment which is north of the split, and 21597 show the large fragment which is south of the split. These two fragments - marked 2 and 4 in the Station 6 map - are the only two that are readily visible in the TV. Frames 21598 to 21601 show Gene emplacing the TGE, starting at about 165:00:58.]

165:00:00 Cernan: Bob, I'm going to have to give you a good battery brushing at the next site. I can't get...I can get half of them, but I can't get the other half. It's too slopey.

165:00:14 Parker: Okay. We copy that.

165:00:19 Cernan: But the covers are open. (Pause)

[Gene stows the dust brush, gets his tongs and attaches them to his yo-yo with a small clip that fits onto the shaft. His yo-yo is attached to the hoses just above his left hip.]

165:00:25 Cernan: What are you working on, Jack?
 165:00:26 Schmitt: I'm taking a pan.
 165:00:28 Cernan: Very good. I'm coming right now. (To Parker) I bet you a dollar to doughnuts that you don't get a TGE reading.
 165:00:35 Parker: Yeah. Gene, if it's easy enough to take it off, why don't you take it off the Rover; and we'll try and level it in the stuff (the soil).

[Gene moves to the rear of the Rover, uncovering Jack who is well up slope, taking the pan. In order to aim the camera for each exposure in the series, Jack bends his knees, his feet behind him, bounces up onto his toes, and arches his back.]

165:00:45 Schmitt: (Responding to Parker's suggestion about putting the TGE on the ground) Aw, come on. (Guffaws, wondering if they are serious)
 165:00:47 Cernan: I'm not sure there's any place to put it on the ground level.
 165:00:53 Schmitt: No, you have to dig a place.

[Jack's visor is up and his face is clearly visible. Fendell zooms in on him. His feet are hidden by the near rim of the crater in which he is standing.]

165:00:58 Cernan: (Not convinced this is a good idea) Yeah, I'll do it. (Pause) Okay. It's coming off. Well, I'll set it right up here.
 165:01:11 Schmitt: It's going to fall down the hill. You'd better stomp off a good place.
 165:01:17 Cernan: Yep. (Pause) That looks level to me. (To Jack) Can you see it from there?
 165:01:28 Schmitt: Well, I can see it.
 165:01:30 Cernan: I mean, is it (level)...
 165:01:31 Schmitt: I don't know. I have no perspective anymore.
 165:01:33 Cernan: I don't either. Mark. Gravity.
 165:01:37 Parker: Copy the mark.
 165:01:38 Cernan: It's flashing. Okay; now let me get to work. (Pause) Okay. Straighten out my fender (which) got a little kinked here, which isn't going to help us.

[Jack moves farther away from the Rover, deeper into the crater. He is visible only from the waist up. He turns to the southeast.]

165:01:54 Parker: Hey, Jack. And we see your gold visor is up. You may want to put it down out here in the Sun.

[Jack climbs out of the crater and moves cross slope, angling uphill and to the east.]

165:02:02 Schmitt: Well, I think I might...I can't see with it down; it's scratched! Bob, I'll use it. I think I can monitor that one (his visor). (Pause)

165:02:13 Schmitt: Hey, I'm standing on a boulder track. (To Gene) How does that make you feel?

165:02:17 Cernan: That makes me feel like I'm coming over to do some sampling. (Pause) Think how it would have been if you were standing there before that boulder came by.

165:02:33 Schmitt: I'd rather not think about it.

[Gene moves uphill and east.]

[Cernan - "It's not just walking uphill that's difficult, it's walking sidehill, too. In one-sixth gravity your stability changes and you need a new approach. You have to work at it a little harder."]

[Jack is standing in the middle of the boulder track, manipulating the scoop and a sample bag. In contrast with the problems he had at Station 3, Jack isn't having any particular difficulty doing solo sampling and pours soil into the bag with relative ease.]

[Schmitt - "(Laughing) My hands must not have been tired. And you learn how."]

165:02:36 Cernan: Okay, let's go. You got a spot picked while you're here?

165:02:39 Schmitt: Well, the big thing is, let's get the boulder and then get in that east-west split. Bob, I got an undocumented sample from the middle of the boulder track.

165:02:58 Parker: Copy that. Soil sample?

165:03:00 Cernan: Whew!

[Jack leans his stomach on the scoop handle. Gene is at the shadowed, northwest corner of Fragment 2, the boulder immediately north of the east-west split.]

165:03:03 Schmitt: Soil sample. (Pause) Gene, if you hit them off in there, it's going to be awful hard to find them, that's the problem.

[That is, it would be hard to see fragments that fall in the shadow area.]

165:03:14 Cernan: Did you pick a spot - a good spot - while you were over here?

[Jack has joined Gene at the north boulder; Jack puts his gold visor up, again.]

165:03:19 Schmitt: No, I didn't. I just was looking at it. I think we need to get in the light, though.

165:03:24 Cernan: I can see with my gold visor up.

165:03:26 Schmitt: Let me put a sample in your bag (SCB).
165:03:28 Cernan: Okay. Go ahead.

[Jack stands uphill of Gene and puts the sample in Gene's SCB.]

165:03:29 Schmitt: It's bag...(Quietly, to himself) Shoot.
(To Parker) It's 534.
165:03:39 Cernan: This boulder looks fairly uniform from top to bottom.
165:03:42 Schmitt: We've got to get a reference sample of this soil.
165:03:45 Cernan: Let's get where we can get that 90-degree picture, too. So we really ought to get on the Sun side.
165:03:51 Cernan: (Pointing at a spot about shoulder height on the boulder) Let me get that slab right there, though, to start with. I can get that one off.
165:03:55 Schmitt: Well, there's no...Let's go over on the Sun side because we can't really photograph it.
165:04:00 Cernan: Okay. I got to get out of here first. Let's go through the split (between the boulders).

[Gene moves south; his gold visor is up also. Then, he pulls it down.]

165:04:04 Schmitt: Well, okay. Be careful, though. (Pause) Why don't we sample the split first so we don't...
165:04:14 Cernan: Look at that overhang. Man, I tell you, if you get your shovel down there, you'd have a (garbled).

[Jack follows Gene to the split.]

165:04:17 Schmitt: Yes, let's sample in the split first so that we don't get it too messed up. And then we can sample some of this stuff. Not...(Gesturing south) We want this overhang over here, Geno - the north facing one.

[Gene has been looking at the west face of the north boulder and Jack wants him to work the north face of the south boulder.]

165:04:30 Cernan: Right here?
165:04:32 Schmitt: Yeah. I got to sneak by over there. Whoops! Don't shuffle too much dirt in there.
165:04:39 Cernan: Okay. You by me so I can set the gnomon down.
165:04:41 Schmitt: Not quite. Don't think I can make it - without hitting you. I can't.

[At the surface, the two boulder fragments are separated by about three or four feet. Jack tries to pass Gene to the north. Gene takes a couple of small steps closer to the south boulder, rests his hand on it, and creates a space big enough for Jack to pass.]

165:04:46 Cernan: Okay. Now try it.
165:04:48 Schmitt: Okay. (Pause)

[Cernan - "The video of our work at this station really shows what it takes to work on a slope in the confines of a pressure suit. You can see that our movements are totally different than they were on the flat and level ground. If you start stepping downhill, your center of gravity shifts. You could hear me talking about leaning over the Rover to dust things. If you do it from the top side, you're going to fall down over the Rover. If you do it from the bottom side, you can't quite reach that far. And, if you do it cross hill, you've got a similar problem. I think this whole station is a good example of working in a sloped environment in one-sixth gravity. You don't have boulder fields to trip over, but you've got an undulating, sloped surface you're trying to work on. I haven't seen this in a long time. You look at the TV picture and the bodies are all cocked at 15 or 20 degrees. It's totally different from anything else we've seen. Now, granted, the Rover is on a slope as well and that probably accentuates it. But the combination of the TV and our comments really tell the story."]

165:04:54 Cernan: Ready?
165:04:56 Schmitt: Okay.
165:04:57 Cernan: Let me set the gnomon down...
165:04:58 Schmitt: Set it down just outside the shadow there. Right...Whoa. Right there. That's good. There's still some good clean ground there. Okay.
165:05:06 Cernan: (Dropping the gnomon) Okay. I can get back far enough to take these pictures. I want to go get a stereo pan around the corner anyway. Let's see if I can't start here with about 5/6. I'm so close. (Pause)

[Gene steps back to take the pictures, bumping his PLSS against the north boulder. Gene's photos are AS17-140-21401 to 21404 and show the gnomon from cross-Sun and the shadowed face of Fragment 4, the south boulder. AS17-141-21604 is Jack's down-Sun and 21605 is his locator to the Rover. Note the dirt on Gene's feet and legs.]

165:05:21 Schmitt: I'll tell ya...I'll get a...
165:05:25 Cernan: I must have a boulder behind me.
165:05:26 Schmitt: I'll get it. Let me...
165:05:28 Cernan: I'm going to go around the cor(ner)...I got it now. (Pause)
165:05:37 Schmitt: Okay. You got a bag?
165:05:39 Cernan: All set.

[Gene briefly raises his gold visor and then puts it down again.]

165:05:42 Schmitt: Okay. I'm going to get the shadowed material. (Pause)

[Jack has moved a little east and now leans way under the north-facing overhang, supporting himself with his left hand on the boulder while he use the scoop in his right hand and leans far forward.]

[Schmitt - "I was trying to get as far under the boulder as I could."]

165:05:51 Cernan: (Holding the sample bag) It's in bag 312, Bob.

165:05:53 Parker: Copy 312.

165:05:56 Schmitt: And it's...It's from...I think you saw where I got it. It's about a half a meter back of the limit of the overhang. (To Gene) Put it (the sample bag) down. Put it (lower) down.

[Gene is holding the bag while Jack tries to pour in soil from the scoop, a difficult operation because of the stiff suit arms. Jack wants him to hold the bag lower to make the pouring easier.]

[Cernan - "I wasn't holding it in a way to make it difficult for him, it was just suit restriction. You seek out the most convenient and least restrictive positions while reaching out far enough and low enough. From his point of view, it would have most convenient if I got down on my knees and held the bag, but only if I could have stayed there for ten minutes. But you take a sample and then you move ten feet; you take another sample and then you move again. So, unless he's going to go back and forth, you have to move together and you both have to be on your feet. It's a compromise."]

165:06:08 Cernan: Okay. Can you reach it?

165:06:10 Schmitt: I will in a minute. You can turn it a little bit towards me. (Pause)

[Jack hops uphill to the east of Gene, while Gene turns to keep the sample bag in position.]

[Schmitt - "I'm surprised that, with me moving like that, the soil stayed in the scoop. And I was reaching upslope some, so it was a tough maneuver."]

165:06:19 Schmitt: Okay; 312. (Pause; presenting his SCB) And the soil outside the overhang will be next.

165:06:38 Cernan: Okay. Go get it. (Pause)

[Schmitt - "There is more TV coverage at this station than I thought. I had forgotten that we had sampled together for a while. What I remember is being alone, working on the contact between the two breccias (the vesicular and non-vesicular materials described at 164:57:06) while Gene was taking some pans."]

[Jack scoops a sample just outside the shadow, leaning on the boulder again with his left hand. The scoop mark on the ground is very reflective.]

165:06:45 Schmitt: And the first one is from the upper 2 centimeters.

165:06:52 Cernan: Bag 313.

165:06:55 Parker: Copy 313. (Pause)

165:07:00 Schmitt: (Pouring) And the second one is from probably 2 centimeters down to about 8 (centimeters).

[Jack collects the second sample, then stands still while Gene puts the bagged first sample in his SCB.]

165:07:12 Parker: Copy that.

165:07:17 Schmitt: Bob, it looks like the fragment - or the boulder - just to the south of us has some inclusions in it - light-colored inclusions.

[Jack pours the soil into the bag and presents his SCB.]

165:07:29 Cernan: Bag 472 on that.

165:07:33 Parker: Copy 472 on that. You mean the south half of the split boulder?

165:07:38 Schmitt: (Gesturing) Yeah. I haven't seen inclusions in the other half.

165:07:45 Cernan: Okay?

165:07:46 Schmitt: Okay. Now we need boulder stuff. You happy with that, Houston? (To Gene) Let's get (garbled, overlapping conversation).

165:07:53 Cernan: (Garbled)

165:07:55 Schmitt: (To Gene) Got your hammer?

165:07:57 Parker: Yeah, we're happy with that for an east/west split.

165:07:59 Cernan: (Garbled) (Pause)

[The gnomon staff is inclined about twenty degrees, pointing north and indicating just how much of a slope they are contending with. Gene is hammering on a protrusion on the south boulder at about shoulder height. He hits it a dozen times.]

165:08:09 Schmitt: It's a little hard, huh? (Pause) I think...

165:08:13 Cernan: (No longer hammering) I've got to find a corner I can get at.

165:08:15 Schmitt: Yeah.

165:08:18 Cernan: (Moving north, away from the boulder) Let me get an "after" picture down in this hole (that is, where they got the soil sample).

[Gene's after pictures are AS17-140-21405 to 21408. AS17-141-21606 may be Jack's after.]

165:08:21 Schmitt: Oh, that's right. You almost stepped on the...I forgot the "after", too. (Pause) Hey, there are chips up here on top, also. That's been spalled off.

165:08:40 Cernan: Yeah.

165:08:41 Schmitt: We can get some of those, but...

165:08:42 Cernan: Looks like somebody's been chipping up there.

165:08:44 Schmitt: Looks like there's been a geologist here before us.

165:08:47 Cernan: Let me get the gnomon. I think I can get some of these pieces over here. I want to get that 90-degree angular flight line around this boulder, too.

[In order to reach down for the gnomon, Gene comes forward on his toes to keep his PLSS centered as he bends his knees.]

[Cernan - "It was just easier to bend my knees like a guy with a bad back might do. It was just easier to bend my knees to let my arms down low enough. You learn very, very quickly. The human being is very adaptable. You don't have to think about those things; you just do it. Somehow, that computer up above your neck just picks out the easiest approach.]

[They move off to the east behind the boulder, going gingerly and apparently downhill.]

165:08:56 Schmitt: Bob, the more I look at this thing...Now, here's the piece that fell off. Here's the piece that was knocked off up there.

165:09:04 Cernan: Yeah.

165:09:05 Schmitt: Look at that.

165:09:06 Cernan: We ought to bring a big piece of that home. That's obvious. It's obvious...

165:09:09 Schmitt: How about this one up here? Take your picture. I think we can just lift that off. See that?

165:09:15 Cernan: Stand by. (Pause)

[Gene comes into view, backing up to take pictures of the south boulder. His photos at this location are AS17-140-21409 to 21412. In 21409, note the slope relative to the flat valley floor.]

165:09:22 Schmitt: I'd better get...

165:09:23 Cernan: I'll get a "locator" from here.

[Gene takes a "before" and then turns to take a "locator", AS17-140-21412.]

165:09:25 Schmitt: Okay. I was going to get my down-Sun, but I'm afraid I'll...

165:09:31 Cernan: You may be down-Sun if you do.

[AS17-141-21607 is Jack's down-Sun.]

165:09:33 Schmitt: Yeah, we'll get some. (Can) you get it?
 165:09:36 Cernan: Yes. Will it come off?
 165:09:37 Schmitt: Let me see. (Pause) Yeah.

[Fendell pans up, then looks at the soil in the split.]

165:09:43 Cernan: Just throw it in my bag. It's broken, but it's "in place". That's a nice, big piece, too. It's about the size of a...
 165:09:52 Schmitt: (Laughing) Why don't you put it in mine. I can't get up to you.
 165:09:52 Cernan: (Garbled) okay?
 165:09:54 Schmitt: Got it?
 165:09:56 Cernan: Yeah, I got it. (Backing up to take a series of flightline photos) Don't move.

[Gene's flightline photos of the northeast faces of Fragments 4 and 5 are AS17-140-21413 to 21433. We include only 21420 and 21421 in this publication of the Journal.]

165:10:02 Schmitt: Okay, Bob, there's a big spall lying on the ground here that has been knocked off up there, from right on top of the boulder. And, I tell you, the more I look at the south half of this boulder, the more heterogeneous in texture it looks. It looks as if it may be either a recrystallized breccia of some kind, or you had a gabbroic anorthosite magma catch up an awful lot of inclusions. I guess I prefer the latter explanation (pause) because of the extreme vesicularity of the rock.
 165:10:43 Parker: Okay; very interesting.

[Fendell tilts the TV camera up to watch Gene doing a flight-line stereo in the split.]

165:10:47 Schmitt: Now, a few of the inclusions are. Well, they're all subrounded to rounded, and a few of them are very light colored. I'm going to try to get...
 165:11:00 Cernan: I'm coming around the corner with a flight line stereo.
 165:11:03 Schmitt: Are you going to do it now? Okay. Well, you know, I ought to get one shot back here with a black and white. I'll get this half black and white.
 165:11:09 Cernan: Okay, if we could get...
 165:11:12 Schmitt: I think we ought to pick up a piece of that spall there by the gnomon...
 165:11:14 Cernan: I can break it off. (Garbled) top.
 165:11:17 Schmitt: There's one right by the gnomon we can just pick up. It's a finer-grained vesicular rock than...Wait...Where...Jeez...

[Gene moves behind the south boulder. Jack follows, using the scoop as a cane in his right, uphill hand. His PLSS remains visible until Fendell pans away. Otherwise they are both out of view for quite a while.]

165:11:26 Cernan: Oh, oh, oh, oh...
165:11:29 Schmitt: I thought I was going to get this half.
Okay.
165:11:34 Cernan: I don't care. I started down, Jack.
165:11:36 Schmitt: Well, they like to have some of it in
black and white, you know.
165:11:40 Cernan: I'll get that rock. (Pause)

[Gene's photos of the sunlit portion of Fragment 2 are
AS17-140-21434 to 21440.]

165:11:48 Schmitt: I forgot to look at the objectives for
the station. I hope we're meeting them.

[The relevant checklist pages are LMP/CDR-10 and 11.
The fact that neither of them has even glanced at their
checklists at this station - and rarely do so at most of the
other stations as well - is an indication of just how well
prepared the J-mission (Apollos 15, 16, and 17) crews were.
None of them depended very much on the geologic portions of
their cuff checklist because they understood the geologic
objectives and also were prepared to make real-time decisions
- with input from Houston - on the tasks to be performed.
Only when they got to a station could they know what was
going to be important and, when one compares the mode of
operation of these crews versus the first three crews, the
difference is striking. Of course, on the first three
flights - particularly Apollo s 11 and 12 - geology was of
secondary importance compared with the main task of flying
the LM. The J-mission crews all had the advantages of
training as backup crews on a landing mission and then could
devote as much as 40% of the training for their own missions
to geology and the other scientific tasks. In addition, with
three 7-hour EVA's at their disposal - compared with two 4-
hour EVA's - and with the mobility of the Rover to give them
a greater variety of geology stops to explore, real-time
decisions made more sense. The mission planners recognized
this by including only generic tasks in the checklists.
Nonetheless, here at Station 6, Jack and Gene are operating
more independently than they or any other crew operated
during all of the Apollo surface operations. Houston is
making almost no suggestions, confident that with an 45-
minutes of time budgeted for this station, Jack and Gene
won't miss anything important. In a few moments, at
165:14:44, when Jack takes a moment to get his thoughts
organized about what they want to do at this station, Parker
will summarize for them the objectives listed on LMP/CDR-11;
but, basically Jack will ignore him.]

165:11:53 Cernan: Well, we want to get 500's of that
boulder track. I know I want to get that. (Pause)

165:12:03 Schmitt: Okay. A piece of that spalled rock that was sitting by the gnomon...Ooh, watch out gnomon. How about that?... (The sample) is in bag 535.

165:12:26 Cernan: You got one in there already?

165:12:27 Schmitt: Yup.

165:12:28 Parker: Okay. We copy that one, Jack.

165:12:30 Cernan: You won't be able to reach...You won't be able to reach my bag.

165:12:33 Schmitt: No, but you can put it in mine. (Pause) Can you reach it? (Pause)

165:12:43 Cernan: Working at it.

165:12:45 Schmitt: Bob, one of the light-colored inclusions looks like it may be anorthositic...(Correcting himself) gabbroic anorthosite...Let me get my terms straight. The host rock has dark-enough zap pits that it's probably gab - ah - anorthositic gabbro, if I didn't say that. Some of the light-colored inclusions have slightly lighter-colored glass, and they may be the gabbroic anorthosite.

165:13:20 Parker: Okay, I copy that, Jack.

165:13:21 Schmitt: (To Gene) Inclusions like this one and that one.

165:13:24 Cernan: Yeah. Some of those inclusions get to be bigger than the size of a baseball. There's one here and a couple up there.

165:13:28 Schmitt: Let me borrow your hammer.

165:13:30 Cernan: Yeah. Jack, try a little higher. See that one right on the ...Right there. Right...(Pause) Well, that's a hard rock.

165:13:54 Schmitt: (Unable to break it loose) No.

165:13:55 Cernan: That's a hard rock.

165:13:56 Schmitt: You might be able to do it; I can't. (Pause)

[With the astronauts out of sight, Fendell makes a close-up examination of the shadowed west face of Fragment 2 and then does a site panorama.]

165:14:01 Cernan: I can't get down there. (Pause) Okay, we need some of the soil outside the shadow here.

165:14:08 Schmitt: Yep. How about over where your bag went? Let's move around here...I think there is some...Oops! Get on this slope over here. Okay. How about out over here? Are we supposed to get a...(Glancing at LMP/CDR-11) Where are we here?

165:14:32 Cernan: I don't know. I'd like to get...(Pause) Well, when you face uphill, your camera faces down.

[That is, Gene is having to lean forward to maintain his balance and, as a result, his camera is pointing into the hill. In order to get a picture, then, he would either have to lean back or take the camera off the RCU bracket.]

165:14:39 Schmitt: We want to get a rake on the rim of that little crater down there, I guess. And...

165:14:44 Parker: Okay, 17. Roger. You were asking about objectives. (Reading LMP/CDR-11) Of course the primary objective is documented samples of the blocks; and then, also, we'd like to get some of the rake and soil sample out in the surface, namely, the rim crater there, if that's available. And one of the things, of course, we're looking for is the variety of rocks here, if there's more than just the one boulder. You can sample the boulder for a while, but we would be interested in seeing if there is more than just the single type of rock. Probably, also, samples from both sides...

165:15:11 Schmitt: (Trying to interrupt Parker's oration) Okay...

165:15:12 Parker: ...both halves of the rock...

165:15:14 Schmitt: (To Gene, speaking under Parker) Let's get working.

165:15:15 Parker: ...What we said this morning in terms of combining Stations 6 and 7 to an hour and 20 minutes...

165:15:18 Schmitt: Come on up here, Geno.

165:15:19 Cernan: (To Jack) Okay.

165:15:20 Schmitt: If you can.

165:15:21 Parker: And so it's sort of your option as to how much time you spend here and how much you go on to Station 7 and spend. If you feel that it's worthwhile, we could spend essentially all that hour and 20 minutes at this station. But if we did that, we'd like to get a fair variety of blocks, if they're available.

165:15:39 Schmitt: (Responding to Parker, matter-of-factly) Okay.

[Schmitt - "It's fairly clear from the tape that, during this period when Parker was talking to us, it was the wrong time because he made it difficult for us to talk to each other and we were trying to get some sampling done. And that's probably why I was fairly short, responding with just an 'Okay'. Now, I suspect we continued to work while he was talking; I don't think we stood around. Of course, I'm not sure when would have been a good time to interrupt us. (Laughing) Even though we asked the question, we probably didn't want an answer."]

[Cernan - "I want to emphasize the point. We never stood around and listened. We never stopped doing what we were doing. We could listen while we were taking a pan or getting a sample or whatever it was."]

165:15:40 Schmitt: (To Gene) Geno, we can sample some of the light-colored group...As a matter of fact, this block looks different.

165:15:44 Cernan: Well, so does that big one...

165:15:45 Schmitt: It's greyer.

165:15:46 Cernan: ...That's why I've been photographing it.

165:15:49 Schmitt: What it is, I think...

165:15:51 Cernan: ...It's a blue-grey.

165:15:52 Schmitt: ...it's a big blue-grey rock, itself is crystalline, I believe. The inclusions are much more sharply defined, and it's nonvesicular; and it's included, or at least it's in contact with the very vesicular anorthositic gabbro. Right up there. See that?

165:16:13 Cernan: Yeah, a whole big one. I just...

165:16:15 Schmitt: Did you get some pictures of it?

165:16:17 Cernan: As I bounced around there, I took pictures of it.

165:16:18 Schmitt: Look, we can get some of that light-colored stuff in there, along with the blue-grey.

165:16:21 Cernan: We ought to get as big a piece of that inclusion as we can. There's...

165:16:24 Schmitt: See it up in there.

165:16:25 Cernan: Yep. (Pause) I think we're out of line of sight with them. We're behind a boulder.

165:16:32 Schmitt: Yeah, sorry about that. But...

165:16:34 Parker: We can hear you loud and clear. We're just looking at rocks right now.

165:16:37 Schmitt: (Garbled)

165:16:39 Cernan: Okay, Bob, the boulder downslope (that is, the south boulder) is more of a light-grey, vesicular boulder. The one Jack just talked about with some of the larger white inclusions is less vesicular, and it's more of blue-grey rock. And if I don't fall on my tail here, I'll get...

165:17:01 Schmitt: The "locator" is of Henry.

[Being high up the slope, they can easily distinguish craters on the valley floor. Jack's photos of the inclusions at the southeast corner of Fragment 1 are AS17-141-21608 and 21609. Fragment 2 is beyond Gene is 21608. 21610 is the locator to Henry. Gene's photo of Fragment 1 is AS17-140-21441.]

165:17:06 Parker: Copy that. (Pause)

165:17:10 Cernan: Okay, let me try and get up there.

(Pause) Henry? We must be high enough to see something. I haven't even looked back.

165:17:22 Schmitt: Let me get a close-up before you start pounding.

[Jack's close-up s are AS17-21611 to 21614.]

165:17:27 Cernan: I might go from this angle too. (Pause) That will give them something. (Pause) A little different up in there too, Jack.

165:17:44 Schmitt: Yup.

[Fendell is looking at Henry Crater. There are boulders clearly visible in the south wall. Gene is taking a series of close-ups, which are AS17-140-21442 to 21455.]

165:17:46 Cernan: We ought to try and sample that. (Pause)

165:17:49 Schmitt: Okay. Let's get the...You want me to get my scoop under there? Probably will fall out.

[That is, the sample would fall out of the scoop.]

165:17:56 Cernan: Okay. (Let's) get as many of these pieces as we can. I don't know how many are going to come out. (Long Pause)

165:18:17 Schmitt: (Hearty laugh)

165:18:18 Cernan: Outstanding! Outstanding! (Laughing)
This whole thing will come out here in a minute. (Pause)

[Fendell is looking at the South Massif. The tilt of the horizon gives a good indication of the extreme Rover tilt.]

165:18:25 Cernan: I'll watch it. I'll watch it.

165:18:27 Schmitt: Got it?

165:18:28 Cernan: Move your arm up or down. (Pause) Okay. I got it in case we don't get another one. (Long Pause)
Hey, we're getting good at that.

165:18:56 Schmitt: Yeah. Can't hold that much longer.

165:19:00 Cernan: Yeah. Let me get up on this...Up here.
Oh.

165:19:03 Schmitt: Why don't we get a bag out. Let me put these in a bag.

165:19:06 Cernan: That's why I'm getting up here so I can...

165:19:07 Schmitt: Oh, okay.

165:19:08 Cernan: ...just get my balance. Bob, 556 is one of the light-colored inclusions in the blue-grey rock.

165:19:17 Schmitt: It's chips.

165:19:18 Cernan: Chips of it.

165:19:21 Parker: Okay. Copy that.

165:19:22 Schmitt: I think we lost that other one. That's good enough.

165:19:26 Cernan: I got it; I know where it is.

165:19:27 Schmitt: That's all right. It's not a lot of sample, but it's representative, I think. It looks a lot like that sugary rock I sampled yesterday (at Station 2) , doesn't it? Found in the...That we sampled in the...

165:19:43 Cernan: Yeah, it's pretty easy to break up; it's really not very coherent (means "cohesive") at all.

[Jack is referring to the last boulder the sampled at Station 2.]

165:19:45 Schmitt: You know, I thought last night, Bob, that I should use the word "aplitic" for a texture that we saw in that inclusion yesterday on the South Massif.

[Schmitt - "A good layman's translation of 'aplitic' is a coarse, sugary texture - like raw sugar.]

165:19:54 Cernan: If I could keep from falling on my tail.
 165:19:56 Schmitt: Can you get a...
 165:19:57 Cernan: I want to...(Pause)

[Jack may take AS17-141-21615 about here.]

165:20:06 Schmitt: (Garbled). (Pause) Okay, you going to get some of that?
 165:20:07 Cernan: Yeah, that's a different kind; that's a more beat up inclusion of some sort. (Pause) Oh, there's a nice piece coming out. Oh, wait a minute...Don't lose it.
 165:20:21 Schmitt: I got it. I've got it.
 165:20:23 Cernan: Got it.
 165:20:25 Schmitt: Okay. (Pause)
 165:20:29 Cernan: Okay. We have another inclusion that, on the surface, has a more reddish-brown texture (means "color"). Interior looks pretty much the same; it's a very light grey.
 165:20:40 Schmitt: This looks like a piece of breccia Looks like a fragment breccia that got caught up in this thing.
 165:20:46 Cernan: Yeah, well, the whole thing is obviously a breccia. I'd sure like to get that...
 165:20:50 Schmitt: Well, I'd say...I'm not sure (that) it's obviously a breccia. I think it may be an igneous rock with breccia inclusions.
 165:20:56 Cernan: Well, okay, but look at all these things...
 165:20:58 Schmitt: Which is sort of in the same class.
 165:21:00 Cernan: (That) sort of makes a breccia...
 165:21:01 Schmitt: Well...
 165:21:01 Cernan: ...out of the big rock.
 165:21:02 Schmitt: Okay.
 165:21:03 Cernan: Except you can...
 165:21:04 Schmitt: I can't get in there, Geno, you'll have to.
 165:21:05 Cernan: Okay.
 165:21:06 Schmitt: (Trying to fit a sample in Gene's SCB) No way...
 165:21:07 Cernan: Let me...
 165:21:09 Schmitt: Watch it. Hold still. Oops. (Pause) I think it's easier for you (to put the sample bag in Jack's SCB). Did I give them a number on that? No.
 165:21:20 Parker: Negative.
 165:21:22 Cernan: It's 536.
 165:21:28 Schmitt: Squash it...Cramp it a little bit, if you can; a little more. (Pause)

[Schmitt - "I was trying to get a sample in Gene's SCB and he must have been upslope of me. So I probably handed it to him so that he could put it in my SCB.]

165:21:35 Cernan: Did you get that 536, Bob?
 165:21:37 Parker: Roger. 536 for the last one.

[The last sample taken - at 165:19:08 - was put in bag 556 and the one prior to that - at 165:12:03 - went in 535. There is discussion in Houston about the possibility of a misread bag number.]

[Schmitt - "They would have asked us if it wasn't right but, probably, one bag came from one side of the pack and one from the other."]

165:21:39 Cernan: Let's get a...
 165:21:40 Parker: And...
 165:21:42 Cernan: Okay. Let's go get the host rock here.
 165:21:44 Schmitt: How about that...How about that...Whew. How about that piece?
 165:21:50 Cernan: How about this one, with the inclusion? Maybe I can get this one.
 165:21:53 Schmitt: Okay.
 165:21:55 Parker: Okay; and, 17, we'd like...
 165:21:57 Cernan: That may have been a little optimistic.
 165:22:01 Parker: Do you guys have a feeling that the two halves of the big boulder are different rocks? Or is it the same rock split?
 165:22:10 Schmitt: No, they were all one boulder, I think. They are just two major rock types in wherever they came from. And I tried to describe that to you. We have the contact in the central boulder (Fragment 2). There're really three big boulders (Fragments 1, 2, and 4+5). The central boulder had the contact between the light-grey rock - or the blue-grey rock - and the vesicular anorthositic gabbro.

[Schmitt - "The boulder didn't split along the contact, largely because the vesicular breccia (which is referred to here as 'vesicular anorthositic gabbro') was intruded as partially-molten material. It was hot enough to metamorphose about a meter of the blue-grey breccia it intruded. You could tell that because there were small vesicles - which indicate some partial melting - in that contact zone which then died out as you got away from the contact."]

165:22:37 Parker: Okay. And you guys have that pretty well photo-documented, right?
 165:22:42 Schmitt: Yeah, it's in pretty good shape. We're working on it still.
 165:22:45 Parker: Okay. Copy that.
 165:22:49 Schmitt: Try going on the side there, Geno.
 165:22:52 Cernan: Just went from the side, Jack.
 165:22:54 Schmitt: That's enough. You got a piece of the...
 165:22:56 Cernan: (Garbled) host rock.
 165:23:00 Schmitt: I think you can get this one up here, can't you?
 165:23:01 Cernan: I wanted that one cause it had that inclusion wrapped in it. (Pause) Let me go to high (cooling) here for a minute. (Pause)

[The combination of a high Sun angle and the difficulty of working on the hillside makes this one of the few times that either of them uses the high cooling setting.]

165:23:16 Cernan: Which one are you talking about? This one here?
 165:23:18 Schmitt: Yeah, I just...(Pause) It's about to come. (Pause) Oh, oh, oh, okay. I've got it. I've got it.
 165:23:38 Cernan: Okay.
 165:23:39 Schmitt: Okay. I need this in a bag.
 165:23:41 Cernan: They're both host rocks; we can put them in the same bag.
 165:23:43 Schmitt: No, let's don't. No, they're different places. 537...
 165:23:47 Cernan: (Garbled)
 165:23:48 Schmitt: ...is a chip of the blue-grey rock; and the blue-grey host rock...(Pause) And let me get that other one. (Pause) Ahh!
 165:24:10 Cernan: Oop. Be careful. (Pause) Pick the rock up while you're there. It's right at your hand.

[Jack has probably fallen.]

165:24:21 Schmitt: I will. (Pause) Okay.

[Fendell finds Earth by panning to the low-gain antenna on the Rover and then following its pointing.]

165:24:40 Cernan: (Let me put) my little hammer somewhere.
 165:24:44 Schmitt: Okay. And 538 is another sample of that material...a little dustier (sample). (Guffaws)
 165:24:53 Parker: Okay. We copy that.
 165:24:57 Schmitt: That's the blue-grey, Bob, with the inclusions in it. Now the blue-grey, the more you looked at it, it looks like a...
 165:25:04 Cernan: Give me your left...(correcting himself) Your right hand.
 165:25:05 Schmitt: Huh?
 165:25:06 Cernan: Give me your right hand. Turn it over. Turn it over. Turn it over.
 165:25:12 Schmitt: Well, I did. How do you want it over?
 165:25:14 Cernan: You kept turning it over in the same direction. Like that, so I can fix that.

[Schmitt - "I don't know what this was, unless my watch band was coming loose or something like that."]

165:25:19 Cernan: Okay. Now give me your bag, and I'll get it in there. (Pause)
 165:25:24 Schmitt: (To Parker) The blue-grey rock, on closer examination, looks like a partially recrystallized fragment breccia. It's very hard. (Pause)
 165:25:40 Cernan: And I'm going to...

165:25:41 Schmitt: Are you going to get the "afters" in there?

165:25:42 Cernan: Yeah, I'll get them. I want to do a little bit better documentation on this thing. (Calling) Bob...

165:25:46 Schmitt: I'm going to go over and look at that contact.

165:25:48 Cernan: ...I got a few close-up stereos of the inclusion that we tried to sample, and I'm going to see if I can't give you a little flight-line stereo around this thing. If I can stay on my feet. (No answer; long pause) Do you read me, Jack, okay?

165:26:35 Schmitt: Yeah, I hear you.

[Fendell finds Jack east of Fragment 2.]

165:26:37 Parker: And Houston reads you loud and clear, also. (Pause)

[Gene's flightline of Fragment 1 is AS17-140-21456 to 21481. 21475 shows the soil on the upslope shelf which Gene will sample at about 165:28:42.]

165:26:47 Cernan: (To Parker) You can see where we've been pounding on this rock. We didn't succeed in getting samples everywhere. (Pause) And I'm giving you a "90-degree corner".

[Jack is looking at the southeast corner of the north boulder, almost "treading" sand to keep his balance on the slope. He may be taking photos AS17-141-21616 to 21620.]

165:27:02 Schmitt: Bob, it looks to me like there are inclusions of blue-grey in the gabbro...(correcting himself) in the anorthositic gabbro.

165:27:11 Parker: Positively outstanding.

165:27:13 Cernan: Are you saying you think this whole big...You think this whole big blue-grey thing is an inclusion?

165:27:18 Schmitt: Yes, sir. And there's some little ones over here.

165:27:21 Cernan: Yeah, but then within the blue-grey, we've got all these other fragments.

[Someone in Houston notices that the bottom of Jack's SCB seems to be loose.]

165:27:24 Schmitt: Well, that's right. It's just several generations of activity; and it looks like the gabbro, though, picked up the fragmental breccia as inclusions. (Pause) Bob, It really looks that way right now. There's a small one here in the...

165:27:49 Parker: Okay, Charlie (Duke) is here mumbling something about it looking just like House Rock.

[John Young and Charlie Duke visited House Rock at the rim of North Ray Crater on EVA-3 of Apollo 16. It was the largest lunar boulder sampled by any of the crews. It was literally the size of a good-sized house, being about 12 meters high, 25 meters long and about 20 meters thick. Tracy's Rock consists of five large fragments of what was once a single boulder about 6x10x18 meters. For comparison, Turning Point Rock is about 6 to 7 meters high and Geophone Rock is 3 meters high.]

165:27:56 Schmitt: It's very crystalline. I'll tell you, it's not a breccia, not like House Rock. Not to take anything away from House Rock, though.

165:28:05 Cernan: Hey, Bob, there's a lot of mantling on a very shallow slope of a fracture here on one of the upslope blocks (Fragment 1). I would assume it's just part of the talus picked up as it's rolled down. But if it's worth sampling, you might think about it. (Pause)

[Parker waits to get a recommendation from the Backroom but, getting no prompt answer, makes the decision himself.]

165:28:34 Parker: Okay, Gene, if you can get that fairly readily, why don't you...You can perhaps just scoop it up with the bag.

165:28:42 Cernan: That's exactly what I can do.

165:28:44 Parker: If you can get up to the rock there.

165:28:45 Cernan: It will be in my flight line stereo, and it's going to be bag 557. And I'll take an "after" and show you where it came from.

165:28:58 Parker: Okay. Copy that.

[Out of sight of the TV camera, Gene takes the sample and the after, which is AS17-140-21482. Later, Gene will take a panorama from higher up the hill which will also show the mark left in the dirt where he took the sample. Two frames in the pan show Jack walking around the east corner, headed away from the camera.]

[Cernan - "I haven't seen the rock from this perspective (frames 21474 and 21482) in nearly nineteen years. My hand print really shows you how big the rock is and, in 21482, you can see across to the South Massif and the Scarp. The Scarp looks small in this photo, but I remember how big it was (80 meters) because we went up it."]

[The patch of dirt on the north face of the boulder is the subject of a painting by Apollo 12 astronaut Alan Bean. Bean took up a career as a professional artist after he left the Astronaut Corps and, in the years since, he has developed a considerable reputation as a space artist. As a result of the particular painting in question, those who know the story call the Station 6 boulder "Tracy's Rock". Tracy is Gene's daughter and she was nine years old at the time of the mission.]

[Cernan - "It was on this part of the rock that Al Bean wrote "Tracy", my daughter's name, in one of his paintings. After we came home I started to see a picture of the boulder in lots of places. It was the picture of Jack going past the corner of the rock (AS17-140-21496), one of the pictures from my pan. It became very popular. One day Al Bean came by and said he was doing a painting of it. And it was a big painting, six feet by three feet or something like that. Al likes to have stories in his paintings and he wanted to talk about it. So we talked about the slope and how hard it was to climb up there and I said that, if I'd known the picture was going to get so much notoriety, I wished I would have done something that I hadn't even thought of at the time. And that is to have printed Tracy's name in the dust. Al's daughter Amy and Tracy had grown up together and he asked 'How would you have done it'. So I wrote it out on a piece of paper and, some time later, he called and wanted me to come over and look at what he'd done. He had erased the place where I'd taken the sample and had put in Tracy's name, instead. And in the little story he put with the picture, he said that he'd done it to save me the trouble of going back to do it myself, and to save the taxpayers the expense of sending me back."]

[Jack leaps upward about a foot, kicking his heels back briefly before he lands.]

[Schmitt - "I was having trouble getting up to exactly where I wanted to be to look at the boulder."]

[Cernan - "I can't see why a geologist would jump up and down in the air like this except to show his enthusiasm over finding a new and different rock. And, all joking aside, it really looks like he's trying to get closer to the rock and the slope made it hard to move."]

165:28:59 Cernan: This is the easiest part of the rock in the world to work. Man, here's a big white clast. There's one on top about a foot and a half across, and here's one. (It) must be 2 feet across...3 feet. And that's in the blue-grey. (Pause) Feel like a kid playing in a sandbox. (Pause)

165:29:30 Schmitt: (Balancing on his downhill leg) Well, Bob, I think I've done the best I can. I'd say that they're pretty clearly inclusions of blue-grey in the anorthositic gabbro here near the contact.

[Jack walks slowly uphill, leaning into it, knees dramatically bent. His SCB is clearly loose. Parker makes a misidentification.]

165:29:45 Parker: Okay. And Gene, your bag is hanging by one hook there. Be careful, if you can...(Correcting himself) Or, LMP...

165:29:53 Cernan: Okay. I gave you 557, I believe. Didn't I?

165:29:57 Parker: Roger. We have that one. (Pause) And whoever is giving us 557...
 165:30:02 Cernan: Okay, I'll have Jack fix my bag.
 165:30:03 Parker: Yup.

[While facing more or less north, leaning into the hill, and using the scoop in his left hand as a cane, Jack leans far enough forward that he can grab a fist-sized rock off the ground.]

165:30:07 Schmitt: Okay, Bob, by accident...I didn't think I could do it, but I got a sample of the inclusion. And it's in bag 539.
 165:30:20 Cernan: Hey, Jack, that's your bag (SCB) that's hanging by one hook. Let me go get it.
 165:30:23 Schmitt: Oh, they're talking to me, huh?
 165:30:24 Cernan: Yeah, because I didn't...
 165:30:25 Parker: Yup.
 165:30:26 Cernan: I didn't think they could see me. I'm way up on top! (Pause)

[While Jack examines the bagged sample, Gene hops into view from behind Fragment 2. Jack seals the sample bag by grasping the ends of the metal sealing strip and flipping the bag over it.]

165:30:33 Schmitt: And it's blue-grey with light colored...
 165:30:39 Cernan: (Presenting his SCB) Put these in my bag.
 165:30:40 Schmitt: ...inclusions in it. (To Gene) All right. (To Parker) But the whole thing (Fragment 2) seems to be pretty well altered or metamorphosed...compared to the major rock (Fragment 1) we just sampled...(compared) to the other blue-grey rock. (Pause) This bag (Gene's SCB cover) is terrible. I can't...It won't latch.
 165:31:00 Cernan: Man, there's a dark hole in there where you...
 165:31:02 Schmitt: Don't let me...(Pause) Ah! I'm not...

[Jack is having a difficult time reaching Gene's SCB. Because of the slope, if Jack is to reach the top of Gene's SCB, they have to be standing on virtually the same hill contour. Gene can stand facing uphill, leaning into the hill, but Jack has to face him and lean sideways into the slope. Jack's right leg is fully extended downhill, and his left leg is bent at the knee.]

[Schmitt - "Plus, he's taller than I am. That was always a problem."]

165:31:13 Cernan: Here's another bag to put in there before you go away.
 165:31:14 Schmitt: (Taking a full sample bag from Gene) Oh, okay.. (Pause, grunting) It won't latch.
 165:31:22 Cernan: Well...

165:31:23 Schmitt: Not at this angle.
 165:31:25 Cernan: Just put the thumb on one side, and I'll...
 165:31:29 Schmitt: It's bent or something. There, that's pretty good.

[Jack presents his SCB by turning to face uphill and using the scoop as a cane.]

165:31:31 Cernan: Now let me fix your bag. (Pause)
 165:31:41 Parker: And, 17...
 165:31:42 Schmitt: Okay, Bob, I think that inclusion will give you an example of what...
 165:31:49 Cernan: That'll stay on.
 165:31:50 Schmitt: ...what the anorthositic gabbro did to the blue-grey breccia.

[Gene moves east of the Fragment 2; Jack examines Fragments 4 and 5 while he listens to Parker.]

165:31:57 Parker: Okay. We copy that. And we're ready for you guys to leave this rock and press on and either get the rake soil and cores near that crater down below the rock just a shade (that is, a short distance), or else go on to some other different variety rocks in the area.
 165:32:20 Schmitt: Well, I tell you, going down to that crater is not a problem. Getting back up is.
 165:32:28 Parker: Okay, well, find a decent area to get the rake soil from and a couple of cores.
 165:32:30 Schmitt: Tell you what, Gene, I could go down there and start a rake, and you could come down there.
 165:32:34 Cernan: Okay. Yeah, I don't think you ought to try and walk back up, Jack. Let me get a pan from right here where I got this sample; (that is, upslope of Fragment 1).
 165:32:40 Schmitt: Okay. I'm going to come over and...I'll go get the rake and get the gnomon.
 165:32:43 Parker: 17, it's not that vital to get to that crater. We just need a good place for a rake soil and a double...(correcting himself) a single core.
 165:32:50 Schmitt: (Standing in the split, examining Fragment 2 and not facing Gene) Hey, get uphill a little bit, if you can, for the pan, so that you don't...so you see my other pan station.
 165:32:59 Cernan: Where was it?
 165:33:00 Schmitt: It was over there in that crater, just uphill from the Rover.
 165:33:03 Cernan: I'm going up there.

[Jack moves west, going downslope a little and out of the TV picture.]

165:33:05 Parker: Hey, and, 17, we aren't all that gung-ho about that particular crater, if it's that much of a job to

get down to it and back up. We just need a decent place for a rake soil sample and a single core.

165:33:18 Schmitt: Okay.

165:33:19 Cernan: Bob, we don't move around from here too much. I tell you, these slopes are something else.

165:33:23 Parker: Yeah. We agree with that, from what we see on the television. So use your judgment, and get them where it's the best place

165:33:30 Cernan: Well, you might take a look at me walking up. But I don't think I can get to the top. (Pause)

[Fendell finds Gene beyond Fragment 2 and, out of sight, Fragment 1.]

165:33:38 Cernan: I just got to get a place I can get a pan from. Right here. Right in this little hole. (Pause) (Gesturing) Okay, now I left the gnomon down there.

165:33:50 Schmitt: Okay. I'll have to go get it. (Pause) I think we'll setup right here near the Rover.

165:33:55 Cernan: I think I'll go and save some water, back on Intermediate. Okay.

165:34:01 Parker: Copy that.

[Gene switches his cooling and then starts the pan. Jack crosses the TV picture, headed east to get the gnomon. This is the reason he appears in Gene's pan. This pan, marked "north pan" on the Station 6 plan map, is AS17-140-21483 to 21509. This superb set of pictures shows not only Jack going back to the Rover with the gnomon (21497, and see also 21496), but also the lightened area around the LM, which is visible just over the summit of Tracy's Rock in 21495. In 21493, we can see the rake sitting out ready to be used. In 21501 we get a good view up-Sun into the gap between the Sculptured Hills and the East Massif, and in 21503, we get a good view toward Station 7.]

165:34:03 Cernan: Hope my lens is clean. (Pause) Bob, from up here, the light mantle is not evident until you see the angular reflection up on the scarp. Very thin, light patches might be evident out on the valley, but not nearly as pronounced as I might have thought from this altitude. (Long Pause)

[Cernan - "You really had to lean to get the horizon in the pan. And I don't think I was able to get the uphill pictures."]

[Fendell pans clockwise away from Gene to look for Jack. AS17-140-21489 shows the Scarp.]

165:34:53 Cernan: Oh, and there's Challenger! Holy Smoley! (Pause) You know, Jack, when we finish with Station 8, we will have covered this whole valley from corner to corner!

165:35:18 Schmitt: That was the idea.

165:35:20 Cernan: Yeah, but I didn't think we'd ever really quite get to that far corner. Not 2, but this other one (Station 8). And we're going to make it!

[Cernan - "I wish I'd climbed to the top of the mountain to get even a better view. But, even where we were it was a much better panorama than we got from the Scarp. We couldn't see much from the Scarp. Over here, we could see everything: Challenger, the Scarp, the Sculptured Hills, and everything. I do remember this. It was fantastic - like coming over a hill and getting a look into a great big valley somewhere in the middle of Idaho."]

[Fendell pans back to Gene, who is leaning way back to shoot uphill photos.]

[Schmitt - "In order to find a level place, Gene went to a crater and stood, not in the bottom, but on the downslope wall which would be nearly level."]

165:35:31 Schmitt: (Having taken another opportunity to examine the boulders) Bob, that blue-grey rock near the contact with the anorthositic gabbro does get some vesicles in it. I think they'll show up in Gene's pictures. (Pause)
165:35:52 Parker: Okay. We have that too, Jack. (Pause)

[Schmitt - "This examination of the boulder shows the evolution of my thinking as I was getting new information. The final impression that I had - which was born out by the samples - was of a blue-grey breccia intruded by - or enclosed by, we don't know which - vesicular, tan-grey material which also turned out to be a breccia. Now, when I first approached the boulder, the vesicles and crystals I could see in the matrix around them led me down the path of thinking that I was looking at a truly igneous rock. And it had not occurred to me yet that I might be looking at an impact breccia that got hot enough to melt. And it took the whole time of examining it - until right at the last - before I came to the correct conclusion. At the last, I saw the vesicles in the contact zone which pretty well confirmed it all. It took a while to work that through and to get away from thinking that I was looking at an igneous, anorthositic gabbro that had caught up pieces of other things. Normally, a field geologist would sort all those multiple working hypotheses as you go along and then eventually come to a conclusion. And that's what you write down. But here, what we see is a large part of my thinking process being verbalized. If we had had to stop after the first few minutes, we would have had all the wrong answers.

"My guess is that the vesicular breccia was produced in the Serenitatis impact, that it was injected downward into the crust and then migrated back up along fractures in the ejecta. And, in that context, the blue-grey breccia may be pre-Serenitatis - who knows, perhaps Tranquillitatis ejecta or something like that. We'd seen the same blue-grey rock at Station 2. There was tan-grey breccia at Station 2 but that

wasn't vesicular. Probably, the first place we saw the tan, vesicular breccia was at Turning Point Rock and, again, I was thinking there in terms of it being igneous."]

165:35:58 Cernan: (To Parker) Okay. I just ran out of film at 160. And I'm about two pictures short of the pan, and they (the missing frames)'re upslope. I think I can cover most of that with the 500. (Pause)

165:36:20 Parker: Okay, Gene. (Are) you going to go to the Rover and change your mag now?

165:36:26 Cernan: Well, Jack's going to need some help from me.

165:36:29 Parker: Okay. Let me know when...

165:36:31 Schmitt: I'm starting to rake.

[Gene moves downhill, going down into the boulder track and then back out. He uses a hopping gait, but with his right foot forward about six to ten inches.]

165:36:33 Parker: Let me know when you get to the Rover to change the mags after you get done with that, and I'll tell you what mag to change.

165:36:40 Cernan: Jack, if you got...

165:36:40 Parker: But press on and help Jack with those first.

165:36:41 Cernan: Jack, if you got enough film, I'll just come and help you.

165:36:43 Schmitt: Okay. (Pause)

[Gene trips and falls to his hands and knees, apparently without hitting the camera on the ground. He came over a small mound - possibly a crater rim - and, as he came off the mound, caught his trailing left foot, started to tilt sideways over his right foot and lost his balance.]

[Cernan - "I had some speed coming down, even though I was coming cross slope. It was so hard to get up there and so easy to come down, so I was moving. I was coming cross slope because, to come straight down, I probably would have gone head over heels. You couldn't come straight down that hill very fast. It's like skiing. If you go straight down, you're really going to motor. So you've got to shallow up the slope. But I got off balance, got on one leg, and fell into the hill. When I was watching this just now, I thought I was going to roll; but I didn't. I kept my balance pretty well. And I've got to tell you, agility goes along with the responsibility of command; and, to prove the point, I can only refer you to the help I received in getting that deep core out of the ground back on EVA 1."]

[Gene is, of course, reminding us of Jack's spectacular fall at 121:01:05.]

165:36:54 Schmitt: (Having seen the fall) (Are you) okay?

165:36:55 Cernan: Yup. (Pause) (Calling to Parker)

Remind me to dust my camera, too, will you?

165:37:02 Schmitt: Don't forget to dust your camera.

[Schmitt - "(Laughing) That's a bad habit of mine. When people ask me to remind them to do something, I'll say it right then so I'm not held responsible for remembering."]

[Gene shifts position so that his feet are downhill. He then pushes back with his hands to get up on his knees and, as his PLSS rotates past the point of his knees, he rises to his feet.]

165:37:04 Parker: Okay. We'll keep track of that for you, Gene.

[Gene continues on his way, using the same gait at the same speed. Fendell does not follow him and, rather, starts a clockwise pan of the site.]

[Schmitt - "By this third EVA we were very confident. We didn't worry about falling. Maybe we should have, but we didn't. What I want to know is how come he didn't get kidded about that fall like I got kidded about the fall at Ballet. That's just as spectacular."]

165:37:10 Cernan: (To Jack) Okay. Did you get any before pictures?

165:37:12 Schmitt: I'm getting them now.

165:37:13 Cernan: Okay.

[AS17-141-21621 to 21623 are cross-Sun befores of the rake site and 21624 is a down-Sun.]

165:37:16 Schmitt: (Laughing) 'T ain't easy, McGee.

[Schmitt - "This was an expression out of the old 'Fibber McGee and Molly' radio program."]

165:37:18 Cernan: Man, I tell you, these slopes are great. I wouldn't mind being up on top coming down, but...Hey, that boulder track is quite a trench!

165:37:24 Schmitt: Yes, sir.

165:37:26 Cernan: That thing must be a meter or 2 deep, huh!?

165:37:29 Schmitt: Okay; the big rake. Well, I think I'll try...

165:37:36 Cernan: Wouldn't it be easier to (pull the) rake downhill.

165:37:37 Schmitt: It would, but the stuff wouldn't stay in. (Laughs) Right? (Pause)

165:37:43 Cernan: Well, I don't know. It's a thought. (Pause) Make sure you get that one by the...

165:37:52 Schmitt: Yeah, I will. (Long Pause) We're not really supposed to be selective about raking.

165:38:14 Cernan: No you're not (being selective), you're just covering the area.

165:38:18 Schmitt: That's why I set up there. (Long Pause)

165:38:33 Cernan: A selective sample is better than no sample at all.

165:38:39 Schmitt: Let me put some in there (meaning, in the bag Gene is holding). Okay. (Pause)

165:38:47 Cernan: Bag 558.

165:38:50 Parker: Copy 558.

165:38:55 Cernan: Bob, most of them are...

165:38:57 Schmitt: Let me go another couple of swipes.

165:38:58 Cernan: Okay. There's one (rock) a couple of inches (across). Most of them are an inch or so or smaller. They're angular to subrounded fragments. Some of them look like the inclusions. As a matter of fact, the ones that are broken open look like some of the light-colored inclusions we saw in the big boulder. The others are too dust covered to say anything about.

165:39:17 Schmitt: A couple of them look fairly coarsely crystalline. (To Gene) Okay. Put these in there.

165:39:24 Cernan: Big deal! (Laughs) We ended up with three more.

165:39:34 Schmitt: Let me get an "after," such as it is. Oh, we want the...

165:39:37 Cernan: They want the soil here.

165:39:38 Schmitt: Soil, that's right.

165:39:40 Parker: That's affirm. (Pause)

165:39:46 Schmitt: Okay. You want to put that in (Jack's SCB)?

165:39:47 Cernan: Yeah, I'd better put it in before I... (Pause) Okay. Let's try for the soil. (To Parker) 559's the soil.

165:40:02 Parker: Okay. Copy that. And, 17, our present plans from the (Backroom) are (that) we'd like to get the single core, the 500 millimeter shots - and, I guess, maybe one could do one, and one could do the other. And then we'd like to press on and do a short Station 7, unless you think you have got a fair variety of rocks here. The feeling is that you have (garbled) significant variety of rocks.

165:40:21 Schmitt: (To Gene) Here. Little more, little more, little more. (Pause)

[Fendell's pan crosses the back of the Rover. Neither Jack nor Gene is in sight. They are probably due west of the Rover, hidden by the gate.]

165:40:28 Cernan: Okay, Bob. I'll get the core and let Jack get the 500's.

[Cernan - "(Smiling) I didn't want to let Jack use the hammer because I was afraid he'd hurt himself."]

165:40:30 Cernan: 559 is the kilogram of soil. I think we've pretty much covered the general variety we've seen here. I think we're seeing most of them in that boulder.

165:40:41 Parker: Okay. And so we'd like to go on to Station 7 then - when you get the 500 and the core - in hopes of finding a variation of boulders along the front. (Pause)

[There is a discussion in Houston about having Gene do the 500 mm photography because of his longer arms. Jack apparently had had some trouble handling the 500 mm during training.]

165:41:02 Cernan: (To Parker) Okay. (To Jack) Let me know when you get it. (Pause)

165:41:09 Schmitt: Okay. "After".

165:41:12 Cernan: Okay, why don't you get the 500, and I'll get the core.

165:41:14 Schmitt: And the LMP's on (frame count) 120.

[AS17-141-21625 to 21627 are Jack's cross-Sun afters. Note the tongs in 21625.]

165:41:16 Parker: Copy 120 there. And, Gene, if you want to change, we recommended magazine Foxtrot or Fran (Magazine 146), as the case may be.

[Fendell begins a counterclockwise site pan.]

165:41:24 Cernan: Okay. Will try Foxtrot Franny. (To Jack) Don't forget to get (a 500 photo of) that boulder track.

165:41:29 Parker: (Talking through Jack's following remark) And while you're at it, Gene, ...

165:41:30 Schmitt: This once, I'm going to have to lean against the Rover to do it.

[That is, Jack will have to brace himself in order to steady the 500-mm camera to shoot upslope.]

165:41:31 Parker: ...you might remember to dust your camera when you're leaning over the seat. (Pause)

165:41:38 Schmitt: Let me look at your camera. (Pause)

165:41:47 Cernan: Oh, man. If this Rover wasn't here, we'd roll downhill.

165:41:50 Schmitt: Hey, Bob. I think we could use an "upper" (drive tube) here if you want to save the lowers.

165:41:56 Cernan: I think so, too.

[The 'lower core sections have reinforced tips but, at this site, the soil is soft enough that one of the 'upper' sections could be used without fear of damage, thereby conserving the supply of lowers.]

[Schmitt - "Obviously, I didn't remember what the core tube count was."]

165:41:57 Schmitt: Whichever you want. (To Gene) Do you want your...

165:41:59 Cernan: No, I'll get it. Why don't you get your 500, and I'll...

165:42:01 Schmitt: Okay. But do you want a core? Watch the fender.

[Gene rounds the front end of the Rover, apparently in a controlled skid.]

[Cernan - "I was just sidestepping as I was coming around the Rover, sidestepping to slow down and turn. By this time I was long familiar with operating in the suit, and I appreciated the slope I was on. So I just turned and sort of sidestepped into where I wanted to stop."]

165:42:03 Cernan: The core's in there, isn't it?

165:42:04 Schmitt: Well, there's some under my seat if you want to use those.

165:42:05 Cernan: I'll use those.

165:42:06 Parker: Standby, Jack. We have three lowers and two uppers, so we'd just as soon use the extra lower here in the single core. That'll give us two uppers and two lowers left...

165:42:16 Schmitt: Okay.

165:42:17 Parker: ...for doubles. (Pause)

165:42:19 Schmitt: There should be a lower in there, Geno.

165:42:20 Cernan: Yeah. Bob, any special place you want that? Just out here on the slope?

165:42:26 Parker: That's affirm...

[Fendell finds Jack at Gene's seat, 500 mm camera in hand. The rammer and core caps - among other things - are visible on the left side of his PLSS.]

165:42:27 Schmitt: Should have put the gnomon up. Well...

165:42:30 Parker: Just out there on the slope. (Pause)
(Talking through Jack's following remark) I guess if you saw a crater you might look at that,...

165:42:33 Schmitt: (To Gene) You don't have any film to document, either.

165:42:33 Parker: ...but primarily we're looking at the crater.

165:42:35 Cernan: I'll get it. I'll get it, Jack. Don't worry. (To Parker) Okay. (Pause) We have a couple of dents in our wheels. That's better than having a flat tire. (Long pause)

[Jack goes east from the Rover; the lens cap is off.]

165:43:19 Cernan: (To Jack) Did he say "in a crater"? (No answer; pause)

165:43:27 Schmitt: I'm not sure what he said. Thinking...

165:43:32 Cernan: How do I get this doggone... (Garbled)
turn to come off? (Pause)

[Fendell pans the TV clockwise. Off camera, Gene is taking the scoop off of the extension handle so that he can attach the handle to the core.]

165:43:39 Schmitt: You got to unlock it.
 165:43:41 Cernan: Yeah, it is unlocked.
 165:43:43 Schmitt: Okay. Now push down and turn.
 165:43:46 Cernan: Okay. I got it.
 165:43:48 Schmitt: How am I going to see up there to shoot this thing?
 165:43:52 Cernan: Well, why don't you lean against the rock? Go over there and lean against it.

[Cernan - "It was difficult to shoot uphill, because you couldn't lean back very far. So I suggested that Jack lean against the rock.]

165:43:57 Schmitt: Well, I have to do something. I was trying to get so I could lean against the Rover, but that ain't going to work.
 165:44:04 Cernan: The Rover isn't steady enough for you to lean against.
 165:44:07 Schmitt: Well, it's steady enough. There's just no place to lean.

[Jack passes in front of the south-looking TV; he is going east. Fendell reverses direction to follow him.]

165:44:09 Parker: Okay. And, Jack, and if you'll listen for a minute, I'll tell you some possible 500-millimeter targets the people have in mind. One, the LM, if you can see it from there. Two, Nansen, if you can see it from there. Three, Lara; and four, Shorty. In other words, I guess they're talking about looking along your traverse from yesterday. It would be mostly the back shots, apparently. And then, also, the South Massif, and I don't know what you can get of boulder tracks leading up the North Massif. And most of those will be looking downhill towards the LM, Stations 2, 3, and 4. Over. Nansen, Lara, and Shorty.
 165:44:48 Schmitt: I got you, Bob.
 165:44:50 Cernan: Yeah, the LM is visible by the way.
 (Long Pause)

[Fendell finds Jack against the west face of the north boulder, leaning his PLSS against it for stability while he aims the 500 uphill to the northwest. His SCB is loose again. Jack's first series of pictures, of the North Massif, is AS17-139-21186 to 21193.]

165:45:27 Schmitt: Okay. I got a set of (pause) what looks like the outcrop from which the boulder came. (Long Pause)

[Jack adjusts the camera and then takes a few more pictures.]

165:46:10 Schmitt: I'm afraid they're moved a little bit.
(Long Pause)

[Jack tries to point the camera higher.]

165:46:26 Schmitt: No, I can't; that's it. I got a few pictures looking up the boulder track and then off to the left a little bit; and one off to the right. And I think...I'm not sure how well they overlap; that's just an awful hard shot.

[Jack now points the camera toward the west to take pictures of Shorty, Lara, and the Scarp. These are AS17-139-21194 to 21202. 21194 and 21195 show Shorty; and 21201 is the best of the Lara pictures.]

165:46:46 Parker: Okay; good on that. (Pause) And if you're done with that, have you got a frame count - or, you're still taking them, I guess, it looks like.

165:46:58 Schmitt: Yeah. (Pause)

165:47:08 Cernan: Okay. My camera is clean. Magazine Foxtrot is on about frame 2, and I cycled through it. And I've got the core all set, and I'm going to go get it. And I didn't hear where you said to put it, Bob.

165:47:31 Parker: Anywhere.

165:47:36 Cernan: Oh, man, you're easy.

165:47:39 Parker: And did you get your camera...

165:47:40 Cernan: Anywhere. Not the bottom of a small crater, huh? (Pause)

165:47:47 Parker: Any place. And did you get your camera dusted?

165:47:52 Cernan: Yeah. I got it all dusted and the mag's changed.

165:47:56 Parker: Good.

165:47:58 Cernan: It's core 48.

165:48:01 Parker: Copy that. (Pause)

[Fendell pans the TV counterclockwise, away from Jack who is still shooting pictures west toward Stations 2, 3, and 4.]

165:48:06 Cernan: Okay. I'll even get you a picture of it. (Pause). Oh me, oh my. (Long Pause)

[Fendell reaches the counterclockwise stop without finding Gene. Fendell reverses direction and pans clockwise. He finds Jack, now shooting pictures toward the south.]

165:48:23 Cernan: Can you get the LM from there?

165:48:27 Schmitt: Yep.

[They are two hours and fifteen minutes into the EVA. AS17-139-21203 to 21205 are Jack's pictures of the LM.]

165:48:30 Cernan: That core went in very easy, Bob. I pushed it in about a quarter of the way. And about another five or six whacks, and it's in all the way. (Long Pause as he takes two pictures of the core tube) Okay. Come on out now, baby. (Pause)

[Gene's core tube photos are AS17-146-22291 and 22292.]

165:49:31 Schmitt: Okay, Bob. . Shorty, and Station 3, and Station 2, and what else?

[AS17-139-21206 and 21207 are two additional pictures of Shorty and the Ballet Crater area.]

[Fendell finds Gene downslope of the Rover. He has the core in hand and is leaning forward into the slope. He has taken a couple of pictures of Jack, still taking 500's from against the rock. These are 22293 and 22294.]

165:49:45 Parker: And any sort of outcrop you see in the South Massif.

165:49:52 Schmitt: I thought we shot those.

165:49:54 Parker: Okay. If you got those, fine.

165:49:58 Schmitt: No, I mean the other day.

165:50:01 Parker: Well...

165:50:01 Schmitt: I'll try again.

[These pictures are AS17-139-21208 to 21211.]

165:50:02 Parker: Stereo is stereo is stereo, I guess.

165:50:03 Cernan: Okay, and I got you a little soil mech(anics)... (Stops to listen to Parker)

165:50:10 Schmitt: (To Parker) Well, but it's not stereo; it's right along the same line.

165:50:13 Cernan: ...little soil mechanics of the hole, which stayed intact; very nice and round.

[Gene climbs to the Rover, taking short, choppy steps; it is a difficult climb. His picture of the empty hole is AS17-146-22295.]

[Cernan - "I didn't have to go very far, so I came straight up. It would have been really tough in Earth gravity, but in one-sixth gravity at least we could hop and get fairly good distance. I'm getting maybe a foot with each hop, just like hopping up some steps on two feet, step by step by step.]

165:50:18 Parker: Okay. We copy that.

165:50:23 Cernan: Okay! (Pause)

165:50:32 Schmitt: Oh, man!

165:50:33 Cernan: (Reaching the gate) Yes, sir, we got a couple of dented tires!

165:50:39 Schmitt: Okay. My hands have had it.

165:50:42 Parker: Okay; good enough.

165:50:43 Schmitt: You aren't going to get anything else out of me if I keep taking pictures.
 165:50:46 Parker: And, Gene, what's a "dented tire"?
 165:50:51 Cernan: A dented tire is a little, oh, a little golf-ball size or smaller indentation in the mesh. How does that sound to you? Doesn't hurt anything.
 165:51:03 Parker: That sounds like a dented tire; that's how it sounds.
 165:51:04 Schmitt: Frame 31 (on the 500 mm magazine), Bob.
 165:51:05 Parker: Copy frame 31.
 165:51:08 Cernan: That's sort of like what it is. (Pause)
 165:51:14 Schmitt: Okay. LMP('s camera) was what? 120? I guess we can get to the next station with that.
 165:51:21 Parker: Roger.
 165:51:22 Cernan: Yeah, I got a brand new mag on.
 165:51:23 Parker: And we'd like to get you guys rolling as soon as feasible there.
 165:51:29 Schmitt: Yes, sir. It's our policy.

[Gene takes the extension handle off the core; then turns north to see what Jack is doing.]

165:51:31 Cernan: Okay. I'll need your rammer, so if you'll just turn right. (Pause) Good timing. (Making a seismic-charge joke) Pin's out; core tube is safe. (Pause) And full! I knew it was. (Pause)

[Gene replaces the rammer on the left side of Jack's PLSS.]

165:51:59 Cernan: Okay. You take this and put this under your seat, if you want, Jack. And I'll get the TGE. (Pause) Oh, let me put your shovel back on (the extension handle) for you. I'll get it.
 165:52:08 Schmitt: Get that?
 165:52:09 Cernan: Yeah.
 165:52:11 Schmitt: (Going to his seat, carrying the core tube) Don't lose that (scoop). (Garbled, but probably meaning "I wouldn't know") what to do (without it). (Pause)

[Gene is re-attaching the scoop to the extension handle.]

165:52:27 Schmitt: Okay. Did you give them the (core tube) number?
 165:52:28 Cernan: Yeah, they got the number.
 165:52:29 Parker: Roger, we've got it.
 165:52:30 Schmitt: Under the LMP's seat.
 165:52:33 Parker: Copy that; under the LMP's seat.
 165:52:34 Cernan: (Laughing) I'm sneaking up on the TGE.
 165:52:41 Schmitt: You need some help?
 165:52:42 Cernan: No. No, I was just sneaking up, that's all.

[Jack steps back and uncovers Gene, who is leaning far forward, into the hill, to punch the TGE button. "I'm sneaking up" is a joking reference to one of the Apollo 16 experiments. At one of the stops on their second EVA, Young and Duke collected a soil sample with a tool that looked a bit like a man's wallet mounted at the end of a meter-long handle. The wallet-like part could be opened, exposing a patch of cloth. The idea was to approach a meter-high boulder from the direction of the LM, moving as slowly as possible to avoid kicking soil onto the sampling site, and then reach over the boulder and press the cloth patch on the surface beyond the rock. In principle, the very top layer of soil, protected by the rock from LM effluents, would be caught on the cloth. The final step was to close the wallet to protect the sample. Duke had a great deal of fun describing the scene to Houston as Young was "sneaking" up on the chosen boulder; and this is Gene's reference.]

165:52:46 Schmitt: (I'll) come and let you lean on me.
 165:52:47 Cernan: No, I got it. 670, 109, 801; 670, 109, 801.
 165:52:58 Parker: Okay. We copy that. (Pause)
 165:53:07 Schmitt: I wish we...The one thing I didn't do. While you're doing that...
 165:53:18 Cernan: What didn't you do?
 165:53:21 Schmitt: (Going around the front of the Rover) Didn't get pictures of those foliated vesicles. I don't think the ones you had were in that kind of rock. (Pause)

[Here, Jack goes to take a quick series of close-up pictures of the flattened vesicles. These are AS17-141-21628 to 21636.]

165:53:34 Cernan: I don't want to lose that thing (the TGE), so I guess...
 165:53:36 Parker: Okay, 17, when you get back on here, we don't need any charges, and we'll leave the SEP turned off.

[Fendell pans the TV clockwise.]

165:53:53 Schmitt: I'm not sure...Did you turn it off, Gene?
 165:53:55 Cernan: Yeah, I turned it off. (Pause) I turned it off. Okay. Let me see. We want to move on to (Station) 7 here. (Reading LMP/CDR-11) Rake; talus; documented core; you got your stereos; we got two pans; TGE; camera. (Looking at the traverse map on LMP/CDR-12) Okay, we're going to head east and look for Station 7. (Reading LMP/CDR-15) block variation; contact change; and get a different sample of rocks. Okay, I sure want to get one or two of those nice ones in the big bag while you're over there.
 165:54:28 Parker: Okay...
 165:54:29 Schmitt: Open the gate, and I'll bring one.

[They have to open the gate to get at the big bag.]

165:54:30 Parker: ...Seven(teen)...Okay. And let me know when you get ready to get back on the Rover there, 17.

(Pause)

165:54:43 Cernan: (To Jack) Guess what isn't opening again. (Pause) Should, though. It's all set right.

[Gene is having trouble opening the gate. The latch is fouled with dust.]

165:54:53 Parker: You could put them under Jack's seat if it's easier. (Pause)

165:55:09 Cernan: Okay. What do you want done to the SEP while I'm here? Do you want the blanket left open?

165:55:13 Parker: Negative. We'd like the blankets closed and taped down again, if possible, and both switches left off. We won't touch it again until Station 8.

165:55:25 Cernan: Oh, the tape's not going to stick anymore, I'm afraid.

165:55:28 Parker: Well, try.

165:55:29 Schmitt: Big bag open?

165:55:30 Cernan: Yeah, it's all open. All set.

165:55:32 Schmitt: I need a normal sample bag for one here. It's pretty fragile.

165:55:37 Cernan: Okay. (Pause) Oh, that doggoned thing's not going to...That tape is full of dust now. (Pause) Okay. Wait a minute, Jack.

165:55:45 Schmitt: Here, let me get this big one. I'm about ready to drop it. (Pause) It looks like a gabbro.

165:55:56 Cernan: Here's sample bag 560.

165:56:01 Parker: Copy 560.

165:56:02 Schmitt: And 560 has an undocumented, except by the pans, very white...(It) looks like a crushed anorthosite. It looks like some of the inclusions in the breccia...(correcting himself) grey, recrystallized breccia.

165:56:20 Parker: Okay. We copy that.

[Fendell finds the LM; the lighter-grey surface discoloration caused by the descent engine is obvious and the LM is a black and white dot at it's center. The dot is black on the west; white on the east.]

165:56:22 Cernan: Jack, when you get around, and we close this gate, you might try and hit that top of that SEP down again.

165:56:26 Schmitt: I will. (Pause)

165:56:30 Cernan: Hey, Bob, you're staying keyed an awful long time. We can hear a lot of what's going on back there. (Pause) (To Jack) Wait a minute. Let me get this out of the way. (Pause) Okay. Close it. (Pause) Yeah.. That's got it.

[Parker has a foot switch so that he can speak to Gene and Jack. Normally, he releases the switch when he is

talking with the Flight Director but, here, is leaving the switch depressed.]

165:56:47 Schmitt: Okay, that's tight.
 165:56:49 Cernan: That's got it. Okay.
 165:56:50 Schmitt: Oop, oop, oop. Why'd that come off?
 165:56:52 Cernan: Well, because it (the gate)'s not locked. It's (garbled) that never was locked.
 165:56:59 Schmitt: (Laughing) We lucked out. (Pause)

[Fendell finds Jack, who is raising his seat so that he can stow the drive tube. Had the gate swung open, they might have lost some tools. Later in the EVA, during their drive back to the LM from Station 9, that is exactly what will happen. The gate will swing open and they will lose both extension handles along with the rake and scoop. Gene takes a couple of pictures of Jack. These are AS17-146-22296 and 22297. Note that his gold visor is up and, therefore, we can see him in the suit.]

165:57:10 Cernan: (To Parker) Okay. We're moving (meaning "busy").
 165:57:12 Schmitt: Sort of.
 165:57:14 Parker: And, before you get on, remember to close the battery covers if they...
 165:57:21 Cernan: Yeah. (Pause)

[Jack gets his seat belt out of the way by draping of it over the Rover SCB.]

165:57:30 Schmitt: Your camera lens looks all right, Geno.
 165:57:32 Cernan: Yeah, I dusted it already.
 165:57:33 Schmitt: Oh. (Pause) Okay. Cover closed... (Going to the SEP receiver behind his seat) Okay. Do they want it on or off? Leave it off, huh?
 165:57:43 Parker: Off.
 165:57:43 Cernan: Leave it off, but try and close that cover as best you can.
 165:57:47 Schmitt: Well, I'm afraid the tape has had it.
 165:57:49 Cernan: I know it.
 165:57:51 Schmitt: (Leaning across his seat) You want us to tape it again, Bob? (To Gene) What did you do with the tape?
 165:57:56 Parker: If you can grab the tape right off, but don't spend a lot of time on it.

[Schmitt - "I think we're both sounding tired after working on this slope. There isn't as much joking as when we first got there. We're quieter."]

165:57:59 Schmitt: (To Gene) What did you do with that tape?
 165:58:05 Parker: Let's worry about it at Station 7, if we're going to worry about it. Press on.

165:58:09 Schmitt: Okay.

165:58:11 Cernan: Yeah. Let's forget it now. It's too hard to work on here, and it's not going to take just a minute. It's going to take too much time.

165:58:15 Schmitt: I'm not sure I can get back on here.

[The Rover is rolled about 20 degrees - with Jack's side down.]

165:58:18 Cernan: Well, let me give you a hand.

165:58:20 Schmitt: We need any a...We don't need any...

165:58:22 Cernan: No.

[As noted previously, Jack's gold visor is up. His helmet remains facing the TV camera through all of this, but he turns his head about 60 degrees to look downhill to the south.]

165:58:23 Schmitt: Nothing. As a matter of fact...

165:58:24 Cernan: I can drive, Jack.

165:58:26 Schmitt: Why don't you drive down and get so you're not...You can get on...

165:58:29 Cernan: You can go downhill very easy.

165:58:30 Schmitt: Yeah.

165:58:31 Cernan: Okay. Let me get the TV; The battery covers are closed.

165:58:35 Schmitt: Let me carry...

165:58:36 Cernan: Why don't you just go down there.

165:58:37 Schmitt: ...I'll carry the Rover sampler, just in case.

[Jack extracts the sampler, which is stowed vertically next to the control panel.]

165:58:40 Cernan: Got it? Okay. I'll get that out of your way, too.

165:58:47 Schmitt: Okay. I'll head down to that...Actually, I'll sidehill over to those boulders right over there and then see if that's any change (in rock type).

[Jack starts downhill; Gene leans over the right-side battery covers.]

165:59:01 Cernan: Okay. You might, if you get another sample, a large sample, you might grab it, and we'll throw it in the footpan here.

[Gene wants to get a large rock that they can use in the close-out ceremonies back at the LM. The plan is to split the rock into dozens of pieces for distributions to museums around the world. See 169:43:06.]

165:59:09 Cernan: And I'll see if I can't find a level spot to...

165:59:11 Schmitt: I sort of ought to have my scoop, too.
165:59:13 Cernan: ...help you get on. No, don't take too much; just take that (LRV Sampler). That's all you need.

[Gene goes around the front of the Rover; Jack has only gone a few feet to the southeast.]

165:59:17 Schmitt: How about letting me have your hammer, then?

165:59:20 Parker: Okay; and, 17, can you verify that the gnomon is back in the Rover?

165:59:29 Cernan: Gnomon is on the Rover. The TGE is on the Rover.

[Fendell finds Gene standing a few feet south, examining the Rover. Jack is beyond him, moving diagonally across the slope and toward the southeast.]

[Schmitt - "One of the things that bothered me physically was doing a lot of sidehill traversing at Station 6. On going east on the south-facing slope for some distance, the inside ligament on my left leg began to feel fatigued because the right leg was so much down and the left leg was so much up. Most of the stress was on the left leg, and it is the same ligament that I had damaged skiing years before in '58 or '59; and I suspect that that was the reason for that. It was a pretty bad pull and, after it recovered, I never felt it again except for going sidehill right in this part of the traverse. I started to tire and I could feel that ligament. It wasn't bad, but I could tell it wasn't normal."]

[Cernan - "About five or six weeks before the flight, we were playing softball and I pulled my planteres (a small calf muscle associated with the Achilles tendon). I was running between second and third base and I thought somebody had hit me in the bottom of the right leg with a machete. And I just doubled up. I was on crutches for about a couple, three or four days. If it was ripped, I was done (that is, off the flight). It was strained or pulled but not ripped, I guess, and I had some great concern as to whether the doctors would consider it recovered enough for me to fly. But I guarantee you that, less than a week after I was off the crutches I was in a suit doing EVA training. Hurting like hell. And I really wondered how it would be on the Moon. When we did go, I could feel it the whole time I was doing some of these things, but never to the extent that it either hobbled me or could down my mobility. It just hurt. It had healed very, very quickly and I'm not so sure...And it sounds a little crazy; but I think part of your physical well-being depends on your mental well-being. And I'm not so sure that, mentally, I didn't want to fly that flight so bad that it either healed faster or I didn't know it hurt. There were times during the surface activities that I did feel it; but I don't remember feeling a thing during the stuff we've just gone through at Station 6. Also, it's possible that,

subconsciously, the injury may have influenced my choice of hopping and skipping rather than Jack's long, loping stride. When you were hopping, you had to plan on maintaining a special kind of balance each time you came down, but you had two feet supporting you all the time. I'm not sure, but maybe I did hop to make my leg feel more comfortable."]

165:59:32 Schmitt: The rake.

165:59:33 Cernan: The rake is on the Rover. The scoop's on the Rover. We got the...You put the core under your (seat) pan, right?

165:59:38 Schmitt: Yep, that's right.

165:59:39 Cernan: Okay. I'm going to power up and see if I can't come down and get you. (Pause) It's fun walking downhill! Boy, that boulder track is impressive.

[Gene moves the TV to its stowed position.]

165:59:56 Parker: Okay; and, 17, when you get moving...

165:59:58 Cernan: (The track is) very symmetrical.

165:59:58 Parker: ...we want to get, and I quote, "a maximum variety of hand samples with a minimum amount of documentation, in a minimum amount of time at Station 7". It's just an attempt to see what kind of variety we can get along the face of the front. Over.

166:00:17 Cernan: Roger. (Pause; static)

[The remainder of this EVA was reviewed with Gene and Jack, together, in Santa Fe, New Mexico in September 1991.]

[Cernan - "I'd like to reminisce with Jack - a little bit - because, for what it's worth, we're sort of authenticating history, nineteen years later. It wasn't until Eric and I sat down in my office and watched the films and listened to our voices that I recalled the steepness of that slope at Tracy's Rock. Because Al Bean painted the picture, I've seen the hill a million times; but, in the years since we were there, I've never fully appreciated that you and I were walking at an angle on the side of the hill and that getting on and off the Rover was typical of the problems it caused."]

[Schmitt - "I think it was one of the USGS (U. S. Geological Survey) guys who said that it was a twenty degree slope where we were parked. And there was a break there. The boulder probably hit and broke when it hit that break in slope and, above us, it was probably 25 or 26 degrees."]

[Cernan - "I recall climbing up there to do that pan, and being way above you. And I think this is important so that people can know what your ability is to maneuver around on slopes. And I don't think anyone else ever really encountered...I don't know what they did on Apollo 14 when they went up Cone Crater..."]

[Schmitt - "Apollo 14 didn't have a twenty degree slope. They had enough to make them work (about 10 degrees), but

they didn't have as good a suit. They didn't have the new waist joint."]

[Cernan - "I just wanted to mention this. It was the one thing that impressed the devil out of me when we reviewed it. The still pictures and a lot of the TV don't show it, but it was really steep."]

[Schmitt - (Laughing) "That's because the camera was always tilted twenty degrees."]

[TV off. In the copy of the audio tapes used to prepare the journal, the next five lines are buried under static and remarks by the Public Affairs commentator.]

166:00:29 Cernan: Okay. Well, I'm not sure I can get on without ending up in your seat.

[Gene's side of the Rover is the upslope side.]

166:00:32 Schmitt: Need some help?

166:00:34 Cernan: No (garbled).

166:00:38 Schmitt: I shouldn't have left.

166:00:40 Cernan: No, no. I don't need any help. I'll get on.

[Cernan - "For Jack to have gotten on that downhill seat, even if he'd jumped up there he probably would have fallen back off. For me, it was much easier to get on the uphill side but it was steep enough that it really did feel like I was going to end up in Jack's seat."]

[Schmitt - "It wasn't worth the effort for me to try to get on. By this time, we didn't have any problem with walking some distance."]

[Cernan - "The only thing about it is that Jack really did enjoy riding on the downhill side."]

[Schmitt - "(Laughing) That might have influenced my decision as well."]

166:00:49 Cernan: (Static clears) I probably ought to turn my water off of Max if that's where it is. It's cold. I don't want to run out today. (Long Pause) Well, the roll indicator says 15 degrees; and the pitch indicator says about 12 (giving a total slope of nearly 20 degrees). I don't know if I believe all that. Bob, you with us?

166:02:08 Parker: Go ahead. Right. We're with you.

166:02:10 Cernan: Okay. I'm rolling.

166:02:11 Parker: Copy that. (Long Pause)

166:02:33 Cernan: Man, this is still a slope. Jack, I'm going to pull around and in the front of the way you're facing.

166:02:43 Schmitt: I can go down...There's a crater over here, (garbled). (Pause) Oh, there you are.

166:02:53 Cernan: This is much better. How is this?

166:02:56 Schmitt: That's great.

166:02:59 Cernan: We ought to be able to pick up lots of those fragments out in that field out there.

166:03:06 Schmitt: Be right with you.
 166:03:07 Cernan: Okay. (Pause) Bob, I just came downslope reading 193/3.1; just about 100 meters to pick up Jack.
 166:03:18 Parker: Okay, copy that.
 166:03:22 Schmitt: Okay. Bag 48 Yankee has a sample of about a one-third-meter boulder that was lying in...that's sitting right smack dab in a little crater of it's own.
 166:03:44 Parker: Copy that.
 [48 Yankee contained Apollo samples 76030 through 76037. The largest fragment - 76035 - is a piece of blue-grey breccia. Interestingly, 48 Yankee also contains a 2.5 gram piece of basalt (76037).]
 166:03:45 Cernan: Oh, Jack!
 166:03:46 Schmitt: What?
 166:03:47 Cernan: Oh, you just kicked a snowstorm of dust across here.
 166:03:50 Schmitt: I'm sorry. I just fell, too.
 166:03:52 Cernan: Did you? You all right?
 166:03:53 Schmitt: Yeah. Want your hammer?
 166:03:55 Cernan: Yeah.
 166:03:58 Schmitt: Okay.
 166:04:00 Cernan: I got to drop it (the hammer) in the pan here. Hold on to it, I think. (Pause)
 166:04:08 Schmitt: Couldn't help that one.
 166:04:12 Cernan: Yeah. I think, (when) we get (to) some more level spots, I can dust this thing (the battery cover) back there.
 166:04:15 Schmitt: Am I really on?
 166:04:18 Cernan: You're high. You're (seat belt is) twisted. Go away from you one twist. Okay. (Pause) Is it caught in something? Yeah, it is. You're...Oh, wait a minute...Get up, get up, get up. You've got...You're sitting on...Get up.
 166:04:31 Schmitt: What am I sitting on?
 166:04:32 Cernan: You've got to get out. You didn't put this away. Wait a minute. Get up...Out...All the way.
 166:04:37 Schmitt: Oh, that thing.
 166:04:38 Cernan: Yeah, this thing.
 166:04:39 Schmitt: That's right.

[Neither Jack nor Gene has any idea what "this thing" might have been. A quick review of the dialog hasn't revealed any clues. "It" is probably not the roll of tape, in part because Jack doesn't think the tape roll was big enough to have made him sit high.]

[Schmitt - "Why couldn't we have said what it was!"]

[Cernan - "You and I knew what was going on, but nobody else could have followed it."]

166:04:40 Cernan: That's where (means "why") you're setting high.
 166:04:41 Schmitt: I knew I'd forget that. (Pause)

166:04:50 Cernan: Okay. Now, let me get this thing out.
 (Pause) Okay. (Pause)
 166:05:07 Schmitt: Okay. Let's press. Better get (the
 seatbelt) latched. (Pause) Okay.
 166:05:21 Cernan: All set?
 166:05:22 Schmitt: Yep.

[The best TV record of an astronaut getting on a Rover is probably that of Charlie Duke at one of the Apollo 16 EVA 2 stations. Fendell recorded Jack mounting the Rover at Stations 3 and 7. The best still is AS17-134-20453, which Gene took of Jack at Station 9.]

[Cernan - "When you're sitting in the seat, you can't see what's going on in the seat. The other guy is the one whose got to look."]

[Schmitt - "It's all by feel."]

166:05:23 Cernan: Okay. (Pause) We're rolling; Bob.
 166:05:39 Schmitt: LMP frame (count) is 130.
 166:05:43 Cernan: You got a lot of static now?
 166:05:44 Schmitt: Yup.

[Cernan - "We were hearing static from the ground. But, as you can hear in the tape, they were reading us loud and clear. We were probably hearing carrier static."]

166:05:45 Cernan: Okay.
 166:05:48 Schmitt: Hey, you got a rock on your right of your (garbled).
 166:05:49 Cernan: Yeah, I got them. (Garbled) (Pause) I got the low-gain (antenna) set.
 166:05:56 Schmitt: Hello, Houston. Do you read?
 166:05:57 Parker: Roger. We read loud and clear.

[Jack's pictures taken during the 700 to 800 meter drive to Station 7 are AS17-141-21637 to 21645. The blocks on the right of 21638 are at the center of 21642 and the Station 7 boulder is at the right in 21645.]

166:06:02 Schmitt: Okay. (Pause) Okay; how about that field...Not this block, but (out where) there's sort of a collection of them...
 166:06:10 Cernan: Yeah. Way out there...
 166:06:11 Schmitt: ...way out there.
 166:06:12 Cernan: ...about 300 meters or so.
 166:06:13 Schmitt: Oh, at least. Yeah. Oh; going into the Sun, I can't see a thing to tell you about Wessex Cleft, that we haven't already said.
 166:06:22 Parker: Okay. Station 7 is nominally 208 and 3.3, but it's any group of any significant boulders you want to stop at in reality.
 166:06:31 Schmitt: Understand. (Pause) (To Gene) Ohhh, easy.

166:06:42 Cernan: You feel like you're on a downslope over there?

166:06:43 Schmitt: Yeah. I feel like you're about ready to spin out downhill any minute.

166:06:46 Cernan: Do you? (Tongue in cheek) I don't feel that at all up here. (Pause)

166:06:54 Schmitt: Bob, it's hard to give you much (description), looking into the Sun the way we are.

166:07:00 Cernan: We must be about 200 meters up the slope, looking at that little valley (Taurus-Littrow) down there, Jack, on the right?

166:07:05 Schmitt: Yeah. I think you're right. The pattern on the slope really doesn't look much different than on the light mantle. Matter of fact, it looks very much like light mantle, except for these large blocks that are in it.

166:07:23 Parker: Okay. Copy that. And you guys may still have your visors up. We can't tell, but you might be better off with them down, if you've forgotten that they're up.

166:07:26 Schmitt: Well...Boy, I can't see. My hands work just as well (as an eye shade) as my visor, as a matter of fact.

[During this EVA, Jack frequently has his visor positioned at about eye level. This provides him some shielding from the direct Sun while giving him a view of the ground unobscured by scratches in the visor. At this point in the review, Gene and Jack discussed the possibility that Jack was using one hand to steady himself as they drove on the slope. Jack doubts he could have reached the accessory staff mounted on his side of the console. They think he was probably holding onto a bar like the one shown on Gene's side of the Rover in AS17-146-22296, which is Gene's picture of Jack at his Rover seat taken at the end of Station 6.]

166:07:35 Cernan: No, I can't believe mine could be up.

166:07:38 Schmitt: You've got a crater right in front of you.

166:07:39 Cernan: Yeah. I got it.

166:07:41 Schmitt: Okay. That looks like a pretty good pile to work on.

166:07:42 Cernan: Yeah. Let's go over in there.

166:07:43 Schmitt: Hey, wait a minute. Okay.

166:07:46 Cernan: Bob, what heading are you going to want me to park on? Why don't we get in that flat area, Jack, so I can dust the radiators.

166:07:50 Schmitt: Yeah.

166:07:52 Parker: We have no constraints, Gene. This is going to be a very short station. Probably not more than 10 or 15 minutes. Just to grab, as I say a maximum variety of hand samples with a minimum amount of documentation and a minimum amount of time.

166:08:12 Cernan: Okay. We do a pan, and pick up a lot of those small ones, Jack.

166:08:15 Schmitt: Yep.

166:08:16 Cernan: Rather than trying to chip. (Pause)
 166:08:22 Parker: Okay. We would like to have the...
 166:08:23 Schmitt: (Garbled)
 166:08:24 Cernan: I'd like to see us a little more level.
 166:08:25 Parker: ...TV camera and its mirrors and stuff
 dusted there, however. But we won't do anything to the
 battery.
 166:08:30 Schmitt: I thought you were going to stop back
 there.
 166:08:31 Cernan: Well...
 166:08:33 Schmitt: Okay.
 166:08:34 Cernan: I was going out here around this big one.
 166:08:36 Schmitt: I'm sorry. I misunderstood you.
 166:08:37 Cernan: Yeah. (Pause) See, there's a lot of
 little ones up in here I want to...
 166:08:49 Cernan: (To Parker) Okay. Do not do anything to
 the batteries. Understand.
 166:08:52 Parker: Roger.
 166:08:53 Schmitt: I can't figure out where you're going to
 stop.
 166:08:54 Cernan: Right in here. Right here to give you as
 much of a level spot as I can. That's about as level a spot
 as I can find. I'm inside the slope of a crater. Bob, I'm
 at 200/3.3.
 166:09:08 Parker: Copy that. (Long Pause)
 166:09:24 Schmitt: You want me to help you with the dusting,
 Geno?
 166:09:26 Cernan: No, I'll get it. Only one guy can do it.
 (Pause)
 166:09:34 Cernan: I just...You take a pan "before", and
 we'll start picking up some of those samples, and I'll take a
 pan afterward. (Pause) Well, let's see here. (Pause) See
 what kind of variety we can get here.
 166:09:51 Schmitt: There is another one of our blue-grey
 breccias, I think, over there: recrystallized breccias with
 some of that crushed anorthosite in it. (Pause) I think
 right in here. I'm going to take the pan at about...
 166:10:08 Parker: And, Jack, what's your frame count?
 166:10:13 Schmitt: 131.
 166:10:14 Parker: Okay. Press on. (Pause)
 166:10:23 Schmitt: Bob, I'm going to take the pan at 11 feet
 (focus), so you can see the fragments that we're going to
 pick up here. Then we can take another one for location
 work.
 166:10:40 Parker: Copy that. (Long Pause)

[TV on. Jack's pan is AS17-141-21646 to 21664.]

166:11:07 Cernan: Should have it, Bob.
 166:11:09 Parker: We've got a TV. And, I repeat, we'd like
 to get some dusting of the (TCU) mirror and the lens of the
 TV; (dust the) TCU and the TV.

[Gene moves the TV so that he can dust the lens.]

166:11:22 Cernan: Let me get you out of the Sun. (Pause)
I wouldn't do this for anybody but you, you know that.
166:11:39 Parker: Okay. Looks good, Gene. Thank you.
(Long Pause)
166:12:01 Cernan: You know what? I'm getting tired of
dusting. (Long Pause) My primary tools: the dustbrush and
the hammer. And my head. (Pause) Okay. You ready to start
picking (up small rocks)?
166:12:35 Schmitt: Picking.
166:12:37 Cernan: Okay. (Pause)

[Fendell finds Jack WSW of the Rover, bagging a sample.
He is leaning forward, but only a little more than he would
at a level site.]

166:12:44 Parker: And...
166:12:45 Cernan: You notice the temperature difference
with that high Sun angle?
166:12:47 Schmitt: Yup.
166:12:48 Parker: Roger. You're probably letting in a lot
of infrared through without having that gold visor down, too.
That's sort of an infrared shield.
166:12:57 Cernan: Yeah, but mine's been down all the time,
Bob.
166:12:59 Parker: Copy that.
166:13:00 Cernan: Except in the shade.

[Jack lowers his gold visor, then closes the sample bag
by holding it by the two tabs at the top and twirling it
three times. He is leaning on his scoop again, handle
against his stomach.]

166:13:05 Schmitt: Okay, 540 is the first bag of selected
samples.
166:13:11 Parker: Copy that.

[Gene joins Jack and collects a fist-sized sample with
his tongs.]

166:13:15 Schmitt: Okay. I'm going to leave you (Gene's
SCB) open, but don't let me...
166:13:17 Cernan: Let me get...Here, put that one in there.

[Gene moves alongside Jack so that they are side-by-
side, facing north.]

166:13:19 Schmitt: Wait a minute, let's get a bag on it.
We're getting too many rocks, and we don't know where they
came from. (Pause)
166:13:31 Cernan: I don't think it will fit. Will it?
166:13:33 Schmitt: Well, we'll wrap it a little bit.
166:13:36 Cernan: Yeah, wait a minute, it will fit.
(Pause) Wait a minute. (Long Pause)

[Gene presents his SCB; Jack has dropped the scoop.]

166:14:03 Schmitt: Okay. Bag 541 is partially around another big rock in Gene's collection bag. (Pause)

[Once again, Jack retrieves the scoop by stepping on the head so that the handle rotates up to about waist height. With practice, this has become an easy procedure. Gene moves farther west to a large boulder.]

166:14:23 Cernan: Did you get pictures of this thing here?

166:14:25 Schmitt: Yeah; well, not the big rock yet. Not in focus anyway.

166:14:29 Cernan: (Stopping about a shadow length away from the boulder) I got to do that.

166:14:32 Schmitt: I was just collecting (fragments) in this area.

166:14:34 Cernan: Why don't you keep grabbing a few, and I'm going to...

166:14:38 Schmitt: That's what I'm doing.

[Gene hops sideways to the north, taking a flight-line stereo. These photos are AS17-146-22298 to 22315.]

166:14:39 Cernan: It's one of the blue-grey rocks, Bob. And it's got a light-colored fragment that runs the full height of it, about a meter and a half thick. And then it's got the blue-grey rock on the other side. As a matter of fact...(Pause) Let me look at it closely. (Pause) It's a fragment in it all right.

[Gene is still taking pictures for the flight-line stereo; Fendell pans southward to Jack who is collecting small rock fragments with the scoop.]

166:15:13 Parker: Okay. Copy that, Gene. And remember to document around the corner if you're trying to get some photo-documentation of the boulder. (Pause)

[Having bagged the first set of fragments, Jack collects some more. He has the head of the scoop angled 90 degrees to the shaft and is having a much easier time at solo sampling than he'd had at Station 3.]

[Cernan - "I notice that we seem much more relaxed during EVA 3. We were confronted with more ambitious things but, even little things like picking up the scoop that we would have commented on earlier in the mission, we were just doing."]

[Schmitt - "In EVA 2, we were always behind the timeline."]

[Cernan - "Early on, we were shouting to Houston and now we're more in tune. I think that, in another week of this, it would have become pretty routine - 'routine' in the sense

that everything we did wasn't brand new, wasn't a new challenge."]

[Schmitt - "I think that the third EVA included not only all of those things but, also, a realization in the back of your mind that this was the last one."]

[Cernan - "We wanted to drag it out as long as we could."]

166:15:29 Cernan: Bob, I wouldn't be absolutely positive, but it sure looks like I see a dikelet in here, that's in the inclusion. And I'm going to get a close-up stereo of it. I'd call it a dikelet, if you pinned me down.

166:15:43 Parker: Okay. Copy that.

166:15:45 Schmitt: Pin him down. (Long Pause)

[Jack moves about ten feet to the south to get some more fragments. In order to collect and bag the samples, he rests the head of the scoop on the ground after he gets a fragment or two, then bends down as far as he can and grabs the shaft about a foot off the ground. This grip makes it relatively easy for him to pour the samples into a bag. Gene's close-ups of the boulder are AS17-146-22316 to 22328. He is using the tongs to make sure that he is the right distance away for good focus. In 22325, one of the dikelets runs horizontally across the frame about 2/3rds of the way up.]

166:16:10 Cernan: I wish I could break a sample right off. Here's another one. It is a dikelet! There's three or four of them!

166:16:14 Parker: Okay. Copy that, Gene. Very good.

[Jack moves a few feet north and collects another fragment. Fendell pans to Gene who is examining the northeast corner of the boulder. The top of the boulder is just a bit above the top of Gene's head. We can see Gene using his tongs to gauge his distance.]

166:16:23 Cernan: Ohhhh, me, oh, my. (Pause) The material in the dike looks...Yeah, it is, it is, it (the blue-grey, dike material)'s not covering it (the light colored host rock). It's between the lighter-colored rock, and it's the blue-grey rock.

[Cernan - "I remember this episode very, very vaguely. I didn't describe it very well."]

[Schmitt - "You're going through a lot of thought and you're only articulating every once in a while."]

[At most stations, Gene has spent the first few minutes cleaning up the Rover while Jack has taken a look at the local geology. Here, the roles are different. While Gene dusted, Jack took a "before" pan and then started sampling.]

[Schmitt - "The assigned task was to get a collection of fragments."]

[Cernan - "Quickly. Along with some general documentation."]

[Schmitt - "And, generally, sampling of this kind was my task because we had decided that the scoop was the fastest way to do it."]

[Cernan - "The rock was an added attraction, a target of opportunity. So I went over while Jack was picking up his samples."]

[Schmitt - "That's generally the way we worked on field trips."]

166:17:05 Schmitt: 542 is another bag of goodies.

166:17:08 Parker: Copy that.

166:17:09 Schmitt: Gene, let me get rid of this.

[Gene is scrapping fragments off of the face of the boulder; Jack puts the soil sample in his SCB.]

166:17:11 Cernan: Oh, wait a minute. I got...I got...Well, maybe it isn't a dikelet. Maybe it's just a screen covering, a flow covering.

166:17:18 Schmitt: No, you got...They're dikes.

166:17:19 Cernan: Let me...let me...

166:17:20 Schmitt: (Putting the soil sample in Gene's SCB) They're little veinlets of...

[Schmitt - " 'Dikelet' was a much better term than 'veinlet'. They're injected magma, melted rock."]

[Cernan - "And you didn't teach me that word before we started, either."]

[Schmitt - "I think you knew 'dike' before..."]

[Cernan - "Yeah; but 'dikelet'...I don't ever remember you telling me to use that word. (Tongue in cheek) Jack used to give me all these words and he'd say, "Now, when you get up there, Cernan, use these. It will impress the hell out of them. I had a list of words written down like a football player has a list of plays."]

[Schmitt - "The guy that literally did that was Conrad. He had a list of geology phrases in his checklist, but he never used them. Of the first three crews, we probably had Beano and Pete as far up the curve in geology training as anybody. The last exercise they had in Hawaii just went beautifully. They were on top of everything we threw at them. So we expected the same thing to happen on the Moon and, yet, not a word! Not a word! Afterwards I found out - and I'm not sure exactly how - that they specifically decided not to say anything because, in the mean time, some of my scientific 'friends' had publicly made fun of Buzz talking about mica-like particles ('biotite' was the word Buzz used) that he saw sparkling on the surface. And they do sparkle like mica!! He'd seen it on field trips. But these assholes - I'll say that on tape - were making fun of Buzz because he described the way things looked. I'll tell you, I chewed a lot of guys out about the criticism of Buzz."]

[In October 1991 telephone conversations with Conrad and Bean, both said that they did not remember the criticism of Aldrin and both said that they never decided to avoid the use of specific geology terms in order to avoid criticism during their own mission. In addition, Bean stated in strong terms that it would have been completely out of character for Conrad to let criticism of Aldrin influence his own behavior. Both did have lists of geology phrases in their checklists, lists which Conrad says "Jack gave to us, maybe to poke fun at the guys who had criticized Buzz." Neither Conrad nor Bean saw the lists before they got to the Moon, and neither used any of the phrases, primarily because, in Conrad's words "nothing appropriate ever came up". A secondary reason was that, again in Conrad's words, "I decided it wasn't proper to be funny about that." As he says in his commentary to the Apollo 12 transcript, his prime concern with regard to geology descriptions was to avoid using his favorite geology word, which was "stuff". He had promised Uel Clanton that he would use either a proper geology term or the word "material" and Clanton had bet other members of the science team that Conrad would keep his word.]

Whatever actual events that preceded Apollo 12, and whatever agreements Conrad and Bean may have come to between themselves about the use of geology terms, the important point here is Jack's justifiable annoyance with those who criticized Aldrin. At several places in the Apollo 17 commentary, Jack and Gene make a compelling case for the use of descriptive comparisons while doing field work. Precise terminology can be applied after the fact and after the samples have been examined by professionals in a shirtsleeve environment.]

166:17:22 Cernan: Let me get this whole thing in a bag. I got a rock, Bob. It's fractured, primarily around the dike. It's in several pieces, but we're going to put it all in one bag.

166:17:35 Schmitt: (Getting a new sample bag) 543.

166:17:38 Cernan: Oh, man, they're going to have to assemble that.

166:17:39 Parker: Copy, 543.

[Gene and Jack are standing side-by-side, facing west and examining boulder.]

166:17:45 Schmitt: Here.

166:17:46 Cernan: Here, I got...I got...Let me get it piece by piece. (Pause)

166:17:52 Schmitt: Okay. We need to get a...Put one of those dikes in another bag. (Pause) Bob, it looks like some fraction of the blue-grey material has obviously...

166:18:06 Cernan: Not too full. That's all right.

166:18:07 Schmitt: ...intruded.

[Schmitt - "The reason that you don't hear any surprise in my voice (at Gene's discovery of the dike), is that what we had seen at Tracy's Rock was that you were getting partially-molten breccias in contact with the blue-grey rock. And here, some of that melt had been injected into the broken, crushed anorthositic fragments. So, while it wasn't a surprise, it was still a great find. (Laughing) And the only thing I had to do was to keep guiding Gene on using that hammer."]

[Cernan - "(In mock seriousness) You took my only playtoy away from me."]

[Schmitt - "Hey, you were the only one who could hold it. I designed it, but I never could hold the damn thing. The handle was too big. We learned before we went that Gene was better in grasping the hammer; and the only thing I had to teach him to hit the edge of a rock instead of the center. 'Brute-force Cernan,' I kept thinking."]

[Cernan - "I've got a short, stubby hand, but I've also got a lot of strength in it. When you're grabbing that hammer, you're really grabbing it with your forearm muscles. That's where you get tired. The hammer, I didn't have any trouble with. (To Jack) If you remember, your hands were really hurting. Do you remember the blisters we had on our knuckles and it felt like our fingernails were driven back into the joints."]

166:18:09 Schmitt: (To Gene) Huh? Now, can you get that dike there?

166:18:12 Cernan: (A) piece of it?

166:18:13 Schmitt: This thing.

166:18:14 Cernan: Yeah.

166:18:15 Schmitt: Can you get that?

166:18:16 Cernan: (Getting his hammer) I can get it right here.

166:18:17 Schmitt: No, I think...No, get the piece with the...You get more of it, right there.

166:18:20 Cernan: (Hitting the boulder eight times, swinging the hammer through relatively large arcs on the later strokes) Yeah. (Pause) It's this soft, white inclusion again. It breaks pretty easy. (Pause) Oh, it's got to be a dike. Look at that.

166:18:30 Schmitt: It is. (Pause) (Reassuring Gene) It is. (Pause)

166:18:36 Cernan: Okay.

166:18:40 Schmitt: (Putting the sample bag in Gene's SCB) Okay, 544.

166:18:41 Parker: Copy that.

166:18:42 Cernan: Oh, yeah, it is, because I just broke into it.

166:18:44 Schmitt: Yeah.

166:18:45 Cernan: I'm looking...

166:18:46 Parker: (Covering the next three, short lines) And we'd like to have you guys moving again in 5 minutes to get to Station 8 on time.

166:18:46 Schmitt: Get all of that?
 166:18:47 Cernan: Yeah. I'll get it all.
 166:18:48 Schmitt: Well, you don't have...(Stops to listen to Parker) Yes, sir. (Pause) Looks like, although the blue-grey up on the hill looked like a fragment breccia, if this is still related, then it's been (through) some partial melting at some time.
 166:19:11 Cernan: There's a preserved contact between the dike and the...
 166:19:13 Schmitt: That's what I wanted.
 166:19:14 Cernan: ...white material.
 166:19:15 Schmitt: That's what I wanted.
 166:19:16 Cernan: Why don't we get this big piece of dike now?
 166:19:17 Schmitt: See if you can get...Whoa! Don't hit it again. There, you've still got some contact there.
 166:19:25 Cernan: Now, there's some good contact. Man, that'll do it.
 166:19:29 Schmitt: Okay.
 166:19:30 Cernan: (Putting the hammer away in his shin pocket) That'll do it.
 166:19:32 Schmitt: Dike and intruded rock in 544. Now, these dikes are a dark bluish-grey. And it looks they're very finely crystalline - maybe with some...
 166:19:45 Cernan: Get my bag. I'll take some close-up's.
 166:19:46 Schmitt: ...very fine phenocrysts.
 166:19:52 Parker: Okay. We copy that.

[Jack puts the sample bag in Gene's SCB; and then moves south about a meter along the rock face.]

166:19:54 Schmitt: We ought to get...Well...We ought to get a piece of the normal grey that the dikes are coming from. (Pause) You got your hammer handy still?
 166:20:03 Cernan: Yep. (Pause; handing Jack the hammer) I want to get this...
 166:20:06 Schmitt: Go ahead.
 166:20:07 Cernan: ...finish documenting this thing. (Pause)

[Gene touches the rock with the tongs held in his outstretched hand in order to establish a focus distance. This close-up afters are AS17-146-22329 and 22330.]

[Cernan - "There's two things here: the transfer of authority with the hammer going to Jack (general laughter), and then the measurement of the focal distance. And you notice how easy it is for me to get the hammer out. I don't even look down. I just reach down, feel the handle, and it comes out."]

166:20:13 Schmitt: Ah-hah! Hey, over here on this side, it looks like the vesicular anorthositic gabbro.

166:20:23 Cernan: I got to get some regular pictures around this side. Okay. Here's the...(Pause) That one won't come off; this one will. (Pause) Got it?

[Jack has hit the rock ten times. The scoop falls to the ground behind Gene.]

[Schmitt - "None of the strokes were hard. Just little taps to break away the edge of a fracture."]

166:20:38 Schmitt: Yeah.

166:20:39 Cernan: (Getting a new sample bag) 561.

166:20:40 Schmitt: That's a sample of the grey - looks like recrystallized breccia - that the dikes are continuous with.

166:20:50 Parker: Okay. And a...

166:20:52 Schmitt: And a...Bob, it's my turn to say "and a." And the vesicular rock...(Pause)

[Jack steps south again, Gene following and trying to reach his SCB. Jack gets another sample loose with five hammer strokes.]

166:21:13 Cernan: Let me finish the stereo around the corner here.

166:21:19 Parker: Okay. And you guys have dropped the scoop there on the ground. And we're ready for you guys to leave.

166:21:26 Schmitt: I know you are.

[Gene moves east to take photographs. Jack moves out of the way. Gene's photos are AS17-146-22331 to 22338.]

166:21:31 Parker: And you might grab one FSR (Football-Sized Rock) on the way out.

166:21:37 Cernan: Okay. We'll do that.

[Jack's lifts off a hand-sized sample he's knocked loose. The fresh surface on the boulder looks bright white in the direct Sun.]

166:21:39 Schmitt: Okay. There's that one. The vesicular anorthositic gabbro is in...What is it? 562.

166:21:49 Cernan: 562. I'll get this in there, and you take the...

166:21:51 Schmitt: I got to get the scoop.

166:21:53 Cernan: ...scoop, and I'll get the hammer. Then (I'll) make sure your bag (SCB) is closed.

166:21:57 Schmitt: Yes, I've got to check yours, too. Let me get uphill from you, though.

166:22:00 Cernan: (Closing Jack's SCB) Wait a minute. (Pause) Give me the hammer. How's that? Can you get it now?

[They rotate 90 degrees around a common center, putting Jack with his back against the rock and, primarily, putting Gene below him.]

[Cernan - "This scene here - where Jack's getting up hill so he can get to my SCB while I'm getting the hammer put away - is a pretty good example of how we were no longer struggling with each and every tasks. By the third EVA a lot of these things were beginning to come naturally. You could combine actions and you became more productive and efficient in your use of time."]

[Schmitt - "Again, just to point out the obvious, in the first EVA it wasn't quite that way. Things like putting the hammer away took longer. And what that points out is that, no matter how much we had trained in the suit, until you get in one-sixth gravity, your motions don't become habit. But very quickly, once you're in the right environment, you learn to do things almost automatically."]

[Cernan - "We could never train in a one-sixth gravity environment. For the record, we've got people all over the country doing studies for lunar base and Mars habitats. And there's only eleven people in the entire world who've ever been in anything but one gravity or zero gravity. There's only eleven people who can tell you about one-sixth gravity or who, perhaps, can extrapolate to Mars gravity. I just say that because, while that experience is around, we ought to at least tap it. And I don't think we do. Think about it. We've got thousands of hours of spaceflight experience - all the Soviet experience, all the Shuttle experience - and there's eleven human beings alive (Jim Irwin having died prior to this review session) who've experienced reduced gravity other than zero gravity."]

[Schmitt - (Straight faced) "And only two who really understand it."]

[Cernan - "I agree. Strictly speaking, in terms of most recent experience, how can you argue with that? But, it's something serious. We've got all these studies. Everybody and their brother's doing a study about how you're going to operate, work, live, and function. And what they need to think about is how you learn to adapt. On that first EVA, that hammer was almost a handicap. It was always in the way. I knocked a fender off. But later, somehow, subconsciously, I knew it was there and worked around it. I was able to get at it or put it away much more quickly without making it a specific task. I was able to get at tools I needed concurrent with doing other things, instead of making each one a separate task. I didn't have to say, 'Time out, I'll get the shovel. Time out, I'll get my hammer out of my pocket.' Just a minute ago, when Jack walked away from where we had been working, on his first step he stepped on the head of the scoop so that he could grab the handle and walk on. It wasn't a special task where he got down on one knee and took another thirty seconds to a minute before he could press on. I think it's pretty easy to adapt. But, here again. With all these studies about what kind of mobility we need and how we're going to adapt and what tools we're going to need to get the work done, I don't know that anyone has ever

been asked any questions. I haven't been asked , for the most part."]

[Schmitt - "I participated in one or two studies; but, as far as I know, those studies aren't used. The Essex study for crew systems down at Houston has a lot of that stuff in it. But, if you ask anybody if they've seen it, they say they haven't. It's typical. All these studies are done and, even if they're good, they stay on the shelves along with the bad ones. Nobody ever looks at them and they go do the work again. I don't know how you break through that."]

[In 1993, the Apollo astronauts were finally invited to the Johnson Space Center to participate in a series of structured interviews about their lunar work experience. A draft report - authored by Mary Conner and others - is being circulated in early 1994.]

[A question then arose about the value of contacts with prior crews to their training for Apollo 17.]

[Schmitt - "I think that, for Gene and me, those contacts were a major part of assimilating the experience that others had had. An example is Gene's consciousness about the cables for the heat flow probe. He was aware that John Young had lost track of them and pulled them out."]

[Cernan - "We probably focused on the problems that other people had had. The problems that Apollo 14 had getting up to Cone Crater. The problems of Apollo 16 with the cables. And I think that probably 15 was as good an all 'round training experience for follow-on crews as any. Because they had a little bit of everything: the Rover, the drill, rugged terrain. So it was a good presentation of the kind of things that you wanted to be aware of."]

[Schmitt - "At this stage in the game (twenty years later), it's hard to remember all the things that you assimilated from the crew debriefings and from watching their performances. But I'm sure that there were a lot of things in the back of your mind that you learned and prepared for. So, by the time we flew, we had the benefit of all of that experience."]

[Cernan - "And there's always the undocumented conversations when you're in someone's office or wherever you might be. Saying 'Hey, John, did you really have a problem here' or 'What were you thinking there?' We worked and traveled together and I'm sure there were a lot of informal discussions. I can remember talking to John (Young) about the tendency, when you're coming down, to drift backwards or sideways. I wanted to land with a positive foot-per-second forward velocity. I wanted to bias my zero horizontal velocity so that I wouldn't drift back into something I couldn't see. I know that Stu Roosa - having just flown Apollo 14 - worked very closely with Ron and was very interested in the orbital science aspects of our mission."]

166:22:07 Schmitt: This is one of the worst bags (SCB) we've had. The latching, it just doesn't stay down. (Pause) If we get time somewhere, we ought to change that out. (Pause)

166:22:28 Cernan: Two of the corners are...
166:22:29 Schmitt: Yeah. Well...
166:22:31 Cernan: How's she doing?
166:22:32 Schmitt: It's okay. It'll hold for a while.
(Pause) Okay.

[Gene tries to pick the scoop up with the tongs but can't. He then heads for the Rover. Jack goes for the scoop. He leans on the boulder with his left hand, and goes down to get the scoop with his right.]

166:22:52 Cernan: Okay. Here's an FSR that's about...
166:22:54 Parker: And, Jack, you're untied. One side of your bag is undone again.
166:23:01 Cernan: Oh, I'll get it for you.

[Gene gets the hammer out, intending to use it as a support so that he can get down to grab the rock. Before kneeling, he notices that the tongs, which are attached to his yo-yo, will be in the way, so he pushes them behind him. Then, he puts the hammer to use in virtually the same way that he used the drill during ALSEP deployment - by leaning on it with one hand. At first, he doesn't quite go to his knees.]

166:23:09 Cernan: (To Parker) Here's a football-size rock that was 50 percent buried.

[Gene has trouble getting his hand around the rock. He is now on his knees.]

166:23:12 Schmitt: Can you grip it? (Pause)

[Cernan - "I found a narrow part of the rock that I could grip."]

[Gene pushes back off the hammer without moving his feet. As his PLSS rotates far enough back, he rises to his feet. On Apollo 16, at Station 1, Charlie Duke had a similar struggle picking up a large rock, now known as Muley, for geologist Bill Muehlberger.]

166:23:20 Schmitt: I'll get the gate open.
166:23:22 Cernan: Remind me to get your bag.

[Gene tosses his hammer so that he can change grip as he catches it.]

[Cernan - "That's a great scene. I love that."]

166:23:23 Cernan: Hey! Did you see the way I handled that hammer!?
166:23:24 Schmitt: Yeah.
166:23:25 Cernan: Tell you what, I'm getting accustomed to things. (Pause)

[Cernan - "I think that this is what this whole EVA is about. Aside from the geology, you're seeing a much more productive use of time."]

[Jack takes hold of the gate and starts to open it.]

166:23:33 Cernan: That gate's a little sluggish, too, Jack. (Pause) Boy, I think everything is so full of dust (that) nothing wants to move any more. (Pause)

166:23:50 Schmitt: Okay. That one (the FSR) looked like a piece of the grey rock, I think.

166:23:52 Cernan: (Mounting something on the gate) You know, I'll bet I didn't push the gravimeter here. Did I, Bob?

166:23:55 Parker: No. We'll get it at Station 8.

166:23:57 Schmitt: No. They didn't tell us to.

23:00 Cernan: Okay. Jack, you're going to have to close the gate, and I'll have to hold the big bag over the top.

166:24:03 Schmitt: Okay.

166:24:05 Parker: Okay. And, Jack, before you leave, we'd like you to change mags before you leave this station.

166:24:13 Schmitt: Yes, sir. I'll do that.

166:24:15 Cernan: Uh, oh.

166:24:16 Schmitt: It's...

166:24:18 Cernan: Wait a minute.

166:24:19 Schmitt: I've got it.

166:24:20 Cernan: Yeah, but don't push.

166:24:21 Schmitt: I won't.

[Fendell pans away from them, counterclockwise.]

166:24:22 Cernan: (Still struggling with the sticky gate latch) One of those little...Okay, now you can push. Okay, that's locked. (Pause) Well, it's in. Wait a minute, wait a minute, wait a minute. (Let me) see what's going on in there. This thing isn't released all the way. (Pause) Uh, Uh. Pull it out this...That's it. Push. Okay, now...

166:24:48 Schmitt: There, you got it. It went in.

166:24:50 Cernan: Okay, that's the dust again. Now, the bag's in the way. Let me get the (big) bag out.

166:24:55 Parker: Okay. And, Gene, you might get the...

166:24:56 Cernan: Okay. Now shove it. (Pause) That's too much. Wait a minute, wait a minute, wait a minute. Let me...Okay. (Pause) Let me lift it up and (then you) do it. (Pause) Well, wait a minute, I've got to tweak this thing. Okay, now shove it in. Right now. (Pause)

166:25:19 Schmitt: That got it. No? (Pause) Why don't you play with it, and I'll see if I can change a (film) mag. (Pause)

166:25:34 Cernan: Well, dadgummit! That latch is...

166:25:40 Schmitt: Gone?

166:25:41 Cernan: I'll lock it. I'll just push that latch...That latch is just sticking, that's all. It's just dust, again. I don't know what you do about those problems.

166:25:48 Schmitt: Okay, what magazine did you want, Bob?
 166:25:51 Parker: Magazine Mike, as in Mary.

[This is Apollo magazine 142.]

166:25:54 Cernan: Okay. It's latched.
 166:25:56 Parker: Gene, you might spend your time taking
 a...
 166:25:57 Cernan: It's latched.
 166:25:58 Parker: ...standard 74-foot pan while Jack is
 changing his mag, if you got a chance there.
 166:26:07 Cernan: That's a splendid idea, sir. And that's
 exactly what I'll do. (Pause)

[Fendell finds Jack at Gene's seat and, beyond him to
 the NW, Gene kangaroo hopping uphill, away from the Rover.]

166:26:19 Cernan: I don't mind going uphill, because it's
 so much fun coming down. Down in my little hole here. Oh!
 That's stability. That's stability. (Long Pause)

[Gene has gotten into a small crater that provides him
 with a fairly level place on which to stand. He then does a
 slow pirouette, staying on his toes as he does the
 photographic panorama. His visor is up. His pan is AS17-
 146-22339 to 22363. 22345 is a good picture of Jack at the
 Rover.]

166:26:58 Cernan: Boy, Challenger looks a long way away.
 That's 3 kilometers, huh? (Pause)
 166:27:11 Schmitt: Yup. (Pause) Okay, mag's changed.
 166:27:28 Parker: Copy that.
 166:27:32 Schmitt: (Turning to look at Gene) Bob, those two
 bags with the goodies in them, will have enough soil to be
 representative of the area we sampled, too, I think.
 166:27:41 Parker: Okay, copy that.

[Schmitt - "Here, the 'goodies' I'm talking about are
 the individual fragments that we sampled right off the bat.
 It's not a new sample. As I was listening to this, at first
 I thought I was off doing something I shouldn't have been.
 But I'm sure I'm just adding another comment about that first
 sample I took with a scoop."]

166:27:43 Parker: And did you guys get your bags fixed up
 there, Jack? We were concerned about your SCB for a while.
 166:27:48 Schmitt: No. We have to do that.
 166:27:50 Cernan: We'll do it.
 166:27:51 Parker: Okay.

[Jack goes to the gate; Gene hops back to the Rover.]

166:27:52 Schmitt: Look at my camera lens and see how dirty
 it is. (Pause)

166:28:07 Cernan: (Working on Jack's SCB) Now, it's the other hook that came...Turn a little more left. (Pause) No, it didn't come off, I don't think, unless it...The bottom's off, but the bottom is not going to stay on. And it's not...You're not going to lose it. The tops are so tight you'll...Your bottom's loose, but that's because your harness shrunk a little bit.

166:28:28 Schmitt: Okay. (Garbled)

166:28:29 Cernan: Let me (garbled)

166:28:30 Parker: Okay. It looked like, from time to time, guys, that only one of Jack's hooks was hooked. On the top.

166:28:37 Cernan: They're both on, and they're both tight. And...

166:28:41 Parker: Okay. We copy.

166:28:45 Cernan: ...I got the bottom hooked again, too.

166:28:46 Schmitt: Yeah. Okay.

166:28:47 Cernan: But the bottom is not going to stay.

166:28:49 Schmitt: Okay. Check my lens.

166:28:51 Cernan: Oh, your lens is beautiful! What's mine look like? Can you see it? (Pause) Yeah, I know it's clean. Let's forget it.

[In Houston, Parker is told that the LCRU is getting hot. Gene goes to the front of the Rover; Jack goes around the back.]

166:28:58 Parker: Okay; and, 17, as you get around to the front there, Gene, would you dust the LCRU; we don't think you did that here, and the top of the TV camera. And, Jack, would you take a peek at the SEP temperature for us?

166:29:12 Cernan: I'm sorry, Bob. I already did that when we stopped at the station.

166:29:16 Parker: Okay. If It's been done...

166:29:17 Schmitt: SEP temperature is about 115.

166:29:24 Parker: Copy. 115. (Pause) Okay, then. Press on.

166:29:30 Schmitt: Okay. (Long Pause)

[Gene moves the TV to its stow position; Jack hops into his seat just before Gene turns the TV off.]

166:30:06 Cernan: Jack, this is tied down everywhere. You're just going to have to watch it.

166:30:11 Schmitt: I will. Okay, I'm in. (Pause) Hey, we seem to do an awful lot of down-Sun driving for - (correcting himself) or up-Sun driving - for all the planning we did.

166:30:22 Parker: Yeah. Wait until we come home from station 8, then we'll take care of it.

[The traverse map for the drive to Station 8 is LMP/CDR-16 and the traverse description is LMP/CDR-17.]

166:30:27 Cernan: Okay.

166:30:28 Parker: And, Gene, as you get started there, we'd like a couple of Rover battery temperatures; at least one, we know what the other one says. And, Jack, we might get a frame count from you...Oh, excuse me, we already got that. Thank you, because it's changed.

[One of the battery temperature gauges has failed.]

166:30:48 Cernan: Well, okay, (the battery temperature is) 110; and CDR, by the way, is about 73 on the frames.
 166:30:49 Parker: Copy that. (Pause)
 166:31:00 Cernan: Okay, Bob, I'd like the range and bearing to the...We're roll...We...
 166:31:04 Schmitt: How did you get in reverse?
 166:31:05 Cernan: I don't know. (Pause) Okay. We're rolling, and I'd like the range and bearing to the next...
 166:31:14 Parker: Okay. We want a heading of around 125. and there's going to be a small turn, I think it's at SWP Crater, at 225 and 3.4, there'll be a slight turn. That's a heading of 125 is what you should start out on.
 166:31:33 Cernan: That's what I'm looking for.
 166:31:35 Parker: And 225 and 3.4...
 166:31:36 Schmitt: I thought we were bypassing...
 166:31:40 Parker: No, we just do that...
 166:31:41 Schmitt: I thought we were bypassing SWP.
 166:31:42 Parker: ...during the mission planning stages.

[Jack thinks that both he and Parker are making a sarcastic reference to some pre-flight discussions about SWP, but doesn't remember the context. As Parker has said, the cuff checklist shows a slight course change as they round the southwest rim of SWP.]

166:31:49 Cernan: (Waits for Parker to finish) 225 and 3.4. Okay.

[Cernan - "I've been reading ahead and I want to warn you that there's another important geologic observation coming up at 166:33:28."]

166:31:53 Schmitt: That's pretty close to nominal.
 166:31:55 Cernan: Yeah. I got my...Man, I tell you, this little navigation map I've got on my cuff checklist (LMP/CDR-16) is unquestionably the greatest thing that I've ever done.

[Schmitt - "The other guys may have just had the EVA map with the traverse on it. And you (Gene) said, 'Why don't we put that in the cuff checklist.' It wouldn't surprise me."]

[This conjecture is correct. Neither the Apollo 15 nor 16 cuff checklists contained traverse maps.]

[Cernan - "I tell you what. It may go back to my days in the Navy when we were doing low-altitude run-ins, and we would take a big sectional map. Your track might turn you left and right and south and we would cut the map in sections

and we'd paste together so that you'd always have the navigation line - the run-in line - going away from you so that you were always flying forward no matter whether you were flying north or south or whatever. Even today I fly that way. I turn maps and mentally strip it in the direction I'm going. So, this could be an evolution of that."

[Schmitt - "I think that's right. I think that Dave (Scott) and John (Young) used the map. Gene had the map up in front of him, but he wanted it translated into a strip format for the cuff checklist."]

[Cernan - "It's like a watch. Where's the most convenient place to put a watch? On a wrist. Not in a pocket. Pocket watches are nice, but the most convenient place to put it is where you can glance at it easily. That's why the cuff checklist, itself, was a great idea; and putting the maps in made it even better."]

[Schmitt - "The idea of the checklist, itself, goes back to Apollo 8. Bill Anders asked for one listing the things he was going to describe from lunar orbit. It wasn't a cuff checklist, but the checklist that Neil had sewn on his sleeve evolved from that."]

[Cernan - "The support crews deserve credit for a lot of these little ideas. Something might have been a problem on a previous mission and someone like Ed Gibson (who came up with the idea of the stay-open, spring-bound cuff checklist for Apollo 12) could come up with a simple fix that people on the prime crew might not have had time to think about. And, by the time of Apollo 17, the cuff checklist wasn't just a checklist of the things you wanted to do, it was a geologic flight plan."]

166:32:09 Schmitt: Sure hard to tell where north is on it, though. (Pause)

[Schmitt - "Now, as this line indicates, from my geologic experience - to contrast with Gene's Navy experience - you're used to keeping the map oriented one way and translate, in your mind; where north is. I never did it very well, but a lot of people are able to do that."]

166:32:18 Cernan: Trying my best to keep you out of those slopes.

166:32:22 Schmitt: That's all right. I'm learning to tolerate it. (Pause) Okay, Bob. We're pretty close now to...No, we're not. We're still about 100 meters, I think, from where the break in slope is with the plains. But we're away from the block population except for scattered... (except for) two great big blocks out ahead of us, this side of the SWP Crater. But the average population is down to the 1 percent or less, again. (That is, one percent of the surface is covered by rocks ("blocks") bigger than about one centimeter.) That average population really never changed up in here. Just the big blocks were around. (Pause) I saw some little...

166:33:13 Parker: (Lost under the Public Affairs Commentator)

166:33:14 Schmitt: ...half-meter to one-third-meter, glass-lined, pit-bottom craters. (Pause) Look at the size of those things (the big blocks)!

166:33:28 Cernan: Boy, aren't they big mammas...mamoos.

[Jacks traverse photos are AS17-142-21671 to 21691. 21674 is a photo of the "big mamoos". Mamoos is slang for breasts.]

166:33:32 Schmitt: (Laughs) And it looks like they're probably the same thing that we sampled. They have the inclusions in them, white inclusions. They look like a mixture of the grey of the recrystallized breccia, and the tan-grey of the anorthositic gabbro. (Pause) That must...Hey, look! There's Van Serg. Blocky-rimmed crater. That's the other side of Cochise there. See it?

166:34:13 Cernan: Yeah. Way over there.

166:34:15 Schmitt: Yeah! Cochise is certainly a shallow crater, although we knew that. It doesn't have any...It only has one place I can see that has any blocks on the inner wall of Cochise. Otherwise, it has a surface much like what we're driving on - for walls and for the floor. One place on the south-southeast wall, there is a concentration of blocks much like we saw in Henry or in Horatio. But the rest of the crater seems to be pretty well mantled. (Pause) Van Serg is a very blocky rim crater, big blocks up on the rim.

166:34:53 Cernan: Do you have a lot of static, Jack, or is it just me?

166:34:54 Schmitt: No, I think it's just you. People are always giving you static. (Pause)

166:35:02 Cernan: Bob, if you are still reading me, I'm looking at the Sculptured Hills, and I still have that (impression of an) old man, wrinkled-face appearance, even up close at this Sun angle. And those wrinkles go from, generally, upslope at the west to downslope at the east.

166:35:22 Schmitt: Hey, are you...No, you're right at the edge of Cochise. Aren't you?

166:35:28 Cernan: Where? Right here?

166:35:29 Schmitt: Yeah. Aren't you?

166:35:30 Cernan: No, we're not that close. Uh-uh. Cochise is up at...See that rim where those blocks are?

166:35:34 Schmitt: No, that's a small crater.

166:35:36 Cernan: Oh, I'll bet you that's Cochise up there. We've got to go quite a ways yet to get to...

166:35:41 Parker: How about a range and bearing there, guys?

166:35:42 Cernan: This sideslope driving is really a tough...

166:35:45 Parker: How about a range and bearing?

166:35:46 Cernan: Okay. It's 210/3.4.

166:35:49 Parker: Copy that. 210/3.4. And you should be somewhat north of Cochise there, as per planning, although

you may be cutting south to try (to avoid) going directly up-Sun.

166:36:03 Schmitt: I guess that's some other...

166:36:04 Cernan: That's just a depression. I think Cochise is over that rim.

166:36:05 Schmitt: That's just a depression. Yeah, yeah.

(Pause) Those are getting warm. (Pause)

[Jack is probably saying that his hands are getting warm; either that or he has noticed the battery temperatures. However, only the temperature gage for battery 1 is working - the other having failed during the rest period. In addition, the battery 1 temperature at the next stop will be 115 degrees. Prior temperatures on this EVA were 95 at the start of the EVA, 100 when they left the LM, and 108 at the start of Station 6. The temperature at the end of EVA 2 had been 114 degrees.]

[Cernan - "I've got to believe that it's not batteries. We could start to feel the Sun penetrating the suit on the third EVA. We were driving into the Sun, sitting still. We were not going in and out of shade. Everything that was in the Sun, stayed in the Sun for twenty or thirty minutes."]

166:36:14 Cernan: Boy, I tell you that. Every bump you go over on a sideslope is just accentuated. (Pause)

166:36:25 Parker: Yeah, we don't think you're anywhere near Cochise.

166:36:31 Schmitt: Yeah. I agree.

166:36:32 Cernan: Yeah. I think it's over that rim up there.

166:36:37 Schmitt: That's just a big, shallow depression. (Pause)

[They are roughly 300 to 400 meters north of Cochise.]

166:36:40 Cernan: All I'm doing is flying the 3.4-kilometer arc right now.

[Cernan - "We do that a lot when you're flying an approach. I don't know why I was doing that. Maybe it was the Sun angle or the slope. It wasn't the direct route to where we were going; but, by staying at 3.4 from the LM, we were going to get there."]

166:36:47 Parker: Say again there, Gene.

166:36:48 Schmitt: There's another one of those deep craters that doesn't have a blocky rim.

166:36:57 Cernan: Okay. 214/3.4.

166:37:00 Parker: Copy.

166:37:03 Schmitt: That's one of the more striking characteristics of the mantle are these craters that look, as far as the diameter-to-depth ratio is concerned, like they ought to be fairly young. But there's no blocks on the rim,

and they seem to have this mantled appearance, just like some of the large craters. (Pause)

166:37:26 Cernan: As I look up Wessex Cleft from just about abeam of it...(Turning to avoid an obstacle) Let me get over here...It still shows me an albedo change and a surface wrinkle-texture change.

[Gene is driving generally southeast as he drives his 3.4-km arc as he approaches SWP. The Cleft is north, to his left; however, as he maneuvers to avoid craters and rocks, occasionally he gets a look in that direction.]

166:37:44 Schmitt: Yeah, I think so. You've got it at the same Sun angle more or less, on part of it there.

166:37:48 Parker: Okay. Copy that. You guys may be getting just a little far north...

166:37:49 Cernan: It's sort of a perfectly formed saddle in there.

166:37:50 Schmitt: Yeah.

166:37:51 Parker: ...You may want to head just a little south to avoid running right into the middle of SWP Crater.

166:37:57 Schmitt: Yeah. I think we see it now. Is that SWP?

166:38:00 Cernan: Well, I don't know. I don't...

166:38:02 Parker: SWP will be at 225 and 3.4.

166:38:09 Cernan: Yeah. That's my...That's what I'm shooting for, Bob.

166:38:11 Parker: Okay.

166:38:12 Cernan: I'm just flying a 3.4 mile...(correcting himself) or, kilometer arc.

166:38:17 Parker: Roger. I was going to suggest that.

166:38:19 Schmitt: Bob, there's something I haven't mentioned, but if one had time on the next (lunar) program (after Apollo)...

166:38:31 Cernan: I think that's SWP right there, Jack.

166:38:32 Schmitt: ...you can sample secondary craters, and they tend to have blocks either in them or on one rim, suggesting that you could tell directions if you put your mind to it. Directions of where the secondary came from. These are small ones.

166:38:48 Cernan: Did we ever get a piece of glass in place?

166:38:50 Schmitt: Yes, I did yesterday.

166:38:51 Cernan: Documented in place?

166:38:52 Schmitt: Yep.

166:38:53 Cernan: Okay.

166:38:54 Schmitt: That's what I was trying to protect in the SRC yesterday.

166:39:00 Cernan: Here's SWP, Jack. It's coming right up, and I'll go along the southern rim.

166:39:05 Schmitt: I wish I wouldn't lose...(To himself) Start concentrating. I'm forgetting to take my pictures.

166:39:10 Parker: Roger, Jack. Don't forget to take your pictures.

[Schmitt - "It strikes me - because of the casualness of Bob's little gibe - that, here we are, two hundred thirty thousand miles from Earth, third EVA, three and a half kilometers from the relative safety of the LM, and it sounds like we're down at the local Circle K (a chain of convenience stores), for crying out loud! Human beings and their psychological adaptability is just unbelievable!"]

[Cernan - "There you were, in a space suit, two inches away from the vacuum of the universe. Every time you made a move - from Earth orbit to translunar coast to lunar orbit, out of the Command Module to the Lunar Module, to the lunar surface, out of the Lunar Module, out on the surface in your suit, jump in the Rover and drive out about as far as you can theoretically walk back - you added a link in a chain that you have to gobble back up to get home. And, yet, you only think about it when you have to think about it."]

[During discussions with Pete Conrad and Alan Bean about the Apollo 12 mission, they said that the main factor limiting how far they got from the LM was concern about the health of the spacecraft. If there was a problem with the LM, they wanted to be able to get back relatively quickly so that they could take care of it and/or leave. The suits and backpacks were of lesser concern.]

[Cernan - "The health of the LM was always a concern. Based on an accumulation of experience, by the time of Apollo 17 we had more faith in the LM and, at least for our flight, actually powered it down. But my personal feeling is that, should something have happened to the suit or the Rover, I was on the spot to be able to do something about it. Whether I could or not was another story. But I, at least, was in control. But if I'm 3.6 kilometers from the Lunar Module and something happens in the spacecraft, I'm not there to do anything about it. So, when you left the LM out there all by itself, that was the weak link in the chain. If we had a problem with the suit, we were going to scoot back home to the LM."]

[Schmitt - "I've really been searching my memories of all the flight planning we did - and I did a lot of it for the EVA's - I don't remember concerns about the LM ever coming up. I remember concerns about suit leaks, about the energy levels it would take to walk, what was a reasonable distance to walk, and things like that. Pete's flight was the first pinpoint landing. We didn't know we were going to land as close to that Surveyor as we did. And so the EVA planning was pretty general and we thought a lot about what we were going to do if we didn't land close to it. I just frankly don't remember the security of the LM being an issue. I may be totally wrong. My thought in those days, as I recall, was that the ground was going to be watching that LM very, very carefully and was going to tell the crew. They were going to be close enough to get back in a hurry anyway."]

[Cernan - "The ground could tell you, but they couldn't do anything. They had absolutely no control over the LM. I've always felt - and this is not a knock at the LM, because the LM was one of the finest flying machines built for the purpose at hand - but I felt more comfortable in my suit. The LM was literally built to just get the job done, while the suit was almost over-engineered. When we pressurized the LM - whoop - it expanded like an oil can. It didn't scare me, but you did realize that you were at the mercy of a little tin can with a few motors running and blowers blowing and what have you. We convinced ourselves we could have gotten in our suits in three and a half minutes but, in the real world, we would have needed more time..."]

[Schmitt - "I think there was a (vacuum) chamber test - something associated with a chamber test. One of the tests was delayed because somebody stuck a pencil through the skin of the LM."]

[Cernan - "It was your minimum housing requirements on the lunar surface. Would I live in a LM for a month on the Moon? Aside from the lack of volume and so forth, I don't think that would be a judicious approach. I think you would have to get in something more stable. The LM is a good transfer vehicle and we lived in it for three days. But I don't think it would be adequate for any long period of time."]

[Schmitt - You wouldn't want a lot of long-term activity going on in there. There's just too much chance of damaging it. Every time we went in and out, we'd bang against the DSKY."]

[Cernan - "We've had a long digression, but I think that the person who utilizes this information for any reason - ten years, twenty years or, just from a historical point of view, a hundred years from now - ought to know the feelings of the people who were really there. It's an important part of this document."]

166:39:11 Cernan: I'll tell you, if we don't concentrate, we end up...

166:39:16 Schmitt: (To Parker) Okay. I'll quit thinking and just take pictures. (Pause)

166:39:24 Schmitt: There's a crater...That double pit-bottom crater. That's the first one of those I've seen.

[Schmitt - "The more I think about what I said, the more I think that there were two pit-bottom craters side by side. Maybe there's a picture that shows it."]

166:39:27 Cernan: Right here, Jack, you're going to be able to peek right over the top of SWP. (Pause)

166:39:34 Schmitt: Right.

166:39:36 Cernan: Right here. How's that grab you? That's SWP, all right.

166:39:40 Schmitt: SWP's a bigger hole than I thought it was. (Pause) SWP even has some blocks in the wall.

166:39:53 Cernan: Yeah, but the eastern and southeastern rim of SWP are just continuous...Ooh!...They're just continuous with the slopes of the Sculptured Hills.
 166:40:04 Parker: Okay. Copy that. (Pause)
 166:40:16 Cernan: (To Parker) How does 238/4.2 sound for the beginning of (Station) 8?

[Schmitt - "Because things were so ill-defined over here at the Sculptured Hills, it was decided that we would pick the exact place."]

[Cuff Checklist page LMP/CDR-18 indicates the general area in which they intend to do Station 8. Gene is referring to the northern end of the area, specifically to the spot marked 8A on both LMP/CDR-17 and 18. He will actually stop at 226/4.0, which is spot a bit north of 8A but - because of the displacement of the LM from the planned landing site - at virtually the same range.]

166:40:19 Schmitt: Hey, you're...
 166:40:24 Cernan: May have to take these slopes just the most comfortable way we can.
 166:40:28 Parker: 238 and 4.0 (is what) we're expecting for Station 8, the beginning of it. 238/4.2...(correcting himself) 4.0. Excuse me; 4.0.
 166:40:40 Cernan: Roger.
 166:40:43 Parker: And remember again, Station 8 is a very flexible area. You just get to a place where it looks like it's feasible to sample the Sculptured Hills (material).
 166:40:53 Schmitt: That's right.
 166:40:54 Cernan: Yep. (Pause) Let me tell you, this Rover is a machine. I don't know if it saw that hill we're climbing, but I did. (Long Pause)
 166:41:26 Schmitt: How's your...How're you doing?
 166:41:28 Cernan: Doing fine. I'm trying to get around SWP over here and start hitting the...
 166:41:34 Schmitt: (The) East Massif has outcrops on it (that) I can see now on the north side. And they, (like the North Massif outcrops), also tend to have linear upper terminations. And some of those line up as if there's roughly horizontal structure within the upper one-half of the East Massif.
 166:42:01 Parker: Okay. Copy that, Jack. (Pause) Stop thinking and take pictures.
 166:42:13 Schmitt: (To Gene) Go by that little dark crater over there. (To Parker) There's a very blocky-rimmed small crater, that's a dark-rim crater instead of a bright rim like we'd seen some around that looked fresh. It partly may be the angle at which we're approaching it.

[Jack takes AS17-142-21693 and Gene takes AS17-146-22364 at about this point.]

166:42:35 Cernan: Bob, we're on the southeastern rim of SWP at 226 and 3.6.

166:42:41 Schmitt: (To Gene) Why don't we get some samples of that material in there.
 166:42:43 Parker: (Responding to Gene) Copy that.
 166:42:44 Cernan: Right here?
 166:42:46 Schmitt: Okay. Keep driving toward the rim and then just (do) a shallow curve. Okay. Now, curve it.

[AS17-142-21693 to 216696 are Jack's photos of the approach to the crater.]

166:42:53 Cernan: Got your spot?
 166:42:54 Schmitt: Okay. Right...Just keep going, and I'll stop you. (Pause) Whoa, straight ahead. Good, good.
 166:43:03 Cernan: Okay, Bob. 226/3.6. There's a highly fragmental, small crater about 30 or 40 meters across, right on the southeastern rim of SWP. And most of the fragments are football size and smaller, and they're very angular. And probably the inside of that rim is...
 166:43:26 Schmitt: Turns out that they'll break. They're clods.
 166:43:28 Cernan: Are they clods?
 166:43:29 Schmitt: Yup.
 166:43:30 Cernan: I guess that's going to be about 70 percent covered on the inside of the rim with these things.
 166:43:34 Schmitt: It's all instant rock (soil compacted in the impact), but the crater rim looks dark compared to other fresh craters like this that we've seen.

[Schmitt - "My erstwhile colleagues (in the lunar geology community) don't like the term 'instant rock'. They call it regolith breccia. I got taken to task at some talk I gave."]

[Cernan - "It is instant rock! (Jack laughs) I used to think of rock forming over hundreds of thousands of years; but, all of a sudden, now I know what it is. 'Instant rock' adds dynamics to the description."]

[Schmitt - "What's happening in this area is that we've gotten a whole bunch of ejecta blankets from large craters like Henry, Cochise, and Shakespeare on top of each other. It's a very thick regolith, and craters which would have normally gotten to bedrock just penetrated farther into regolith, formed a lot of instant rock, and that's what's been thrown up on the rims. That's what we've sampled here and that's what we'll see at Van Serg (Station 9)."]

166:43:47 Cernan: (The sample is in LRV Sampler bag) 50 Yankee.
 166:43:48 Parker: Copy. 50 Yankee.
 166:43:51 Schmitt: And the frame count is 26. LMP frame is 26.
 166:43:59 Parker: Copy that. Press on.

[AS17-142-21697 is the last frame Jack's takes before they get to Station 8.]

166:44:01 Schmitt: Yeah, you're...
 166:44:04 Cernan: We are; we're rolling.
 166:44:05 Parker: And, 17, we're hoping to go to station 8A...
 166:44:06 Schmitt: (To Gene) Yep. Your wheels are just chewing those things (the clods) up.
 166:44:08 Parker: ...the northernmost section of Station 8, if we can, of course.
 166:44:14 Schmitt: (To Gene) Yeah. I think...I think we ought to head just about...
 166:44:18 Cernan: Yeah. We'll get there.
 166:44:20 Schmitt: Well...I think we ought to get below the highest peak up there because that seems to have the rocks on it. (Pause)
 166:44:27 Cernan: I only see one rock (garbled)...
 166:44:29 Schmitt: (Garbled) straight ahead.
 166:44:29 Cernan: ...See that one. Of course, I don't know whether that came down. Doesn't look like it may have come down from the top. (Pause)

[Gene is correct. Once they stop and climb up the hill to examine the rock, they will find that it is glass coated and, therefore, that it was almost certainly thrown onto the mountain side from somewhere else.]

166:44:40 Schmitt: Certainly aren't many rocks. It's certainly not like the old North and South Massifs. (Pause)
 Yeah, there's one big rock over there. That doesn't look like...It might be a(n exotic)...(Pause)

[During the review, we discussed the matter of what Jack had intended to say and concluded that "exotic" - a rock thrown in from elsewhere - was most likely. Gene suggested "You ought to program a computer to think like Jack thinks, feed it this sentence, and let it finish it. (General laughter) It would be a tough task."]

166:45:01 Cernan: Well, let's head that way. That's about where the station is, anyway.
 166:45:03 Schmitt: I think we're starting to see blocks. That one is so...so unusual...
 166:45:13 Cernan: That's about the station. That's the northernmost station anyway. There's another one there.
 166:45:20 Schmitt: Well, this probably is...We can get the other smaller population around it. I'm worried about that one being exotic to the Sculptured Hills.
 166:45:25 Cernan: Yeah, it doesn't look like it rolled...
 166:45:27 Schmitt: No.
 166:45:28 Cernan: But I don't see any others, do you?
 166:45:30 Schmitt: Well, there's some small ones up in there. Off to about the 2 o'clock position (relative to the direction of travel). But I think that's all. We're going

to have to be satisfied with small ones. Big ones don't get down. There's some big ones way up on the slope.

166:45:43 Cernan: Yeah, I see those. (Pause)

166:45:48 Schmitt: Watch it; crater. (Pause; they've hit the crater) You're (low-gain) antenna (needs to be adjusted)...

166:45:59 Cernan: Yeah, let me get it for them. (Pause) Okay. We're at 227/3.9.

166:46:06 Parker: Copy. 227/3.9. (Pause)

[There was no change in the quality of the comm when they hit the crater, suggesting that Houston is still reading them through the LM.]

166:46:12 Cernan: I think it's worth...There's smaller ones around here, too, Jack.

166:46:19 Schmitt: Yeah. That looks like subfloor from here.

[Schmitt - "It think we were still on the ejecta blanket of a crater - maybe Bowen (or SWP) - big enough to have penetrated to the subfloor and to have thrown rocks up the slope. So, what I was trying to do was get us away from that and get as far up the hill as we could go. We wound up at the northwest end of the Station 8 area."]

166:46:23 Cernan: What's it (the immediate area) look like? If it doesn't look worthwhile stopping, I'll move on up over there.

166:46:27 Schmitt: Yeah, it looks like subfloor. I would recommend that we...

166:46:29 Cernan: All right.

166:46:30 Schmitt: ...try to get up to some of those. I don't know whether we can or not. What's your pitch indicating?

166:46:35 Cernan: Well, that doesn't mean anything.

[The pitch meter has been broken since early in the mission.]

166:46:42 Schmitt: See that...Those two up there would be reasonably well up the slope. (Pause)

166:46:47 Cernan: Bob, no parking constraints on the battery?

166:46:49 Parker: Roger. No parking constraints. We'll park at 045, Gene. Or wherever you like, really.

166:46:57 Cernan: I have to park about 045 because I've got to be pointing uphill so we can get out.

166:47:01 Parker: Okay. Any place you want to. 045 is fine.

166:47:03 Cernan: Jack, I'm going to park...

166:47:06 Schmitt: How about just the rim of that little crater there?

166:47:09 Cernan: Well, this is so level right here, Jack, I'm going to just park it...

166:47:12 Schmitt: Well, I was just thinking on top of that crater is closer to the...That's level, too, on the rim. And it'll give them a good view of the sampling area. (Pause) I think we can...If we work on those blocks there, we're in pretty good shape. (Pause)

166:47:26 Schmitt: Bob, we're directly downhill, and that is (to say, directly downhill) from the highest point that I could see up on this first Sculptured Hill. (Pause)

166:47:40 Cernan: Bob, I'm parked at (a heading of) 026; bearing is 226; distance, 6.6; range, 4.0; amp-hours, 85 and 80; battery is 1...I think it's 115; and the motors are all off-scale low.

166:48:02 Parker: Okay...

166:48:03 Cernan: Not really, but...Okay...

166:48:06 Parker: And here, we would like...

166:48:07 Cernan: ...0 (and) 230 on the forward ;and off-scale low (on the left rear); 220 on the right rear.

166:48:19 Parker: Okay. We copy that. We'd like to get the usual dusting here. (Pause) Up front.

166:48:26 Cernan: Yeah. And I'm fairly level.

166:48:28 Schmitt: Not really. (Laughing)

166:48:30 Cernan: I'm not, huh?

166:48:33 Schmitt: I just about rolled downhill again.

[Schmitt - "Your ability to sense a slope in one-sixth g is not as great as it would be in one g. The extreme, of course, being zero g where you wouldn't sense a slope at all."]

[On all of the Rover missions, the crews drove up slopes which seemed much steeper once they got off the Rover and tried to stand.]

166:48:35 Cernan: Oh, man. (Laughs) I am pointing uphill, aren't I?

166:48:38 Schmitt: Yeah.

166:48:43 Cernan: Well, at least we don't have a sideslope.

166:48:44 Parker: And, 17, we'd like...

166:48:46 Cernan: (To Parker) Battery covers stay closed?

166:48:47 Parker: Battery covers stay closed. But we do want the LCRU, and the TV camera, and the TCU (Television Control Unit) dusted. (Pause)

166:49:05 Cernan: Okay. (Pause)

166:49:14 Parker: And, 17. we'd like the SEP blankets opened and dusted one more time.

166:49:22 Cernan: I think you're a dreamer, Bob, but I'll do it.

166:49:27 Parker: Roger. We keep hoping. (Long Pause)

[The SEP electronics package has long since shut itself off because of too high a temperature.]

166:49:41 Cernan: Start doing your thing, Jack. It's going to take me a little while to get this dusted.
 166:49:46 Schmitt: Bob, the first block I looked at here looks like subfloor gabbro.
 166:49:56 Parker: Okay. We copy that. (Long Pause)

[TV on.]

166:50:14 Cernan: Should have it (the TV), Bob.
 166:50:17 Parker: Okay. We've got a picture.
 166:50:22 Cernan: You even sound better. (Pause) Battery covers are awful dirty, but I will not dust them as long as you're happy.
 166:50:34 Parker: Yeah. I don't think dusting the battery covers gives us any cooler batteries.
 166:50:40 Cernan: Well, I know; but it keeps the batteries from getting dust in them. I've had pretty good luck with them. They've been pretty clean.
 166:50:47 Parker: Roger on that. (Long Pause)

[Fendell pans counter-clockwise.]

166:51:10 Cernan: You are dusted; and you're shiny bright. All over.
 166:51:14 Parker: Okay. Copy that. (Pause) We thank you. Ed (Fendell) thanks you.
 166:51:24 Cernan: And we all thank you. Listen, if Ed thanks me, that's enough. (Pause) A man couldn't ask for any more than that. (Pause)

[While Fendell is panning counterclockwise through NE, Jack runs rapidly across the picture, going cross slope to the southeast. He is taking 3-4 foot strides.]

[Cernan - "Jack is really covering some territory. The fact that the camera is panning in the opposite direction makes it look faster, but he's really moving across that slope."]

166:51:43 Parker: I think your LMP just ran away.
 166:51:44 Cernan: Okay, I've got my thing... (Hearing Parker) Where'd he go? (Calling) Jack?
 166:51:50 Schmitt: What?
 166:51:51 Cernan: Oh, there you are. I thought maybe you fell in that crater I'm looking at. (To Parker) Okay. I'm going to give you a TGE reading.
 166:51:56 Parker: Roger. Give us a mark.
 166:52:00 Cernan: Our fender's beginning to fade and, uh-oh, the clip came off (the replacement fender but not the Rover) on the inside; that's what's wrong. We'll have to fix that before we start. The outside one's holding, but the inside one's not.
 166:52:13 Schmitt: Bob, all the blocks bigger than 20 centimeters that I've looked at up here are subfloor gabbro in appearance.

166:52:24 Parker: Copy that.

166:52:26 Schmitt: I've looked at about five. (Pause)

[Fendell reaches the TV's counterclockwise stop, and then reverses direction.]

166:52:35 Parker: Did we get a mark there on the gravimeter, Gene?

[Gene had not given a mark, having been distracted by the fender clip.]

166:52:40 Cernan: Thirty seconds ago, Bob.

166:52:42 Parker: Roger. I copied it. Just wanted to check. (Pause)

166:52:51 Cernan: Okay, Jack. You find anything up there?

166:52:53 Schmitt: Gene, I'm going to go up and look at this one rock. Why don't you set up and sample any one of these other big ones. They're all the same. Like the one near the Rover. And I'll go up and try to get this big one down there.

166:53:10 Cernan: Well, okay.

166:53:12 Schmitt: It's the only one left to look at, but right now we're dealing with subfloor material, I think.

166:53:17 Cernan: What about some of these little fragments that seem to be sitting more on the surface?

166:53:20 Schmitt: Yeah, we're supposed to rake here. We'll get those with the rake.

[Fendell finds Gene north of the Rover at an appreciable distance. Jack is beyond him, hopping upslope and approximately three times farther away.]

[Schmitt - "With that slope, the kangaroo hop was the only way to move."]

[Cernan - "You couldn't really go one foot in front of the other uphill, because you can't get your foot high to take that step. So you hop."]

[Schmitt - "I don't recall anybody ever walking up stairs in a pressurized suit."]

166:53:23 Cernan: That one up there, by the way, is sitting on the surface: These others are submerged.

166:53:27 Schmitt: Yeah. That's why I want to look at it.

166:53:29 Cernan: You don't have a hammer, but if you need me, I'll come up there because I think that may be worthwhile.

166:53:34 Schmitt: I'll roll it down to you.

166:53:35 Cernan: Yeah. Thanks a lot. (Long Pause)

[Gene makes his way cross slope to a boulder due north of the Rover. Jack is climbing farther uphill to another rock. Fendell starts to follow Gene, doesn't find him, and goes back to Jack. Gene's cross-Sun stereo pictures of the

rock near the Rover are AS17-146-22365 and 22366. 22367 is a locator to the Rover.]

166:53:56 Parker: A reminder, 17. We'd like to have you leaving here in three-zero minutes to make up some of the (extra) time we spent at Stations 6 and 7.

[Fendell finds Jack leaning over the upslope boulder. The plan map of Station 8, extracted from the Apollo 17 Preliminary Science Report, indicates that the boulder is approximately 53 meters ENE of the Rover. The TV record suggests that the boulder is directly uphill from the Rover. According to the mission report, Jack's heart rate peaks at about 167:05 at 122 beats per minute. Gene's peaks at about 167:10 at about 122 beats. These times correspond, roughly, to the times when each of them makes their way back downhill to the Rover. However, the uncertainty in the plotted times is unknown and these peaks may also represent the climbs up to the rock.]

[Cernan - "I got tired just watching this. We weren't breathing hard; but Jack's voice, when he got up to the rock, was forceful - which we tended to do in those circumstances. You had to blow it out."]

166:54:07 Parker: And we'd also remind you that we'd like a rake soil sample here, too. That may be the only way we try and pick up some stuff other than subfloor, if that, indeed, has come down from the top of the Sculptured Hills.

166:54:20 Schmitt: Okay, Bob. This rock is a big chunk of shattered, but still visible, bluish-grey anorthosite. It's glass-coated, and it actually looks like it's vesicular. I'm going to roll it downhill so we can work on it. Well, I'll document it first. (Pause)

[Schmitt - "Good idea, Jack."]

[Jack has taken cross-Sun photos of the boulder and is now taking a down-Sun from the right at a distance about equal to his shadow length. His cross-Sun stereos are AS17-142-21698 to 21700, his down-Sun is 21701..]

166:55:01 Schmitt: Did you copy that?

166:55:02 Parker: Roger. I copy that. We'll be watching it coming.

166:55:08 Schmitt: Okay. But the point is, as Gene said, it's the only rock - (the only) big one anyway - in the area that I see that's perched on the surface as if it might have rolled here.

166:55:26 Parker: Okay. Copy that, Jack. (Pause)

166:55:36 Schmitt: But I don't see a (boulder) track.

[Fendell zooms in on Jack. The rock is perhaps a foot high and two across. From later evidence, it is also about two feet long in the direction away from the camera. It is also broader on the bottom than the top.]

166:55:42 Cernan: Man, this one here is tough as a...
 166:55:45 Schmitt: Well, we can get some small ones.
 166:55:47 Cernan: Yeah, that I'm going to do. I tell you, this one is so...
 166:55:51 Schmitt: I thought you might be able to break it up.
 166:55:52 Cernan: Well, there's no...there's no corners on it. (Long Pause)

[Jack moves a few steps uphill. He turns his camera toward the Rover, takes a locator, then moves to the upslope side of the rock. The locator is AS17-142-21702; and 21703 is another down-Sun.]

166:56:24 Schmitt: (To Gene) Ready for this?
 166:56:26 Parker: We're ready.
 166:56:28 Cernan: Bob, 563 is the sample.
 166:56:31 Parker: Copy, 563.

[AS17-146-22368 is a cross-Sun after of this sample.]

166:56:32 Cernan: Over here to the (garbled under Jack).
 166:56:36 Schmitt: Are you ready? Are you ready for this?
 166:56:39 Cernan: I'm not sure I am, but go ahead. (Pause)

[Jack flips the rock over with his right foot. It starts to roll toward the Rover, but veers toward the right. Jack follows and kicks it again to keep it going. After a short while, it lands in a shallow depression and stops.]

166:56:50 Schmitt: (To the rock) Go! Roll! Look, I would roll on this slope, why don't you?
 166:56:56 Cernan: Five-sixths gravity that's missing. (Pause)
 166:57:02 Schmitt: Hey, I'll bet you they would like, if I didn't step on it, a sample out of the bottom of that thing. (Pause) Yup. (Pause)

[Jack climbs back up to the place where he'd found the boulder, intending to sample the soil which it had been covering. Gene comes into view briefly, going away from the Rover and hopping uphill.]

166:57:30 Cernan: These others all look...You're right, Jack, they look like what we've been sampling (that is, the subfloor gabbro). (Pause) And they're all pretty well mantled except the ones you got up there. There's one more piece I see on the side of that crater that may not be.
 166:57:43 Schmitt: Bag 545 will be soil from under that anorthosite boulder. (Pause) Bob, the only thing that bothers me about that boulder being subfloor - I mean Sculptured Hills - is that it's glass-coated.
 166:58:12 Parker: Copy that.

[Gene reaches the rolled boulder. Jack is still sampling soil at the original boulder site, this time holding the sample bag low and at arm's length. He is holding the scoop nearer the handle than the head.]

166:58:13 Schmitt: It may have been thrown in here by an impact. (Pause; turning) Oh, you're here!

[Jack goes down to Gene.]

166:58:23 Cernan: Well, let's sample it, and then roll it down.

166:58:25 Schmitt: Well, okay. I never would have moved it if I thought you were coming up.

166:58:28 Cernan: Well, I wasn't coming up; but I looked at some of those others, and there's only one more...

166:58:32 Schmitt: Okay. Well, I got it documented up in place. Let's...That's not the...I think that's the side that was down. Let me roll it over...

166:58:40 Cernan: (Placing the gnomon) Well, let me get a piece of that side since it was underneath. Then we'll roll it over and get a piece of the other side.

166:58:43 Schmitt: Good thinking. (Pause) Ah...Okay, yeah. Let's do it (take documentation photos) again. Except I got dust all over it (the rock).

166:58:56 Cernan: (Left of the rock) Well...

166:58:57 Schmitt: (Right of the rock) The albedo...The down-Sun picture's not going to mean much. Let me get this (soil) sample in your bag. (Pause; going to Gene) I think we ought to change your bag because the stuff's going to start flying out.

166:59:12 Cernan: Okay.

166:59:13 Schmitt: It won't stay closed.

[AS17-146-22369 and 22370 are Gene's stereo photos of the exotic boulder, taken prior to sampling.]

166:59:14 Cernan: Jack, after this one, there's only...There's one more in that crater (near the Rover). It may be from that crater, but I don't know.

166:59:21 Schmitt: How's your hand for hammering?

166:59:23 Cernan: Ohhhh.

166:59:25 Schmitt: This will be easy. This will be easy.

166:59:26 Cernan: The old hammering hand...

166:59:27 Schmitt: This will be an easy one, Gene. (Pause)

[Gene moves to the right of the rock and slightly below it, and hits it six times with the hammer. Jack moves upslope of the rock. Gene is raising the hammer to head height.]

[Cernan - "I still can remember the reverberation through my body when I hit a hard rock like that. Your whole body would feel the impact of that hammer. By this time, I

wasn't feeling inhibited from taking good solid swings. But I would have hated to miss it and hit my shin."]

[Schmitt - "I could feel it through the ground, through my feet, like a minor earthquake. And you could see where I moved when you started to swing? I never stood in front of you."]

[On at least two occasions during Apollo 16, Charlie Duke lost his grip on the hammer. Gene never did.]

[Schmitt - "That's one reason why I didn't use it. I never felt like I had control of it"]

166:59:40 Cernan: Two pieces for you.

166:59:42 Schmitt: Okay. Let me...

166:59:43 Cernan: Oh, that's a pretty one inside!

166:59:44 Schmitt: Well, it's stained by the glass coating.

166:59:46 Cernan: Oh!

166:59:47 Schmitt: It's stained by that glass coating.

166:59:49 Cernan: That's a pretty one inside! Can you get that? Here, take my hand. (Pause)

[They are standing side-by-side. They hold hands, Gene's right and Jack's left. Jack goes to one knee to get the fragment, then gets up.]

167:00:00 Schmitt: Thank you.

167:00:02 Cernan: While I'm at it, I'm going to chop another piece off right here.

167:00:03 Schmitt: Yeah, get more than that. (Pause)

[Gene strikes the rock three times.]

[Cernan - "You notice that I'm standing a little below the boulder. It's something you do automatically."]

[Schmitt - "Human beings are basically lazy. And you naturally find the easiest way to get to it. One thing I noticed back at Station 7 is that, the first time I dropped the scoop, I stepped on it to get the handle up so I could grasp it. The second time, it was over at the rock and I just leaned against the rock and reached down."]

[Cernan - "That stepping to get the handle is something I do on the golf course all the time. If I happen to drop a sand wedge along the edge of the green - while I'm putting - and I go back to get it. Jack's right, we're lazy and we pick the easiest way out. I always step on the face of that club."]

[Schmitt - "I play golf, but I never do that. My clubs are too good for that. (General laughter)"]

[Cernan - "Jack never needs but one club when he's up to the green, and the putter's got a flat face and it's awful hard..."]

[Schmitt - "You don't want to step on your putter, anyway. It's bad luck."]

[Cernan - "Well, I've got all those high angle clubs with me when I'm around the green."]

167:00:08 Cernan: Piece right there. You've got three pieces laying around. (Pause) Let's get those before we lose them. (Pause)

[Jack gets the fragment with the scoop.]

167:00:24 Cernan: Bag 564. (Pause)

[Gene drops the bag.]

167:00:32 Cernan: Maybe. (Pause)

167:00:36 Schmitt: Okay.

[Gene retrieves the bag with his hammer.]

167:00:37 Cernan: I got it. Oh; you already got them in the bag?

167:00:39 Schmitt: No.

167:00:43 Parker: We copy; 564 from the bottom of the boulder. (Pause)

[Jack pours the sample into the bag that Gene is holding.]

167:00:50 Cernan: Sure that's the bottom, huh?

167:00:51 Schmitt: Yeah. It (the fragment) got mixed with local soil. (Pause) I'm pretty sure (that's the bottom). Let's turn it over. I think I'd recognize the top, although it's got dust all over it now.

167:01:05 Cernan: I think I'll get one more swap (rhymes with "wrap") off there. I don't want to seal this. Let me get another swap off there. I can get it.

167:01:10 Schmitt: Okay. (Pause)

[Gene hands Jack the sample bag and then leans on the rock so that he can retrieve his dropped hammer. He gets up easily and then strikes the rock seven times.]

167:01:37 Schmitt: Well, that (fragment) disappeared.

[Gene changes his position from the right of the rock to above it.]

167:01:38 Cernan: (I'll) hit it this way. One time. (Pause)

[Gene changes his mind and shifts back to the right. He hits three blows.]

167:01:51 Cernan: That disappear, too? That probably went into orbit.

167:01:53 Schmitt: Yeah.

167:01:55 Cernan: Boy, is that pretty inside. Whoo! We haven't seen anything like this! I haven't. Unless you've been holding out on me.

[Gene strikes the rock nine times.]

167:02:02 Schmitt: No, this is a nice crystalline rock.

[From the way that both of them react, it is evident that, after the final blow, a fragment flies off to the right.]

167:02:05 Cernan: (Turning to look) Okay, I see that one.

167:02:07 Schmitt: Where did that one go?

167:02:08 Cernan: That's a good one. I'll go get it with my tongs. That's a good one. That one I worked too hard to get. (Pause)

[Gene goes about 20 meters to the right of the boulder, using a skipping gait as he goes slightly downhill.]

[Cernan - "I was braking as I was going downhill and then I hopped on two feet coming back up. You can see the degree of that slope. It was a lot of work; I wasn't making much progress."]

167:02:22 Cernan: Hey, I see how it (the Moon) makes boulder tracks! I just made one. It just skipped along (and) made those little pothole craters as it went.

[When Gene and Fendell return to the rock, Jack is examining it on hands and knees.]

167:02:30 Schmitt: Hey, Houston. This is about a 50-50 mixture of what looks like maskelynite or at least blue-grey plagioclase, and a very, let's say, light yellow-tan mineral, probably orthopyroxene. It's fairly coarsely crystalline.

167:02:57 Parker: Copy that.

[Cernan - (Tongue firmly in cheek) "I had that description written in my checklist, too. (General laughter) And, when I had to go pick up the chip of that boulder, Jack immediately picked up the cue and described it himself. Jack, this was going to be my big moment! You were going to let me do the whole thing, but you couldn't stand it."]

167:02:59 Cernan: Which bag do you want? (Pause)

167:03:07 Parker: Okay. When you guys get done with that rock, we'd like to get to the rake sample, please. And that's probably just as well done by the Rover as anyplace else. We don't seem to see anything worthwhile here doing besides that.

[From his hands and knees position, Jack gets a sample bag and hands it to Gene.]

167:03:20 Schmitt: (Referring to the fragment) You got it?
 167:03:21 Cernan: Yeah. (Pause)

[Jack pushes back off of the rock but can't get his PLSS back far enough to rise. On the third try, he rocks his PLSS back far enough that he starts to tip over backwards. Once the PLSS is over his feet, he rises and hops back under the PLSS to catch himself.]

167:03:29 Cernan: Okay. That went in the same bag, Bob, as the rest of the chips from the bottom. All the chips from the bottom are in 464.

167:03:37 Parker: Copy...(Pause)

167:03:46 Schmitt: Here, let me roll it over. (Presenting his SCB) Go ahead. Want to put it in?

167:03:47 Cernan: Yeah.

167:03:48 Schmitt: Okay. (Pause)

167:03:54 Cernan: Oh, boy.

167:03:59 Schmitt: (To Parker) By "coarsely crystalline", (I mean that) probably the average grain size will turn out to be about 3 or 4 millimeters, maybe - maybe half a centimeter. (To Gene) Hold this, and I'll...

167:04:08 Cernan: Well, I got to go get a couple of pictures.

167:04:10 Schmitt: You gonna roll...Yeah, we've really gotten that one messed up.

167:04:13 Cernan: Yeah.

167:04:14 Schmitt: That's all right.

167:04:16 Cernan: If you'd hold your scoop where that one came off, it'd help.

167:04:18 Schmitt: (Getting his scoop, which is planted to the left of the rock) Yeah; I was just going over there.

167:04:20 Cernan: On that other side.

167:04:21 Schmitt: It's going over there.

167:04:22 Cernan: This side is clear. That last one I took off. Okay.

167:04:26 Schmitt: (Positioning the scoop over the rock for Gene's after) Right there.

[AS17-146-22371 is Gene's after.]

167:04:29 Cernan: Okay, that's good. Let's move the gnomon, and we won't roll it over on the gnomon. (Long Pause)

[Gene moves the gnomon well away of the rock to the left. He then gets down on hands and knees and flips the rock with his right hand.]

167:04:44 Schmitt: Watch it. Watch it. (Pause)

[The rock rolls about 2 meters, landing with the same side up.]

167:04:49 Schmitt: Oh, yeah! That other side is the one that was up. (Pause)

167:05:03 Schmitt: (Kicking the boulder over) Well, I'm not sure now. It's got so much dust on it. But let's...(Pause)

[Gene gets up in two tries; then gets the gnomon.]

167:05:17 Cernan: That's not going to roll down that hill unless we get it on edge.

167:05:20 Schmitt: No. (Pause)

167:05:24 Cernan: Get it from up here. Boy, look at that glass on it. That's what you said, huh?

167:05:29 Schmitt: Yup.

167:05:30 Cernan: Which side was the glass on when you looked at it?

167:05:32 Schmitt: It's on all sides. It's on all sides.

167:05:34 Parker: 17, there's probably not much point in spending a lot of time out here trying to decide which is the top. It's not big enough, anyway, really to worry about...

167:05:41 Schmitt: We're not.

167:05:43 Parker: ...the top and bottom samples that are radiologically significant.

[Schmitt - "I think that what I had in mind was to get top and bottom samples for solar wind dating. We also had a plan to get soil samples from way underneath boulders, samples that had been shielded from cosmic rays. Bob was thinking about the cosmic ray issue; I had in mind solar wind dating of when the boulder got there. The solar wind doesn't penetrate more than 500 Angstroms (5×10^{-8} m); whereas cosmic ray secondaries wind up at two or three meters. So we were both right; I just never explained to him what I was doing."]

167:05:48 Schmitt: Well, let's...(To Parker) If you don't want another sample, then we can go ahead.

167:05:51 Cernan: Well, let me get a piece of this glass.

167:05:55 Schmitt: Righto. (Long Pause)

[The fragment comes off on hit number seventeen. Some of the blows are audible, unless the sound is being produced by Gene's microphone tapping on the neckring or some similar phenomenon.]

167:06:10 Cernan: There it is. (Pause)

167:06:17 Schmitt: Okay. Let me try to get them.

[Gene gets a sample bag from Jack, who is collecting the fragment with the scoop.]

167:06:27 Cernan: Put them in here.

167:06:29 Cernan: Okay; a piece of the glass from it, Bob, is 546.

167:06:31 Parker: Okay. We copy 546.

167:06:32 Cernan: Along with a little of the local soil.

[Jack pours the sample into the bag. At some point after he finishes collecting the soil, he takes AS17-142-21704 and 21705.]

167:06:40 Parker: And now we're ready for you guys to rake...

167:06:41 Schmitt: Okay. We'll go rake.

167:06:43 Parker: ...and I guess they suggest the crater rim if possible. Probably over there near the Rover.

167:06:50 Schmitt: Okay. (To Gene) Now you got a sample of that big block down there, huh?

167:06:56 Cernan: Yeah.

167:06:57 Schmitt: (Starting downhill) Okay. Don't forget your gnomon.

167:07:02 Cernan: Whoo! Oh, boy. Bob, on my frame count 85.

167:07:11 Parker: Copy, 85 for the Commander. (Pause)

[Jack uses what might be described as a "hop, skip, and jump" gait. Gene's after pictures of the boulder are AS17-146-22372 to 22374.]

167:07:20 Schmitt: Too bad I don't have my skis!

167:07:22 Cernan: Jack, did you get a pan up here?

167:07:24 Schmitt: No.

167:07:25 Cernan: I'll get one.

167:07:26 Schmitt: Good, I forgot. I got interested in skiing.

[Jack switches to a two-footed skiing stance and makes repeated sounds of skis gliding and, as he goes, trying to hop from side to side.]

[Schmitt - "I'd started out trying to stride downhill. And it didn't work."]

167:07:39 Schmitt: Shhh. Shhh. Shhh. Shhh. Shhh. Shhh. Whoo! Can't keep my edges. (Pause) Shhhhoomp. Shhhhoomp. Little hard to get a good hip rotation.

[Schmitt - "Somebody was inspired to put out a "Ski the Moon" poster, this one just a white sphere on a black background."]

167:07:50 Cernan: Let's see, I must be looking back at...Well, there's SWP. (Pause) Oh...Golly, I don't know. (Pause)

[Fendell returns to Gene. AS-17-146-22375 to 22397 are the photos in Gene's pan. 22379 show the footprints he made when he went to retrieve the sample at 167:02:08. 22386 to 22389 show Jack at the Rover.]

167:07:57 Cernan: I'm looking back at the complex - Cochise and Shakespeare - and I can see the LM. (Long Pause)

167:08:36 Cernan: (Looking uphill) Hey, Bob. One interesting thing up here, you can see the erosional pattern of the talus (or) the mantle that - I call it a mantle, but (I mean) the talus - that's on the Sculptured Hills. There's little...little boulder tracks of all sizes from (means "made by") all these little clods. And they all, of course, point downhill or nearly downhill.

167:09:00 Parker: Okay. Copy that.

167:09:04 Schmitt: Hey, Bob. In the interest of time, I'll document this (rake sample) without the gnomon.

[Jack's before photos or the rake site are AS17-142-21706 to 21711. Note that he has used the rake to give scale and a shadow.]

167:09:11 Parker: Okay. I presume Gene's got the gnomon up there?

167:09:15 Schmitt: Yeah. I should have brought it, but...

167:09:17 Parker: Okay. Don't forget the gnomon, Gene.

167:09:18 Schmitt: ...I didn't think about it.

167:09:20 Parker: And we concur...

167:09:22 Cernan: (Grabbing the gnomon and starting downhill) Don't forget the Gene, gnomon!

167:09:23 Parker: ...with documenting without the gnomon. (Pause)

[Gene's final picture of the exotic boulder, taken before he picked up the gnomon, is AS17-146-22398.]

167:09:30 Cernan: Whee! Boy, when you do this, and you're going downslope, that first step is a long one! (Pause)

167:09:39 Schmitt: I'm having...(Pause)

167:09:45 Cernan: (Doing long, two-footed hops) This is the best way for me to travel. Uphill or downhill.

167:09:48 Schmitt: What's that?

167:09:50 Cernan: Like this. Two-legged hop.

167:09:53 Schmitt: There seems...Yeah.

167:09:54 Cernan: And on level ground, I can skip. I don't like that loping thing.

167:09:59 Schmitt: Oh, the loping's the only way to go.

[Fendell can't keep up with Gene.]

167:10:01 Cernan: Well...See, when I'm on level ground, I can skip. But this two-legged thing is great! Man, I can cover ground like a kangaroo! (Pause)

[Cernan - "When you were hopping, I felt that you could really take off and still have significant control if you anticipated and shock-absorbed your landing. It really was the only way to travel downhill. I think that if you stride on a slope, you shift your weight too much from one foot to

the other and, in one-sixth gee, once you start to shift your weight your more apt to go kattiwampus."]

[Schmitt - "Well, you know, it's hard to stride going downhill here on Earth, too. If you go down a twenty degree slope and you start striding, you just don't feel like you've got much control."]

[Cernan - "Yeah. And when you hop, you can lean back like you do in skis and control your center-of-gravity and not have it out in front of you. (Pause) I can relate to this. This is fun."]

167:10:20 Cernan: Oh, okay. You documented already; I was just going to put this (gnomon) in the field of view anyway.

167:10:24 Schmitt: Yeah. On the "after" we can have it there. (Long Pause)

[Fendell finds them at the foot-high rock NW of the Rover. Jack is raking; Gene moves out of the picture again.]

167:10:56 Cernan: Well, what do you think about that? There's not much (that is, no rocks) in here worth...Man, there's just nothing...This has been totally mantled with talus. Well, it is; because that downhill pattern goes right down the slope of this crater, and...Actually, it goes upslope of the crater! This may be on a ray somewhere. Because it goes right downhill...This little, skinny boulder-trail pattern goes right up the slope.

167:11:33 Schmitt: (Still raking) I think those are later than the crater by a long ways.

167:11:36 Cernan: Did you sample anything over here?

167:11:40 Schmitt: No, I haven't done anything...

167:11:41 Cernan: I'm going to pick up the piece out of that little...

167:11:44 Schmitt: Yeah, get this...

167:11:45 Cernan: ...crater.

167:11:46 Schmitt: Want your gnomon over there?

167:11:47 Cernan: No. I'll just take it to it. (Pause) Let me know when you're ready for a bag.

167:11:55 Schmitt: (Having taken about 15 to 20 short swaths to this point) Well, I'm about ready. (Pause)

[Gene takes several pictures as he works in the crater. AS17-146-22399 to 22402 before showing the crater wall from the inside and, beyond, Jack, the rake, the gnomon, and the LRV.]

167:12:06 Cernan: You about ready?

167:12:07 Schmitt: Yep.

167:12:08 Cernan: Okay. (Pause)

[Gene arrives with a sample bag.]

167:12:17 Schmitt: (To Parker) I raked about a 2-meter square area - maybe...yeah, about 2 meters - and down to 4 or

5 centimeters for these. Pretty good population. (To Gene)
They all going to go in?

167:12:35 Cernan: They're all in; (starts to give Parker
the bag number)...

167:12:37 Schmitt: Wait, wait.

167:12:38 Cernan: ...565.

167:12:39 Parker: Okay. Copy that...

167:12:40 Cernan: 565.

167:12:41 Parker: Sounds great. Sounds like a good rake
sample for a change.

[Jack presents his SCB.]

167:12:45 Cernan: Yes, sir.

167:12:47 Parker: And this is a "kilogram-of-soil"
location, fellas.

167:12:51 Schmitt: Yes, sir.

167:12:54 Cernan: Jack, your bag (SCB) is full; we're going
to have...No, it isn't, but we ought to change it when we get
back there (at the Rover), anyway. And that one ought to go
under your seat.

167:13:00 Schmitt: Well...Okay.

167:13:01 Cernan: Get your kilogram. I'll be ready to take
it. (Pause)

167:13:15 Cernan: (Getting a sample bag ready) The
kilogram is in 566.

[As can be seen in AS17-142-21706, the sides of the rake
forward of the handle are made of metal sheet rather than
being tines. Therefore, Jack can tilt the rake and turn it
into a big scoop.]

167:13:19 Parker: Copy that. (Pause) And, remaining here,
we'd have primarily a trench, if you fellas think it's
feasible. We'd like to be moving in one-one minutes. Eleven
minutes. (Pause) And we could use a pan from this lower
location also, probably.

167:13:36 Cernan: (To Jack) Why don't you go back and dig
a trench at the Rover?

167:13:39 Parker: Roger. That sounds good to us.

167:13:41 Cernan: Okay.

167:13:43 Parker: And we also remind you of getting...

167:13:44 Cernan: Jack, once you get a trench at the
Rover...

167:13:44 Parker: ...a pan at the lower section there.

167:13:45 Cernan: ...(garbled) scoop (garbled). (Pause)
I'll get the sample here that I got documented now and...

167:13:53 Schmitt: Did you...Is that all going to go in
there?

167:13:55 Cernan: Yeah, it'll go.

[Jack has just finished pouring a third batch of soil
scooped with the edge of the rake.]

167:13:57 Schmitt: Can you twist it?
 167:14:00 Cernan: Yeah. (Garbled)
 167:14:03 Schmitt: That rock may have been too much. Take that rock out, and...

[Jack presents his SCB.]

167:14:07 Cernan: No, it'll stay. (Pause) We're going to have to put it in mine, though. (Pause) Well, let me try. Since we're going to unload your bag, this may be the last one. That's the last one for your bag.
 167:14:23 Schmitt: Okay.
 167:14:25 Cernan: Okay?
 167:14:27 Schmitt: Did you get anything out of that little crater?
 167:14:28 Cernan: (Going into a meter-deep crater just north of the rake-sample site) No. But I'm going to right now.
 167:14:29 Schmitt: Okay.
 167:14:30 Cernan: Why don't you get your "after" picture (of the rake site) over there and go down and get that trench. I'll come down...
 167:14:34 Schmitt: You don't want a bag? Okay.
 167:14:35 Cernan: I can bag it. I can do it myself here.
 167:14:37 Schmitt: Okay. (Long Pause)

[Jack goes SE of the rake site to take a flight-line series of photos. He hops north after each picture to get a stereo sequence. These photos are AS17-142-21712 to 21715. 21713 and 21714 show Gene sampling in the crater with his tongs. 21716 show Gene examining his sample.]

167:15:04 Cernan: Boy, almost pure white and very friable. Oh, boy, is it. Pure white! Right out of a small little pit crater on the side of this crater I just walked in, Houston. And it's pure white, very friable. I got about, well, one big piece and several small in 567.
 167:15:31 Parker: Copy that. (Pause)

[Gene's after of the sample location is AS17-146-22403.]

167:15:37 Schmitt: (On his way to the Rover) Bob, the walls of the big craters around here - that is, the ones that are, say, 15 meters in diameter - tend to be a little bit lighter albedo than ones down in the mantled area. (Pause) I'm afraid those pictures on that rake may be through a dust-colored lens.

[Having hopped out of the crater, Gene gets the gnomon.]

167:16:12 Cernan: Well, they were also in my documented sample here, too. (Long Pause)

167:16:31 Cernan: (Hopping toward the Rover, almost tripping) Okay. Where do you want this trench? On the side of this crater?

167:16:34 Schmitt: Well...

167:16:35 Cernan: I'll drop my gnomon...

167:16:35 Schmitt: ...I don't know. I was just thinking about that. I think we ought to get out in the inter crater area to see if there's any stratigraphy to whatever the talus is.

167:16:54 Cernan: Okay, Jack. I'm going to leave the gnomon right here...

167:17:00 Schmitt: I'll get it.

167:17:02 Cernan: And, while you're digging that trench, we've got the pan to get, but I want to fix this fender.

[Fendell finds Jack leaving Gene's seat, headed for the gate.]

[Schmitt - "The level of emotion seems to have dropped off a little bit. We'd been walking up and down that hill for quite a while."]

167:17:06 Schmitt: I guess the pan's mine, isn't it, this one?

167:17:08 Cernan: Yeah, it is. And I want to fix the fender before...

167:17:10 Schmitt: Okay.

167:17:11 Cernan: ...before we leave. (Garbled)...

167:17:12 Parker: Okay. We agree with that, and you might get us...

167:17:13 Cernan: ...one, and I'll tighten...

167:17:15 Parker: ...you might get us the gravimeter reading there, Gene, while you're at it. And if you have time, you might drop the gravimeter on the ground, and we'll get a reading with it on the ground as well.

167:17:28 Cernan: Holy Smoley!

[Jack is probably taking before pictures of the trench site. AS17-142-21717 and 21718 are the cross-Sun pictures.]

167:17:29 Schmitt: The gravimeter is coming up.

167:17:31 Cernan: 670, 096, 001. 670, 096, 001.

167:17:40 Parker: Copy that.

[Fendell reaches the counterclockwise TV stop and reverses pan direction.]

167:17:45 Cernan: You want it dropped on the ground, huh?

167:17:46 Parker: Gently.

167:17:49 Cernan: Gently. I can't find a general level spot, but I'll level it. If it takes pictures...(correcting himself), or, if it does it's thing on the Rover (which isn't very level), it'll do its thing here.

[AS17-142-21719 is Jack's down-Sun before of the trench site, showing Gene in the background taking the TGE of the Rover.]

167:18:06 Parker: Yeah, this is just to get a check...
 167:18:11 Cernan: Okay. Mark. (Garbled)
 167:18:12 Parker: Copy that. (Pause)
 167:18:24 Cernan: It's fender-fixing time; it's camera-taking-off time. (Pause) And I think I'll zap myself with a little cool water.

[Cernan - "The reason the camera comes off is that I've got to get close to the fender. The camera keeps you about a foot away from anything. Plus you bang up the lens."]

[Schmitt - "There's something I don't think I mentioned back at Station 7. We were talking about manipulating things more easily. When I was getting samples into a bag, I had mastered how to do that without the camera interfering; where, on the first and second EVA's - like Station 3 - I hadn't figured it out."]

[Cernan - "If you had to bag something yourself, you had both a vision and an access problem. So you had to find out where your arms met each other above or below the camera."]

167:18:36 Parker: And how's the trench going, Jack?
 167:18:43 Schmitt: Oh, down. (Pause)

[Fendell zooms in on the rock at the rake site.]

167:18:50 Cernan: Oh, man, I tell you. When you call for cold water, does it come in nicely. Whew! (Pause) I'm really happy with this fender, really happy with it. (Pause)
 167:19:17 Schmitt: Bob, I have gotten a wall now, in one place, that's standing about 25 centimeters high. And it shows no apparent change in the texture of the soil to that depth; except possibly at the lower 5 centimeters, there's some zones that might be slightly more granular. Particle size may be up a little bit.

[Jack's speech pattern has slowed noticeably. He spends time searching for words.]

[Schmitt - "Part of the reason is that I'm tired. It also happens when I'm thinking and trying to talk simultaneously - which I never did very well."]

167:19:55 Parker: Okay. I copy that. Probably just three samples will be sufficient, then.
 167:20:02 Schmitt: I think so. Maybe four.

[Schmitt - "It was a judgment call based on how deep the trench was. You'd take one at the bottom, one is the middle, and a skim off the top."]

167:20:07 Cernan: Be there in a minute, Jack.

167:20:09 Schmitt: Oh, that's all right. I can probably get started. (Pause)

[Jack's heart rate is down to about 90 beats per minute. Gene's is only down to about 110.]

167:20:22 Cernan: Ohhhh, boy!

167:20:24 Schmitt: Need some help?

167:20:25 Cernan: Nope. (Pause) Boy, we're sure giving this suspension system a workout. Whew! I can even see it. (Long Pause)

[Cernan - "I was leaning over the fender, putting pressure on the Rover; and I think I was bouncing it up and down. I think that each wheel had a V-type torsion bar (see AS17-134-20453, the picture Gene took from the front of the Rover of Jack mounting the vehicle at the end of Station 9) because the Rover had been folded up for storage in the LM. We didn't have shock absorbers because we would have had dust problems."]

[Schmitt - "The Rover was parked with the rear end downhill, so you were more or less able to stand there looking at it."]

[Fendell finds Jack southeast of the Rover, trying to angle the scoop head. He had it oriented vertically to dig the trench and now wants to set it at right angles to the handle so that he can sample the trench. Unfortunately, the locking mechanism is now thoroughly fouled with dust. He bangs the scoop head with his hand.]

167:21:02 Schmitt: Well, everything's getting awful dusty.

167:21:05 Cernan: Boy, everything is stiff. Everything is just full of dust. There's got to be a point where the dust just overtakes you, and everything mechanical quits moving.

[Schmitt - Anyone planning to work on the Moon or Mars ought to have Gene's statement engraved on their forehead and on the inside of their glasses."]

167:21:14 Schmitt: (Still struggling) Like scoops. (Pause)

167:21:22 Cernan: I'm not sure whether Detroit would like the fender, but it will sure buy the fix. Okay, it's fixed.

167:21:31 Parker: Okay. Copy that.

167:21:33 Cernan: And I'm happy; I like it.

167:21:34 Parker: Roger. We copy that. And copy it again.

[Jack gives up on the scoop head and sets it at angle of about 20 degrees from vertical.]

167:21:40 Parker: And we'd like to have you guys moving in about 3 minutes.

167:21:41 Cernan: And again on the (garbled). (Pause)

167:21:46 Schmitt: (Responding to Parker's "3 minutes") Good luck!

167:21:49 Cernan: You need any help (garbled) bag those samples, huh?

167:21:51 Schmitt: Yes, sir. I think I do. I can't adjust my scoop to my self-bagging method.

[Schmitt - This confirms what I thought back when we were going through Station 7 - that the 90 degree angle was something I'd worked out in order to bag samples more easily when I was working alone. I'd hope to do that here while Gene was doing something else; but, now, Gene's come over and we'll go back to two-man sampling routine."]

167:21:55 Cernan: (Going to Jack) Let me get back on some lighter cooling here, too, to save some water. Okay, now.

167:22:05 Schmitt: Okay; the bottom 10 centimeters...

167:22:07 Cernan: Let me get your bags...I left my camera off when I...

167:22:10 Schmitt: ...of a...

[Gene gets one of Jack's sample bags.]

167:22:12 Schmitt: Well, shoot! I didn't take a picture of the trench after I dug it. Let me take one shot. (Pause)

167:22:22 Cernan: What's this? The bottom?

167:22:23 Schmitt: (Backing up to take pictures) That's the bottom.

[Jack's pictures of the trench are AS17-142-21720 to 21723.]

167:22:25 Cernan: Okay. The bottom is in 548. It's very cloddy. Looks very much like the surface we're standing on except it clods up quite a bit more. Can you tell anything from the trench itself?

167:22:37 Schmitt: I told them...I talked to them a little bit about it.

167:22:39 Cernan: Okay.

167:22:40 Schmitt: It looked a little coarser-grained, but that's all. (Pause)

167:22:50 Cernan: It sure holds a nice wall, though.

167:22:54 Schmitt: Yep.

167:22:55 Cernan: That's the kind of wall I expect those core tubes held.

167:22:59 Schmitt: You got another one (bag)? Okay. Skim of the upper...We'll see how well I do. (It's a) skim sample of the upper half centimeter. Maybe a centimeter deep. (Pause)

167:23:26 Schmitt: (Pouring) Okay. Can you hold that?

167:23:28 Cernan: I'm going to put it in your bag.

167:23:30 Schmitt: (Presenting his SCB) Is it going to fit in there?

167:23:31 Cernan: Well, there's no choice, right now. Let me...Yeah, these little ones will fit in there. (Pause)

Stand by. I want to put this one in there, too. That's in bag 549.

167:23:43 Parker: Copy that. (Pause)

167:23:57 Cernan: (Sealing the bag and putting it in Jack's SCB) Okay. Try again. (Pause)

167:24:05 Schmitt: Okay, the upper...Below that skim: the next 5 centimeters. (Pause)

[Schmitt - "After I got the skim, I just stuck the scoop part way in the wall and scraped upward to get the next 5 centimeters."]

167:24:20 Schmitt: Put it (the bag) down, Geno.

167:24:23 Cernan: Well, just put it (the scoop) over it (the bag).

167:24:24 Schmitt: Well, I can't turn it (the scoop). (Pause)

[Gene has been holding the sample bag at about chest height, thereby forcing Jack to fully extend his arm and raise it over his head to pour.]

167:24:33 Cernan: 550.

167:24:36 Parker: Copy that. (Pause)

167:24:39 Schmitt: (Scrapping a deeper section of the trench wall) And the next 10 centimeters down...(Pause) (To Gene) Can you get this one too?

167:24:45 Cernan: Yep. (Pause)

[Gene gets another sample bag and holds it at about the same height; Jack solves the pouring problem by rotating the scoop.]

167:24:55 Cernan: Now, I got to get your bag (SCB).

167:24:57 Schmitt: (Presenting his SCB) Okay. That was the next 10 centimeters; and, then, the first sample, of course, was the 10 centimeters below that.

167:25:04 Parker: Roger. Copy that.

167:25:05 Cernan: And that last bag was 551.

167:25:07 Parker: Okay. Copy that. We're ready for you guys to move out.

167:25:13 Schmitt: Okay.

167:25:15 Cernan: You didn't get a pan here. While I clean up the Rover, you can get your "after" of the trench in the pan.

167:25:21 Schmitt: I will.

167:25:23 Cernan: I'll get the TGE and clean up the Rover.

167:25:25 Parker: That's affirm. We agree with that.

[They both turn to look at the trench.]

167:25:27 Schmitt: What's the key that keeps...I keep getting keyed.

167:25:31 Cernan: It sounds like Bob's stepping on his foot
mike.
167:25:33 Schmitt: Yeah, he's so excited...
167:25:35 Cernan: Okay...
167:25:35 Schmitt: ...he can't stand it.
167:25:36 Cernan: You done with the gnomon?
167:25:37 Schmitt: Yup.

[Jack has taken two final afters of the trench. These
are AS17-142-21724 and 21725.]

167:25:39 Cernan: Okay.
167:25:41 Schmitt: I'll get the pan.
167:25:42 Cernan: (Getting the gnomon and heading for the
gate) You get your pan, and I'll get the TGE and clean up.
167:25:43 Schmitt: You took a pan up the hill there?
167:25:45 Cernan: Yeah; I took it way up there, somewhere.
167:25:47 Schmitt: Okay. I'll take it right here, then.
(Pause) Uh, oh.
167:25:56 Cernan: What?
167:25:57 Schmitt: Samples came out.
167:25:59 Cernan: A sample came out?
167:26:00 Schmitt: I'll pick it up.
167:26:01 Cernan: Yeah, your top came open. It's awful
full, Jack. If you can't get it, I'll get it with the tongs.

[The top of Jack's SCB is flapping open. Two sample
bags have fallen out.]

167:26:06 Schmitt: Go ahead and go to work, and I'll get the
pan first. I lost two of them, I guess.
167:26:12 Cernan: Yeah, those are the last two I put in
there. Your bag is so full they won't stay. Let me give
them a reading here. Hey, Bob, can I move it on the Rover
and then give you a reading?
167:26:22 Parker: Yes. As long as you're careful not to
hit the button while you're doing it.
167:26:25 Cernan: Yeah, I can. I'll do it. (Responding to
Parker) I won't hit the button. Just easier to do it that
way. I don't know why I asked you; I know I can. (Pause)

[Jack's pan photos are AS17-142-21726 to 21745. 21727
shows the Rover tracks made as they approached this stop and,
as well, Cochise Crater just above the center of the frame.
21729 to 21731 show Gene picking up the TGE so that he can
put it back on the Rover. 21734 shows the exotic, rolled
boulder. 21741 shows a dramatic secondary crater made by
ejecta from some distant impact. this is an excellent pan.]

167:26:42 Cernan: Even this thing (TGE) doesn't want to go
on; it's so dusty. Okay. It's on and it's locked, and
here's your reading. 670, 117, 301; that's 670, 117, 301.
167:27:00 Parker: Okay. We copy that.

[Schmitt - (To Gene) "I don't know if you were aware of it or not, but one of the most successful experiments that we conducted was the portable gravimeter. They got great readings all across the valley; and the interpretation is great about the depth of the basalt fill in the valley - about two kilometers deep."]

[Cernan - "I'm glad; and I do think I remember that. But it was always a pain number one in the butt."]

[Schmitt - "And what it tells you is that the valley used to be almost five kilometers deep before it fill up. The eruption of mare basalt started very soon after the valley formed; but there's as much as a hundred million years of play (meaning 'uncertainty'), there. Serenitatis formed at something like 3.8 billion years ago - something like that - and the oldest basalt that we brought back - from Station 5 - came out at about 3.7 something. Nobody knows for sure how many flows there were or how thick they were. Some of the late basalts in Imbrium are relatively thin - ten meters or so. Some of the layers that they see in Hadley Rille are relatively thin. But whether that applies to the stuff deeper down, nobody knows. You may have had pretty thick cooling units. It just depends on how fast that stuff came out. Probably most of the basalts - in the early phases, anyway - when the flows first start in a basin like Serenitatis, it probably erupts from literally millions of centers. It's not like out on the West Mesa of Albuquerque where you had a single crack and that's where the basalt came up. Initially, a basin like Serenitatis - 500 kilometers across - is fractured to beat all hell and, so, anything coming up from below has an infinite number of choices. And then, gradually, most of those seal off and the later flows come out of a few, discrete, individual eruptions."]

167:27:02 Cernan: I've got to dust that thing (the TGE) the next time around. Jack, we've got to do some bag (SCB) changing here.

167:27:10 Schmitt: Yup.

167:27:12 Cernan: I'll get those things with my tongs. You can't get them. You'd have to bend over. Every time you jump around, you come close to losing something. (Pause)

167:27:35 Cernan: (Arriving with the tongs and picking up the first sample bag) I'll just take them back there. Put them under the seat.

167:27:38 Schmitt: Okay. (Pause) You want me to take that one?

167:27:42 Cernan: (Now getting the second sample bag) No, I got it.

167:27:43 Schmitt: Okay. (Pause)

[They head toward the Rover.]

[Cernan - "Coming down those shallow slopes is poetry in motion. That's productive use of your time. If you could do something like helicopter skiing - have somebody drop you off

at the top and pick you up at the bottom - you could really cover a lot of territory."]

[Schmitt - "In that Essex study, my proposal for the Mars part of it was that you have a Rover that you can run either manually or automated. So if the pair were out working, you could have somebody else, say back at the base or the lander, remotely move it to where you want it. And then, after you leave, it can be operated remotely from Earth or from Mars orbit. I don't think it would be a big weight penalty; all it is electronics."]

[Another sample falls out of Jack's SCB. It comes out in the forward direction and into Jack's field of view before it hits the ground. He stops and turns to look.]

167:27:58 Schmitt: Damn.

167:28:00 Parker: You got another one dropped there, Gene. Jack got it.

167:28:04 Cernan: Another one?

167:28:06 Parker: Jack's getting it.

167:28:07 Cernan: Okay. (Pause)

[Jack gets the fallen sample with the scoop and carries it back to Rover as in an egg-and-spoon race.]

167:28:13 Cernan: Jack, we've got to make a place in here for that full bag. Let me put the small can over there, and core tube over there.

167:28:23 Schmitt: (Holding the sample, still in the scoop, up to the TV) Have a sample.

167:28:27 Cernan: Okay. Let me take your bag off first.

167:28:31 Schmitt: Okay. Well, you might as well fill it as full as you can.

167:28:33 Cernan: Yeah, I am. (Marveling at the weight of Jack's SCB as he starts to take it off) Holy Smoley!

(Laughing) Turn to the left. (Pause) Okay. It's off. Let me fill it. (Pause)

[Gene is at Jack's seat with the SCB. Jack goes to the gate.]

167:28:57 Schmitt: Your bag isn't in much better shape.

167:29:00 Parker: Roger. We'd like to have you check the Commander's bag. You might put them both under the seat there.

167:29:08 Schmitt: Well, we're running out of bags, aren't we?

167:29:10 Parker: Okay. We've got one bag left...we should have there. It was on the gate, right?

167:29:19 Schmitt: Okay...

167:29:19 Cernan: Yeah. We had put it (the SCB which had been on the gate) under the seat. Okay, bag number 4 (which Jack has been wearing) is absolutely full. (Pause) and it's under Jack's seat.

167:29:40 Parker: Okay. I suggest that you take the other bag that's on the gate there, and put that on either you or Jack. And also, the Commander's bag is pretty full also, we suspect.

[Gene has removed an empty SCB from under Jack's seat.]

167:29:52 Schmitt: Why don't you put it on me? Mine gets full faster, somehow.

[The reason, of course, is that Jack is doing most of the sampling while Gene holds the sample bags and then puts them in Jack's SCB.]

167:29:56 Parker: You might check Gene's bag anyway.

167:30:00 Cernan: Stay there, stay there. I'm trying to get the bottom hook.

167:30:03 Schmitt: Oh, I'm sorry. (To Parker) I checked it. He's got about six samples to go.

167:30:11 Parker: Okay. And...

167:30:12 Schmitt: And I just want to be sure that it's locked down. (Pause)

167:30:17 Cernan: Okay. Well, turn to the left so I can get this other hook. (Pause) Okay. It's not coming out; I guarantee you that. Now...

167:30:27 Parker: Okay. And SCB 5 is one for the LMP if you want to take it off the gate.

167:30:29 Cernan: ...(garbled) check yours one more time. And that's locked.

167:30:34 Schmitt: We got it.

167:30:35 Cernan: (Turning so that Jack can check his SCB) SCB-5 is on the LMP.

167:30:37 Parker: Okay. Copy that.

167:30:39 Cernan: There is nothing on the gate. (Pause)

167:30:44 Schmitt: Well, I think that (Gene's SCB top)'ll stay down, but it's not very good...

167:30:46 Cernan: Okay. I've got one more loose sample I'm going to throw in the big bag back there. You happy (with the SCB)?

167:30:51 Schmitt: (Referring to the loose sample) A local one, you mean?

167:30:52 Cernan: Yeah.

167:30:53 Schmitt: Well...

167:30:54 Cernan: Well, let me leave it under your seat.

167:30:56 Schmitt: No, let's...Can I put a bag around it?

167:30:57 Cernan: No, it's got a bag around it. It's all bagged. It's right there.

167:31:00 Schmitt: (Garbled)

167:31:00 Parker: (Seeing Jack standing idle) Okay. Jack, while Gene's doing that, why don't you read the SEP temperature, or somebody read the SEP temperature anyway, and close the blankets.

167:31:09 Schmitt: Okay. I'll do that. (Pause)

167:31:14 Cernan: Okay, Bob. Let's see, you got your (gravimeter) readings...
 167:31:20 Schmitt: 120, Bob, 120.
 167:31:22 Parker: Copy. 120.
 167:31:26 Schmitt: Those blankets just aren't staying closed. (Pause)
 167:31:33 Cernan: Okay. I guess we're ready to head on out. Do you agree?
 167:31:36 Parker: Okay. And, Gene, when you go to change the LCRU, we'd like you to turn it to Off. O-F-F, on the Power switch, the Internal Power, External switch. And we'll be reading you through the LM. It will give you a chance to cool down the LCRU on the way home to Station 9.
 167:31:57 Cernan: All right.
 167:32:00 Schmitt: And, Houston, what's the temperature limit on the DSEA (the SEP Data Storage and Electronics Assembly)?
 167:32:08 Parker: Stand by, Jack. (Long Pause)

[Schmitt - "I think that I was getting so that I didn't quite trust Houston. They kept having us fool around with the SEP and my feeling was that it was probably gone. So I'm trying to prod them a little bit, having just told them that it was 120 (degrees) and my memory, at the time, was probably that that was way outside the limits. Literally, the science room was leading us down the garden path on the SEP, because all this SEP stuff we were doing was wasting time. It had quit working when? Sometime in the first EVA, didn't it? As with the (long-period) gravimeter, they should have bit the bullet far sooner than they did. They knew what the limits were, but they kept having us dust it and tape it!"]

[At 167:59:07, Parker will tell the crew that the SEP receiver turns itself off at 108 degrees. The temperature was 103 degrees at 163:43:51 at the start of the EVA but was 110 degrees by the time they got to Station 6. According to the Preliminary Science Report, the receiver switch was - unfortunately - in the Standby position, and no data was obtained during that drive. We note that Jack had reported putting the switch in the On position at the start of the traverse at 164:19:32. According to the Preliminary Science Report, some data had been recorded during EVA 2 on the outbound drive to Station 2 and on the in-bound drive from Station 4. The crew reported a SEP temperature of 105 degrees when they got to Station 2. We note that the SEP temperature was 112 degrees throughout the inbound EVA-2 traverse, higher than the supposed cutoff, and yet data was supposedly obtained.]

[TV off.]

[Schmitt - "I was wearing my visor with the lower edge at about eye level and, with it there, all you're getting is indirect sunlight reflected off the surface. And you don't go around staring at the Sun, anyway."]

[The Sun elevation is about 38 degrees. It was 13 degrees at landing.]

167:32:23 Cernan: Do you read us, Bob, through the LM?
 167:32:26 Parker: Roger. We read you through the LM. Do read us through the LM?
 167:32:31 Cernan: Yeah. Not as well, but we're reading you.
 167:32:33 Parker: Okay. And the temperature limit, Jack, is 160. We'll just leave it as is until we get back to the LM.

[This may be a temperature at which physical damage may occur to some of the SEP components. Parker doesn't mention the 108 degree shut off until 167:59:07, when they get to Station 9.]

167:32:40 Schmitt: Okay. I was going to say, we could take it out and put it under the seat or something, but that sounds all right.
 167:32:46 Cernan: Okay. An EMU status check. I'm at 3.88 (psi suit pressure), and I got 48 percent (oxygen), no (warning) flags, and I'm Intermediate cooling.
 167:32:58 Parker: Copy that.
 167:33:00 Schmitt: And the LMP is at 47 percent, no flags, 3.86. Hey, Gene?
 167:33:12 Cernan: Yeah.
 167:33:13 Schmitt: Well...Bob, I guess...Remind us to change the LRV sampler (the "dixie cup" sampler) at the next station. It's almost out of bags.
 167:33:20 Parker: Okay.
 167:33:21 Cernan: Well, let's do it next time around.
 167:33:23 Parker: Okay. When you get on, Jack, you can give me a frame count as you start moving.
 167:33:28 Schmitt: Yep. (Pause) (To Gene, who has fallen) Hang on. Need some help?
 167:33:39 Cernan: (Nonchalant) Nope.
 167:33:41 Schmitt: Go downhill. Get your feet downhill.
 167:33:43 Cernan: Yep. (Pause) Okay.
 167:33:50 Schmitt: Let me help you.
 167:33:51 Cernan: (Laughs)
 167:33:56 Schmitt: Watch it, there's a crater right behind you.
 167:33:58 Cernan: I got it. I got it. (Pause)
 167:34:03 Schmitt: Here. Here. Grab my hand.
 167:34:07 Cernan: Okay, now, just push up on my head.

[By pushing back on the front of Gene's helmet, Jack can get him rotating back over his knees.]

167:34:10 Schmitt: Okay. I'm not going to do it too hard. Going backwards.
 167:34:14 Cernan: It's all right; just push up. Okay.
 Okay.

167:34:19 Schmitt: (Chuckling) Boy, are you...(Chuckling)
 You('ve) got your pockets completely filled with dirt.
 167:34:23 Cernan: Well, extra sample.
 167:34:25 Schmitt: Do we throw those pockets away this time
 around?
 167:34:28 Cernan: (Laughing) Extra sample. (Pause)
 167:34:30 Schmitt: Are you a mess!
 167:34:31 Cernan: (Laughs) Well, that one was coming for a
 long time!
 167:34:33 Schmitt: My hand's are already tired from dusting
 you.
 167:34:37 Cernan: That one was coming. I keep trying to
 blow the dust off my camera, which is very frustrating.
 167:34:42 Schmitt: Very ineffective, too. (Pause)

[Cernan - "At least I fell off camera."]

167:34:50 Cernan: (Preparing to mount the Rover again)
 Okay. Do we try that trick again? (Long Pause) You know
 that happened on an upslope getting on the Rover. Okay. I'm
 all locked in. Let me know when you are. How come we
 haven't deployed any charges? I guess the last one...I
 remember when that one is. Okay.
 167:35:20 Parker: We'll deploy one at Station 10.
 167:35:23 Schmitt: Okay. I'm in. (Pause)

[Cernan - "I don't remember this particular event
 but..."]

[Schmitt - "I can't believe I don't remember it."]

[Cernan - "It may be that I just fell on my ass trying
 to get on the Rover. But I never had problems getting up,
 and that's why I'm confused as to what this is."]

[Gene takes a moment to re-read the dialog starting at
 167:33:28.]

[Schmitt - "The thing I don't understand is why you
 couldn't do a push-up."]

[Cernan - "I don't understand either. I just don't
 recall that at all."]

[Schmitt - "You know what it may have been? You may have
 started to kick to get on the Rover, then fell, and you were
 lying next to the Rover..."]

[Cernan - "Caught by the slope against the Rover."]

[Schmitt - "Yes. Which meant you couldn't rotate
 backwards. And my gratuitous advice was to get your feet
 downhill! (General laughter) And you must have had a
 feeling at some other time - probably Station 6 or 7 - that
 you were coming close to missing (the seat)."]

[The dialog at 166:48:26 and following indicates that
 Gene parked the Rover pointed into the hill and without much
 of a sideslope. This suggests that Gene fell with his feet
 uphill. To get up by himself, he had to get his feet pointed
 downhill - as Jack suggested - and, because he had the Rover
 next to him, getting turned around would have been
 difficult.]

167:35:30 Cernan: Okay. (Consulting checklist page LMP/CDR-20) We're heading to Station 9 pointed about 267. Okay, and they're reading us through the LM, so I won't worry about the low gain. We're powering up. The switch is on. Okay, I'm going to make a turn to the right.

167:35:43 Parker: Okay. And the updated (Rover) headings, since you're at the north end of Station 8, will be something like about 240.

167:35:54 Cernan: Okay, Bob. 240.

[The heading of 267 indicate on the checklist for the drive to Station 9 would have been valid had they done Station 8 at the south end of the planned area. Because they are at the northern end, their average heading will be more to the south.]

167:35:58 Schmitt: Bob, I think your rake sample here at the Sculptured Hills is going to have to tell the tale combined with the observation that most of the blocks we saw were, like (the one) Gene sampled, looked like subfloor gabbro. It's conceivable that the Sculptured Hills could be the same kind of material. I think it's fairly clear that the boulder population does not resemble the massif (boulder) population at all.

167:36:34 Parker: Okay. Copy that. (Pause)

167:36:44 Schmitt: (Laughs)

167:36:45 Cernan: You been riding on this downslope all the time!?!

167:36:47 Schmitt: (Laughing) Yes, but...

167:36:48 Cernan: And you hadn't said anything, huh?

167:36:50 Schmitt: Scary, isn't it?

167:36:53 Cernan: (Laughing) Man, I'm glad I'm driving!

[Cernan - "The 240 heading - southwest - put me on the downslope side of the Rover. And what I'm saying here is that I'm never going to put myself on the downslope again."]

167:36:57 Parker: Okay. And, Jack...

167:36:59 Cernan: (Still laughing)

167:36:59 Parker: ...when you're not holding on with two hands, we'd like the frame count from you.

167:37:02 Schmitt: Wait a minute. Yeah. (To Gene) Is that Van Serg over there?

[Van Serg is WSW of Station 8, beyond the southern rim of Cochise but short of Shakespeare.]

167:37:08 Cernan: Ahhhh...

167:37:11 Parker: Should have a bearing (at Station 9) of 234...

167:37:13 Cernan: I think it's...

167:37:13 Parker: ...and a range of 2.1.

167:37:14 Schmitt: I don't know...No...It's...

167:37:19 Cernan: (To Parker) Okay. (Pause) (To Jack)
 We got to get around SWP (means "Bowen") here and then ...
 Well, that's...
 167:37:26 Schmitt: Yeah.
 167:37:27 Cernan: ...and then head on more westerly.
 167:37:30 Schmitt: LMP frame is at 80.
 167:37:33 Parker: Copy 80.
 167:37:36 Cernan: SWP..(correcting himself) or Bowen, I
 mean. Bowen, I guess that is.
 167:37:38 Schmitt: Well...(Pause) That's SWP over there.
 Bowen is out here ahead of us.
 167:37:46 Cernan: Yeah. (Pause) Guess he said...
 167:37:50 Schmitt: Bowen isn't much of a crater on the map.

[During the initial stages of the drive, they are headed more or less southwest, toward the South Massif and Bear Mountain. Jack's traverse photos are AS17-142-21746 to 21751.]

167:37:53 Cernan: ...225? What did you say, Bob? 225
 what?
 167:37:56 Parker: 234 / 2.1.
 167:37:58 Schmitt: 234...
 167:38:00 Parker: Heading ought to be about 240; 240 for a
 heading for there. (Pause)
 167:38:05 Cernan: Did you hear him? I didn't hear him.
 167:38:07 Schmitt: 240. Are you not reading him?
 167:38:09 Cernan: But what did he say for bearing and
 range? That's what I'm interested in.
 167:38:10 Parker: (Enunciating the digits slowly) 234...
 167:38:11 Schmitt: 240. State bearing and range, Bob.
 167:38:13 Parker: ...2.1.
 167:38:17 Cernan: Okay. I got that. (Long Pause)
 167:38:38 Parker: Okay. And we think you're even farther
 north than I was saying. Maybe it's about 215 would be your
 heading for there.
 167:38:48 Cernan: Okay, Bob. I'll find it. 234/2.1.
 167:38:51 Parker: Roger.

[Cernan - "Because of the slope and the craters, we made some wide turns and I just wanted to know where we wanted to go, not how to get there."]

167:38:55 Schmitt: And all the big blocks still look like
 subfloor from the Rover. But "big blocks" in here are only
 about a third of a meter in diameter. And they're subrounded
 to subangular. Okay. We're out on the plains again now,
 just off the break in slope (coming down off the Sculptured
 Hills) (Long Pause)
 167:39:41 Cernan: That stuff sure looks like outcrop down
 in the East Massif on the lower slopes, where the high albedo
 is. Doesn't it? See it over there?

[The East Massif summit is SSE of their present position. As Jack's photos - AS17-142-21752 to 21754 - show, they have turned south for a moment, possibly to get around Bowen.]

167:39:48 Schmitt: Yeah. Yeah; it does. (Pause) It was one of my guidelines for the geophone deployment...(correcting himself) (I mean) "guide points". (Pause)

[Schmitt - "When I was laying out the east geophone line, I had picked out a point on the horizon to walk towards."]

167:40:22 Schmitt: There's some more of that blue-grey rock there on the east end of the South Massif, down low.
167:40:25 Cernan: Yep.

[They are headed southwest again. Jack's traverse photo covering the drive from here to the rim of Cochise are AS17-142-21755 to 21764.]

167:40:26 Schmitt: It looks like it might have been a slump block or something.
167:40:27 Cernan: Yep. You can see it's blue-grey because of it's contrast with the light mantle.
167:40:31 Schmitt: Yep. It might be a slump block, or something like that.
167:40:35 Cernan: Jack, I'm going to go to the left.

[Cernan - "Note the change in course."]

167:40:36 Schmitt: You going to go through...(Laughs)
167:40:39 Cernan: Need 234...
167:40:41 Schmitt: (Garbled).
167:40:42 Cernan: No, No. I'm going over here. This is closer. It's a shorter cut.
167:40:44 Schmitt: That's probably Bowen there, don't you think?
167:40:46 Cernan: I think...
167:40:47 Schmitt: Ahhh, well (not sure)...
167:40:49 Cernan: Well, see, we never got too far...
167:40:51 Parker: How about a range and bearing, guys.
167:40:52 Schmitt: (Garbled) aren't very far from SWP.
167:40:54 Cernan: Maybe we got too far east. (Responding to Parker) Okay. It's 228/3.4. And we're moving along at 10 to 12 clicks. That's all it'll hack.
167:41:05 Parker: Copy that. (Pause) How about an amps reading? We haven't had one of those for a couple of (garbled)
167:41:11 Schmitt: Starting to rain again.

[The replacement fender has started to fail, flapping around and allowing the rear wheel to shower them with dust.]

167:41:15 Schmitt: Got a crater ahead of you.
 167:41:18 Cernan: Oooh, boy.
 167:41:21 Schmitt: Down-Sun isn't much easier than up-Sun.
 167:41:23 Cernan: It's just easier on the eyes. (Chuckles)
 You just can't see any more, that's all. (Pause) You don't
 have that static, huh?

[At Houston's request, they turned the LCRU off at
 167:31:36 and are transmitting directly from their OPS
 antennas to the LM.]

167:41:34 Schmitt: Nope. (Pause) Hope you've still got an
 (OPS) antenna; I haven't looked recently.
 167:41:44 Cernan: Well, there's no holes in the high gain.

[A hole in the high-gain antenna would indicate would
 indicate that Gene had caught his OPS antenna in it and
 broken it off. Gene doesn't remember having such troubles in
 training.]

167:41:47 Schmitt: Might have hit it on a rock (when you
 fell at Station 8).
 167:41:51 Cernan: (Reacting to a rock or crater in their
 path) Oh, boy!
 167:41:53 Schmitt: Okay. We're back into the mantle area
 population of fragments is still one percent or so. The
 crater out off to our left, which is at 227 and three point
 ...What is that? Three point what? Three?
 167:42:11 Cernan: 3.3; 227/3.3.
 167:42:15 Schmitt: It is a fairly good-sized depression, but
 it's completely mantled. There's no blocks showing in the
 wall at all. (Pause) How do you read, Bob?
 167:42:29 Parker: Loud and clear. We're listening.

[Note that, despite Jack's earlier complaints about
 needless acknowledgments from Houston, here he wasn't to make
 sure that they are being heard.]

167:42:38 Schmitt: Now, there's a crater in the wall of that
 depression or the small one near it. And it has one big
 block in the side, as if it penetrated the mantle and exposed
 some of the wall of the depression. Just about a 30-meter
 crater. (Pause)
 167:43:07 Cernan: Valley of Taurus-Littrow is not planar!
 167:43:11 Schmitt: No, it isn't. (Pause) I'm glad we
 changed it to a "subfloor" instead of the "plains" unit.
 (Gene laughs)

[Schmitt - "I think that, at some point in the deep,
 dark past, the geologists at Flagstaff may have called the
 valley fill the 'plains unit'. You referred to these things
 as they appeared in the (overhead) photographs - the floor,
 the plains of the valley. They may have called it the plains

unit at one time and then, because we're talking about the rocks - what's underneath that floor - decided to refer to it as the subfloor basalt."]

[The decision to call the bedrock "subfloor" seems to have come fairly late. The November 6, 1972 edition of the Apollo 17 Lunar Surface Procedures volume (the OPS plan) contains a paragraph headed "Plains Materials" describing the valley fill. There is a footnote to the paragraph title which reads "Or, better, 'subfloor material' to avoid confusion with the more familiar usage of 'plain' meaning the valley floor independent of any stratigraphic connotation." Prior to the flight, the geologists were not sure just what Cernan and Schmitt would find out in the middle of the valley. "The relative evenness of the valley floor at the landing site suggests that a basin-filling unit (plains material) that apparently submerged all but the highest projections of hill-forming (that is, massif) material was emplaced after formation of the trough (that is, the valley). Such fill might consist of volcanic flows (here, they were hoping for younger volcanics over mare basalts), colluvium derived from the adjacent uplands, or sheets of breccia (that is, flat layers of breccia from Imbrium and/or Serenitatis). Similar material may fill nearby uplands basins (e.g. Littrow) or may underlie the topographic bench around the eastern edge of the Serenitatis basin. Plains material is presumably exposed in the bright walls of the craters on the plains. The abundance of blocks in the crater walls and on their rims indicates that the plains material is either indurated or contains large indurated blocks. The large craters may penetrate through the plains material into the underlying massif or (Sculptured) hills units, which may represent their ejecta. Plains materials appear to be younger than the bulk of the massif and hill material and is probably older than the youngest mare fill of the Serenitatis basin. Hence, an age of Imbrium or pre-Imbrium is inferred for the plains material."]

[Schmitt - "From memory, I believe they expected to see "dark mantle material" as the top unit and then had three options for the block-forming subfloor: (1) basalt, or (2) the down-faulted top of the Serenitatis ejecta, possibly partially molten 'sheet breccia', or (3) debris derived from the highlands. Also, they had no idea how thick the subfloor material might be."]

167:43:22 Schmitt: Okay. We're in the inner wall of the depression here, and the rocks still look like subfloor gabbro. Boy, there's certainly not much variety. (Pause) In general, there are few exotics ...

167:43:34 Cernan: Ooh, now that's got to be Cochise.

167:43:36 Schmitt: Ah, look at Cochise.

167:43:37 Cernan: That's Cochise!

167:43:38 Parker: Roger. We think you're coming up on Cochise.

167:43:39 Cernan: Get yourself a couple pictures while you're looking right at it.

167:43:42 Schmitt: Could you swing right. Swing right.

[AS17-142-21765 shows the approach to the rim of Cochise, and 21766 to 21768 show the interior of the crater.]

167:43:44 Cernan: Bob, we are on the northeastern rim of Cochise.. I'm going to work my way around the other side.

167:43:50 Schmitt: And Bob...

167:43:51 Parker: Roger. Copy that.

167:43:51 Schmitt: ...looking at the western wall of Cochise, I can see a contact within the subfloor between albedo units, one of which is a light tan-grey and the other is a light blue-grey. (It) may reflect the two kinds of subfloor gabbro we've already sampled. Vesicular and non-vesicular. And that contact looked like it was dipping...(The) apparent dip in the wall was to the north. In the west wall dipping to the north about 20 degrees.

[The contact is visible in AS17-142-21780, dipping down to the right, just above the TV camera and intersecting the right-front corner of the TV camera mirror. The picture was taken at about 167:48:42.]

167:44:35 Parker: Okay. Copy that. (Pause) Which one's on top? Can you tell?

167:44:48 Schmitt: Yeah. The blue-grey's on top. I'm sorry.

167:44:51 Parker: Thank you. And you got a bearing and range there at the rim of Cochise?

167:44:52 Schmitt: I took a picture of it and...

167:44:56 Cernan: (Answering Parker) Okay. We're at 228/3.0, and we're headed south and not quite on the east rim.

167:45:05 Parker: All right.

[AS17-142-21769 to 21777 are taken as they skirt the rim of Cochise, headed south at first and then southwest.]

167:45:08 Cernan: I'll give you a hack at the east rim.

[That is, when they are east of the center of the crater.]

167:45:16 Schmitt: Bob, I got a picture of that contact, so...

167:45:21 Cernan: (To Parker) I took some pictures right into Cochise, too, when we were coming up.

[AS17-146-22404 to 22408 are Gene's pictures from the east rim of Cochise.]

167:45:24 Schmitt: Good. It'll show on yours, too, probably. I hope. (Pause) Okay. We're sort of on the inner... (Garbled)

167:45:36 Cernan: Mark. 230/2.9. We're on the east rim.

167:45:39 Parker: Copy that.

167:45:40 Schmitt: Well, we're sort of inside the east rim a little bit.

167:45:43 Parker: Well, don't get too far inside.

167:45:44 Schmitt: We're halfway between the rim and where the blocky wall starts.

167:45:50 Parker: All right. Copy that.

167:45:52 Schmitt: Did you get that, Bob?

167:45:53 Parker: Yeah. We got that. (Pause)

167:46:04 Schmitt: Cochise is much like Horatio - actually, more like Camelot, although not as blocky in the walls, in general - in that it has blocky walls but a mantled rim. (Pause) Again, all the blocks I see in here - big ones and blocks down to about 20 centimeters - are subangular, in general, and appear to have the appearance of the subfloor gabbro; although most of the smaller rocks do not appear to be highly vesicular.

167:46:47 Parker: All right. We're copying that all. (Long Pause)

167:47:05 Cernan: We're at 232 and 2.7.

167:47:10 Parker: Roger. Copy that. (Pause)

167:47:23 Schmitt: Watch it. (Pause)

167:47:29 Cernan: You know what happened there?

167:47:31 Schmitt: What?

167:47:32 Cernan: I was just about to take a picture, and the minute you take your eye off anything...

[Gene's picture is AS17-146-22409.]

167:47:35 Schmitt: Yeh. (Pause) I got another view of that contact, and let's put that on the northwest wall of Cochise and dipping to the southeast. (Is) that right?

167:47:54 Cernan: South and east is to our left.

167:47:58 Schmitt: No, no, no, no, no. Put it on the northwest wall dipping to the northeast. (Pause)

167:48:08 Cernan: Yeah, that's right. (Pause)

167:48:14 Schmitt: See that, Geno, can you see that over there?

167:48:16 Cernan: Oh, yeah! I can see it now between the grey and blue-grey?

167:48:18 Schmitt: Yeah.

167:48:19 Cernan: Oh, yeah! Yes, I sure do.

167:48:23 Schmitt: Can you swing in there, and let me get another shot of it?

167:48:25 Cernan: You betcha. (Pause; Jack laughs) Now, there's a good view right here.

Jack's photos into Cochise from this location are AS17-142-21778 to 21782. Gene's are AS17-146-21410 to 22412.]

167:48:35 Schmitt: Okay now, I need to have you go left.
(Pause)
167:48:40 Cernan: Okay. I got two of them in there, too.
167:48:42 Schmitt: Great.
167:48:43 Cernan: Look at that rock right in front of us.
It looks like a contact between a blue and a grey.
167:48:47 Schmitt: Oh, yeah, there it is. Yeah, you're
right.
167:48:48 Cernan: We can't get down to it, but take a
picture.
167:48:50 Schmitt: Well, I think we've done...I think we've
got that (contact) relationship. I think we got it at
Station 1, as a matter of fact.

[Cernan - (Tongue still firmly in cheek) "At 48:50,
where Jack says 'I think we've got that relationship', I
don't want anyone to misinterpret the fact that we've been on
the Moon three days. (Laughing) 'We can't get down to it,
but at least we can take a picture.' "]

[Schmitt - "It'd be a little hard to have a relationship
in those suits, anyway."]

167:48:55 Cernan: But that's a big beautiful boulder on
the...
167:48:56 Schmitt: Yeah, that's...
167:48:57 Cernan: ...inner rim...
167:48:59 Schmitt: ...that's quite a block.
167:48:59 Cernan: ...inner south rim of Cochise.
167:49:00 Schmitt: Oooh...
167:49:01 Cernan: It's a single block.

[This is the block in AS17-142-21777.]

167:49:02 Schmitt: That's how you bend your tires.

[Schmitt - "Gene was still talking about the rock in
Cochise, and I was talking about a rock he hit."]

[Cernan - "We're moving pretty rapidly through this
area. If you're going ten kilometers (per hour) and you hit
a football (sized rock), you feel it. We put some dents into
those wire-wheel tires."]

167:49:03 Cernan: Well, that's what it (the wire wheel)'s
for. (Pause) Boy, that's a nice...Oh, man, would that be
(garbled)...
167:49:07 Schmitt: Well, now, that might be glass covered.
That might be a glass coating; the way it sort of hangs on
the outside there. Hard to say.
167:49:17 Cernan: We're at 234 - can't see it - 2.5.
167:49:23 Schmitt: Starting to sling dust. I wonder if
we've lost our fender.
167:49:25 Parker: Roger. Copy that.
167:49:26 Cernan: No, they're on there tight. (Garbled)
warp.

[Gene seems to be speculating that the fender has warped. He had tightened the inside clamp at Station 8 and, once he and Jack reach Station 9, they will take another look. At 167:56:11, they find that the fender has, indeed, warped. Gene brought the fender back to Earth. It is currently on display at the Smithsonian's National Air And Space Museum in Washington. The rear portion of the fender - the last two or three inches that would have borne the brunt of the rooster tail - appears to be badly worn.]

[Schmitt - "And if there is dust between the clamp and the map, it may be slipping."]

167:49:27 Schmitt: You think that's Van Serg? Right over there.

167:49:29 Cernan: Well, let's see...(Pause)

167:49:32 Schmitt: There it is. Betcha you.

167:49:37 Cernan: Yeah. I think you're right, because that's just about the right place. Let's see, 234 and 2.1 is where I want to go, and I'm at 230/2.5.

167:49:45 Schmitt: Okay, our...

167:49:46 Cernan: Pretty close.

[Jack's photos taken during the drive from Cochise to Van Serg are AS17-142-21783 to 21788.]

167:49:47 Schmitt: Our block population in here now - on the south rim of Cochise and out ahead of us - looks like it's up to 5 percent. (Pause) And it all looks like light, tan subfloor gabbro...or tan-grey. You don't see much blue-grey; not out on here. (Pause) There's a recent hit, (a fresh crater).

167:50:23 Cernan: This Rover is getting tested for what it was built for now.

167:50:26 Schmitt: Yeh. (Pause)

167:50:35 Cernan: I tell you it handles just the way as advertised, maybe even better.

167:50:41 Parker: Okay. We think you guys are getting to the point we ought to swing a little bit west to make that 234/2.1.

167:50:48 Cernan: Yeah, I am, Bob.

167:50:53 Schmitt: I think we've got it. Tallyho...

167:50:54 Cernan: Bob, that's my fix. I'm just navigating to it.

167:50:57 Parker: Okay. Copy that.

167:50:59 Cernan: I know where. I'll get there.

167:51:00 Parker: Roger.

[Cernan - "I was getting irritated with Bob for telling me how to get where I'm going. There was a touch of it a page or two ago and you're seeing it again here. What Bob doesn't see is that you don't just go from here to there. I might have to go around something, and I can see why I'm saying "Damn it, I'm too good of a pilot not to know where

I'm going! Don't tell me; just tell me where I need be and I'll be there.' Jack used to get irritated at Bob, and this is the first sign of my irritation."]

[Throughout these transcripts, Gene has shown great restraint in the face of provocation - from Jack, from Parker, and from the little misfortunes that are inevitably part of such a mission. After three days, he may be getting a little tired and, consequently, a little less willing to ignore minor irritations.]

[Cernan - "That may be. But, see, now he's infringing on my ability to navigate. He's telling me how to fly. And he doesn't know what the terrain looks like. He doesn't know how many football-sized rocks we're banging into and how many little craters we've got to go through and what the Sun is doing to us and what sightseeing we're doing along the way so that we can get up on the rim of a crater so we can get a picture. Yeah, I'm probably getting tired."]

167:51:00 Schmitt: We have a Tallyho on Shorty...I mean of Van Serg. (Parker chuckles) How about through there, Geno?

167:51:07 Cernan: Thanks.

167:51:10 Parker: Let's not pre-judge the crater too much.

167:51:11 Cernan: You want 234/2.1. Okay.

167:51:16 Parker: And remember we talked about parking on the southeast rim.

167:51:17 Cernan: It wanders like...Our wander-factor in here has got to be 50 percent.

167:51:21 Parker: Copy that.

[Cernan - "We had been moving at 10 or 12 klicks for a while but we're not moving that fast here. We're picking our way through here, probably at low speed, but as fast as we can get through the block field. With a wander factor of 50 percent, I've got to drive 15 meters to go forward 10."]

167:51:25 Schmitt: Bob, you're being cut out. I can't tell what you're saying. (To Gene) Isn't that where we want to go, over there?

167:51:32 Cernan: 23...Well,...

167:51:34 Schmitt: Well...Look, (garbled) way to get...

167:51:34 Cernan: ...(garbled) found the crater.

167:51:36 Parker: 234 or 232...

167:51:37 Schmitt: No, we didn't. It's there on the right.

167:51:37 Parker: ...It doesn't make much difference, 17. If you see Van Serg, that's what we want.

167:51:43 Schmitt: Well, you're...

167:51:44 Cernan: Let me wander over that way. That's where I want to get, but I couldn't go there because of that...(Pause)

167:51:52 Schmitt: There's a different looking rock there.

167:51:54 Parker: And remember, we're talking about parking on the southeast rim. (Pause)

[AS17-142-21789 shows the Van Serg ejecta and 21790 shows the rim.]

167:52:02 Schmitt: (To Gene) Yeah, I think you're going to have to bear right.
 167:52:03 Cernan: Yep. That's why I...I've got to get through this (boulder) field, though.
 167:52:06 Schmitt: Yeah, I know. (Laughs; Pause) Okay, Bob. We're still primarily in an extreme block field here now. It's up to a 20 percent cover, and...(20 percent cover) of fragments, mostly the subfloor. Some of it looks quite highly shattered. I just saw one piece that looked like a white anorthositic rock.
 167:52:37 Cernan: How's this look to you? We can go farther up there, I guess. Let me go farther up.
 167:52:41 Schmitt: Well, okay, if you can get up.
 167:52:40 Cernan: Get a little farther on the southeast. A little higher...
 167:52:45 Schmitt: (Garbled) to overdo it.
 167:52:46 Cernan: Well...(Pause)
 167:52:50 Schmitt: There is some greyish rocks that are...Oops! High centered.

[Gene has scrapped the bottom of the Rover on a rock.]

167:52:58 Cernan: Right, coming up here. I turn to the right and park right here.
 167:53:02 Schmitt: (Returning to his description of the greyish rocks)...that have somewhat of a swirl texture.
 167:53:07 Cernan: Okay, Bob, we're at 230/2.2.
 167:53:13 Parker: Copy that. Copy you parked.
 167:53:19 Cernan: Yep. What did I say? 230? I meant...Yeah, bearing is 230/2.2, and I'm parked on a heading of 320, which gives you a better view.
 167:53:36 Parker: Copy 320 for the parking.
 167:53:43 Cernan: Yeah, 330.
 167:53:46 Schmitt: Oh, boy. This (seatbelt) is getting harder and harder (to release). (Long Pause)
 167:54:01 Cernan: (Garbled; Pause)
 167:54:08 Schmitt: Well, what's wrong with it, now. I might have got it twisted.
 167:54:09 Cernan: Here, let me look at it.
 167:54:11 Schmitt: Got it hooked, but not so I can get it undone.
 167:54:14 Cernan: Here, let me look at it. I'd say "stay put", but I don't think you have any choice. That fender just curled under, that's where we're getting the dust. (Pause) Starting to warp. Look at those other fenders, talk about warping.

[Cernan - "I'm out of my seat and I'm walking behind the Rover to see if I can't help Jack with his twisted seatbelt. And, while I'm there, I see the fender curled under. That's

where we're getting our dust. And, maybe the other fenders were getting hot and twisted in the Sun."]

[Schmitt - (To Gene) "Isn't it remarkable, though, that - even with the transcript - you have no image of looking at those fenders. I run into that all the time."]

[Cernan - "I can create the image here of what they looked like, but it's today's image; it's not a recollection."]

[Schmitt - "Now, having read this and having heard about my belt, I can remember that now. It's a real image."]

[Cernan - "Certain things hit me like that, too. But I don't remember seeing the replacement fender curling or the others being warped. I would be kidding you if I said it was a recollection."]

[Schmitt - "Another example, for me, of not having an image is all that floundering around you apparently did beside the Rover (at Station 8). And of me trying to get you stood up. Very faint bells have started to ring. And it didn't come immediately."]

[Cernan - "Me, too. And, then, I can go back earlier to Tracy's Rock and that whole slope and that whole affair came back to me beautifully. It was there. I remembered it. I remembered working around that rock. I remembered the slope. But, here, I'm losing it."]

167:54:32 Schmitt: Did I get it (the seatbelt) twisted or something?

167:54:34 Cernan: Yeah, you did twist it when you put it on. Okay, scrunch down.

167:54:37 Schmitt: I'm scrunched.

167:54:38 Cernan: Okay. (Pause) You had one twist in it.

167:54:43 Schmitt: Boy, that makes a difference (by shortening the belt).

167:54:44 Cernan: Sure does. Here. (Pause) Your footpan's down, too.

[Gene has rotated Jack's footrest out of the way.]

167:54:52 Schmitt: I'll get it. (Pause) It's lost it's stiffness in there. Okay, I guess now I'll plan for Shorty, huh? Or Van Serg.

167:55:08 Cernan: Okay, LCRU Power's On.

167:55:10 Schmitt: Van Serg looks like a blocky-rim, fresh impact crater right now.

167:55:16 Parker: Okay. We copy that. How about scuffing your feet and seeing if it looks orange underneath?

167:55:18 Schmitt: Slight differences...(Stops to listen to Parker) Don't worry.

167:55:29 Parker: And, Gene, before you go away, we'd like the rest of the Rover readouts, like batteries. And how about a SEP temp readout before one of you guys leaves there?

167:55:45 Cernan: Can you get that (SEP) on that side, Jack.

167:55:47 Schmitt: I will.

167:55:48 Cernan: (To Parker) Should have TV.
 167:55:49 Parker: Rog. We have it, and I'm sure that Ed (Fendell) would like a good dusting job up front.

[TV on. Jack is at the SEP; Gene is leaning over the instrument panel from beside his seat.]

167:55:55 Schmitt: Well, there's so much...
 167:55:59 Cernan: I'll dust it if you can't read it.
 167:55:59 Schmitt: ...dust.
 167:56:00 Cernan: I'll get it.
 167:56:01 Schmitt: I've got it.
 167:56:02 Cernan: I'll get it.
 167:56:03 Schmitt: (I'll wiped the dust of the SEP) just over the gage. It's about 125 on the SEP.
 167:56:10 Parker: Okay. Copy that.
 167:56:11 Schmitt: Boy, everything is really bad now. The (replacement) fender warped.
 167:56:14 Cernan: Yeah, the fender dug under. See if you can straighten it out.

[Fendell pans counterclockwise, past Jack who may be trying to put some fore-aft creases in the fender to prevent the back end from folding under.]

167:56:18 Parker: Okay, and leave the covers...
 167:56:18 Cernan: Okay. Amp hours, 82 and 80. Battery, 122 and off-scale low. Forwards are 210, 240; Rears are 225 and 220.
 167:56:41 Parker: Okay. We copy that.
 167:56:43 Cernan: That's just a sample of the kind of dust we would have got, Jack, if we hadn't of had that fender yesterday. Fender's almost worn out.

[When the replacement fender was installed, the map sheets were quite stiff; they no longer are.]

167:56:51 Schmitt: Can you get a (lens) dustbrush, and let's check our cameras.
 167:56:55 Cernan: Stay where you are, and I'll give you a zap-a-reen-o, wherever you are. (Pause)
 167:57:13 Schmitt: Okay. (Pause) Got it?
 167:57:16 Cernan: Yup.
 167:57:17 Schmitt: Okay, how many bags do I have.
 167:57:19 Cernan: I don't know, but I've got a lot of dusting to do here.
 167:57:22 Schmitt: Do you have a lot of bags?
 167:57:24 Cernan: Yeah. I must have...I've got four of them is all.
 167:57:27 Schmitt: I'd better change my bag (that is, get a new pack of sample bags to hang on his camera).
 167:57:31 Cernan: Can't even read the Rover.
 167:57:33 Schmitt: Yeah. I have an empty bag (SCB) on me now, right? Collection bag?

167:57:36 Cernan: Empty. (Pause)
 167:57:44 Parker: Okay, 17...
 167:57:44 Schmitt: Don't know how much time do we have here?
 167:57:46 Parker: Okay, 17. We're looking at a nominal
 Station 9 here. You've got about 25 minutes remaining.

[Fendell pans past Gene, who has the large dust brush in hand, headed for the LCRU.]

167:58:01 Schmitt: No such thing as a nominal station any more.
 167:58:03 Parker: This may be the first and only one of the traverse.
 167:58:09 Schmitt: The geology won't let it be nominal. Okay, I've got some new (sample) bags, Bob.
 167:58:13 Parker: Okay. We copy that, Jack.
 167:58:15 Schmitt: And I guess I'm pretty good on film.
 167:58:17 Parker: Okay. And you're going to get a radial sample here...
 167:58:19 Schmitt: Well, maybe I'm not.
 167:58:19 Parker: ...and so you might check your Rover sample(r) (the LRV sampler) bag supply.

[Fendell reaches the counterclockwise stop and reverses direction. The cuff checklist pages pertaining to Van Serg are LMP/CDR-21, 22 and 23. The accompanying plan map of Station 9 shows the position of the Rover relative to the rim.]

167:58:25 Schmitt: That's right. I want to take that.
 167:58:27 Parker: And you might give me frame count or check it to make sure you're okay.
 167:58:34 Schmitt: I just did, and it's 123.
 167:58:35 Parker: Okay, good enough.
 167:58:41 Cernan: (Calling to Houston) How do you want the SEP blankets?
 167:58:43 Parker: Leave them closed, please, Gene...
 167:58:45 Schmitt: Open, I think.
 167:58:45 Parker: ...as closed as they'll get.
 167:58:47 Schmitt: Closed. (Pause)
 167:58:53 Cernan: We been riding with this thing off?
 167:58:55 Schmitt: What?
 167:58:56 Cernan: SEP?
 167:58:58 Schmitt: Yeah, it should be off.
 167:58:59 Cernan: Yeah, it is. Doesn't seem like it'd get much data that way. Even if it's hot.
 167:59:05 Parker: Yes, but it's automatic...
 167:59:06 Schmitt: I guess they're worried about getting it so hot it...
 167:59:07 Parker: It shuts itself off when it gets above 108, so it's no good anyway.
 167:59:13 Cernan: Are you kidding? Oh, boy.
 167:59:17 Parker: We've been hoping all day. It's been off all day, since Station 6. We've been hoping that it would

cool down so that we could get some more data, but it's not, obviously.

167:59:27 Cernan: It's not going to make it, Bob.

167:59:29 Parker: That's obvious by now.

167:59:33 Cernan: That's a shame!

167:59:34 Schmitt: (Changing subjects) This is starting to look like a (U.S.) Geological Survey expedition. The vehicles are all covered with dust. (Long Pause)

[Fendell examines a small, blocky-rimmed crater near the Rover.]

168:00:03 Cernan: Oh, look what's in there. (Long Pause)
I don't think I can read that unless I dust it with a lens brush. (Pause)

168:00:32 Schmitt: Okay. Get my...(Pause)

168:00:43 Cernan: Okay, can I get by you here? (Does) my bag (that is, his SCB) look all right to you?

168:00:49 Schmitt: Yeah, it's still closed.

168:00:51 Cernan: Okay.

[Fendell finds Jack at the gate; Gene at his own seat.]

168:00:53 Schmitt: Okay. What are we going to do here? (Consulting checklist) We're going to go up there and sample on the rim; look at the walls and the floor, and miscellaneous, and...

168:01:07 Cernan: Well, we are on the rim (garbled).

168:01:08 Schmitt: ...then you're going to take 500 millimeters when you get back to the Rover while I do a radial sample.

168:01:16 Cernan: (Flipping a checklist page) Okay.

168:01:17 Schmitt: But the first thing we do is go up to the crater. Bob, I think the mantle objective here really is immaterial, because the blocky ejecta around the crater covers...Oh, boy...

168:01:40 Schmitt: (Stepping back from the Rover to look around) Well, it looks like it extends several hundred meters out from the rim. Say a couple of hundred meters.

168:01:50 Parker: All right. Copy that, Jack.

168:01:52 Schmitt: We're pretty close to the rim.

168:01:55 Parker: Yeah, we can see that.

[Gene get the gnomon from behind his seat and then gets the dust brush from under his seat and brushes the gnomon, trying to clean the color chart and the grey scale. After brushing for a moment, Gene taps the color chart with the brush to get some more dust off.]

168:02:01 Schmitt: I'll go up on the rim, Gene, and see what we've got. (Long Pause)

[Gene stows the dust brush and goes to the gate.]

168:02:23 Schmitt: (Singing) "Tiptoe through the tulips.
Du-de-du-du, Du-de...
168:02:26 Parker: Okay. Let's get Grav (TGE) before you
guys leave.
168:02:31 Cernan: (Cheerfully) I'm getting it right now!
Let me see; anything else you want me to do while I'm here?
168:02:37 Parker: Negative.
168:02:44 Schmitt: Sure look like shocked rocks to me.
(Pause)

[Gene goes to his seat, gets the tongs and attaches them
to his yo-yo.]

168:02:53 Cernan: Lot of glass splattered on some of these,
Jack.
168:02:55 Schmitt: Yep. (Pause) We might even find some
shatter cones. But don't tell anybody. (Pause) Well, I'll
say one thing for old Van Serg: it's blocky. Whoo!!
168:03:22 Cernan: (At the gate) Mark. Gravimeter.
168:03:24 Parker: Copy that.

[Gene goes past the front of the Rover, headed for the
crater rim.]

168:03:30 Schmitt: Bob. This is about...I think this is the
only clearly...(Pause) Well, I won't even say that. This is
at least a large, blocky-rim crater. But even it has the
mantle dust material covering the rim, partially burying the
rocks. And it's down on the floor, as near as I can tell,
and on the walls. The crater itself has a central mound of
blocks that's probably 50 meters in diameter - that's a
little high - 30 meters in diameter.

[Fendell finds Jack, standing on the rim; Gene has
almost reached him.]

168:04:27 Schmitt: Many of the blocks are...
168:04:30 Cernan: (Arriving at the rim) Holy Smoley!

[Cernan - "This is recall to me. This I've seen before.
We're just over the rim of the crater."]

[Schmitt - "You can remember walking up and, the first
time you look in the crater, there's a lot more crater there
than you think there is. I remember Van Serg pretty well."]

[Gene and Jack will both take pans of the interior of
the crater. Jack's consists of frames AS17-142-21798 to
21824 and will be taken at 168:20:21. 21802 shows the mound
at the bottom of the crater.]

168:04:31 Schmitt: ...intensely shattered in that area, as
(are) the ones that are on the walls. I don't see any sign
of organization to the blocks in the walls, right now.
There's a possibility that, on the west wall, there's an
indication that there's slightly darker grey rocks starting

about halfway down the crater. And that level is coincident with what appears to be a bench on the northwest wall. And hints of that bench - it's not continuous - but hints of it are around on the north wall and, I think, right below us. Yeah, on the southeast wall. (Pause) The rocks are pretty badly broken in many cases. Well, I haven't seen any real glass yet. Yet. (Pause) We'll start looking at them a little more carefully. Some of them...That looks like a breccia right there in front of us.

[Gene has put the gnomon down and is taking cross-Sun "before" pictures AS17-146-22413 and 22414. Jack is taking down-Sun photo AS17-142-21791.]

168:05:54 Cernan: Yeah. There's some interesting patterns on the surface. (Pause)

[Gene starts to move in before Jack finishes his down-Sun picture. He may be having trouble with either the f-stop or focus.]

168:06:00 Schmitt: Stand by. Wait, wait, wait. I keep...Aw! (Pause) Sorry, Geno, but...

168:06:18 Cernan: Okay?

168:06:19 Schmitt: (Turning toward the Rover) (I'd better take a locator. Afraid I haven't been doing my duty on locators, occasionally. (Pause)

[AS17-142-21792 to 21794 are Jack's locators to the Rover.]

168:06:40 Cernan: (Garbled) that?

168:06:41 Schmitt: Yup. I got it.

[Gene has moved beyond the rim crest and is now only visible from about the shoulders up.]

168:06:45 Schmitt: Okay, Gene's tearing apart one of the...

168:06:49 Cernan: Here. There you go.

168:06:50 Schmitt: ...very intensely fractured rocks. And it comes off in small flakes. Let's get this one, because this will be the best oriented one for documentation. Plus, why don't you get that one you've got inside there?

168:07:05 Cernan: Yeah, I am.

168:07:08 Schmitt: (Holding a sample in his scoop) Got a bag?

168:07:14 Cernan: Bag 568 is a fragment from the surface.

168:07:20 Schmitt: Yeah, that's a corner, I think, off the block that Gene documented here.

168:07:25 Cernan: Yeah; it is.

168:07:27 Schmitt: (Presenting his SCB) We'll get another sample that'll be from inside the block. (Pause)

168:07:39 Cernan: (I can) get it with this (the tongs) real easy. (Pause)

[Jack gets another sample with the scoop.]

168:07:49 Cernan: Here's a whole big...We ought to take that just as is. (Pause) Well, put a bag around one end if we can. Here, the other end is smaller.

168:08:01 Schmitt: Yeah (garbled)...

168:08:02 Cernan: Let me hold this end. Let me hold it, and you put the bag on. (Pause) That's breccia, too.

That's...

168:08:08 Schmitt: Well, it's...

168:08:09 Cernan: Well, see that? See the white fragments in there?

168:08:11 Schmitt: Yeah. It certainly...

168:08:12 Cernan: It's got a lot of very small...

168:08:13 Schmitt: It looks like this big one over here.

(To Parker) You know, it might be that these might be pieces of the projectile. I don't know. 'Cause it doesn't look like...It's not subfloor. (Pause) (To Gene) Okay. Pin it down. (Pause)

[Schmitt - "It's a big rock - too big for a bag. The bag's on one end and I'm trying to get it down in the bottom of his SCB so that the bag stays attached."]

[Cernan - "We did that a number of times, to protect or identify a rock."]

168:08:35 Cernan: Well, that's wrapped in...

168:08:37 Schmitt: If you put it end down, it may stay in the bag.

168:08:42 Cernan: I doubt it.

168:08:43 Schmitt: What's the number?

168:08:45 Cernan: It's 480, and it's a relatively tabular shape, and it's about...

168:08:54 Schmitt: (Presenting his SCB) And it's going to ...

168:08:55 Cernan: ...10 inches long.

168:08:56 Schmitt: And it's highly friable. It breaks apart.

168:08:59 Cernan: Oh, not so much.

168:09:01 Schmitt: In small chips. Well, you did it with your hands there. I call that "being friable", compared to what we've seen anyway.

168:09:10 Cernan: Okay, and let me get an "after" or two.

[AS17-146-22415 to 22416 are Gene's afters.]

168:09:11 Schmitt: Let me get a soil right over here.

(Pause; having difficulty with the scoop head again) Okay. The soil next to the boulder, down to about 3 centimeters, is in bag 569.

168:09:35 Parker: Copy that.

168:09:37 Schmitt: (To Gene) Okay. (To Parker) And the soil and chips about two-thirds of a meter from the boulder...(To Gene) Get another one?

168:09:50 Cernan: Yeah

168:09:56 Schmitt: (The samples) are in bag 570.

168:09:59 Parker: Copy that. (Pause)

168:10:10 Cernan: Okay?

168:10:11 Schmitt: (Presenting his SCB) Let me get over here. (Pause) You're going to step on your gnomon there.

168:10:15 Cernan: Oh, I wouldn't step on my gnomon. I'm going to get this one crimped.

[Gene seals this sample bag by twisting the tabs, rather than flipping the bag.]

168:10:24 Schmitt: Okay. (To Parker) There, very clearly, is a central mound. And now that we've looked at this one, the mound looks like it's composed of grey fragment breccias much like what we've just sampled...

168:10:37 Cernan: Stay still.

168:10:38 Schmitt: ...Dark grey. And again it might be related...

168:10:42 Cernan: Jack.

168:10:43 Schmitt: (Moving out of the way so that Gene can take "after" photos AS17-146-22417 and 22418) Oh, excuse me. I didn't hear you. (Finishing his prior thought)...related to the projectile. Now, we've got to see if there is subfloor up here, or whether we're dealing with another unit somewhere. (Pause) Got your "after".

168:10:53 Cernan: Okay. I don't see any...

168:10:58 Schmitt: Well, the more coherent rocks...This looks like subfloor.

168:11:00 Cernan: I don't see any orange material either.

168:11:02 Schmitt: Not yet. (Pause)

168:11:08 Cernan: This particular rock we've sampled has tabular fractures (that is, a set of parallel fractures), and in one-half of the rock, they are definitely oriented. (Pause)

[They both look around, looking for Shorty-like features and/or pieces of subfloor gabbro.]

168:11:26 Schmitt: Boy, I'll tell you, I don't...(Pause) (To Parker) There's more dust on these rocks. It's harder to see a fresh surface. They're not as clean. (Pause)

[Jack moves farther beyond the rim crest and goes out of sight.]

168:11:40 Schmitt: That's subfloor.

168:11:42 Cernan: Lookit. And even the floor of the crater is mantled down there.

168:11:44 Schmitt: You know, that seems...Yeah. That seems like a...what you got? A piece of glass?

168:11:51 Cernan: Yeah, I think it is glass. At least it's glass covered. Just glass covered. Houston, I've got an undocumented sample. It's about 2 meters west of where we just sampled. It's a glass-covered, oh, baseball-size rock in 571.

168:12:09 Parker: Copy that. (Pause)

[Jack moves southwest, parallel to the rim, his head and shoulders coming into view.]

168:12:14 Schmitt: A lot of these blocks up here, Houston - particularly the more fractured ones, but even some that aren't - are a grey-matrix, fragment (means 'clast') breccia. And it looks like, really, the fragments are quite fine. On the rim anyway, we haven't seen any large fragments. The largest I've seen is about 2 centimeters. But down in the (central) mound you can see some fragments that are probably half a meter in diameter.

[Schmitt - "For clarification, in this paragraph my use of the word 'fragment' is confusing. I had started to use 'fragment' when I should have been using 'clast'. A 'fragment' is sort of a loose piece of rock lying around; these were pieces in a breccia, so they're 'clasts'. I never found out what the light-colored clasts are; I don't think I ever looked into it. There was a mixture of material thrown from the sides of the North Massif and the subfloor-(derived) regolith, so the light-colored clasts are probably the pulverized and reworked material from the North Massif bound up in a matrix of regolith breccia."]

[According to the Preliminary Science Report, the Van Serg "soil breccias" contain "a variety of clasts, including basalts, several types of glasses, some breccia fragments with accretionary coats, and a variety of recrystallized feldspathic rocks presumed to be derived from the surrounding highlands." The caption to figure 7-4 suggests that at least some of "light-grey" clasts are the pieces of feldspathic breccias.]

168:12:57 Cernan: (Having joined Jack) Jack, are you going around that rim of the crater up there?

168:13:00 Schmitt: I was just looking at rocks.

168:13:01 Cernan: Well, okay.

168:13:02 Schmitt: We...

168:13:03 Cernan: I want to get a pan before I leave back there.

168:13:05 Schmitt: Oh, yeah. We need to see if we can get some of the subfloor. I'm not sure I understand what's happened here, yet. This should have brought up subfloor according to the theory, and it hasn't.

[Because they are well out on the valley floor and shouldn't be standing on more than a few meters of regolith

and/or mantling, an impact the size of Van Serg should have brought up subfloor gabbro.]

168:13:16 Cernan: That looks like some of the...Look at some of the breccias, the blue breccias with the big old slabby white...(Look at) the fracture face with the white inclusions.

[Schmitt - "What Gene's referring to, here, is that this stuff looked a little bit like the blue breccias up on the North Massif (at Stations 6 and 7) because, in appearance, it was dark, bluish-grey with the white clasts. As it turns out - and I don't remember if we came to the conclusion before we left (the Moon) or not - these were those regolith breccias."]

168:13:25 Schmitt: Down there.

168:13:26 Cernan: Yeah, down in the floor itself.

168:13:28 Schmitt: Yeah, it has that appearance all right. Hey, Gene...

168:13:30 Cernan: Do you see that rock...

168:13:30 Schmitt: (Garbled)

168:13:31 Cernan: ...that rock that's fractured in sort of a pyramid shape down there? Out here on the right? The right end of the floor down there. That big one?

168:13:39 Schmitt: Yeah.

168:13:40 Cernan: It's sort of pointing west...

168:13:41 Schmitt: Yeah.

168:13:42 Cernan: ...(Correcting himself) Pointing east. That's a unique fracture, isn't it?

168:13:45 Parker: Roger, 17...

168:13:45 Cernan: And there's another one that's fractured almost in a...(Stops to listen to Parker)

168:13:46 Parker: ...And we'd like to be moving from here in about 10 minutes, so we probably better be trending back toward the Rover, unless you're seeing something really great out there.

168:13:54 Schmitt: Well...Hey, Bob, we ought to find out whether or not...(We ought to find out what the rock is here, if you've got a little time.

168:14:02 Cernan: Jack, let me to put this in your bag and start...I'm sorry.

168:14:02 Parker: Rog. You got 10 minutes. I'm just telling you to start thinking about getting back.

168:14:10 Schmitt: Yeah. We're always thinking that way.

[Jack finally presents his SCB to receive Gene's glass sample.]

168:14:11 Cernan: Okay, Bob. One thing I noticed we do uncover. There's a lot of, oh, 2-, 3-, 4-millimeter-size fragments of glass we're kicking up all over the place.

168:14:23 Schmitt: Yeah.

168:14:24 Cernan: Little glass balls.

168:14:25 Schmitt: (Moving southeast along the rim crest)
Hey, Gene?
168:14:26 Cernan: Almost like Pele's (Tears)...

[Pele's Tears are small drops of volcanic glass, a reference to the Hawaiian volcano goddess and to geology field trips Gene took to the Big Island of Hawaii.]

168:14:27 Schmitt: Gene?
168:14:28 Cernan: Yeah.
168:14:29 Schmitt: Can you come over here? I think there's some subfloor here. We ought to...
168:14:33 Cernan: Okay.
168:14:34 Schmitt: We ought to try to document it. But I tell you, most of the rocks are the fine-fragment breccias.
168:14:40 Cernan: Let me see if I can't get one of those little...
168:14:42 Schmitt: There's some glass. Hey...
168:14:43 Cernan: (Stopping about 4 meters northwest of Jack) You see, if they're like Pele's...
168:14:45 Schmitt: Okay.
168:14:46 Cernan: ...Eyeballs or whatever they are.
168:14:49 Schmitt: I think we can get some over here. If you're careful coming over here, we can get glass that looks like it may have crystallized (that is, solidified) in place here.
168:14:55 Cernan: (Joining Jack) Okay. I'm talking about those little balls, too.
168:15:01 Schmitt: See that...Whoo, take it easy...Take it easy.
168:15:03 Cernan: Where are you? Right there?
168:15:04 Schmitt: (Pointing with the scoop) Yeah, but put your gnomon right over here, and we can get (indicating) that for glass and that for subfloor.
168:15:10 Cernan: Okay. Let me...
168:15:11 Schmitt: But I'm not sure that is. It may be breccia. Everything is covered with dust here, and it's hard to tell the types. Most of the rocks we're seeing are breccias. (Pause) Make sure that glass is in your stereo. (Long Pause)

[Jack takes down-Sun picture AS17-142-21795; Gene gets cross-Sun stereo pair AS17-146-22419 and 22420.]

168:15:43 Cernan: (Finished with his stereo pictures)
Okay.
168:15:45 Schmitt: Be careful with it. (Pause)

[Jack turns toward the Rover to take locator photos AS17-142-21796 and 21797; Gene moves in with the tongs to collect the sample.]

168:15:48 Schmitt: Oh, shoot! (Long Pause)
168:16:04 Cernan: I don't have any bags so...

168:16:06 Schmitt: (To Parker) Okay, the glass looks like a glass agglutinate. (Pause)

[Jack takes the glass sample, but drops it.]

168:16:12 Schmitt: Oh, no!

168:16:15 Cernan: It break?

168:16:17 Schmitt: (Relieved that it didn't break) Good. I think that will survive going back (to Earth) now. (Pause)

[Gene retrieves the sample with the tongs and Jack takes it again.]

168:16:24 Schmitt: Okay. It's a frothy glass agglutinate; it's going to be in bag 481.

168:16:37 Parker: Copy that.

168:16:40 Schmitt: And it looks almost like a cowpie-type of bomb, Bob, if you'll pardon the expression.

168:16:50 Parker: I will. I don't know about anybody else.

168:16:50 Schmitt: Although it's not flattened. It's an aggregate of glass in...Or, it's a pile of about four fragments, much like the one we're sampling. (Pause)

168:17:10 Cernan: Jack, we want to get a good scoop sample here. Maybe can we get some of those little fine pieces of glass around.

168:17:19 Schmitt: And it (the agglutinate) looks like it's in place from the day it was born.

168:17:20 Parker: Copy that.

[Fendell de-zooms and it's hard to see any detail of what they are doing.]

168:17:21 Cernan: Oh, God, ding dumb! (Pause)

168:17:27 Schmitt: I'm having a hard time with this one.

168:17:31 Cernan: (I'll get) a piece of that rock right behind it. (Pause) (Garbled) (Pause)

168:17:45 Schmitt: Want a bag? (Pause)

[Fendell zooms in again. Gene gets a sample bag from Jack's supply.]

168:17:48 Cernan: Yup. Let me turn around. (Pause)

168:17:56 Schmitt: (Trying to fit the rock in a sample bag) Just not going to be able to get that one in the bag, I don't think. (Long Pause)

[Schmitt - "The sample was just a little too big for the bag."]

168:18:15 Cernan: Okay, Houston. My sample's in 482. It's a rock, but it doesn't look like subfloor. It looks like the blue-grey material we've been seeing...the breccia-type material.

168:18:27 Schmitt: Yeah.

168:18:28 Cernan: I don't think there's any difference (if the sample bag is sealed or not). (Pause) Got it in! (You) might just as well throw them in my bag. (Pause)

[Gene presents his SCB.]

[Cernan - "At this stage of the game you get frustrated trying to use your hands. Not that the enthusiasm isn't there. During the first EVA you probably would have shoved it in there but it gets to the point where its difficult. Your dexterity is not what you want it to be. I think you're probably more efficient with your hands; you learn to adapt with your hands as well as with anything else, but now you're fighting (fatigue)."]

[Schmitt - (To Gene) "In terms of what you could do ungloved, how much less efficient are you?]

[Cernan - "Less than half."]

[We then asked Gene if, compared with the start of the EVA, he was taking longer to do tasks or had lost the ability to do certain tasks.]

[Cernan - "I don't think you lose your ability; you just get frustrated. You're probably smarter in the use of your hands. You know what you can't do, so you don't try to do those things. So you say, 'Well, it's almost done, so I'm not going to worry about the rest of it.' I can almost hear the frustration. Three consecutive days, twelve hours a day in a suit, is a long time."]

168:18:42 Parker: Okay, and...

168:18:43 Cernan: You want a scoop out of here, though, Jack.

168:18:45 Parker: ...17, why don't we get that scoop sample as the first sample of Jack's radial sample, 17?

168:18:54 Cernan: Okay. (To Jack) That's right. You're getting a radial sample. That's fine. I forgot you were doing that.

168:19:00 Schmitt: Oh, man.

168:19:01 Cernan: That's all right, Jack. That won't come out. Just put it in there. (Pause)

168:19:12 Schmitt: (Stowing the sample in Gene's SCB) Oh, boy. Okay. Let's let that one be the last...

168:19:16 Cernan: (Handing Jack the other sample) Here's one.

168:19:17 Schmitt: Well, okay. (Pause) Those are the last ones that you can take (in the CDR SCB).

168:19:24 Cernan: Gonna lock?

168:19:27 Schmitt: No, I don't...Stand by. I'm working on that. (Pause)

[Gene takes a step farther away from the Rover, a maneuver that puts him a bit lower than Jack and makes working on the SCB a bit easier.]

168:19:37 Schmitt: Okay. (Pause) Okay, before you go back...

168:19:47 Cernan: I got to get an "after" a picture here. And I want to get a pan of this thing (the crater). We can get a stereo pan as you start your radial sample.

[They will each take a pan, the distance between them giving a wide stereo of the crater. Gene's after, cross-Sun stereo pair is AS17-146-22421 and 22422.]

168:19:57 Schmitt: Yeah. You take the "after" from there, and I'll go over here and...

168:20:04 Cernan: Okay. You...

168:20:05 Schmitt: Well, wait a minute.

168:20:05 Cernan: ...you need the gnomon?

168:20:06 Schmitt: No.

168:20:07 Cernan: Okay. I'm going to go over behind me and take part of the stereo.

168:20:10 Schmitt: Where are you going to take your pan? Let me see.

168:20:12 Cernan: From behind me, where we were.

168:20:14 Schmitt: (Moving 15 feet south of Gene, along the rim crest) Well, I think I'll just take my radial right from here to the Rover.

168:20:17 Cernan: That's great. That's great. Just do that, and then you'll be right back at the Rover.

168:20:21 Schmitt: (Planting his scoop) And I'll take my pan from here, so you...(Long Pause)

[Gene moves northeast, along the rim, using the loping, foot-to-foot stride; Fendell follows him. AS17-142-21798 to 21824 is Jack's Van Serg pan. 21802 shows the central mound in the crater and 21811 to 21813 show Gene taking his pan. The manmade object is 21804 to 21806 is a sample bag dispenser.]

168:20:42 Cernan: (Now skipping) Man, there's about four or five different modes of travel out here.

[Comm Break. Back in Houston, the Flight Director is told that Jack's remaining oxygen supply will limit the EVA to between 7 hours 15 minutes and 7 hours 30 minutes. Gene starts a photo pan; Fendell pans the TV clockwise, away from him. Gene's pan photos are AS17-146-22423 to 22450.]

168:22:06 Cernan: I don't believe it.

168:22:08 Schmitt: What?

168:22:09 Cernan: I think I'm out of film.

168:22:11 Schmitt: You're out of film? (Pause)

168:22:15 Cernan: 150. And it stopped clicking. Jack, I didn't get the rest of that crater down there.

168:22:22 Schmitt: Okay.

168:22:23 Cernan: I only got it (from) 12 o'clock (that is, down-Sun) and around (through north). Well, shucks.

168:22:31 Schmitt: I can get it. (Pause)

168:22:34 Cernan: Well, here's where I...

168:22:36 Schmitt: Well, I'm going to be out of film, too, here before long.

168:22:38 Cernan: Okay. Just don't worry about it then. Just press on with your radial samples.

[Fendell examines individual boulders.]

168:22:41 Schmitt: I got a good pan over here. Did you get the crater at all?

168:22:44 Cernan: I got the right (north) half of it and probably two-thirds of it, so I'm just going to have to let that do. (Pause) Okay. I'm going to see if I can get some 500's while you're doing that (radial sample).

168:23:02 Schmitt: Hey, this isn't going to be an ideal radial sample; but it will have to do. (Pause)

168:23:14 Cernan: (Singing as he heads back to the Rover, using the kangaroo or bunny hop) Hippity-hopping over hill and dale. Dadadadada. Dada. Dada. Dadadada, Dada. (Pause)

[Gene previously sang this song at Station 5 at 146:50:40, also as he was making his way back to the Rover. Fendell finds him halfway back.]

168:23:39 Cernan: Bob, would you tell me what your primary desires are again on the 500, based upon what we have?

[Gene reaches the Rover; Fendell zooms in on Jack, who is still at the crater rim.]

168:23:47 Parker: Okay. The primary desire will be the North Massif: the blocks, and the (boulder) trails.

168:23:55 Cernan: Okay!

168:23:59 Parker: And while you're at the Rover, they want you to take the gravimeter off again, and we'll get another "Rover"... (Correcting himself) Well, another surface measurement here, as well, to check against the "Rover".

[Gene has taken a measurement with the TGE on the Rover and will now make one with the TGE on the ground to see if there is any significant difference. The second measurement is 670,057,101 at 168:29:42.]

[Jack gets his scoop and climbs to the rim, having been slightly beyond the crest.]

168:24:16 Cernan: Okay! (Pause) Here's a reading. I think I owe you one of those, don't I?

168:24:23 Parker: Roger.

168:24:25 Cernan: 670, 037, 801; 670, 037, 801.

168:24:32 Parker: Copy that.

[Jack plants the scoop and starts to use the LRV sampler which is attached to his yo-yo. As Parker indicates at 167:57:40, because the radial sample is nominally a solo

activity, Jack had planned to use the LRV sampler. This is the reason he is wearing it here.]

[Schmitt - "About the only time I ever used the yo-yo was for my LRV sampler."]

168:24:37 Cernan: I didn't know we were going to do both of these things. I thought we were going to do one or the other. But, if we're going to do it, we might as well do it right! (Pause) Mark it. It's flashing. (Pause)

[Jack takes AS17-21825 and 21826, which show Gene at the Rover, taking the TGE off the back. He probably intended these two photos as locators.]

168:25:06 Schmitt: (Taking the bag off the LRV Sampler) Okay, bag...Standby. 52 Yankee is at the rim crest.

168:25:21 Parker: Copy that. (Long Pause)

168:25:35 Cernan: Well, I'll tell you what I'm going to do. I'm going to use the Rover to steady the 500, and see what happens. (Long Pause)

[Jack puts the sample in his shin pocket, gets the scoop and moves northeast, rather than radially. Gene's 500mm photos of the North Massif are AS17-139-21212 to 21238. 21219 is a good photo of one of the outcrops. 21230 to 21238 are photos of the base of the mountain. 21239 to 21248 are shots of Wessex Cleft and the Sculptured Hills. 21249 to 21268 are photos of the North Massif boulder tracks. 21255 is probably the best of these.]

168:26:21 Schmitt: (To Gene) Oh, I should have let you take this scoop back. Oh, no!

[The scoop head has just come off the extension handle.]

168:26:26 Schmitt: Oh, me! Well, shoot! This (radial sample) isn't working out too well, Dr. Parker.

168:26:40 Parker: Say again there, Jack. (Pause)

[Jack leans on the extension handle to retrieve the scoop head. As he rises, he has to run forward several steps to maintain his balance.]

[Schmitt - "I used the extension handle as a prop so that I could reach down, in a dynamic fashion, grab the scoop and regain my balance. I did avoid sticking the female end of the extension handle in the ground. I didn't want to fill it with dust, so I turned it around and used the handle end. This exercise may be an indication of me getting tired and getting a little bit careless in the way I retrieved that scoop because, if I'd tripped, I'd have been on my face...I would have been in Van Serg. Either it was a very dumb thing to do or I had a hell of a lot of confidence in my ability to do it. I suspect it was the former."]

[Cernan - "I think that, all through this station, you can see us getting tired. You can go back to the start of the station and see where everything was going 'normal'. But, here, we're saying thing like 'Well, it'll have to do.' And we wouldn't have been saying that earlier."]

[Schmitt - "We sort of hit a wall here. We'd been out for five hours and, while I don't remember it so much in the first EVA, in the second we had this same emotional up and down. I don't know whether we'll come back up again, here. But we did on the second EVA. We went down (emotionally) at (Station) 3 and back up at 4 and then there was a let down again (during the drive from Shorty to Victory) and then back up at 5."]

[Cernan - "I think this is a combination of the amount of work we did on this EVA on those hillsides and of three solid days of working - and not the greatest amount of sleep. I would predict that if we went out on a fourth day or a fifth day, the total slope (that is, the average trend of their emotional state) - not the up and down of a single EVA, but the total slope - would start darting back up. Who knows? I'm not tired of watching what we were doing, but I sympathize with the amount of effort we were putting out on this third day."]

[Schmitt - "This had to be our most physical day. We rode (and rested) on the Rover for a solid hour getting out to Station 2 on the second day and, here, we only had fifteen or twenty minutes between demanding stations."]

[Cernan - "And they were demanding stations. We haven't had a piece of level ground (during this EVA) until now "]

168:26:53 Schmitt: This isn't working out too well. I've got to get rid of this scoop.

[Jack strides back to the Rover.]

168:26:57 Cernan: Just set it there and take your sample. We'll get it.

168:27:01 Schmitt: I'll take the samples going back. (Long Pause)

168:27:41 Schmitt: (At the Rover) Just like in training, the scoop doesn't stay locked to the extension (handle). (Long Pause)

[Fendell pans the TV camera to Gene, who is still using the 500 mm camera.]

168:28:22 Parker: (After a great deal of discussion in Houston) Okay, 17. We'd like you to press on. We'll abort the radial sample. We'd like to leave here immediately, if not sooner, to head for Station 10. Enough of the 500 millimeters, Gene. And we'll give you some information here on (film) mags. We need the gravimeter put back on the Rover, if you haven't already. If it's on the ground, we didn't get the mark, but it's probably done by now. And

we're going to take the DSEA (the SEP data storage unit) out of the tape recorder here, and we'd like to get that all done pronto.

[Gene has put the lens cap on the 500 and is now putting the camera under his seat. He did give a mark on the gravimeter, at 168:24:37.]

168:29:01 Cernan: Okay. 85 is the mag count on the 500.
 168:29:04 Parker: Copy 85 on the 500.
 168:29:06 Schmitt: I think that's a smart move, Bob. I don't think the radial sample's going to tell you much here.
 168:29:11 Parker: Okay. Let's take a...
 168:29:14 Schmitt: I don't under...I...I...
 168:29:16 Parker: Go ahead. (Pause)
 168:29:21 Cernan: Jack, you ought to get a scoop of that dirt, though.
 168:29:24 Schmitt: Well, there's...
 168:29:25 Cernan: One scoop.

[Schmitt - "Here, I was probably thinking about the sample I'd taken up on the rim."]

168:29:26 Cernan: We don't have a scoop of it, do we?
 168:29:27 Schmitt: Look what's underneath it.

[Schmitt - "While he was talking, I must have taken a swipe into the dirt near the Rover."]

168:29:29 Cernan: Well, I don't know what's underneath it.
 168:29:30 Schmitt: It's white.
 168:29:31 Cernan: Well, I wanted to make sure we got some of those small glass balls.

[Cernan - "I was still thinking about getting some of the glass balls. I wasn't impressed by the white."]

[Schmitt - "I don't think you'd seen it yet. You were on one side of the Rover and I was on the other. In fact, I think I remember that."]

[Fendell pans clockwise.]

168:29:36 Schmitt: Yeah, we'll get a scoop of it.
 168:29:38 Cernan: (Putting the gravimeter on the Rover) Up on the top.
 168:29:39 Parker: 17, we're anxious for you guys to get going.
 168:29:42 Cernan: Okay. Here's your gravimeter reading from the surface; 670, 057, 101; 670, 057, 101.
 168:29:55 Parker: Copy that.
 168:29:56 Cernan: You want me to change my mag at the next station?
 168:29:59 Schmitt: Come here, Gene, quickly. We can't leave this.
 168:30:02 Cernan: What do you got?

168:30:06 Schmitt: This may be the youngest mantle over whatever was...

[Schmitt - "While Gene was reading the gravimeter and was talking to Bob, I must have started to dig a trench. I could dig those trenches pretty fast. In what - maybe twenty seconds - I was able to get several scoops out and I had a flat wall trench."]

[It wasn't obvious at this point in the review whether Jack had been able to get the scoop back on the extension handle. Momentarily, Fendell will find them and, as soon as he does, it is immediately obvious that Jack is using the scoop rather than the LRV Sampler.]

168:30:09 Cernan: Take pictures of it. I don't have any film.

168:30:11 Schmitt: ...was thrown out of the crater.

168:30:13 Cernan: Take pictures of it. (To Parker) Bob, we've got to take 5 more minutes. We'll be right with you.

[AS17-142-21827 to 21829 are Jack's photos of the Station 9 trench.]

168:30:20 Cernan: What Jack's done is, he dug a trench in a southwest-northeast direction, and he discovered - about 3 inches below, 4 inches below the surface - a very light-grey material.

168:30:37 Schmitt: (To Parker) Possibility here...Careful, Geno.

168:30:40 Cernan: Yup. (Pause)

[Schmitt - (Laughing) It doesn't take much to get your enthusiasm back up. Because, all of a sudden, there's a whole different tone in my voice. It may be a combination of having seen something different and the fact that Houston's now put some pressure on us to get out of there."]

[Cernan - "It also shows that you've got to have someone on the spot to make a decision. They're saying get out and we're saying 'Sorry, guys, we're not going to get out for five minutes because we've got something we think is worthwhile.' That's the way you have to operate. The ground is an advisor; it's a flight planner; it's a lot of things. But you've got to make the decisions of what you're going to do with your time."]

[I then mentioned a conversation with Conrad and Bean in which they indicated that they had trained very tightly to their time line. They had a great deal to do, in a small area, and not much time to be on the Moon. I noted that, on the longer missions, the tasks were not spelled out in such detail and asked for comments.]

[Cernan - "It's a natural maturation of the program. More time gives you more flexibility. But, as Jack mentioned earlier, we never did have a nominal station. They give you

thirty minutes and they want an hour's worth of work. It's just normal. Using the time is never a problem."]

[Fendell finds them west of the Rover. The lighting conditions emphasize that Gene has gotten very dirty by this late in the mission.]

168:30:49 Cernan: Take that crust.

168:30:50 Schmitt: Well, I'm trying to get the upper portion there. There we go. (To Parker) The first 2 centimeters (is going in) bag 483.

168:30:52 Parker: Copy, 483. (Pause)

168:31:05 Schmitt: The next 5. (centimeters)..Ahhh...(Pause)

[Gene gets a sample bag from Jack's camera holder.]

168:31:21 Schmitt: ...in 484. (Pause)

168:31:29 Schmitt: (Spilling about half of the sample)

Augh! Get some?

168:31:30 Cernan: I got quite a bit.

168:31:31 Schmitt: That's enough.

168:31:33 Cernan: I got quite a bit. (Pause)

168:31:37 Schmitt: Here, you got to put that away, don't you?

168:31:38 Cernan: Yup.

168:31:40 Schmitt: (Presenting his SCB) And the next 10 centimeters of the light-grey material, will be, probably, in 486. If we're lucky. (If I can) get it (the sample bag) off. (Pause)

[Fendell zooms in on the trench.]

168:32:00 Cernan: Okay.

168:32:01 Schmitt: I think it is 486, right?

168:32:02 Cernan: Yup. (Pause) 485!

168:32:03 Schmitt: 485. Okay. What did I say (for the prior sample) 483, 484? Okay. (Pause)

168:32:11 Cernan: You with us, Bob?

168:32:12 Parker: Roger. We're with you.

168:32:13 Schmitt: He's mad at us now, (for overstaying the station)

168:32:16 Parker: (Softly, in a friendly tone) How'd you guess?

[Houston has been discussing a possible extension at this station. However, the Flight Director is concerned about tired hands.]

[Schmitt - "While we were doing this sampling, in the background on the video tape we can hear Gerry Griffin acting like a Flight Director. In trying to be objective about what we've seen here at this station, I thought he might have taken hold of the apparent fatigue a little bit sooner."]

168:32:19 Cernan: Okay. The third sample is in 485.

168:32:21 Parker: Copy that.

168:32:24 Schmitt: (Ready to pour the sample) Okay.
 Whoops, sorry.
 168:32:29 Schmitt: (Presenting his SCB) Bob, a possibility here is that this upper 6 inches of grey material; in here, is the latest mantling in the area and the light-colored debris may be what's left over from the (Van Serg) impact.
 168:32:45 Parker: Okay, I copy. I understand. But we'd like to get you going. (Pause) In case you didn't get the clue.
 168:32:51 Schmitt: I know.
 168:32:52 Cernan: We're going. Okay. (Pause)
 168:32:58 Schmitt: All right. What else? Magazines.

[Fendell pans clockwise.]

168:33:00 Cernan: No, we'll change them at the next station. Isn't that right, Bob?
 168:33:02 Schmitt: No, I've got to have some. I got to get some, or I can't take...

[Jack needs to take occasional photos documenting the traverse.]

168:33:06 Parker: Okay, 17. We need Jack to put on magazine Nancy (Apollo magazine 143). And we'd like, Gene, for you to pull out the DSEA tape recorder at this station.
 168:33:18 Cernan: Okay, I need a magazine too, Bob. I don't have any film at all.
 168:33:22 Parker: Roger. That'll be Bravo (Apollo magazine 134, which Gene used during the first EVA) if you change yours here, or you could change it at Station 10.
 168:33:29 Cernan: I'll change it here. It's just as easy while we're in there; (that is, while they have Gene's seat raised to get a magazine for Jack).
 168:33:32 Parker: Okay.
 168:33:35 Schmitt: (To Gene) Okay. You want Bravo, huh?
 168:33:37 Cernan: Bravo. And I'll get the DSEA. (Pause) Bravo was outside there; I saw it.
 168:33:48 Schmitt: There you go.

[Fendell finds both of them at Gene's seat.]

168:33:50 Cernan: Let me get this...Hold it long enough for me to get this (dark slide). Then I can get rid of this all at one time.
 168:33:55 Schmitt: Okay.
 168:33:56 Cernan: (The dark slide falls out) Oh!
 168:33:57 Schmitt: Well, that's all right.
 168:33:59 Cernan: I can't put that back in.
 168:34:02 Schmitt: Got it?
 168:34:03 Cernan: I got Bravo.
 168:34:04 Schmitt: Okay. I got that one.
 168:34:07 Cernan: (To Parker) We lost the dark slide out of Bravo, and it's in the dirt. I'm not going to pick it up.

168:34:13 Parker: All right. Copy that. There's no point in putting it back in. It probably wouldn't go in anyway.
 168:34:18 Cernan: No, not dirty. Okay. I'm changed.
 (Going to the gate) And I don't know what the mag count is, but let me get the DSEA. If this thing is true to form, I'm going to have to get in there...I got to...(Surprised) The bow is tripped! (Pause)

[Schmitt - "I don't know why I remember this, but I think that the DSEA - which was the SEP recording tape - had a locking bolt that came up into a slot with a little winged, butterfly-shaped bow that you screwed down. And I think that what Gene found is that it was just sitting in there - that the bow had tripped."]

168:34:30 Cernan: Well, now what's...Hey, we got some rocks in that big bag. Okay. We're done with the SEP. DSEA is coming out. I hope there's something on it. (Long Pause)
 Oh, Jiminy Christmas. I can't even pick up that big bag to close the gate! (Pause) I've got to trip that latch with tongs or something to lock it.
 168:35:50 Parker: Okay. And, Jack; Houston. Over.
 168:35:56 Schmitt: Go ahead.

[Gene goes to Jack's seat.]

168:35:58 Parker: Okay, we've...
 168:36:00 Schmitt: Go ahead.
 168:36:00 Parker: ...had a change of heart here again, as usual. And we're going to drop Station 10 now that we've hurried you so much, and we're going to get a double core here. And we'd like to get some football-size rocks while you're doing that. But double core here, and then we're going to leave here and go back to the LM.

[Schmitt - "I think that ground is showing some sensible decision-making, here. Their taking new information - namely the white underneath the dark that we just discovered and sampled - and deciding to take a double core here, rather taking pot luck at some other place. A bird-in-the-hand type philosophy."]

168:36:19 Schmitt: You don't want a double core here. I don't think we can do it, Bob. It's too rocky.
 168:36:27 Cernan: (To Jack) You don't think we'll get through that stuff you just trenched?
 168:36:30 Schmitt: Well, I'm afraid there are rocks all through it, Gene. We can try, but...
 168:36:34 Cernan: (Going to the gate) Let's try it.
 168:36:36 Schmitt: Well, I don't like to try things that there's a probability of failure on, if you can...You're just going to lose some time. Okay, mag Nancy is on the LMP's camera.
 168:36:44 Parker: Copy that. (Pause)

[Gene takes the scoop off the extension handle.]

168:36:53 Schmitt: (Looking around) Well, you can see the rock population here, Houston. (Pause) But we can try it.

168:37:09 Cernan: It's all right. If we get a single, we get a single out of it.

168:37:12 Schmitt: (Going around the front of the Rover to his seat) Oh, you're doing it, huh?

168:37:14 Cernan: I've got it started.

168:37:15 Schmitt: Well, you're not even...Okay. Not even going to debate the issue?

168:37:18 Cernan: (Cheerfully) Nope. It takes too much time debating it.

168:37:20 Schmitt: Well, let's see how much time it takes. I hope you're right.

[Schmitt - "I think this exchange is another symptom of my being tired."]

[Cernan - "It was a symptom of being tired. My willingness to do the core had nothing to do with my geologic expectations. I was just saying, "Whatever we're going to do, let's just get on with it."]

[Schmitt - "Had I really been thinking, (I would have realized that) those rocks are so soft you'd go through them (with the core) anyway."]

168:37:24 Parker: Okay. And...

168:37:26 Cernan: Okay, and we need a "lower" out of my bag.

168:37:29 Schmitt: Let me get the core.

168:37:34 Cernan: A "lower" out of my bag is all we need.

168:37:33 Schmitt: Watch it. You're in a crater almost.

168:37:35 Cernan: Yeah I want to get (garbled) for you.

[Jack gets a core tube out of Gene's SCB. Gene is holding an upper section.]

168:37:37 Parker: Okay. We have to have you guys moving in 10 minutes. And we'd like to also deploy EP number 5 here.

168:37:44 Cernan: Okay. I'll start on the (garbled under Jack).

168:37:49 Schmitt: ...(Garbled) the lower? (Pause) This is a lower, right?

168:37:54 Cernan: Yup.

168:37:55 Schmitt: You got an "upper"?

[They connect the core tube sections.]

168:38:57 Cernan: Yeah. (Pause) Why don't you get (seismic package number) 5 out, and I'll start on the core.

168:38:05 Schmitt: I'll get that. And I'll put that right there.

168:38:11 Cernan: (Holding the core in front of the TV lens, fitting them together) Okay. The lower is 50; the upper is 37.
168:38:16 Parker: Copy. 50 and 37.
168:38:21 Cernan: Is that "5", Jack?
168:38:22 Schmitt: Yup.
168:38:23 Cernan: Okay. (Pause)
168:38:31 Schmitt: Why don't you put it up...Well...You put the gnomon away. Put it fairly near that trench. At least there is some documentation there.
168:38:40 Cernan: Yup.

[Gene goes around the front of the Rover; Fendell follows him.]

168:38:41 Schmitt: I'll try to have the pan going while you're doing it. Okay, Houston...(To Gene) Which way you going to drive out of here?
168:38:50 Cernan: I'm driving out of here...
168:38:53 Schmitt: Left or right?

[Jack wants to put the explosives package somewhere where it won't get in Gene's way as they leave.]

168:38:56 Cernan: I've got to go right. I got to go right.
168:39:00 Schmitt: Okay. (Pause) Pin 1 is pulled and safe. Pin 2 is pulled (and) safe. Pin 3 is pulled and safe. (Pause)

[Fendell finds Gene hammering the drive tube, north of the Rover.]

168:39:28 Parker: Okay, Jack. And we'll document it back to the Rover, I guess is the best way. That doesn't look too hard, Gene.

[Just as Parker says this, the tube penetration comes to a halt.]

168:39:33 Parker: Until just now.

[After two more hammer blows, Gene seems to break through whatever was blocking progress and the core begins penetrating again.]

168:39:35 Schmitt: Try to...Oops, looks like you proved me wrong!
168:39:42 Cernan: The first core was easy; the second one a little tougher; and then it got tough down at the end.

[Gene stows the hammer in his shin pocket.]

168:39:47 Schmitt: Stay there, I'm getting a picture of you. Okay?

168:39:49 Cernan: Okay.

[AS17-143-21836 to 21858 are Jack's pan photos taken near the rover at the end of Station 9. 21836 and 21837 show Gene hammering the core in. 21838 shows the seismic charge. 21856 to 21858 show Gene carrying the core tube back to the Rover at about 168:40:28.]

168:39:53 Schmitt: I got it.

168:39:55 Cernan: You got it from here?

168:39:56 Schmitt: Yeah.

168:39:57 Cernan: Okay. (Long Pause)

[Gene pulls the core out of the ground with his left hand. It takes about 12 seconds. Gene then rotates the core so that it is parallel to the ground and examines the outside from the top down toward the bit. As he finishes the examination, he lightly touches his forefinger to the soil exposed at the tip.]

168:40:28 Cernan: (It's) full, but it wants to slide out. It's full. No rocks in it. It looks like just the same stuff we've been traveling through.

[Gene goes to the Rover, using his forefinger as a core plug.]

168:40:40 Parker: Okay, Jack. I think you better help Gene with recovering that core there where he thinks it's going to fall out.

168:40:48 Schmitt: You know, I think you're right. And if you'll just wait until I finish the pan, that's exactly what I'm going to do.

168:40:54 Parker: Okay. I didn't know what you were doing.

168:40:56 Cernan: Bob, it's capped.

168:40:57 Parker: Got you. Okay. (Pause)

[That is, Gene has capped the bit end of the lower section.]

168:41:05 Cernan: (To Jack) Just hold the (extension) handle. (Pause)

168:41:12 Schmitt: Okay?

168:41:13 Cernan: I can take this one off. (Pause) It's very loose soil, Jack. And it's...Just any little movement and you'll lose some of it. Let me cap that end. Don't move it.

[Fendell finds them at the gate.]

168:41:23 Schmitt: Uh-oh, you almost knocked some out. Get your...you know where your thing (the rammer) is?

168:41:27 Cernan: Yeah, but I need you...The cap's on you. The last one's gone off the Rover.

168:41:31 Schmitt: That's all right. I'll stay here. Go put your top in. I won't move it. (Long Pause)

[Gene goes to Jack's seat with the lower section. He gets a cap and screws it on, then puts the section under the seat. Jack turns to present the left side of his PLSS. Gene gets a cap for the upper section that Jack has been holding.]

168:42:06 Cernan: Any little movement and that stuff starts...

168:42:07 Schmitt: Yep. (Pause)

168:42:13 Cernan: Okay. (Pause) Turn around. I'll get the rammer (off the back of Jack's PLSS).

168:42:22 Schmitt: Okay.

168:42:24 Cernan: Oh, man! Even these pins are getting stiff. (Pause)

[Gene is talking about the pins that hold the extension handle to the upper section. This is the extension handle which is normally attached to the rake. Gene gets the rammer and goes to Jack's seat; Jack goes to the gate.]

168:42:34 Cernan: Okay, Bob. The top rammed down, oh, almost half way without any effort. (Pause)

168:42:50 Parker: Copy that.

168:42:52 Schmitt: The scoop's back on (the extension handle). (Pause)

168:42:57 Cernan: The bottom rammed down about an inch.

168:43:00 Parker: Copy that. (Pause)

168:43:07 Schmitt: Okay, Robert. Let's see...

168:43:11 Cernan: Turn around and I'll get this.

168:43:12 Schmitt: What was the last thing - let's see - we had to do?

168:43:14 Cernan: A couple of football-size rocks.

168:43:16 Schmitt: You got the D. S. E. A.?

168:43:18 Cernan: I got it.

168:43:19 Schmitt: I got the charge. You got the double core.

168:43:21 Cernan: I got the double core.

168:43:23 Schmitt: And I got one sample of a radial sample.

[Jack giggles at the thought.]

168:43:26 Parker: That's a unique one.

168:43:28 Schmitt: (Laughing) (And the sample is) in my pocket.

168:43:30 Parker: And have we got the gravimeter back on the Rover?

168:43:34 Schmitt: Yes; it's on.

168:43:35 Parker: Okay. Copy that.

168:43:37 Schmitt: And we want to get a large block. Why don't we...

168:43:39 Parker: Okay, and there's a...

168:43:41 Cernan: No, let's get a couple of them. I've got one.

168:43:41 Parker: ...(garbled) here for a SESC from the shallow trench. We'd also like to have you moving in 4 minutes. That's with wheels rolling in 4 minutes.

168:43:51 Schmitt: SESC, huh?

168:43:52 Parker: Roger; but we have to have the wheels rolling...

168:43:54 Schmitt: I don't know if we can do that. We can try it.

168:43:56 Parker: We want the wheels rolling in 4 minutes, so I don't think it's practical at this time.

168:44:02 Cernan: Bob, we cannot get an SESC in 4 minutes...

168:44:04 Parker: Okay. Copy that...

168:44:05 Cernan: ...and roll...

168:44:06 Parker: ...Copy that.

168:44:06 Cernan: ...at the same time. (Pause)

168:44:13 Cernan: Now, I've got to push this latch on the gate...(correcting himself) on the pallet to get it locked.

168:44:18 Schmitt: Need some help?

168:44:20 Cernan: Push the pallet while I trip the latch, will you? Because I got to trip the latch. There's so much dust in that core. (Pause)

168:44:30 Schmitt: Get it?

168:44:31 Cernan: No. No. Wait a minute. Open it up. (Pause)

168:44:40 Schmitt: Wait a minute. Okay.

168:44:45 Cernan: Now...Now that's where...Now let me trip it. (Pause) Okay. Try it. (Pause) Locked?

168:44:58 Schmitt: Yeah.

168:44:59 Cernan: Should be locked now.

168:45:01 Schmitt: That got it. That got it. (Pause) Okay.

168:45:10 Cernan: Got a big rock there, too?

168:45:12 Schmitt: Well, you know, the thing that amazes me is that there's no subfloor around here.

168:45:19 Cernan: I got one here. (Pause) Okay. I'm about ready to clean up the Rover here. (Pause)

[Fendell is looking in the direction of the marker flag on the Explosives Package. It is orange. When Fendell first pointed the TV at the horizon beyond it, he was at minimum zoom and the flag was just a few picture elements across and, therefore, just a faint blur of color. After a while, someone noticed the patch of color and Fendell zooms in to see what it is. Because it is actually in the very near field, rather than in the far field, zooming only blurred it more.]

168:45:36 Parker: Okay, 17. What's out there in the distance on a hillside in the field of view of the camera? The camera is pointing at it. (Pause) Oh, I'll bet that's the Italian (flag)...

168:45:48 Cernan: We've got to get a distance. Which hill? Let me see where you're...

168:45:49 Parker: ...that's the flag, I bet. On the charge.

[There are prior references to the "Italian Flag" at 147:01:36 during the drive back to the LM at the end of the second EVA. The flag is shown here in AS17-143-21837. The actual color is international orange.]

[Schmitt - "I think that it was Bob who told me that they really didn't have any idea - when he started to call us - of what that was. None! And I don't think I've ever seen this sequence in a NASA tape."]

[Cernan - "I have never seen this picture until just now. Never. Never!"]

168:45:54 Cernan: Yeah, you're looking right at it, but it's only 10 meters away.

168:45:59 Parker: Okay. It's hanging in front of the hills. That's the problem.

168:46:01 Cernan: You're looking right at the flag.

168:46:03 Parker: Okay. It's hanging in front of the hills. We thought we had an artifact (in the TV) or something like that. Okay. Press on. (Pause)

168:46:13 Schmitt: Bob, bag 486 is a light-colored rock taken about 3 meters to the right of the Rover. You should be able to pick it out in that last pan, unless the focus was bad.

168:46:30 Cernan: Bob, you got all your TGE readings?

168:46:33 Parker: Roger. We've got that. We'd like to have you climb on.

168:46:40 Cernan: You want the LCRU off?

168:46:42 Parker: Roger. Let's go to LCRU power off.

[TV off; static]

168:46:44 Cernan: Okay, Jack, (pause) we better get going.

168:46:50 Schmitt: Yeah. (Pause) You know, I don't think there is any subfloor in here. The rocks are so dust covered that it's hard to be sure, but no rock I picked up looked like subfloor.

168:47:03 Cernan: Get on there one time. (Pause)

[Gene goes to the front of the Rover to take pictures of Jack jumping in his seat. The pictures are AS17-134-20452 to 20454, of which 20453 is the best.]

[Cernan - "It was sort of a target of opportunity. It was just one of those (unplanned) things you do. And it's a pretty good picture."]

168:47:08 Schmitt: Ready? (Pause)

168:47:12 Cernan: I got three of them that time.

168:47:15 Schmitt: (Laughs)

168:47:16 Parker: 17, Houston. Do you read me through the LM?

168:47:20 Schmitt: You're loud and clear.

168:47:22 Parker: Roger. Thank you.

168:47:25 Cernan: I hope they (the pictures) came out.

168:47:32 Schmitt: Okay. I hope it (the seatbelt)'s untwisted this time, so I can get off.

168:47:38 Cernan: Oh, let's see. If old "twinkletoes" (Gene, himself) can do it. Jack, there's a big one (a rock) right there, in my floor pan. (Pause) That's what I did last time.

(Cernan - "I did whatever I'd done the last time (at Station 8 when he fell as he tried to mount the Rover) - got my foot caught on something, or whatever.")

168:47:53 Schmitt: Okay. I'm on, strangely enough. (Pause) Okay. (Pause)

168:48:05 Cernan: Let's see. Okay. The charge is off to the right. (Pause)

[Because of the four-wheel steering, Gene will turn toward the charge to get around it. If he turned left, the back wheels of the Rover would turn toward the charge - although, in this case, the separation is substantial.]

168:48:23 Schmitt: Yeah, you're all right. You can clear it this way or...

168:48:31 Cernan: Yeah. I see it.

168:48:33 Schmitt: Okay. (Pause, thinking back to Houston's mistaken impression that the out-of focus flag was a background object) I bet you they thought there was some more orange soil over there on the hills. (Pause)

168:48:51 Cernan: Get out of this block field, we'll be able to move it (that is, speed up) a little bit.

[Jack's first photo of the drive back to the LM is AS17-143-21859, which shows a distinctive boulder at the right side of the image. The same boulder can be seen in AS17-143-21847, which is a frame from Jack's pan.]

168:48:56 Schmitt: I wonder where we stand on time.

168:49:00 Cernan: (Looking at his watch) Well, we've been out about 5 hours and 20 minutes or so.

168:49:05 Schmitt: Where are we headed, now that we are moving?

168:49:08 Parker: That's affirm...

168:49:09 Cernan: Well, I'm trying to get out of the block field here, then I'll head back to the southwest. (Pause)

[Cuff checklist page LMP/CDR-24 shows the planned traverse to Station 10. For completeness, pages LMP/CDR-25, 26, 27, 28 and 29 cover the planned drive to Station 10, the planned activities at that station, and the drive back to the LM.]

168:49:21 Schmitt: We going to Sherlock (Station 10) at all, Bob?

168:49:26 Parker: No, we're going straight home...

168:49:27 Schmitt: (To Gene) That must be Gatsby (Crater) over there.

[AS17-143-21860 to 21863 cover the next portion of the traverse.]

168:49:27 Parker: ...you can follow the (garbled, but means the Nav system) home. (Pause) And a reminder, Jack. We can get lots of photos. We've got lots of film left right now.

168:49:43 Schmitt: Okay.

168:49:46 Parker: And, 17. Gene, I guess you're the one that took the SEP out. Do you remember the reading of the SEP temperature when you broke it down?

168:49:57 Cernan: Didn't even look, Bob.

168:49:59 Parker: Okay. Copy that.

168:50:00 Schmitt: It was 125 when we started the station.

168:50:04 Parker: Roger. Copy that. (Pause)

168:50:09 Cernan: That's Gatsby there, I guess, huh?

168:50:10 Schmitt: Yeah.

168:50:12 Cernan: It's not unlike Van Serg, though.

168:50:15 Schmitt: Hey, you know that looks like the mantling...Hopefully, we can get a...Watch your rock. There you go. (Hopefully), we can get a shot looking back to the northwest...

168:50:32 Cernan: Yeah, I'll get that when I...

168:50:33 Schmitt: ...into Gatsby, because it looks like the mantle streams over the side from the southwest. Can you swing to your right and get up a little closer to the rim, there?

[AS17-143-21864 shows Gatsby from the east. 21865 is taken after Gene turns to give them a better view into the crater.]

168:50:48 Cernan: Hey, there is a couple fragments in spots...

168:50:51 Schmitt: Look at that. See that?

168:50:52 Cernan: Yeah.

168:50:53 Schmitt: See that structure. See how the...

168:50:54 Cernan: Yeah.

168:50:55 Schmitt: ...see how the mantle streams over...

168:50:57 Cernan: Yeah; from the northwest. Can you get that?

168:50:59 Schmitt: Yeah.

168:51:00 Schmitt: And from the southwest.

168:51:02 Cernan: Got it?

168:51:03 Schmitt: Yeah. Go ahead. Keep going. (Pause) Good shape. Got it.

168:51:12 Cernan: We're 236/2.1. (Pause)

[AS17-143-21866 and 21867 are additional pictures of Gatsby. AS17-143-21868 to 21870 are taken as they drive south around Gatsby and then drive toward Sherlock.]

168:51:18 Schmitt: Bob, what I'm looking at is the northwest portion of Gatsby, where there's a very, very concentrated block field on the inner wall; (that is, we can see blocks) except where there are, on the southwest, three streams and, on the northwest and north, a continuous stream - if you will - or radial band of mantle that appears to be burying that field (or) overlying and mantling the field. We got some pretty good pictures of it, I think.

168:52:02 Parker: Okay. Copy that.

168:52:05 Schmitt: Bob, I'm more and more convinced there's a mantle. (Pause) One possibility, I guess, is that, if it's a pyroclastic mantle, that in the lunar vacuum environment and with whatever volatiles we're dealing with, the stuff becomes extremely fine upon vesiculation. We may have been on it all the time and not known it...(that is), as far as recognizing it.

168:52:41 Cernan: See, as soon as we come through this draw, how smooth or free of any debris or boulders it is on the other side of the upslope.

168:52:46 Schmitt: Yeah. (Pause) Watch it.

168:52:53 Cernan: Yup. (Pause) Bob, do we have an extra EP (Explosive Package)?

168:53:04 Parker: No. We have two of them behind you. We're going to deploy one. I'll give you a reading soon on that.

168:53:12 Cernan: Okay. Well, one I deploy at the end, I know, (near the place where he will park the Rover at the end of the EVA). I thought we had an extra one here somewhere.

168:53:17 Parker: Okay. Yeah, that's the one we were planning on deploying all along, and it's there. We'll be deploying at a range of 0.1, which is just before you get to the SEP.

168:53:33 Cernan: (Responding to Parker) Okay. (To Jack) I guess Sherlock's going to be right over the top over here. I saw it when we were on that other ridge. (Pause) Hey, you know, there's a lot of bad landing places around here. That low Sun angle, I think, shows most of them up. (Pause)

168:53:57 Schmitt: Bob, I...

168:53:58 Parker: And, Geno, we were looking...

168:54:00 Schmitt: ...I don't under...

168:54:01 Parker: ...at the map here...

168:54:01 Schmitt: ...I don't unders(tand)...

168:54:02 Parker: ...and if you keep going straight to the LM, you're probably going to run into this crater area around San Luis Rey. You probably ought to head somewhat south of directly back to the LM, so we can at least tip the western edge of Sherlock and then pick it up and go from there back to the SEP. It looks like it might be rather rough there in that dotted-lined area, if you can look at the backside of your map, Jack.

[Parker is referring to the contour map on the back of the traverse map.]

168:55:29 Cernan: Bob, I've already been doing it. I'm at 244/1.7.

168:55:32 Parker: Copy that. Thank you.

168:55:34 Cernan: Already been doing that.

168:55:35 Parker: Okay.

168:55:36 Schmitt: And, Bob, about 200 meters back, we crossed back into our standard mantle surface of about one-percent fragment cover...

168:55:44 Parker: Okay 200 meters back, you (garbled). Okay. Copy that.

168:55:46 Schmitt: ...(when we came) out of the block field, which...(Stops to listen to Parker; pause) (To Gene) I can see the LM.

168:55:55 Cernan: Yeah, I can see the LM. And there's Sherlock, where those blocks are.

[AS17-143-21871 to 21873 show the approach to Sherlock.]

168:56:00 Schmitt: Yeah, that's the block field, the Sherlock block field; that's right. That is a block field.

168:56:06 Cernan: Some big ones there.

168:56:07 Schmitt: Yeah. (Pause) Old Station 10. I might even call it "10 Alpha" in honor of the Apollo Program Office. The...

168:56:19 Parker: "10 Bravo", Apollo.

168:56:19 Schmitt: ...Apollo Spacecraft Program Office.

168:56:27 Schmitt: (Hearing Parker) Oh, that's right! "10 Bravo". I knew I'd never get that straight!

[Schmitt - "I think I was using 'alpha' or 'A' for 'Apollo', and Parker was using 'Bravo' in the sense of 'job well done'. It's possible that I had something going with those guys. It's possible, but I just don't remember."]

168:56:29 Parker: Do those blocks look like gabbros to you guys?

168:56:32 Cernan: How fast do you think we're going, Jack, without looking?

168:56:34 Schmitt: I think we're going about 18 clicks.

168:56:39 Cernan: Hey, you're just about right. (Pause) Seems like the first time we've been able to go downhill. (Laughs) Not really. (Pause)

[Schmitt - (Laughing very loudly) "That I remember!!"]

[Cernan - (Laughing) "The fastest we went was coming off of the Scarp and, for a short period of time, we did hit 17 klicks (kilometers per hour). But, here, I think we set this one up."]

[Schmitt - "Sometimes in my talk, I say that, in normal terrain you can push the Rover up to 10 to 12 klicks. But

that, one time going downhill, we had it up to 18 kilometers per hour and regretted it. And we were bouncing."]

[Cernan - "But I do think that we set this one up; we wanted to go down in history. I was with Johnny Rutherford (an American race driver of Indianapolis or 'Indy'-type cars) one time. I'd asked him to give a talk about a year or two ago. Someone asked him a question and he was talking about being the fastest human or having the fastest time at Indy or something and I got up there and said that I didn't think that that was right. I said, 'I drove a little race car about 17 kilometers per hour on the surface Moon;, and that makes me and Jack Schmitt the fastest race car drivers in the world. And he said, 'Well, what are you talking about?' And I said, 'When you add 17 kilometers per hour to the rate the Moon travels around the Earth...' (General laughter)]

168:56:53 Schmitt: Pull close to this big block, if you can over here.

168:56:54 Cernan: Oh, yeah.

[AS17-143-21874 to 21882 are Jack's pictures of their approach to the big block near Sherlock Crater.]

168:56:56 Schmitt: And I'll try to get a reading on what it is.

168:57:00 Cernan: Some pictures of it as we come up to it.

168:57:02 Schmitt: Yep.

168:57:04 Cernan: Boy that's a big one. (Pause)

168:57:10 Schmitt: Watch it!

168:57:11 Cernan: (Garbled) (Pause)

168:57:21 Schmitt: Looks like our old friend, the subfloor...

168:57:21 Cernan: The subfloor.

168:57:22 Schmitt: ...isn't it?

168:57:22 Cernan: Yup.

168:57:23 Schmitt: Yep. Vesicular subfloor. Vesicles are about a centimeter maximum size. They look like they're fairly evenly sorted. And the rock itself seemed to be massive.

[Schmitt - " 'Evenly sorted' is an oxymoron. 'Sorted' implies that there's an non-random organization. 'Evenly sorted' means it's random. It's not very good jargon. It's used; but it's not very good jargon. And by 'massive', I mean that there is no other organization - the material within the vesicles didn't seem have phenocrysts or alignments or anything like that."]

168:57:37 Cernan: 250/1.4.

168:57:38 Parker: 250/1.4.

[Unlike the LM, Geophone Rock, Turning Point Rock, and Tracy's Rock, this boulder is not readily apparent in the

high-resolution pan camera image of the landing site taken from the Command Module.]

168:57:41 Schmitt: Okay, we're back into about a 5-percent rock cover as we cross the edge of the Sherlock block field.
168:57:52 Cernan: That's Sherlock over that rim over there.

[AS17-143-21883 to 21885 are the next in Jack's sequence of traverse photos. 21883 may show the Sherlock rim.]

168:57:53 Schmitt: Yeah. Yeah. (Pause) Once again, all these subfloor blocks look as if they're buried. Not mantled, necessarily, except maybe that one. That... Can you swing right, just a tad?
168:58:08 Cernan: That one's got the mantle blowing up on it, in it...
168:58:10 Schmitt: Yeah.
168:58:11 Cernan: ...in it's fractures and everything.
168:58:13 Schmitt: That's the best example of that, I think.
168:58:14 Cernan: Take a picture of that?
168:58:15 Schmitt: I got it. I got it. Watch....
168:58:16 Cernan: Got it; got it.

[AS17-143-21886 is Jack's photo of the large block on the Sherlock rim.]

168:58:17 Parker: Okay. Now, do those blocks look like the same subfloor gabbro?
168:58:20 Cernan: Yeah, that's just got the mantle...
168:58:22 Schmitt: Watch it! (Garbled) another one.
168:58:24 Schmitt: (Answering Parker's question) Yes. Everything in here, so far, is the tan-grey subfloor gabbro that I've seen. I haven't...Oh, there's one over there that's the blue-grey. But blue-grey is not abundant.
168:58:35 Parker: Okay. Copy that. (Pause) And, 17, as you're getting closer, we're going to want an LRV sample at 1.1 (km) on the range.
168:58:53 Cernan: Okay.
168:58:54 Schmitt: What are we now? 1.2?
168:58:56 Cernan: 1.2.
168:58:58 Schmitt: (To Parker) Okay. We'll try to get block and soil.
168:59:00 Parker: That'd be good.

[AS17-143-21887 to 21890 are taken during the approach to the next Rover sample stop. Note the distinctive rock over the TV camera in 21890 and compare with Gene's photo AS17-134-20455.]

168:59:02 Schmitt: There's a fresh little pit. (Pause) Bob, I am continually impressed by the lack of exotic fragments in here.

[Schmitt - "Two or three kilometers away on either side, we're surrounded by highlands - high mountains with entirely different kinds of rocks. Yet I don't think we ever recognized any fragments of the breccias from the mountains. You would have thought that some would have been thrown in there in 3.8 billion years; but we just didn't see any. The interpretation, now, is that, at about 3.5 (billion years ago), there was a mantling of the dark pyroclastics with a little bit of orange soil mixed in. And then, over time, that's just been reworked into the soil and it's so fine grained that it may have absorbed fragments into it."]

[I asked about the depth of the regolith on the massifs, wondering if it was deep enough that you wouldn't get a lot of ejected fragments.]

[Schmitt - "It's deeper (than on the valley floor), but it should give you some instant rock - some regolith breccias. And those would survive if they were hard enough. They find stuff (from the Massifs) in the soil, but no coarse fragments."]

168:59:20 Cernan: Okay, Jack. How about picking out a place...

168:59:24 Schmitt: (Garbled) .Okay. If you head into that little...Well, that's a crater there.

168:59:27 Cernan: Let me get around it. We can go a little bit further.

168:59:30 Schmitt: Yeah. Maybe...

168:59:31 Cernan: I'll go up on that flat area up there.

168:59:32 Schmitt: Yeah, yeah. (Pause) There are a lots of little fragments over there.

168:59:39 Cernan: "Flat area"; ha, ha. (Pause) (I can stop) any time.

168:59:46 Schmitt: Okay. Now swing a shallow turn. (Pause) Whoa. Well, I don't ...

168:59:51 Cernan: Can you get any of those?

[Jack's photos taken during the final approach to the sample site are AS17-143-21891 to 21893.]

168:59:53 Schmitt: Unfortunately, I can't see them (now, because they're in) the shadow (of the Rover).

168:59:56 Cernan: How about that one right in front of you, in front of the television camera shadow. See that little one up there? Right there.

169:00:04 Schmitt: With the...It's a little big, I think.

169:00:06 Cernan: Upper right...No, upper right. Straight up the line.

169:00:09 Schmitt: Oh, okay. Yeah. If you can get over there, I can get it.

169:00:12 Cernan: I can get there. (Pause)

169:00:19 Schmitt: Oh, I guess I had the wrong...I guess I wasn't looking at the right one. The (Rover) shadow is making it impossible to see down there. Now, see what you can get.

[During our review, Jack noted that, at this point, his voice quality changed dramatically as he looks down to see what he's doing, getting his chin as far down on his neck as possible.]

169:00:29 Cernan: Bob, we're at 253/1.1.
 169:00:35 Parker: Copy that.
 169:00:38 Schmitt: You're going to have to...If we do another sample, you're going to have to swing right so I can see. I can't see this way.
 169:00:48 Cernan: Yeah. (Pause)

[That is, Jack wants Gene to turn toward the north so that there is no Rover shadow on Jack's side of the vehicle.]

169:00:53 Cernan: And 53 Yankee.
 169:00:55 Parker: Copy that. Is that soil or rock?
 169:00:59 Schmitt: That's soil. I can't see to get a rock.
 169:01:03 Parker: Okay.
 169:01:05 Schmitt: Go forward just a little bit, Gene.
 169:01:06 Cernan: Okay.
 169:01:09 Schmitt: Except you're going to get yourself in a box here.
 169:01:12 Cernan: No, that's all right.
 169:01:13 Schmitt: Whoa. (Pause) A little more, sorry.
 (Pause) (Head-down voice quality) Little more. Okay.
 169:01:20 Cernan: Get it?
 169:01:21 Schmitt: I will. (Pause) Got it.
 169:01:30 Cernan: I can't see the LM anymore.
 169:01:34 Schmitt: (Normal voice) Okay. The rock fragment...
 169:01:36 Cernan: That's 54 Yankee. (Long Pause)

[They both take documentation photos. Jack's is AS17-143-21894 and Gene's is AS17-134-20455.]

169:01:50 Schmitt: Awgh! Okay. You got a rock right in front of you, don't you?
 169:01:55 Cernan: I see it. (Pause)
 169:02:07 Schmitt: Rolled over (the rock). Good old Rover.

[Cernan - "I think I was probably going pretty slow. As long as you don't hit those things hard and fast, you're okay. So I just went over it with the wheel."]

169:02:11 Schmitt: LMP frame for that sample (pause) looks like about six-zero.
 169:02:19 Parker: Copy that.
 169:02:24 Schmitt: Six-zero! Have I taken sixty pictures (since leaving Van Serg)? (Pause)
 169:02:32 Cernan: Boy, these rock fields are something else again.

[AS17-143-21895 to 21905 are jack's photos taken during the next few minutes.]

169:02:35 Schmitt: Yeah, 60. Looks like some of our grey variety of subfloor up here, around the rim of that little crater. You know, I'm starting to think that maybe the grey, relatively-nonvesicular subfloor may be (the) deeper fraction, based on what we saw...Well, actually, though...Let's see, that could have been overturned. I don't know. (I'll) take that back. There just isn't much of it around here, although we saw a lot of it in the wall of Cochise.

169:03:23 Parker: Roger. We got that.

[Schmitt - "Obviously, I was just running something through my mind out loud and (when) it didn't make sense to me, I decided to forget about it."]

169:03:25 Schmitt: What do you think this is, San Luis Rey? We're at 252/0.9.

169:03:33 Cernan: I wouldn't doubt it at all.

169:03:35 Schmitt: I'll bet that's San Luis Rey.

169:03:36 Cernan: We're on the east side of it...Mariner and San Luis Rey. (Pause) They're shallow (and) filled with rocks.

[As shown in AS17-143-21906, Gene takes a turn to the south, probably to get around a crater. 21907 and 21908 are subsequent traverse photos.]

169:03:53 Parker: As close as we can tell, you're at one or the other of them.

169:03:55 Cernan: Boy, I tell you they're a lot...(To Parker) Okay. We're at 250/0.9.

169:04:00 Parker: Copy that.

169:04:01 Schmitt: Mariner should look pretty fresh. (Long Pause) Boy, I certainly don't see much variety other than the grey and the tan subfloor varieties. There's old Challenger.

169:04:29 Cernan: There she is. Pretty as a picture. (Pause)

[Schmitt - "I have an image of what the Challenger looked like coming back from Station 5 on the second EVA, but not from here."]

[Cernan - "Me, either."]

[They both take pictures. Jack's is AS17-143-21909. the LM is just to the left of the central fiducial. Gene's is AS17-134-20456. The LM is just under the angle of the high gain.]

169:04:39 Cernan: Boy, I tell you, there's no getting out of this stuff (the boulder fields). You go from one to the other.

169:04:44 Parker: Okay, 17...
 169:04:45 Schmitt: I don't know whether I said it or not...
 169:04:46 Parker: Gene, at a range of 0.1. We're going to deploy the quarter-pound charge, and that'll be Jack's getting off to deploy it like we talked about last night.

[Parker's reference to "last night" may be an indication of how tired he is, as well. I haven't been able to find a discussion of this EP deployment during the closing stages of EVA-2 or during the subsequent discussions in the cabin. More likely, Parker is referring to the EVA-3 pre-brief conducted while Gene and Jack were eating breakfast. It is now about 10:30 in the evening in Houston and, like everyone else, Parker has had three long days.]

169:04:57 Cernan: Okay. (Pause) That's EP-2, Jack.
 169:05:10 Schmitt: EP-2; right. (Pause) Bob, we're moving in and out of areas of, say, 1-percent to 5- to 10-percent blockiness. And where it gets blocky, not only is it more blocky, but we seem to have more of the medium-sized craters in the range of 20- to 50-meter-diameter craters. (To Gene) That may be Mariner right there. (Pause)

[AS17-143-21910 seems to be Jack's only traverse photo taken between the spot where they saw the LM and the fractured boulder at San Luis Rey mentioned at 169:07:24.]

169:06:03 Schmitt: How do you read, Bob?
 169:06:04 Parker: Loud and clear. Loud and clear.
 169:06:10 Schmitt: (To Parker) Hey...Van Serg, let me mention again, was an unusual experience in the plains geology here. (To Gene) That must be part of San Luis Rey or Mariner, one of them.
 169:06:25 Cernan: Yeah That's pretty deep. Pretty deep.
 169:06:30 Schmitt: Yeah, it is.
 169:06:31 Cernan: It's really big.
 169:06:34 Schmitt: Yep. (To Parker) We're at 252 and 0.6.
 169:06:38 Parker: Copy that.
 169:06:39 Schmitt: The crater on our left - that is, south of us - is a large crater. It's somewhat deeper than (other) craters of the same size (diameter) that we've seen. And it, too, though, has large blocks mainly in the walls, although there are blocks up here in the rim, occasionally up to 3 meters (in size). (Pause) Look at that string of blocks over there; that may be it (that is, San Luis Rey).
 169:07:18 Cernan: Yeah.
 169:07:19 Schmitt: That's an edge of a crater, I guess.
 169:07:21 Cernan: Want a picture of that?
 169:07:24 Schmitt: Got it. (Pause)

[AS17-143-21911 may show the fractured rock at San Luis Rey. 21912 to 21923 are taken during the remainder of the drive up to the point where Jack gets off west of the SEP transmitter array to deploy a seismic charge.]

169:07:30 Cernan: Look at the way that thing's fractured. Yeah, this is the San Luis Rey complex, because see how elongated it is?

169:07:37 Schmitt: Yeah. Yeah.

[Cuff checklist page LMP/CDR-28 shows a sketch of the complex. Compare with a detail from the overhead image taken from the Command Module.]

169:07:38 Cernan: Fact is, we're going to cut right through the western half here. (Pause) We're at 244/0.4.

169:07:51 Parker: Copy that.

169:07:53 Schmitt: Bob, I may have said early on - up there at Van Serg - that I saw subfloor, but we never did sample any that I know of. And the dust was thick enough that I'm just not sure. The breccias were the most obvious thing there.

169:08:12 Parker: Okay. Most interesting.

169:08:18 Schmitt: It might have been a window in the plains here, of some kind. But it's strange to see it there, with so much subfloor all around it that we saw. (Long Pause)

169:08:46 Parker: And, Jack, you're going to get a feedwater tone pretty soon.

169:08:51 Schmitt: Got it. (Pause as he switches to the Aux supply) Okay, I should be in Aux(illary) now.

169:09:06 Cernan: 252 and 0.2.

169:09:10 Parker: Copy that.

169:09:11 Cernan: There she (Challenger) is.

169:09:13 Parker: And as soon as we get to the 0.1 (range), let's stop and deploy the charge.

169:09:19 Cernan: All right. (Pause)
 169:09:22 Schmitt: Okay. And then, I guess... (Pause)
 169:09:28 Cernan: Then we'll head back to the LM.
 169:09:30 Schmitt: Yeah.
 169:09:31 Schmitt: I don't go to the...
 169:09:32 Cernan: Unless you want to go to the ALSEP.
 169:09:34 Schmitt: (Chuckles) I think I'm going to. When do I go to the...Oh, you go to SEP. That's right.

[After they unload the Rover at the LM, Gene will drive the Rover out to its final parking place near the SEP transmitter, a spot far enough east of the spacecraft that the TV audience on Earth can watch the launch. This final parking place is called the VIP site, recalling the close-in viewing stands at the Cape reserved for Very Important Persons.]

169:09:43 Cernan: Yeah, I go to SEP when I...Take the Rover around here.
 169:09:44 Parker: We're going to let you play the Return-to-the-ALSEP game there, Jack. We've got a few things for you to do out there, when the time comes.
 169:09:51 Schmitt: (To Parker) Okay. (To Gene) (Has the indicator cycled to) 0.1? No.
 169:09:55 Schmitt: We're almost to SEP. We're about...
 169:09:58 Parker: Rog. It'll be just short of SEP.
 169:09:58 Schmitt: ...50 meters from SEP (transmitter).
 169:10:01 Parker: Is it short of the antenna?
 169:10:05 Schmitt: Well...
 169:10:06 Parker: ...We'd like to have this...
 169:10:07 Schmitt: ...You see, we can get to the end of the antenna...
 169:10:09 Parker: No, no. Let's have it east of the antenna. If we are there, let's deploy it right where you are.
 169:10:15 Schmitt: Okay. We're about 30 meters east of the antenna. How's that?
 169:10:19 Parker: That sounds great.
 169:10:25 Cernan: Okay. And we're measuring 221 and 0.2; 221 and 0.2.
 169:10:34 Parker: Copy that. (Pause)

[The range reading of 0.2 indicates that the Rover navigation system thinks they are 150 to 250 meters from the SEP transmitter, an error of about 100 to 200 meters, depending on whether or not the indicator is about to click down to 0.1. This close to the SEP, the difference between the bearing readout of 221 degrees - about SW - at the true bearing of about 270 is almost meaningless. Further information of the cumulative range error becomes available when Gene gets back to the LM at 169:18:00.]

[Cernan - "It worked great. They knew where we were, even when we didn't."]

169:10:42 Schmitt: There's a rock (that) I stood up down there, and I want to get...

169:10:44 Parker: And it's EP number 2 that we're after, Jack, in case you didn't follow us.

169:10:46 Schmitt: ...It's the only dense (that is, fine grained) rock (I've seen)... (Stops to listen to Parker) Okay.

[Schmitt - "I'd probably noticed this rock during the first EVA when we were laying out the SEP. It was non-vesicular and fine grained., which was what attracted my eye."]

[This rock is sample 70215, an 8.11 kilogram piece of fine-grained basalt. It is the biggest rock that they brought back.]

169:10:53 Schmitt: (To Gene) Hey, our gate's open.

169:10:54 Cernan: It's open!?

169:10:55 Schmitt: Yeah. (Pause) But it looks like everything's here.

[What Jack doesn't realize is that the rake, the scoop, and both of the extension handles have fallen off the Rover, somewhere between here and Station 9.]

169:10:59 Cernan: How about the big bag?

169:11:00 Schmitt: Big bag's there.

169:11:03 Parker: Is that the gate or the pallet?

[The geopallet is attached to the Rover chassis behind the seats. There is a latch behind Gene's seat and, behind Jack's seat, the pallet is attached to the geopost. If the latch on Gene's side was unlocked, then the pallet could pivot. The "gate", in turn, is attached to the pallet and is also hinged behind Jack's seat. The gate latch has been giving them trouble throughout the EVA and it seems most likely that it is the gate that is swinging open.]

169:11:04 Schmitt: It wouldn't dare run away.

169:11:05 Parker: The gate or the pallet?

169:11:08 Schmitt: (Probably mis-speaking) The pallet. I'm sorry.

169:11:12 Parker: Well, that's worse. (Pause)

169:11:17 Schmitt: Seems to ride all right that way.

(Pause) Boy, that dust is getting into everything. (Pause) Dum-te-dum-dum. (Pause) Okay, I'm going to leave the gate like it is. Seems to be all right.

169:11:47 Cernan: Okay.

169:11:48 Schmitt: Okay; EP-2. (Pause) Where is that? There it is.

[The rack containing the explosive packages is mounted behind Gene's seat. In the picture Gene took at Station 9 of

Jack mounting the Rover - AS17-134-20453, it is visible below the rake.]

169:11:57 Cernan: Hey, Jack. You're just going to walk back from here, aren't you?
 169:12:00 Schmitt: I can, yeah.
 169:12:02 Cernan: Well, why don't you just go turn the SEP receiver off? Oh, we did that. The receiver's all done.
 169:12:07 Schmitt: Sure, the transmitter...But you've got to come out here anyway.
 169:12:09 Cernan: Yeah, I've got to come out here. Forget it.
 169:12:11 Schmitt: I can do it.
 169:12:12 Cernan: No, I was just reading ahead, but no sense (in changing). Forget it.
 169:12:15 Schmitt: One thing I want you... Okay. Pin 1. Pulled and safe. Pin 2. Pulled and safe. Pin 3 is pulled and safe.
 169:12:27 Parker: Copied all those.
 169:12:28 Schmitt: (To himself) And I'll try to put it in a depression. (To Parker) I'm going to put it in a depression, if you want. (Pause) Okay. (Looking at LMP-29) And then I've got to take a pan, huh? (To Parker) Will a "locator"...Yeah. How about a locator to the LM?
 169:12:57 Parker: Be fine. (Pause)

[AS17-143-21924 is Jack's locator from behind the Rover. Note that the rake and scoop are missing, having fallen off at some time since they left Station 9. The Big Bag is mounted on the pallet. Gene's comparable photo, taken from his Rover seat, is AS17-134-20457. The SEP transmitter is to the right of the high-gain mast.]

[For future reference in determining the distance of the final Rover parking place from the LM, EP-2 is about 190 meters from the spacecraft.]

[Schmitt - (Comparing the EP-2 locator with the VIP site locator, AS17-143-21932) "It looks like Gene parked the Rover about a third closer (actually about twenty percent) and, when that thing went off, the back of the Rover must have gotten splattered a little bit. This business of the explosives packages brings up the question of long duration activities on the Moon away from a radiation shelter and what you would do in the event of a solar particle event. We didn't worry about them because we figured that the probability was low enough that we'd just deal with whatever happened."]

[Cernan - "And we couldn't have dealt with big ones."]

[Schmitt - "But if you're going to have a lunar base, you're going to have some kind of emergency capability. You'll have maybe a half hour - possibly as much as an hour - warning, although nobody's quite worked that out yet. But one way to deal with it is to excavate a trench with a linear charge, drive the Rover over it (to form a roof), get into the trench and, with an umbilical, attach yourself to Rover

consumables. You have the walls protecting you and you can even think about putting low molecular weight material (e.g. water) in the floor of the Rover to give you additional protection. It's a neat idea; and it actually comes from Jim Blacic up at Los Alamos. And the reason I brought it up here is that people say, "Explosives on the Moon!?" And you've got to remind them that we've already done that."

[Cernan - "I was just thinking that it would be neat to be able to take a little tour back to the valley of Taurus-Littrow and see what things look like. See where the Ascent Stage hit (on the South Massif); see where the Rover is splattered with material from that bomb; see the remnants of the Descent Stage. Even if you had to do it remotely, I would really like to see what that area looks like."]

169:13:04 Cernan: You going to get on, Jack, or walk back? Dealer's choice.

169:13:07 Schmitt: I'll get on.

169:13:08 Cernan: Okay.

169:13:10 Schmitt: Okay. Locator to the LM. I'll give you a frame count, if I can read it: (Pause) 90. (Correcting himself) 92.

169:13:19 Parker: Copy; 92. (Pause)

169:13:29 Schmitt: (To Gene) You're going to have to go left a little, I guess.

169:13:33 Cernan: Go left?

169:13:35 Schmitt: To avoid the (SEP transmitter) antenna.

169:13:36 Cernan: Oh...

169:13:37 Schmitt: Yeah, we don't have to worry about it.

169:13:38 Cernan: ...we don't have to worry about it, but I will anyway.

[Because Gene removed the data storage unit at Station 9, the SEP experiment is now non-functional.]

169:13:41 Schmitt: (Now on the Rover, probably without his seatbelt on) Go ahead.

[Schmitt - "I think that I didn't bother with the seatbelt because I was going to get off in just a little ways to pick up the big rock."]

169:13:45 Cernan: Okay. I'll take it easy.

169:13:46 Schmitt: Oh, that's all right. (Pause) I want to point out a rock to you I set up on end (that) we need to get in a bag. You can let me off there and I'll carry it.

169:13:59 Cernan: Okay.

169:14:00 Schmitt: But drive close enough so I can reach down and use the Rover for support.

169:14:04 Cernan: Where is it?

169:14:05 Schmitt: It's out over here. Between the...

169:14:09 Cernan: On which side of that antenna?

169:14:11 Schmitt: It's...

169:14:14 Cernan: Oh, there it is. Right there?

169:14:15 Schmitt: No. No, it's out...It's near the LM.
 169:14:18 Cernan: Oh, okay. (Pause) I can go across this thing (a SEP antenna wire). I already did. (Noticing a sample bag lying on the surface ahead of them) That bag is empty, isn't it?
 169:14:24 Schmitt: Yeah, that's one I lost. I mean, (one) I dropped. (Pause)

[Schmitt - "I think I tried to do some solo sampling on the first EVA, and I think I'd dropped a sample bag."]

169:14:31 Schmitt: (Voice quality altered because he's got his chin down) Look's like you got over (the antenna wire).
 169:14:32 Cernan: Yep.
 169:14:33 Schmitt: Yeah. (Pause) I think it's that one there that's sort of dark.

[AS17-143-21925 is taken at about this point. and shows the dark rock. Note the Rover tracks and, beyond the LM, the ALSEP.]

169:14:50 Cernan: Up there, straight ahead?
 169:14:51 Schmitt: Yeah.
 169:14:55 Cernan: Bootprints are by it. That must be it.
 169:14:56 Schmitt: That's it, yeah. Can you swing over so I can lean on the Rover when I pick it up?
 169:15:00 Cernan: Oh. (Laughs)
 169:15:01 Schmitt: That's good. No, that's good. That's perfect.

[AS17-143-21926 is Jack's documentation photo of the sample location. AS17-134-20458 is Gene's locator. Note that the Rover tracks in the foreground are not particularly dark. 20459 and 20460 are two subsequent photos Gene takes as he drives closer to the LM, and these show dark tracks.]

169:15:05 Cernan: Okay. You off?
 169:15:07 Schmitt: Okay. I am now...I'd hate to get run over this late in the game. (Pause) Well, now, what did I do that for?
 169:15:18 Cernan: (Laughing) What did you do? Kick it under?
 169:15:20 Schmitt: Yeah. (Pause)

[Schmitt - "It's a classic, old comedy routine. You start to pick something up and you kick it out ahead of you."]

169:15:29 Schmitt: (Kneeling beside the Rover) Need your oil changed?
 169:15:31 Cernan: Yeah. While you're under there, (laughing) would you check my transmission, please?
 169:15:35 Schmitt: (Laughing)

169:15:37 Cernan: (Laughing) Any bubbles on the inside of the tires?
 169:15:40 Schmitt: (Hearty laugh)
 169:15:43 Cernan: Okay. Have you got it?
 169:15:45 Schmitt: Yeah, I got it. Hey, Bob. I got my rock! It's halfway between the SEP and the LM. (To Gene, who has started to drive away) Wait, wait! Let me put it in the big bag. (Pause) It's in the big bag (garbled)...

[As described at 169:46:26, pieces of this rock were later put on public display and are the only pieces of the Moon that the public has ever been allowed to touch.]

169:15:58 Parker: Is this that brown one you saw out here before, Jack?

[This is a reference to Gene's discovery of a piece of brown packing material near here during the SEP deployment. The details are given at 123:03:34 and 123:28:18.]

169:16:00 Schmitt: (To Gene) Okay. Go ahead. (Answering Parker) No, it's a grey one.
 169:16:05 Parker: Okay.
 169:16:06 Schmitt: Oops
 169:16:07 Cernan: Okay?
 169:16:08 Schmitt: Yeah, I just lost a sample. (Pause)
 It's in my pocket, I guess.

[Jack is thinking about the sample he collected at Van Serg with the LRV sampler and, just for a second, forgot that he had put it in his shin pocket at 168:25:35.]

169:16:11 Schmitt: Let me get some tongs.
 169:16:13 Cernan: Okay. (Pause)

[Gene is wearing one pair of tongs on his yo-yo. Jack is getting a second pair off of the gate, rather than getting Gene's as he did at the end of EVA-2. See the discussion at 147:06:38 and following, and at 147:48:55 and following.]

169:16:22 Schmitt: Gene, you can go ahead. I'll walk back. (Garbled)

[Comm Break]

169:17:54 Cernan: Okay, Bob. I'm back at the LM.
 169:17:58 Parker: Roger. We have you back at the LM.
 169:18:00 Cernan: 151, 12.0, and 001.

[The readings are the bearing to the SEP transmitter, the distance driven, and the range from the SEP. Usually, Gene inserts a decimal point into the range readout but, here, gives the raw, three-digit reading rather than saying "0.1" kilometers. The actual bearing is about 080 and the

range is about 150 meters. Because the distance from the LM to the SEP is short, the bearing error is meaningless. The range reading of 0.1 means that the navigation system thinks the range is between 0.05 and 0.15 km, an indication of a relatively small error.]

169:18:11 Cernan: Well, wait a minute.

[Gene may be having trouble with his seat belt.]

169:18:13 Schmitt: Can you get it? I got to get your bag...

169:18:15 Cernan: I got it; I got it.

169:18:17 Schmitt: Let me get your bag off. (Pause)

169:18:27 Cernan: I'm reading 80 on the amps, 78 on the amps...Correction, that's amp-hours. Voltages, 62 and 65. Battery 1 (temperature) is 132, forget 0. Motor temps are 200 and 210 on the rear, 200 and 250 on the forward.

[The battery 2 temperature gage has malfunctioned, hence Gene's "forget 0".]

169:18:56 Parker: Okay. We copy that. (Pause) Okay. And let me brief you here on the close-out tonight, 17. A number of things we're going to do here that are slightly different. We've got some stuff for you over at the ALSEP, Jack, and I'll get with you when you go over there. Nothing we have to worry about in the meanwhile. When we unload the Rover, we're going to take the SESC (Special Environmental Sample Container, sometimes called the "short can") out, and we're going to use that to collect the contaminated sample out behind the footpad there as per plan, and when we take the traverse gravimeter off, we're going to want to get both a grav and a bias reading, because the pallet was swinging in the breeze there. Otherwise, let's press on with the close-out, and we'll get with you as times change. (Long Pause)

[Schmitt - "I believe they were looking for Descent Engine effluents and, to my knowledge, they were never able to detect any."]

[TV on. Jack is stowing drive tubes at his seat. He is on LMP-29 and Gene is on CDR-30.]

169:20:22 Schmitt: Okay, Bob. The core tubes are going in SCB-7...I mean...Yeah, 7.

169:20:30 Parker: Okay. I copy that. (Pause)

169:20:36 Cernan: You should have TV, Bob.

169:20:38 Parker: Rog. We have TV. Thank you. (Pause)

169:20:48 Cernan: Did you get my bag already?

169:20:49 Schmitt: Yeah. (Long Pause)

[Jack takes SCB-7 to the ladder footpad and then returns to the Rover. He is now on LMP-30. Fendell examines the MESA.]

169:21:13 Cernan: Jack?
 169:21:14 Schmitt: Yeah.
 169:21:15 Cernan: We'll have one more to put in here. I'm just going to lay this over here.
 169:21:18 Schmitt: Yeah.
 169:21:19 Cernan: The big one. Man, there's some big ones in there, too.
 169:21:24 Schmitt: We can get some of that subfloor.
 169:21:26 Cernan: Yeah, there's one in my footpan, too. You see it there?
 169:21:30 Schmitt: Yeah; we'll have to...
 169:21:34 Cernan: (At the MESA) Why don't you leave that there for a minute? Okay. What did you say about the TGE, Bob?
 169:21:40 Parker: Okay. We'd like to take TGE, of course, as we planned. Take it off, and we'll try and get both a grav and a bias reading. You might initiate one of them now. We'll initiate another one later on. We've got plenty of time while it's sitting on the ground there to do our thing with it.

[Jack takes another SCB to the footpad; Gene reaches to switch to his auxiliary supply of feedwater. In order to reach back, Gene brings his arm up to about chest height and slightly adjusts the lateral orientation before he swings it back. On this first attempt, he can't quite reach the switch, brings his hand forward about a foot, and then swings it back again, this time successfully getting hold of the switch.]

[Cernan - "That's not atypical. That's what you had to do to work against the stiffness in the bearings.]"

169:21:57 Cernan: Stay where you are, Jack, (garbled)...

[Gene still has to get Jack's SCB off.]

169:22:00 Parker: I see where you've got a feedwater tone coming up pretty soon, Gene.
 169:22:03 Cernan: (Removing Jack's PLSS SCB) Bob, I already got it and I'm in Auto (means "Aux"). Just about 30 seconds ago.
 169:22:06 Parker: Okay.
 169:22:11 Cernan: (Looking into Jack's SCB) Okay. How are we fixed for samples? Here's (SCB) 5, and it's about 1/2 to 3/4 full.
 169:22:18 Schmitt: Well, let's dump...
 169:22:20 Cernan: We've got to carry the SESC up.
 169:22:22 Schmitt: ...let's dump these...
 169:22:24 Cernan: We got (SCB) 3.
 169:22:25 Schmitt: ...(from SCB) 3 in there, the Rover samples.

[SCB 3 was on the accessory staff next to the control panel. Gene and Jack go to the Rover.]

169:22:28 Cernan: Okay. (Long Pause)
 169:22:40 Schmitt: Okay.
 169:22:22 Cernan: We probably ought to put the SESC in there, huh? If there's room for it.
 169:22:47 Parker: Yeah let's put the SESC someplace...
 169:22:49 Schmitt: Where do you want the SESC, Bob?
 169:22:50 Parker: Let's put the SESC someplace where it's accessible to get that contamination sample. We probably want to get it before you go off to the ALSEP, but there's no real hurry on that. We'll see what works in best. I'm not sure where the most convenient place for you...
 169:23:04 Cernan: Yeah. Why don't we get it now, and then we can have this bag...
 169:23:04 Parker: ...to put it right offhand is. That probably is the...
 169:23:09 Cernan: Let's get it now. We can get the bag cleaned up. We can put it in bag 5.
 169:23:11 Parker: Roger. There's probably not very many convenient places to put it. That sounds like a good idea to me.
 169:23:15 Schmitt: Okay. Let me get my scoop (off of the gate).
 169:23:18 Cernan: Get your scoop. Let's get it over with.

[Fendell is looking at the pile of equipment at the ladder.]

169:23:22 Schmitt: Say again, Bob. You want that...(To Gene, having reached the gate) I don't have a scoop, I don't even have a rake.
 169:23:28 Cernan: They're both gone, huh?
 169:23:29 Schmitt: Yup.

[Jack's EP-2 locator - AS17-143-21924 - shows that the rake and scoop were gone at that time. A comparison with AS17-135-20542 suggests that the extension handles came out of the mounting brackets. Those are shown most clearly in AS17-146-22296 which was taken at the end of Station 6. At 169:38:29, they will confirm that the extension handles were lost, that it was a failure of the mounting brackets that caused the losses.]

[Schmitt - "A bunch of Okies going across the countryside, dropping stuff right and left."]

[This is a reference to comic images of refugees from the Oklahoma Dust Bowl, a severe drought of the 1920's, driving to California with all of their earthly possessions piled high on a decrepit truck.]

[Cernan - "It was a good time to lose them, I guess."]

[Schmitt - (Chuckling) "One thing to think about, Geno, is: if I had been successful in getting us a fourth EVA and we had gotten to this point with no rake and no scoop, what

would the mission planners have done in replanning the fourth EVA?"]

169:23:32 Cernan: Use your Rover sampler.
 169:23:34 Schmitt: Yeah.
 169:23:36 Cernan: They both fell off when that thing (the gate) opened.
 169:23:37 Schmitt: Yep.
 169:23:38 Cernan: Here's a full core tube we can't forget.
 169:23:41 Schmitt: Yeah. Oh, that goes in the...
 169:23:43 Cernan: Is there room for it?
 169:23:44 Schmitt: Yeah, why don't you get that scoop (means the LRV sampler) off (the Rover), and I'll put it (the core) over here in (SCB) 4. I mean in 7.

[Jack goes to SCB at the footpad.]

169:23:51 Cernan: That was a good time to lose it. I'm glad we didn't lose it (laughing) any earlier. If we were going to lose it, that couldn't have been more ideal.
 169:23:57 Schmitt: Well, it's appropriate, I guess. (Pause)
 169:24:06 Cernan: We've got two empty core tubes. (I) feel like we took a lot of them, though.
 169:24:09 Schmitt: We'll get it. We'll use them, maybe.
 169:24:12 Cernan: Back here. (Pause)
 169:24:15 Parker: Okay. We confirm that (there are two empty drive tubes and) three full core tubes...
 169:24:16 Cernan: Okay. Let's get this in. If we get it in, maybe (garbled)...
 169:24:18 Parker: ... (garbled) worry about bringing back, there.
 169:24:23 Schmitt: Here's your thing (the SESC).

[Both of them go to the Rover.]

169:24:28 Cernan: We're going to get this SESC now, and get it out of the way, Bob.
 169:24:31 Parker: Roger. We agree with that.
 169:24:36 Cernan: Okay.

[They go around the ladder and then south of the LM, Jack carrying the LRV sampler and Gene the SESC can. They are both moving easily and rapidly. Jack is using a running walk; Gene is kangaroo-hopping.]

169:24:38 Schmitt: Minus-Z, huh? You want it in front of the minus-Z footpad?

["Minus-Z" is the rear (east) footpad, and the sample is to be obtained from under the LM, just forward (west) of that pad.]

169:24:45 Parker: Roger. Sort of underneath where you probably had the...

169:24:49 Schmitt: Looks like a good place.
 169:24:49 Parker: ...solar side of the cosmic ray experiment, there. Between the footpad and the ALSEP doors there. (Long Pause)

[The ALSEP stowage compartment is in the southeast facing sector of the Descent Stage. Gene is holding the SESC while Jack gets some soil with the LRV Sampler. Jack has already taken a pair of stereo, down-Sun, before photos of the sample site. These are AS17-143-21927 and 21928.]

169:25:26 Schmitt: (Is the SESC) full?
 169:25:28 Cernan: Oh, I've got about an inch to go.
 169:25:29 Schmitt: Okay.
 169:25:31 Cernan: Let's fill it up. (Pause) That's good.
 169:25:46 Parker: Okay. And both your feedwaters are up (to speed), 17. So things look good.
 169:25:53 Schmitt: (To Parker) Thank you.
 169:25:56 Cernan: Okay, Bob. (To Jack) (Garbled) that white thing off for me? (Pause)

[Gene is asking Jack to remove the Teflon seal-protector from the SESC.]

169:26:03 Schmitt: Yeah. Here, let me get...(Pause) There, you got her. (Long Pause) Okay. (I'll) take a couple (of pictures) over here.

[Gene's feet have been visible under the LM. He now turns to face the spacecraft. Jack is taking a cross-Sun after stereo pair. These are AS17-143-21929 and 21930.]

169:26:36 Cernan: Let me just go pat the radar. (To the descent radar) Good job. (Pause) (Garbled) radar's (ever been) built better.

[Gene takes AS17-134-20461, a photo of Earth and the rendezvous radar dish, and then starts back toward the Rover.]

[Cernan - "I was patting the radar for doing a good job; I was saying 'Thank you' It was just a personal touch."]

[Schmitt - "There's something in the back of my mind that there was an ad on commercial radio or television at the time that said 'Blank built better'. Ford or Chevy, maybe. And Gene was just putting 'radar' in the phrase."]

169:26:47 Schmitt: Bob, I'm on frame 96, and the short can sample - contaminated sample - is documented by two stereo pairs prior to that (frame). And the "before" is the cosmic ray pictures.

[Here, Jack is referring to the pictures he took after hanging the cosmic ray experiment from the rear strut during

EVA 1. Gene stops a few feet from the Rover, closing the SESC.]

169:27:09 Parker: Copy that (Pause)

[Jack returns to his Rover seat, having come around the north side of the LM.]

169:27:16 Parker: Okay. And which SCB is that going in, Jack?

169:27:22 Schmitt: Number 5.

169:27:24 Parker: Okay. Copy that.

169:27:26 Cernan: Okay. The SCB (means "SESC") is in 5. That what you asked?

169:27:30 Parker: Yeah.

169:27:31 Schmitt: Short can in 5.

169:27:34 Cernan: The (garbled) short (laughs)...SCB.

(Pause) Okay.

169:27:40 Parker: Okay. And while you're doing that...

169:27:41 Cernan: Yeah. (Garbled) your...let me get this...

169:27:43 Parker: ...remember, I want inventories of the stuff as it comes off the Rover and where you put it over there by the footpad, so we can help you keep track of it.

169:27:50 Schmitt: (Going to the ladder with SCB-5) Okay. We've got the big bag...ah...bag 7, bag 5, bag 4 at the footpad.

169:28:09 Parker: Copy that. We've also got SCB-3 with the Rover samples in it on the Rover, if you have any...yeah, you have some of those today.

169:28:15 Schmitt: No, we emptied those into 5.

169:28:19 Parker: Okay. Copy that.

[Jack returns to the Rover.]

169:28:21 Cernan: Okay, Bob. The gravimeter's on the surface. And you want a gravity reading and a bias reading, is that correct?

169:28:27 Parker: Roger. We'll get the grav first.

(Pause)

169:28:34 Schmitt: Okay, Bob...

169:28:37 Cernan: Mark it.

169:28:38 Schmitt: Let's see, where am I?

169:28:39 Parker: Copy that (mark). (Pause)

169:28:45 Cernan: (To Jack) What did you do with the...(To himself) Okay. (Reading CDR-30) "Gravimeter..."

169:28:51 Schmitt: You've got another big rock over here from the...

169:28:54 Cernan: It's in my footpan.

169:28:55 Schmitt: That's from Station 9, right?

[Jack goes around the front of the Rover, having just consulted his checklist.]

169:28:57 Cernan: Yeah. That's what I told them. (At) Station 9, I got a football-size rock, and I've put it in there. (Pause)

[Fendell moves the TV to watch Gene at the right-rear, replacement fender.]

169:29:06 Cernan: Well, we eventually lost one clamp. Let's see what we've got left on here (on the repaired fender). (Pause)

169:29:23 Schmitt: Okay. Gene's football-sized rock looks like it might be glass coated. And it might even have a shatter cone or two on it.

169:29:36 Parker: Okay, Jack.

[Fendell looks at the gravimeter, which is on the ground beyond the right rear fender. Gene's football sized rock is sample 79035, an 8.1 kilogram dark-matrix breccia.]

169:29:40 Cernan: (To Jack) Okay. I'll let you get...

169:29:41 Schmitt: (To Fendell) I don't know what you're focused on...

169:29:42 Parker: And...

169:29:42 Schmitt: ...but here's his rock.

169:29:44 Parker: ...and, Jack, we're making plans here, to change the camera usage at the end of EVA here. And we're going to let you take Commander's camera out to the ALSEP and take a few photos which people think we need. And Gene's going to take your camera out and document the geophone, when he deploys it. We will not deploy it for the long-term experiment, however. And we'll bring both (cameras) back, and carry them to the ETB when we get done.

169:30:17 Cernan: Okay. (Pause)

[When he said "document the geophone", Parker may have been referring to documentary photos of the seismic charge Gene will deploy near the VIP site. "When he deploys it" probably refers to the charge and the phrase "we will not deploy it for the long-term experiment" refers to a planned deployment of the camera on the Rover seat as indicated on checklist page CDR-32. Specifically, the checklist calls out "Pos(ition) LMP cam(era) vert(ically) on seat." Gene remembers that he did put the camera on the seat, with the lens pointed at the zenith. Presumably, the intent was to recover the camera at some future date to get information of long-term exposure to the lunar environment.]

[Cernan - "Parker said 'We'll bring them both (that is, both cameras) back,' but I know what I did with that camera. I left it on the Rover pointed straight up. That's what I planned to do and that's what I did. I can remember specifically wedging it - I don't remember exactly where - somewhere up between our seats."]

[There is further discussion about this matter of the 70 mm cameras at 170:26:25 and 183:40:39.]

169:30:22 Schmitt: Okay. We've got to reverse the rolls of the camera here.

169:30:25 Cernan: While you're getting that, we've got to doff our harnesses. Let me...Before you take this...Are you going to start loading the ETB yet or not?

169:30:31 Schmitt: Well, I'm just about there.

169:30:33 Cernan: Okay. I'll be right with you.

[Comm Break. Gene goes east of his LM with the camera and takes pictures looking back toward the LM and Rover. These are AS17-134-20462 to 20470. 20462 shows Jack at the Rover and the SEP pallet leaning against the north landing strut. 20463 and 20464 are pictures of Earth over the LM; 20463, in particular, is an excellent picture showing the Ascent Stage thrusters and the associated shields. 20465 and 20466 are pictures of Earth over the flag. 20467 is a good picture of Jack at the Rover with the MESA in the foreground. 20468 is another MESA picture, and 20469 and 20470 are pictures of the U.S. flag on the side of the LM. After a while, Jack goes to get the ETB, which is hanging from the edge of the MESA. Jack takes the ETB to the Rover. Gene also returns to the Rover.]

169:31:47 Schmitt: Okay, Bob. I've got the cosmic ray in the ETB.

169:31:54 Parker: Roger. Copy that. It's been in there all along, hasn't it?

169:31:59 Schmitt: Yup. (Pause)

[At the start of this EVA, at 163:56:20, Houston asked Jack to put the cosmic ray experiment in the ETB to protect it from a "little solar storm".]

[Schmitt - "So, originally, it was going to be out there for the full three EVA's and they made a real-time change because they predicted a solar flare? (Chuckling) Thanks guys. What about us? Couldn't we get in the ETB? Well, there's a limited number of things you can worry about. Right, Gene? Like having to deal with Schmitt all the time."]

169:32:05 Schmitt: Mag Foxtrot, or Franny, I guess, we changed it to. (Pause) Mag Donna. (Pause) The DSEA. (Pause) Mag Echo. (Pause) Mag Linda. (Pause) Mag Mary. (Pause) (To Parker) You through with the 500?

[Jack had started the game of using girls names for the magazine at the start of the EVA at 118:15:29. Gene joined the game only once, when he used "Franny" for magazine FF at Station 6.]

[Schmitt - "I was just doing it, looking at the magazines and coming up with names. Probably, I couldn't remember how to spell Eileen."]

[While Jack was talking, Gene crossed Fendell's field of view, going to the LM. He came back to the Rover almost immediately.]

169:33:03 Parker: Roger. We're through with the 500.
 169:33:10 Cernan: Jack, where is the cosmic ray? Did you put that in the ETB already?
 169:33:12 Schmitt: Yeah.
 169:33:13 Cernan: Okay. (Pause)

[Fendell pans clockwise past the ladder.]

169:33:20 Schmitt: I don't think the 500's working anymore, anyway.
 169:33:22 Cernan: It was working last time...
 169:33:23 Schmitt: Yeah, it is.
 169:33:23 Cernan: ...I used it.
 169:33:24 Schmitt: Yeah it is. Okay. Film cycle. Three times. (Pause)

[Fendell finds Jack at Gene's seat. He flips his gold visor down and removes mag Karen from the 500.]

169:33:49 Cernan: Look this away a minute. (Pause) Wait a minute (Pause) Okay. (Pause)

[Gene may be taking a couple of pictures of Jack. If so, they are AS17-134-20471 and 20472. In 20471, note that Jack's visor is raised. In 20472, it is down. 20472 is far the better picture and shows, among other things, Jack's cuff checklist and the high-gain sighting scoop. Note the amount of dirt on the Rover console.]

169:34:06 Schmitt: Okay. In go the scissors. (Pause)
 169:34:16 Cernan: Okay. I'm going to go get a gravimeter reading. (Pause)

[Gene goes around the back of the Rover. Jack begins taking things out of Gene's seat pan.]

169:34:25 Schmitt: Now, let's see. I don't...There it is. (Long Pause) Okay. Mag Karen is in (the ETB).
 169:34:55 Parker: Copy that. That sounds like all of them to us.
 169:35:01 Schmitt: Okay. And there are two on the cameras.
 169:35:04 Parker: Roger.

[Jack is not wearing a camera at the moment.]

169:35:09 Cernan: Bob, I'm reading 670, 010, 701; 670, 010, 701.
 169:35:16 Parker: Okay. Copy that. We're ready for a bias, Gene.

169:35:21 Cernan: Okay. (Pause) (I'm pushing) Bias; and it is flashing.
 169:35:37 Parker: Roger. Mark that. (Pause)

[Jack takes the ETB away. He is now on LMP-31.]

169:35:47 Cernan: Okay. Let me take a look around. Jack?
 169:35:50 Schmitt: Yeah.
 169:35:54 Cernan: Was that bag in there?
 169:35:56 Schmitt: Yes. It's over here on the MESA.

[Fendell pans to the LM.]

169:35:59 Cernan: Okay. (Pause) Let's get rid of these tool harnesses. We don't need those anymore.
 169:36:13 Parker: Yah; that's affirm.
 169:36:14 Schmitt: You've come loose on the right.
 169:36:18 Cernan: Yeah.
 169:36:20 Schmitt: Need to fix it for you.
 169:36:21 Parker: And remember, when they come off, guys, don't get them tangled up in the hoses. (Pause) If you stand still (garbled)...
 169:36:28 Schmitt: Let me pull it off for you.
 169:36:29 Cernan: (Garbled).
 169:36:30 Parker: If you stand still, we'll have Danny untangle it. (Pause)
 169:36:36 Cernan: (Guffawing) Yeah. (Pause) Okay.

[Fendell pans to the MESA and finds no astronauts; he then pans clockwise. This is one of several reference to suit engineer Danny Schaiewitz who participated in many of the training exercises.]

169:36:37 Schmitt: Turn this way. (Pause) Let me get the other side. (Pause) Okay. That's off.
 169:36:55 Cernan: Came off, huh?
 169:36:56 Schmitt: Yeah.
 169:36:57 Cernan: You don't have to get it around those hoses and everything? (Pause) See if you can do it.
 169:37:03 Parker: Works a lot better than the simulations, doesn't it?
 169:37:05 Cernan: They won't find the other one. Standby. (Pause)
 169:37:09 Schmitt: That's the only fallacy. They're not even watching this. Come over here and watch me, Ed. (Pause) Oh, me. Let me have it.
 169:37:19 Cernan: Wait a minute. Move over that way. He can't...Okay....
 169:37:23 Schmitt: Can you see me?
 169:37:24 Cernan: ...see if it comes off.
 169:37:25 Schmitt: (To Ed Fendell) Nod your camera if you can see me.

[Fendell finds them at Gene's side of the Rover.]

169:37:27 Parker: Rog. We can see you.
 169:37:28 Cernan: It's taking too long. Just take it off.
 (Pause)

[Jack waves his arms to dislodge the harness.]

169:37:32 Schmitt: Is it off?
 169:37:33 Cernan: (Garbled)...
 169:37:34 Parker: That is almost easier than at the Cape.
 Roger.
 169:37:37 Cernan: Jack, wait a minute before you...Hey,
 Bob, are we going to need those other core tubes?
 169:37:43 Parker: We'd like to have you leave the two core
 tubes and the extension handle and the hammer and I suppose
 the core cap dispenser here. If we get back in time from
 doing all our appointed tasks at the VIP site and at the
 ALSEP, we'll try and drive a double core here (pause) to end
 things up with a bang.

[Jack takes his harness toward the LM, presumably to
 throw it under the descent stage.]

169:38:02 Cernan: No, don't leave it there. We'll leave it
 here.
 169:38:03 Schmitt: Oh, that's right. You got it.
 169:38:06 Cernan: We'll play games with the extension
 handle, but that's all right.

[Gene doesn't yet realize that the extension handles, to
 which the scoop and rake were attached, were also lost during
 the drive back from Station 9. Normally, they would attach
 one of the extension handles to a core tube in order to
 hammer it into the ground without having to bend over.]

169:38:10 Schmitt: Okay...
 169:38:10 Cernan: Let me set them over here.
 169:38:13 Schmitt: Where am I (in the checklist)? Okay.
 (Reviewing LMP-30) Big bag, all those...
 169:38:22 Parker: 17, did you guys loose your...
 169:38:23 Schmitt: Don't need the LRV sampler any more.
 169:38:23 Parker: ...extension handles when that pallet
 came open?
 169:38:29 Cernan: (Responding to Parker) Yes, but I can
 still drive a core with the hammer if we need to.

[That is, Gene is saying that he can hammer the core
 tube in without the extension handle.]

169:38:32 Parker: Okay. Copy that.

[Fendell pans toward the MESA. Gene is at the gate.]

169:38:35 Cernan: I think. (Pause) Yeah. One (extension handle) went with the rake, and one went with the scoop.

169:38:46 Schmitt: (Returning to the Rover without the harness) Okay, Bob. As I read down that page (LMP-30), it looks like we got it. The ETB check (on LMP-31): I think we had four mags in there, and the DSEA, and the maps, and the cosmic ray.

169:38:59 Parker: Roger. You've got six mags.

[Jack takes the unused core tubes to the MESA. Fendell pans clockwise.]

169:39:00 Cernan: Okay, and...

169:39:01 Schmitt: I guess I'm ready to go to the (ALSEP)...

169:39:04 Cernan: Wait a minute. I want you to do something.

169:39:06 Parker: Okay. One...

169:39:07 Schmitt: (Responding to Parker) Six mags, is it?

169:39:08 Parker: ...one further question...

169:39:08 Cernan: (To Jack) You want these...You don't have...

169:39:09 Parker: ...Did all the FSR's (Football-Sized Rocks) get off the Rover into the big bag?

169:39:15 Schmitt: (Answering Parker) That's affirm.

169:39:17 Cernan: (To Jack) Yeah. This is the one you need anyway. That's (the) color (camera). (Pause) Why don't you see if you can grab a couple (of tourist pictures)? Yeah, right here. (Pause)

[AS17-134-20473 to 20479 are Jack's tourist pictures of Gene. 20474 is a good close-up of the front of the Rover and 20476 and 20477 are the best pictures of Gene. Note the large boulders in the background. These are south of Geophone Rock and are the ones Gene drove past at the start of the EVA-2 traverse.]

169:39:34 Schmitt: Boy, are you dirty.

169:39:34 Cernan: I know it.

169:39:38 Schmitt: Let's see. I don't know whether I can get you.

169:39:41 Cernan: Yeah, you can.

[Fendell finds Jack north of the Rover; the US flag is behind him.]

169:39:46 Schmitt: Ed, you've got your camera in the way.

169:39:48 Cernan: Oh, just take them straight on. That's all right.

169:39:50 Schmitt: (Taking pictures toward the Rover) That's sort of...(garbled). Okay. (Laughs) Such (a) pose. (Pause) Let me get a little different (pause) focus.

(Pause) That looks good.

169:40:09 Cernan: Okay.

169:40:10 Schmitt: (I'll) try one more over here. Have your pick. (Pause) One more.
 169:40:15 Cernan: How's like this? (Pause)

[Fendell pans clockwise.]

169:40:18 Schmitt: Okay.
 169:40:19 Cernan: (Laughing) You got that camera. That's the color camera.
 169:40:21 Schmitt: Yeah.
 169:40:22 Cernan: You take it.
 169:40:23 Parker: Okay...
 169:40:23 Schmitt: I've got to go get a neutron flux probe, I guess, (out of the deep core hole).
 169:40:25 Parker: That's right.
 169:40:26 Cernan: Oh, yeah. That's going to be easy to pull out.
 169:40:29 Schmitt: Okay.
 169:40:30 Cernan: Okay. Let's see if I've got everything in here.
 169:40:32 Parker: Okay. And...
 169:40:33 Schmitt: (To Parker, not having heard his "That's right") You ready for me to go to the ALSEP?
 169:40:36 Cernan: Jack?
 169:40:36 Parker: Roger. We're ready for both of you guys, now.

[Parker is subtly trying to remind Gene and Jack that they had planned a short close-out ceremony before Gene drives the Rover - and, more importantly, the TV camera - out to the VIP site. The close-out ceremony is not listed in the checklist.]

169:40:39 Schmitt: Bob?
 169:40:40 Parker: Roger. Go ahead.
 169:40:43 Schmitt: Hello, Houston.
 169:40:44 Parker: Hello, 17. Stand by. I think we're having a site handover or something.
 169:40:49 Schmitt: Houston, do you read? (No answer) Gene, do you read me?
 169:40:55 Cernan: Yeah, I read you.
 169:40:56 Schmitt: Where's Houston?
 169:40:57 Parker: Okay, 17. We had a...
 169:40:58 Cernan: (To Jack) Well, I don't know (garbled).
 169:40:58 Parker: ...site changeover there, and we've got you again. (Pause)
 169:41:06 Schmitt: (Hearing Parker) Are you ready for me to go to the ALSEP?
 169:41:08 Parker: Rog. We're ready for both of you guys, now.

[Fendell finds Gene at his seat, unfolding a large bag. Parker is still trying to remind them about the close-out ceremony.]

169:41:14 Schmitt: What do you mean? I'm headed for the ALSEP. (Pause)

[Fendell pans counterclockwise.]

169:41:26 Parker: Gene, are you ready for Jack to go to the ALSEP, now?

169:41:29 Cernan: (Consulting checklist to see what Parker means) Oh, let me see. (To Parker) Yeah, he's gone. He's good. I'm ready to get on, and go to the VIP site. (To Jack, having finally remembered the ceremony, calling) Wait a minute, Jack. Wait a minute. Here. Wait a minute. Where are you?

169:41:43 Parker: Yeah. We're trying to....

169:41:43 Schmitt: Right over here.

169:41:44 Cernan: Come on back here a minute.

169:41:44 Parker: ...we're trying to be subtle there, guys.

169:41:46 Cernan: Come on back here a minute. Come on back here a minute.

169:41:50 Schmitt: I didn't realize you were going out there quite so soon.

169:41:53 Cernan: Well, I just looked to see where it is (in the checklist). (Pause)

169:42:00 Schmitt: There. I'll...

169:42:01 Cernan: What did you do with that (rock)...

[Fendell reverses the TV pan direction.]

169:42:04 Schmitt: How about one of...How about this one?

[Schmitt - "Gene is talking about the Station 9 rock he had put in his footpan; and that's already been packed. So I reached down and picked one up. I remember that. It was relatively flat, I think."]

[In 1975, N. G. Bailey and G. E. Ulrich of the U. S. Geological Survey produced an annotated, partial transcript of Apollo 17, selecting out those parts of the dialog of immediate interest to geologists. They identify this hand-sized rock as 70017, a 3.0 kilogram piece of coarse-grained basalt.]

169:42:07 Cernan: You got it? (Long Pause) (Garbled) that one in my footpan?

169:42:25 Schmitt: I put it in the (laughs) big bag.

169:42:28 Cernan: Okay. Here we go, Jack. (Pause) Here's one here. (Pause) Here. All right?

169:42:36 Schmitt: Yeah. Let me get it (the rock), so you won't get it too dirty. Help you. Very good. (Pause)

169:42:44 Cernan: You hold it.

169:42:45 Schmitt: Okay.

169:42:47 Cernan: Got it?

169:42:48 Schmitt: Yeah. (Pause) How about over here?

169:42:55 Cernan: How about right over here against that background.

169:42:58 Schmitt: Yup. (Pause)

[Gene manually points the TV at Jack and then goes out to join him.]

169:43:06 Cernan: Houston, before we close out our EVA, we understand that there are young people in Houston today who have been effectively touring our country, young people from countries all over the world, respectively, touring our country. They had the opportunity to watch the launch of Apollo 17; (and) hopefully had an opportunity to meet some of our young people in our country. And we'd like to say first of all, welcome, and we hope you enjoyed your stay. Second of all, I think probably one of the most significant things we can think about when we think about Apollo is that it has opened for us - "for us" being the world - a challenge of the future. The door is now cracked, but the promise of the future lies in the young people, not just in America, but the young people all over the world learning to live and learning to work together. In order to remind all the people of the world in so many countries throughout the world that this is what we all are striving for in the future, Jack has picked up a very significant rock, typical of what we have here in the valley of Taurus-Littrow.

[Jack hands Gene the tabular, fist-sized rock that he's been holding.]

169:44:45 Cernan: It's a rock composed of many fragments, of many sizes, and many shapes, probably from all parts of the Moon, perhaps billions of years old. But fragments of all sizes and shapes - and even colors - that have grown together to become a cohesive rock, outlasting the nature of space, sort of living together in a very coherent, very peaceful manner. When we return this rock or some of the others like it to Houston, we'd like to share a piece of this rock with so many of the countries throughout the world. We hope that this will be a symbol of what our feelings are, what the feelings of the Apollo Program are, and a symbol of mankind: that we can live in peace and harmony in the future.

[Cernan - "The idea was there; the thought was there. But if I was going to say it again, I'd say it a little bit more eloquently. I'd thought about it a little bit before hand but, like a lot of things, not a great deal. The thought, the idea, but not the words. And I guess we got the point across."]

[Schmitt - "It reads well."]

[Readers will note that Gene's description of the rock as being "composed of many fragments" - that is, a breccia - involves a bit of poetic license. He had hoped to use a breccia in this ceremony and had ordered his thoughts with

that idea in mind. However, there were no large breccias near at hand and, as we've noted, Jack gave him a piece of basalt. In the context, a bit of poetic license seems justified.]

169:45:50 Schmitt: (Taking the rock as Gene hands it to him) A portion of a rock will be sent to a representative agency or museum in each of the countries represented by the young people in Houston today, and we hope that they - that rock and the students themselves - will carry with them our good wishes, not only for the new year coming up but also for themselves, their countries, and all mankind in the future. Put that in the big bag, Geno.

169:46:22 Cernan: In the big bag.

169:46:24 Parker: Roger...

169:46:24 Cernan: We salute you, promise of the future.

169:46:26 Parker: ...Jack and Gene. (Pause) We thank you for your sentiments and your interest.

[Apollo sample 70017 is now known as the Goodwill Rock. Although NASA still has about 80% of the rock in the Apollo collection, nearly 500 hundred pieces of it have been distributed to museums and researchers around the world. In the words of James Gooding, the Curator of Lunar Samples at the NASA Johnson Space Center, the Goodwill samples are "the most widely distributed of any lunar samples".]

[During our transcript review, Jack suggested that the rock they used in the ceremony never made it into the big bag and that the distributed samples might have come from the rock he had collected when Gene let him off the Rover part way back from the SEP site: "There's a piece of (Moon) rock that you can touch in the Smithsonian, and it's off that last big sample I'd stood up on end and kicked under the Rover (at 169:15:07). I think that's where that sample came from. In fact, I think that the samples they sent around to the kids around the world may have come from that same rock. It was a big rock; a real dense, heavy rock (Apollo 17 sample 70215 weighed 8.1 kilograms)."]

[Jack was partly right about this. The Goodwill Rock did make it into the big bag and was put to the intended use. And then, as Jack remembers, pieces of 70215 were also used for public display. According to John Dietrich, who retired as Curator of Lunar Samples at the end of 1991, four display samples - with a total mass of about 300 grams - were cut from 70215 and can be seen at the Smithsonian, at the International Space Hall of Fame in Alamogordo, New Mexico, at the Johnson Space Center, and as the center piece of a traveling NASA exhibition. Unlike most lunar samples which are carefully sealed and protected, the Smithsonian and Johnson samples are routinely displayed so that members of the public can "touch the Moon".]

169:46:38 Cernan: (Taking the rock and returning to the Rover) And now - let me bring this (TV) camera around - to

commemorate not just Apollo 17's visit to the Valley of Taurus-Littrow but as an everlasting commemoration of what the real meaning of Apollo is to the world, we'd like to uncover a plaque that has been on the leg of our spacecraft that we have climbed down many times over the last 3 days.

[Gene has swung to TV around to point at the LM ladder. He is now at the ladder himself and removes a cover off the plaque. He tries to hang the cover on a ladder rung but gives up and drops it to the ground. Jack takes a series of pictures of Gene and the plaque. These are AS17-143-20480 to 20488. 20483 is the best of the plaque pictures, and 20486 is a good close-up of Gene's very dirty gloves. It also shows the armbands holding his cuff checklist and watch.]

169:47:19 Cernan: And I'll read what that plaque says to you. First of all, it has a picture of the world. Two pictures. One of the North America and one of South America. The other covers the other half of the world including Africa, Asia, Europe, Australia, covers the North Pole and the South Pole. In between these two hemispheres, we have a pictorial view of the Moon, a pictorial view of where all the Apollo landings have been made; so that when this plaque is seen again by others who come, they will know where it all started. The words are, "Here man completed his first exploration of the Moon, December 1972 A.D. May the spirit of peace in which we came be reflected in the lives of all mankind." It's signed, "Eugene A. Cernan, Ronald E. Evans, Harrison H. Schmitt, and most prominently, Richard M. Nixon, President of the United States of America." This is our commemoration that will be here until someone like us, until some of you who are out there, who are the promise of the future, come back to read it again and to further the exploration and the meaning of Apollo.

169:48:57 Parker: Roger, Gene. We in Houston copy that and echo your sentiments. Dr. (James) Fletcher (the NASA Administrator) is here beside me. He'd like to say a word to the two of you.

[Gene and Jack start for the Rover but stop again and move to stand in front of the camera as they listen to Fletcher.]

169:49:09 Fletcher: Gene and Jack, I've been in close touch with the White House, and the President has been following very closely your absolutely fascinating work up there. He'd like to wish you Godspeed as you return to Earth, and I'd like to personally second that. Congratulations. We'll see you in a few days. Over.

169:49:35 Cernan: Thank you, Dr. Fletcher. We appreciate your comments, and we certainly appreciate those of the President. And whether it be civilian or military, I think Jack and I would both like to give our salute to America.

[Gene salutes as he stands facing the TV.]

169:49:53 Schmitt: And, Dr. Fletcher, if I may, I'd like to remind everybody, I'm sure, of something they're aware, but this valley of history has seen mankind complete its first evolutionary steps into the universe: leaving the planet Earth and going forward into the universe. I think no more significant contribution has Apollo made to history. It's not often that you can foretell history, but I think we can in this case. And I think everybody ought to feel very proud of that fact. (Pause) Thank you very much.

169:50:43 Fletcher: I'll see you in a little bit.

[Cernan - "Little did we know that it would be this long - nineteen years later and even longer yet - before Man will ever return. I don't think that either Jack or I ever thought - and we kept saying that Apollo 17 was the end of the beginning and not the end - that it would take this long for this nation or mankind in general to decide not only when he's going to return but if he desires to go back to the Moon and then on to Mars. Finally, we're at a point in time where people are beginning to talk seriously about it happening. But as we sit here today, in 1991, we all know it's going to be after the turn of the century before Man goes back again. That, in itself, is almost an unacceptable position to be in. If we had realized that nineteen years ago... We kept saying that, well, we're the last for a while but somebody will be back pretty soon. I've got to believe that both Jack and I certainly felt that it would be in the time frame of the 20th Century.."]

[Schmitt - "I knew things had slowed down. I don't know if you remember, Gene, but, when we rendezvoused with Ron - and I think it was just before or just after we undocked with the LM - Houston read us a statement from Nixon in which he said, specifically, that we were the last people to visit the Moon in this Century. And I really got upset. I think I either showed it or talked to you about it. I thought that was the stupidest thing a President ever could have said to anybody. You may believe it privately, but why say that to all the young people in the world."]

[Cernan - "And don't forget, this was in 1972, so we had thirty years to go before the century was over."]

[Schmitt - "It was just a totally unnecessary thing for him to say. Whoever wrote that speech really blew it with that remark. And I was really upset. Tired, but really mad. It was just pure loss of will."]

[The statement from Nixon was read up by Gordon Fullerton right after Challenger docked safely with America. It reads, "As Challenger leaves the surface of the Moon, we are conscious not of what we leave behind, but of what lies before us. The dreams that draw humanity forward seem always to be redeemed, if we believe in them strongly enough and pursue them with diligence and courage. Once we stood mystified by the stars; today we reach up to them. We do

this not only because it is man's destiny to dream the impossible, to dare the impossible, and to do the impossible, but also because, in space, as on Earth, there are new answers and new opportunities for the improvement of and the enlargement of human existence. This may be the last time in this century that men will walk on the Moon, but space exploration will continue, the benefits of space exploration will continue, and there will be new dreams to pursue, based on what we learned. So let us not mistake the significance or miss the majesty of what we have witnessed. Few events have ever marked so clearly the passage of history from one epoch to another. If we understand this about the last flight of Apollo, then truly we have touched a 'many splendored thing'. To Gene Cernan, Jack Schmitt, and Ron Evans, we say God speed you safely back to this good Earth."]

[Cernan - "I knew we wouldn't be back in ten years; but we're talking about as many as thirty-five or forty years. And that's a generation and a half. The kids who are in grammar school now are the people who are going to be taking those trips back to the Moon and on to Mars. So we've got a generation in there that we've left in limbo. I don't really want to get into this - and the Shuttle is sophisticated flying machine - but, whether it's the Shuttle or Soyuz or Mir, there is a difference between a space program that takes you to 300 miles away from your home planet and another one that sets you out on a voyage a quarter million miles away. There are significant differences, both technologically and philosophically. And, quite frankly, I'm a little disappointed in us, at this time, to know that we're really not much further along than we were back then."]

[Schmitt - "We're not as far. Then, at least we had a technology base. Now, we've got to rebuild it."]

169:50:45 Cernan: (To Jack) Okay, babe. Let's go to the AL(SEP)...Okay, Bob. I owe you a bias reading.
 169:50:51 Parker: Okay. Or you can get it later. There's no hurry on that. And we're off to the ALSEP...
 169:50:57 Cernan: (Waving into the TV) I'm going to give it to you right now.
 169:50:58 Parker: Okay. Ready to copy. I presume you've a UHT out at the ALSEP, Jack.
 169:51:04 Schmitt: (On his way) That's affirm.

[Gene faces southeast and shades the indicators with his hand.]

169:51:05 Cernan: 337, 417, 101; 337, 417, 101.
 169:51:16 Parker: Okay. Copy that.
 169:51:20 Cernan: Are you through with this (gravimeter)?
 169:51:25 Parker: Roger.

[Parker laughs, realizing that Gene wants to see how far he can throw the TGE.]

169:51:27 Cernan: (Repeating his question) Bob?
 169:51:29 Parker: (Laughing) Roger. We're through with it.
 169:51:30 Schmitt: (To Gene) Be kind. Be kind.
 169:51:32 Cernan: Well, I love it, and I'm sure it did a good job...
 169:51:35 Parker: Well, we're not through with you, Gene, so don't throw yourself too far!
 169:51:40 Cernan: No, sir. I just don't want to hit old Challenger there. (Pause)

[Gene throws the gravimeter toward the southwest with a half hammer-throw motion. It lands out of sight, behind the Rover.]

169:51:52 Schmitt: That was unkind.
 169:51:56 Cernan: You did the javelin!
 169:51:59 Schmitt: That was unkind.
 169:52:01 Parker: Roger, Gene. And we...
 169:52:02 Cernan: I didn't throw it as far as I could have. I just...
 169:52:03 Parker: ...we timed the parabola for that, and we have one excellent measurement of "g" on the Moon now.
 169:52:12 Cernan: Yeah, I didn't get you a pendulum, but I don't know where I would, Bob. Okay. I'm going to have to take you out to the VIP site!
 169:52:22 Parker: Okay. We're ready for that, and we'll...
 169:52:24 Cernan: If you concur?
 169:52:26 Parker: Okay. (Pause)

[In Houston, Experiments suggest to Flight Director Gerry Griffin that, as a result of Gene's treatment of the gravimeter, "that calls for another bias reading." Griffin replies, "You'll have to get it yourself.]

169:52:37 Cernan: (Looking at his checklist) Well, let me make sure I got everything. Okay. (Pause) Remember, we...

[TV off. Gene is on CDR-31.]

169:53:05 Cernan: Okay. Bob, I guess you're reading me through the LM, huh?
 169:53:08 Parker: Roger. Read you through the LM. You guys both read me through the LM?
 169:53:13 Schmitt: That's affirm.
 169:53:15 Cernan: Okay. The first thing I want to do...Tell John (Young) I'm going to do it exactly like he wants. (Pause) Okay. (Pause) The (LMP) camera is under the seat, I hope. Let me look. (Pause) Yeah, camera's there. (Pause)

[Cernan - "John Young drove his Rover out there to do the same thing - to get a picture of liftoff. And John may have told me something about positioning the Rover."]

[Schmitt - "You know what I think it may have been? I was thinking about it a moment ago. (AS17-143-21932 shows that) you positioned it at an angle to the line between the VIP site and the LM so that the TV camera had a better field of view. When we were looking at the picture before, I wondered why you left it parked that way."]

[Cernan - "I agree. Whatever I'm referring to (here) has got to do with the parking of the Rover."]

169:53:37 Cernan: Jack, did you do something with the dustbrush?
 169:53:39 Schmitt: No.
 169:53:41 Cernan: It was under the seat, right?
 169:53:42 Schmitt: It was, yeah.
 169:53:43 Cernan: Yeah. I want to make sure it is because I'll need it out there.
 169:53:46 Schmitt: No, wait a minute. I don't know that it's there now.
 169:53:47 Cernan: Well, I want to make sure that I can get...that I've got something to dust with (so the Rover won't overheat).

[They no longer have a right-rear fender and, even in the short drive out to the VIP site, it will get covered with dust. If the Rover electrical system is to survive for very long, Gene will have to give it a thorough dusting.]

169:53:54 Parker: Okay. (Joking, very dryly) And, Jack, as you go out to the ALSEP, let me cue in on your next 3 hours worth of work out there, repairing the ALSEP. All right? Over.
 169:54:03 Schmitt: Oh, okay. Go ahead. I'm here.
 169:54:08 Parker: Okay. Number one, we want to retrieve the UHT. And I quote, "tap sharply" - that's "sharply" - on the (LSG) gimbal, which is the center section there, the little square metal piece in the middle...tap sharply on the gimbal with the UHT, and then reverify the level on the LSG. We'll check response here in Mission Control after you've done that.
 169:54:38 Schmitt: (Incredulous) You mean tap on the thing (the bar) that swings!?!
 169:54:41 Parker: That's what they say.
 169:54:42 Cernan: You always wanted to do that, didn't you?
 169:54:44 Parker: Yeah, that's right. (Pause)
 169:54:50 Schmitt: Well, let me see if I can have a clean UHT to do that.
 169:54:56 Cernan: Okay, Bob. Everything (that is, the Nav system) is zeroed.
 169:54:58 Parker: Okay. And I'll be talking to Jack here, Gene, for a while. You can interrupt with your comments talking over me, and I'll try and copy them.
 169:55:09 Cernan: One comment. I got a (warning) flag on the other battery (at) 139 degrees.
 169:55:12 Parker: Okay. We copy that.

[When Gene arrived back at the LM at 169:18:27, the Battery 1 temperature reading was 132 degrees. It is now 139 degrees, hot enough to have tripped a warning flag on the top of the console.]

169:55:16 Schmitt: How much is "sharply"?
 169:55:18 Parker: Sharply is sharply. It's probably not heavily, but sharply. Fairly light, but sharply.
 169:55:26 Schmitt: On the edge?
 169:55:27 Parker: No. You can see that little square metal piece in the middle there?
 169:55:29 Schmitt: On the edge?
 169:55:30 Parker: You see that little square metal piece on there? You can just sort of rap on that...
 169:55:33 Schmitt: Oh, yeah. Okay. Here goes. (Pause) I did it.
 169:55:43 Parker: Okay. And then it says...
 169:55:43 Schmitt: You want me to do it again?
 169:55:47 Parker: Stand by. (Pause)
 169:55:53 Schmitt: That was sort of a moderate "hard tap".
 169:55:58 Parker: Go ahead, and hit it harder.
 169:55:59 Schmitt: It is level.
 169:56:00 Parker: Hit it harder, please.
 169:56:04 Schmitt: Okay. (Pause) (Is that) okay? I can hit it harder yet.
 169:56:17 Parker: Okay. We've observed something there. Stand by. (Pause)
 169:56:28 Cernan: Bob, you might be getting TV the way the antenna's oriented right now.

[Cernan - "As I remember, I went around behind the VIP site and drove up to the spot. So the antenna was probably looking pretty close to the Earth."]

169:56:31 Parker: Okay. Jack, go ahead. We'll do some more stuff here. In the meanwhile, while they're thinking about what's wrong with it...Did you just tap it again?
 169:56:44 Schmitt: No, I didn't touch it. I'm over at the Central Station now.
 169:56:47 Parker: Okay. They're looking at it. All right. Now, we want to take some photographs at the Central Station and a few selected photographs of the ALSEP. Number one, we want a "7-foot cross-Sun" to the south of the ALSEP Central Station and then a 7-foot down-Sun of the Central Station. Over.

[That is, Houston wants photographs taken while he's standing 7 feet north of the Central Station, and then another from the east, with the Sun at his back.]

169:57:10 Schmitt: A 7-foot cross-Sun to the south.
 169:57:12 Parker: That's what it says.
 169:57:17 Schmitt: And then a down-Sun.

169:57:18 Parker: Roger. A 7-foot down-Sun.

169:57:24 Schmitt: You might tell me what they're trying to get with it. I might be able to help them.

169:57:28 Parker: Okay. I presume that what this means is looking to the south. It was cross-Sun originally. I suspect that's what happened here, the way it was written up. So it's a 7-foot looking at all the switches to make sure you guys turned them the right way, I suppose. And then a 7-foot looking down-Sun, so that would be facing west, that side of it.

169:57:49 Schmitt: Okay. I got it. What else?

[AS17-134-20489 is a cross-Sun to the south, but showing the entire Central Station and, beyond it, Geophone Rock. 20490 show the lower part of the north face where the switches are located. 20491 is the down-Sun from the east. All three are excellent pictures.]

169:57:53 Parker: Okay. Now, there's a problem with the Central Station in which they think the south end is buried more deeply in the dirt than they had intended. And the Central Station is, at the present time, getting very warm on the back side, on the south side there. They believe you probably buried it in the ground when you were trying to tilt it to the proper alignment. They're requesting that, when you're at the ALSEP, you remove any soil buildup or debris with a convenient tool. They don't want you to touch it because it's fairly warm. But if you have a UHT or something to move it...Do you have a UHT with you or something with you that you can brush that soil aside with?

169:58:31 Schmitt: Yes, sir.

169:58:32 Parker: Okay. You know the...

169:58:34 Schmitt: It is piled up there. That's a good call.

169:58:36 Parker: Yes. Okay. They'd like that (dirt) brushed away. (Pause) And you can give me a call...

169:58:44 Schmitt: Fortunately, I brought my handy-dandy Rover sampler out.

169:58:47 Parker: Okay. You can brush that (dirt) aside, and give me a call when you think that's cleared up the way it ought to be. That's probably one of those things we didn't think about when we decided to tilt the Central Station.

169:59:00 Schmitt: Well, you couldn't anticipate the soil, Bob. (Pause) It's very soft.

169:59:13 Cernan: Bob, we are at VIP.

169:59:15 Parker: Okay. And Ed Fendell is hard on my back to remind you that it's better to be too far away than too close.

[Because of the great distance between the Earth and Moon and other factors, Fendell will have to command the TV camera to start panning upward about 2 seconds before the actual launch. That way, the camera will actually start

tilting up at the right time. The farther from the LM that Gene parks the Rover, the less of the TV frame the LM will fill and any mistakes Fendell makes in the panning speed won't matter quite so much. From the time that Fendell pushes the button in Houston to move the TV camera until the time he actually sees the camera move is about 6 seconds. In the first two seconds, the signal leaves Houston and travels by land or satellite link to one of the three large transmitters (Goldstone, Honeysuckle, or Madrid), then travels to the Moon (1 1/3 seconds out of the 2 seconds), and activates the TV tracking motors. During the next four seconds, the signal leaves the TV and travels back to Earth where the color-wheel signal is translated into a standard video signal for display in the Control Room.]

[Schmitt - "In my talks I use a 35 mm slide of the TV picture of liftoff (which is necessarily grainy), and I say, "Gene tried to persuade me to go out and get a really good picture of liftoff, but I declined."]

[Cernan - "It would have been great to have a camera on the Moon to watch the Lunar Module come in for a landing. I'd love to have that."]

[Schmitt - (Philosophically) "Some day."]

169:59:29 Cernan: (Agreeably) All right! I thought I was, but I think I may move just a little bit. There's a little rise here I can give you. (Pause) I think I'll give it to you.

169:59:40 Parker: Okay.

[AS17-143-21932 shows the final Rover parking configuration.]

[Cernan - "I sit here (looking at the picture) and swear that I parked the Rover with the wheels straight. That's the final parking? Well, we're behind the LM and it's about the right distance."]

[Schmitt - "Why doesn't it have a fender?"]

[Cernan - "I took it off. Both of them. I took them both home."]

[At some point before he goes back to the LM, Gene will remove the replacement fender - which is now at the Smithsonian's National Air and Space Museum in Washington. He will also remove the rear section of the left rear fender - which is now on display at the Johnson Space Center's Visitor's Center.]

169:59:42 Schmitt: By the way, Bob, the soil gets more cohesive with depth. I hadn't really noticed that before.

169:59:48 Parker: Okay. We copy that

169:59:52 Schmitt: It's quite a bit more cohesive at... (It) feels about the same down to 3 centimeters out here; and then the cohesiveness goes up so (much that) it's difficult to scrape with the Rover sampler.

170:00:07 Parker: Copy that, Jack. (Long Pause)

170:00:49 Cernan: (To Houston) Well, I think you can see almost everything from here.
 170:00:52 Parker: Okay, Geno. And, Jack, let me know when you get done scraping that soil away.
 170:01:00 Schmitt: I will. (Long Pause)
 170:01:21 Cernan: And now comes the hardest (high-gain antenna) alignment of them all! But I'll get it. (Long Pause) Somewhere about there. See if I can't tweak it up for you.

[Gene has parked the Rover pointed a little bit south of west, necessarily in the general direction of the LM so that the TV can be used to watch the launch. Because Earth is in the southwestern sky, the bore sight on the high gain antenna is over the batteries and Gene is having to lean in to do the alignment. The normal Rover heading at one of the geology stops was 045 (northeast). With that heading, the high gain was pointed back over the Rover and Gene could stand comfortably at the front of the vehicle to do the sighting.]

170:02:00 Schmitt: Bob, the east-west level bubble (on the Central Station) is not quite level (that is, it is not quite centered). The north-south is. Do you want me to tweak that up?
 170:02:09 Parker: Yeah, you might tweak that up. We are getting a good signal, but go ahead and tweak it up just a little bit. (Pause) And, Gene, what are you doing these days?
 170:02:29 Cernan: I'm getting the high gain set up for you.
 170:02:31 Parker: Okay. Now you know why we didn't make you park it in that orientation all the time, don't you?
 170:02:38 Cernan: Boy, I'll tell you. It was a piece of cake up until now. (Pause) There, I got you. (Pause)

[TV on]

170:02:57 Cernan: Bob, you're looking right down the center of my eyepiece.

[That is, Earth is centered in the scope.]

170:03:04 Parker: Okay, I don't think...
 170:03:05 Cernan: You should have TV.
 170:03:06 Parker: Yeah, we're getting TV there, Geno.
 170:03:11 Cernan: You getting it?
 170:03:12 Parker: We've got TV.
 170:03:13 Cernan: Well, let me take a look, and clean things up.
 170:03:14 Parker: Okay. I guess you can dust and dust and dust some more for a while.
 170:03:23 Cernan: Let me get this dusting problem out of the way before I do anything else.
 170:03:24 Parker: Roger.

[Gene moves the TV to clean the lens; he points it at the South Massif. He is on CDR-32.]

170:03:25 Cernan: You can look at your vantage point, and if you don't like it, let me know.

170:03:30 Parker: Okay. I'll tell Captain Video (Ed Fendell). (Pause)

[Fendell pans counterclockwise to the stop and then reverses direction. Captain Video was also the name of a character in a children's TV program of the early 1950's.]

170:03:43 Schmitt: Bob?

170:03:44 Parker: Go.

170:03:45 Schmitt: How close can soil be to this back plate of the ALSEP?

170:03:53 Parker: Stand by. I'll check.

170:03:56 Schmitt: It's about 30 centimeters away, most of the places now.

170:04:04 Parker: Okay. That sounds good. We'd like you to return to the surface gravimeter, Jack. What you did had some effect, but not a lasting effect. And we'd like you to "rap even more sharply", more strongly, on the gimbal another three times. And we're again watching it, and we'll let you know what to do. (Pause) And I might tell you that this has all been done recently - this afternoon - up at Bendix on the "qualification" unit, and it survived it and so we aren't in any real danger, apparently, of destroying it.

170:04:39 Schmitt: Okay. Three times, huh?

170:04:42 Parker: Rog. Or up to three times. (Long Pause)

[Schmitt - "Bendix built a production unit (of the gravimeter) that they put through thermal/vibration qualification tests. The qual unit was presumably identical to the flight unit."]

[Cernan - "They generally had a flight unit, a backup unit, and a qual unit (of most pieces of equipment)."]

[Schmitt - "My guess is that they didn't build a backup gravimeter."]

[Fendell has the TV pointed at the LM, with Family Mountain in the background. He zooms in and catches Jack, just barely visible far beyond the LM at the ALSEP site.]

170:05:40 Cernan: Bob, don't let me forget to bring a dustbrush back (to the LM) when I come. I'm going through my checklist...

170:05:44 Parker: Okay. I'll mark that down and remind you. And, Jack, you'll be glad to know that the temperature of the back plate there (on the Central Station) has already dropped twenty degrees - two-zero (20) degrees.

170:05:55 Schmitt: Oh, beautiful! Bob, I don't think that (Central Station) bubble is working.

170:06:00 Parker: Oh.

170:06:01 Schmitt: How's your signal now?

170:06:02 Parker: Stand by. I'll check. But why don't you go to the surface gravimeter? (Pause)
 170:06:10 Cernan: Bob, how's your TV lens? I don't have a lens brush. It looks good from here. I don't want to use this (big dust brush) unless you think so.
 170:06:16 Parker: Stand by.
 170:06:19 Schmitt: (Singing) "Knock three times."

[The first line of this popular song is "Knock three times on the ceiling if you want me."]

170:06:22 Parker: Roger, ...
 170:06:23 Cernan: Are you satisfied...
 170:06:23 Parker: ...Get out of the way please, Jack (means "Gene"); and we'll take a look against some bright soil.
 170:06:29 Schmitt: What?
 170:06:30 Cernan: No, that's me he's talking to. (Pause)
 170:06:37 Parker: Okay. It looks pretty good, Geno. Go ahead.
 170:06:39 Cernan: I don't have one of the lens brushes.
 170:06:41 Parker: Yeah, go ahead. It looks pretty good to us.
 170:06:45 Cernan: Okay.
 170:06:46 Schmitt: Okay, Bob. Here come the raps. Knock three times. (Pause) Okay. (Pause)

[Fendell looks at Geophone Rock and then at the U. S. flag.]

170:07:14 Parker: Okay, Jack. It's really fighting us pretty hard. We'd like you to put the UHT in the socket, and rock it very firmly. Don't pick it up, but rock it very firmly from side to side in all four directions. Move the UHT about 6 inches in each direction while you're doing it.
 170:07:36 Schmitt: Okay. (Long Pause) Okay, I rocked it. It (the gimbal)'s swinging.
 170:08:07 Parker: Okay. Is it reading...
 170:08:08 Schmitt: And the level bubble is (pause) centered. (Long Pause)
 170:08:31 Parker: Okay. We understand it's in good configuration again as far as alignment and leveling is concerned, Jack. Let's go on and take some more ALSEP photos, and let them think about it for a minute.
 170:08:41 Schmitt: Okay. What do you want?

[Fendell pulls back on the zoom.]

170:08:44 Parker: Okay. Next, what we want is some heat flow (photos)...(Pause) Okay. We just got late word. They'd like to do it one more time, and then call it quits. (Pause)
 170:09:06 Schmitt: The rocking bit, huh?
 170:09:07 Parker: Roger. The rocking bit one more time. (Pause)

170:09:17 Cernan: Bob, I may have moved the high gain. Do you see any change in signal?

170:09:21 Parker: Stand by.

170:09:25 Cernan: If you're happy, I won't touch it.

(Pause)

170:09:34 Schmitt: Okay, Bob. It's rocked. The shade is aligned to the Sun now; and it's level.

170:09:46 Parker: Okay. We copy that, and let's go get some ALSEP photos, Jack. I think you got some heat flow photos the other night, besides the two pans. If you did, these may be redundant. They want the cross-Sun and down-Sun of the east hole and cross-Sun and down-Sun of the west hole. And I'm not sure but what you got those earlier. You said you got some extra heat flow, but tell me if you did. All four of these are 7-foot...

170:10:18 Schmitt: I...

170:10:19 Parker: Go ahead.

170:10:22 Schmitt: I'll get the heat flow pictures. (Pause)
One was 11-foot, I think. And then the stereo pair.

[Fendell pans the TV counterclockwise.]

170:10:35 Parker: Yeah. I think all they're asking for is the two 7-foot stereopairs. (Pause)

170:10:47 Schmitt: Okay. That's one of them. (Pause)

[Fendell pans past Gene, who is still dusting. Jack takes three photos of the west heat flow hole. AS17-134-20492 is from the west. Note the rock that Gene used to give the cable a bend from southward to eastward. 20493 and 20494 are a stereo pair from the northwest and show the Central Station and Geophone Rock beyond.]

170:10:55 Parker: Okay. What they're asking for, Jack, is a 7-foot down-Sun and a 7-foot cross-Sun, which isn't quite what we've been taking in the past.

170:11:04 Schmitt: I'm getting the standard ones, Bob.

170:11:08 Parker: Copy that. (Pause)

170:11:13 Schmitt: Okay. You got the standard documentation.

170:11:16 Parker: Okay...

170:11:17 Schmitt: 11-footers and 7-foot stereos.

170:11:19 Parker: Okay. Go ahead. They can't complain about that, certainly.

[AS17-134-20495 to 20497 are Jack's photos of the east heat-flow hole. 20495 and 20496 are a stereo pair from the north. 20497 is a down-Sun.]

170:11:24 Schmitt: Okay. Now what?

170:11:26 Parker: Okay. We'd like a 3-foot shot of the lunar mass spectrometer (LMS), including the orifice where the breakshield was. And, Geno, we are observing some degradation and would like to have the high gain...

[In the Preliminary Science Report, the spectrometer is called the LACE or Lunar Atmospheric Composition Experiment. "Breakshield" is a reference to a dust shield which covers the entrance port and which will be moved back only after liftoff and the detonation of the seismic packages.]

170:11:39 Schmitt: Cross-Sun?

170:11:43 Parker: Yes, Jack; 3-foot cross-Sun. And, Gene; this is Houston. We'd like to get the high gain re-oriented a little bit. We're observing some degradation in the picture.

170:11:54 Cernan: I'll tweak it. (Long Pause)

[AS17-134-20498 and 20499 are Jack's cross-Sun and down-Sun pictures of the Lunar Mass Spectrometer, respectively.]

170:12:10 Schmitt: (To Parker) Okay. Got it. Now what?

(No answer; pause) LMS is complete.

170:12:24 Parker: Okay. Copy that. Now we want to go over (to) the neutron flux, Jack.

170:12:30 Schmitt: Okay. (Long Pause) How's the gravimeter doing?

170:12:47 Parker: We're looking at it, Jack. I'm not sure. (Long Pause)

[Fendell has been panning clockwise and reaches the rear of the Rover. Part of Jack's seat is visible and there is no camera or lens in evidence. However, even if Gene has put the camera in place by now, he remembers putting it between the seats, and that part of the Rover is hidden behind the console. Before going to remove the neutron flux probe from the deep core hole, Jack takes three more ALSEP documentation photos. AS17-134-20500 shows the LEAM and, beyond it, the Central Station, the RTG, and the trash pile. 20501 is an up-Sun of the LSG; and 20502 is a close-up documenting the leveling and alignment.]

170:13:23 Cernan: Hey, Bob. The panel you want covered... (To himself) Yeah, that's the panel. Okay. (To Parker) You want the panel with the On/Off switch and the signal strength switch and so forth covered, don't you?

[Fendell pans counterclockwise. Gene is referring to the line on CDR-32 which says "Cover LCRU C/D panel with 65% blanket". Evidently, this is the control panel on the left side of the unit which, given the orientation of the Rover, is the south side. They want the LCRU mirror uncovered so that it can radiate and keep the unit relatively cool, and they want to cover the side panel with the blanket to minimize the amount of sunlight it absorbs.]

170:13:41 Parker: Roger. And be sure to get the thing to External before you cover it there, Gene.

170:13:47 Cernan: Okay. That was going to be a question of mine.

170:13:52 Parker: Okay. That goes to External.

170:13:54 Cernan: Okay. It's External.

170:13:55 Schmitt: What do you want me to do at the neutron flux?

170:13:57 Parker: Okay. We want a photograph facing south from 7-foot. So a 7-foot cross-Sun, essentially, of the neutron flux in the soil.

170:14:11 Schmitt: Okay. (Pause) Would you like to have the RTG in that picture?

[AS17-134-20503 shows the treadle-and-jack, the thermal cover on the neutron flux probe, the Central Station, the RTG, the rock which is shielding the neutron flux from the RTG, and Geophone Rock in the background. 20504 appears to be taken with a different focus. 20505 shows the drill stem rack.]

170:14:23 Parker: Oh, I suppose if you're generous, you might take a partial pan around to the RTG. (Pause)

[Fendell points the TV at the LM; Gene is in the way.]

170:14:37 Schmitt: Well, it's just about that direction.

(Pause) Okay. Now what?

170:14:46 Parker: Okay. Now let's remove...(repeating for emphasis) remove the neutron probe experiment from the ground, and turn it off.

170:14:57 Schmitt: Okay. (Pause)

[In brief, the neutron probe consists of targets containing either boron or uranium-235 which, upon capturing neutrons, emit alpha particles or fission fragments which are then captured by plastic or mica detectors. The instrument consists of an outer tube containing the detectors and a central core containing the targets. Because the targets and detectors do not cover the whole surfaces of the core and tube, respectively, the core can be twisted so that the target/detector pairs are either next to each other or 180 degrees apart. In the latter case, very few alpha particles or fission fragments are captured by the detectors and, therefore, the instrument is "off".]

170:15:07 Schmitt: No more on the gravimeter, huh?

170:15:09 Parker: No, the gravimeter is looking very bad, still.

170:15:12 Cernan: Bob, do you want...(Stops to listen)

170:15:15 Schmitt: That's too bad. It really is.

170:15:16 Parker: And, Jack, you might note as you withdraw (the neutron probe)...

170:15:17 Schmitt: There it is.

170:15:18 Parker: ...just how difficult it is to withdraw it. Whether or not it's been seized by the soil collapsing around it or not. That's soil mechanic's goody.
 170:15:28 Schmitt: Not at all, not at all.
 170:15:29 Cernan: It won't be, I'll tell you!
 170:15:31 Schmitt: No problem.
 170:15:32 Parker: Okay. We copy that.
 170:15:34 Cernan: Okay. The high gain is tweaked.
 170:15:38 Parker: Okay. We'll consider ourselves tweaked.
 170:15:44 Cernan: And I'm giving the LCRU another zap here (with the dust brush). Boy, I tell you, I ain't going to do much more dusting after I leave here. Ever.
 170:15:56 Schmitt: Okay. Upper probe is Off...
 170:15:56 Cernan: Not (just) today, but evermore.
 170:16:00 Schmitt: ...Mark it.
 170:16:01 Parker: Copy that.
 170:16:05 Cernan: Okay, Bob. (As per CDR-32, near the top) I'm going to put bus B and D, Open, and Aux Circuit Breaker Bypass, On.
 170:16:14 Parker: Okay. Copy that.
 170:16:19 Cernan: (To himself) And let me see. Bravo. Okay. And Delta. Okay. Bravo and Delta.

[Both Gene and Jack are speaking louder to Parker than to each other or themselves.]

170:16:32 Schmitt: Upper probe is Off...
 170:16:35 Schmitt: Mark it.
 170:16:36 Parker: Is that upper or lower, Jack?
 170:16:39 Schmitt: Up...Oh, lower. I'm sorry, Bob.
 170:16:41 Parker: Copy that.
 170:16:44 Cernan: Aux Power circuit breaker is On. Bypass, On.
 170:16:48 Schmitt: And the lower probe is capped.
 170:16:50 Parker: Okay; and, Gene, you need to close that (Rover) Caution and Warning flag. It's a heat sink when it's open, I guess.

[With the flag up, it absorbs more heat than when it is lying flat on the top of the console.]

170:16:59 Cernan: Okay; it's closed.
 170:17:01 Parker: Copy that.
 170:17:02 Cernan: You want me to put a bag in front of that thing?
 170:17:07 Parker: No, I don't think...
 170:17:07 Cernan: Want me to put a bag in front of it in case it pops open again? I guess it won't.
 170:17:11 Parker: No, I don't think so. I can't imagine why it's really a problem anyway, because we got the Bypass On, there, and that heat's not going anywhere.
 170:17:20 Cernan: Okay; and all the switches off. Except my 15 volts.
 170:17:25 Schmitt: Bob, you want me away from the ALSEP now?

170:17:28 Parker: Stand by, Jack. I'll get one more word before we come back to the LM.
 170:17:35 Schmitt: Okay. (Pause)

[AS17-134-20506 shows the LM and some Rover tracks. Jack may have taken this picture while waiting for permission to go back to the LM. Gene and the Rover are visible beyond the LM.]

170:17:43 Cernan: (To himself) Okay, I'll get a camera. Over there. I'm going to look under the seats one more time. Nothing but a 500...Okay. Some used tape. (Pause) Okay. That's closed.

[At this point in our transcript review, Jack remembered that the 500 mm lens was mounted on the third camera which was stowed under Gene's seat. The Apollo 17 Spacecraft Packing List confirms the fact, as does the Surface Checklist. We also noticed in the TV that, at this point, Gene is not wearing his 70 mm camera, having taken it off to do the high-gain alignment and other Rover close-out tasks.]

170:18:00 Parker: Okay. Jack, we're ready to leave the ALSEP.
 170:18:04 Schmitt: (Irony) Well, I hate to do that, Bob.
 170:18:08 Cernan: I'm sorry about that gravimeter, though.
 170:18:10 Parker: Well, you're not the only one. (Pause)
 The word is down here there's a whole room full of people who are sorry. (Long Pause)

[Schmitt - (Telling Gene the LSG story) "The LSG was supposed to be a very-long-period gravimeter to sense free-oscillations of the Moon if a gravity wave went by. It was the only potential Nobel-Prize-winning experiment ever taken into space by Apollo. From the very beginning - the initial drawings - they had a misdesign on the weight of the balance beam by a tenth of a gram. It was never picked up. And I didn't know if you remember or not, but when we deployed the flight hardware for the last time in that big Air Force hanger (at the Cape)...We had insisted on deploying the flight hardware. They weren't happy about that, but we insisted on doing it and they had to repack it. But at that time, we stood around and talk about it and I asked "Have you tested the uncaging of the balance beam in a simulated one-sixth g tilt plane?" And they said, "No." And I said "Why?" And they said, "Because the manufacturer had said it would disclose proprietary information." So I probably said, "Well, you ought to do it," and then just forgot about it. Nobody ever tested the uncaging of that balance beam. And it wouldn't uncage. It was just that one-tenth of a gram too heavy and wouldn't uncage to the degree necessary to be a long-period gravimeter. And if you want to be upset about something, you can be upset about that."]

[A more complete discussion of the LSG can be found at 137:45:08. Fendell finds Gene at his seat. He takes the big bag to the gate. Fendell pans back to the LM, then points the camera down to look at the battery covers and scans the soil near the Rover.]

170:19:03 Cernan: Okay. (Pause) I've got the LMP's (B&W) camera. Nothing in here (under the seats) but couple of old bags. We used about all the bags we had, Jack! Not many here. (Long Pause) Bob, I have the dust brush tethered (to his yo-yo).

170:19:43 Parker: Copy the dust brush.

[The fact that Gene does not mention the 500 mm camera suggests that he has set it between the seats.]

170:19:48 Cernan: Okay; let me get one parting shot (photo) one of the finest running little machines I've ever had the pleasure to drive. (Pause)

[Gene takes AS17-143-21931 to 21934. The best of these is 21932. Note Gene has removed the replacement fender and, from the left side, the rear extension.]

170:20:12 Parker: Okay. And, Geno, some people down here are concerned about whether you've opened the battery covers or not.

170:20:20 Cernan: Yes, sir; they're open.

170:20:22 Parker: I copy that.

170:20:29 Cernan: Oh, what a nice little machine! Parked on a little downslope, but at the heading you want, and I guess Ed's satisfied with the TV response, huh?

170:20:41 Parker: Roger. We're satisfied with the TV, Gene. We're ready for you to take the EP number 3. (Pause)

[Gene is now on CDR-33. In Houston, Fendell tells the Flight Director that the distance is "well over" the 450 feet (137 meters) he needs. Gene's photos shows that the distance is about 145 meters.]

170:20:50 Cernan: Good old Mother Earth is right smack in the center (of the bore site on the high gain antenna).

[Comm Break. Fendell points the TV back to the LM and finds Jack running toward it.]

170:22:00 Cernan: Bob, while we've got a quiet moment here, as I go to deploy that EP charge, I'd just like to say that any part of Apollo 17 - or any part of Apollo - that has been a success thus far is probably, for the most part, due to the thousands of people in the aerospace industry who have given a great deal - besides dedication and besides effort and besides professionalism - to make it all a reality. And I would just like to thank them. Because what we've done here

and what has been done in the past - as a matter of fact, what has been done for 200 years - you've got to contribute (means "attribute") to the spirit of the group of people who form the aerospace industry. And I (say) "God bless you" and "thank you."

170:23:06 Parker: Roger, Gene. And we thank you guys.

170:23:14 Cernan: Well, we're just two little sets of twinkletoes here. There's a lot that goes to getting this Rover running out here that we don't have much to do with.

(Long Pause)

170:23:44 Cernan: And I guess there might be someone else that has something to do with it too, and I've been reading His sign - maybe not from Him directly, but His in spirit - as we run up and down that ladder. And that's "Godspeed, the crew of Apollo 17". And if He's listening, I'd like to thank Him, too. (Long Pause)

[Cernan - "We hadn't gotten off the surface yet, and we still needed all the help we could get."]

[Schmitt - "Somebody, I think, had put the message on a rung of the ladder."]

[Cernan - "I guess it had to be up there. It was just as I barely got out. I guess I've got to go along with that. My nature would have been to see that and read it. It was a response to whoever put it there."]

[Schmitt - "It may have been pasted on the strut."]

[As indicated previously, we have been unable to find anything in the photos that looks like a message. However, we only have a good, sharp images of about the lower two-thirds of the ladder and strut. And it is entirely possible that there is a message to be found when the site is visited next.]

170:24:16 Cernan: Pin 1 is pulled.

170:24:27 Parker: Mark that.

170:24:23 Cernan: I'm at the end of the west SEP antenna. Do you agree with that?

170:24:26 Parker: Roger. Exactly right.

170:24:30 Cernan: Okay. Pin 2 is pulled. Still safe. Pin 3 is pulled, and it's still safe.

170:24:40 Parker: Copy that, and...

170:24:41 Cernan: Wonder what I would do if it wasn't.

(Chortles)

170:24:45 Parker: And now, also, do you have the SEP transmitter turned off there, Gene?

170:24:49 Cernan: No, sir. Thank you. (Pause)

[Once again, Fendell examines the ground near the Rover.]

170:24:53 Parker: Then we're ready for you guys...

170:24:54 Cernan: Okay, Bob...

170:24:54 Parker: ...to get back to the LM and dust and get in.

170:24:56 Cernan: ...it (the charge)'s setting right adjacent to the ring (the SEP antenna spool) on the west end, and I'm going to go back and turn the SEP off.
 170:25:07 Parker: Okay. And when that's done, Gene, we're ready for you and your dust brush to hasten back to the LM and dust each other and climb in.
 170:25:17 Cernan: You know what, Bob?
 170:25:19 Parker: What, Gene?
 170:25:20 Cernan: Great as an experience as it has been, I'd say we're probably both ready.
 170:25:26 Schmitt: Oh, I don't know. Hey, Bob, 55 Yankee is an exotic-looking rock I found about 5 meters south of the neutron flux hole. It's another grey - possibly-grey - basalt. It's just that there aren't many of them around here, and so I picked it up.
 170:25:43 Parker: Copy that.

[AS17-134-20507 may have been taken at this sample site.]

170:25:48 Schmitt: Cheating a little again.
 170:25:51 Cernan: Jack, you'll always be picking rocks.
 170:25:55 Schmitt: Oh, I don't know.
 170:25:58 Cernan: Okay, the (SEP) transmitter is Off.

[In order to estimate Gene's speed in running back to the LM, note that the SEP transmitter is about 145 meters from the LM.]

170:25:59 Parker: Mark that.
 170:26:00 Cernan: (To Jack) I don't blame you. There's so many interesting things around here. (Pause) (To himself) Just don't lose your brush, Gene. Okay, Bob, according to my inventory, I'm going to return to the LM and the (LMP's) camera's going to the ETB.
 170:26:25 Parker: That's affirm. We'll have...

[Cernan - "I can sit here and, just as sure as I'm alive at this moment, I can remember placing that camera (on the Rover seat). And I thought it was such a crime to leave a Hasselblad. But we were going to point it with the lens up so that, someday when someone goes back there, they can see the degradation of the lens from the cosmic radiation. And I guess I didn't do it. What can I tell you."]

[Gene wonders if the memory of putting the camera between the seats is actually derived from training. However, the possibility remains that he put the 500 mm camera on the seat.]

170:26:27 Cernan: And we're done with the TGE.
 170:26:28 Parker: Roger. (Laughs) We'll need a bias reading if you want to use it again, Gene.
 170:26:33 Cernan: Come to think of it, I guess you are (done with the TGE), aren't you. (Pause)

[At 169:51:04, Gene took a moment to see just how far he could throw something as bulky as the TGE.]

170:26:42 Cernan: Where are you, Jack?
 170:26:44 Schmitt: I'm at the MESA.
 170:26:46 Cernan: Okay.
 170:26:49 Schmitt: Trying to snap a snap.
 170:26:50 Cernan: I need a locator here to the LM. (Pause)

[AS17-146-21935 to 21387 are Gene's locators from the place where he deployed Seismic charge 3. Jack is at the LM, out of sight at the MESA. 21938 to 21940 are three additional photos of the LM. Note that the end of the antenna arm and, therefore, the charge, is 35 meters west of the SEP transmitter and 110 meters from the LM.]

170:27:05 Parker: Okay; and, 17, we need you guys in the LM in one-five minutes - fifteen minutes - because of oxygen constraints.
 170:27:16 Cernan: Okay, Bob, my pictures are taken; I'm on the way. (Pause) Oh, boy! Where else can you do this?
 (Long Pause)

[Fendell finds Gene northeast of the LM, moving along with a long, easy skipping stride. He is carrying the replacement fender and the aft section of the left rear fender. See the discussion at 169:59:40.]

170:28:29 Cernan: (At the MESA) If I had landed 30 meters back, Jack, we'd be pitched down 5 degrees. (Pause)
 170:28:37 Schmitt: You're right.

[If we assume that Gene left the Seismic Charge 3 at 170:27:16, the run took 1 minute 25 seconds and his average speed was a very respectable 4.6 km/hr. The Apollo 17 record - at least for recorded runs, belongs to Jack, who twice achieved 5.4 kph: once at 120:27:11 and again at 121:36:36. For reference, the best timed run on a prior mission was Charlie Duke's 4.7 kph run - 50 meters in 38 seconds - back to the LM at the end of the second Apollo 16 EVA.]

170:28:40 Cernan: Okay, what they're saying is, I don't need my hammer any more.
 170:28:44 Parker: Roger...
 170:28:44 Cernan: All we've got to dust and get in.
 170:28:45 Parker: ...We want you to dust and get in. We got one-four (14) minutes remaining before we need the hatch closed.
 170:28:56 Cernan: Okay, Bob. We're doing our best.
 (Pause) Well, that RTV worked on the hammer, but look at it, Jack. It's worn completely to a nub. It's off.
 170:29:21 Schmitt: I guess that's all right...
 170:29:23 Cernan: Look at...Where are you?

170:29:25 Schmitt: I don't know where I am. Oh, boy, how about that?
 170:29:29 Cernan: Okay.
 170:29:30 Schmitt: Okay, sir.
 170:29:31 Cernan: You ready to go on up?
 170:29:33 Schmitt: Well, I don't know. Got to take my camera off. I got another batch of pictures...the LM and the flag and...
 170:29:40 Cernan: Well, watch this real quick.
 170:29:42 Schmitt: Stereo, even.

[These photos are AS17-134-21508 to 21513.]

170:29:43 Cernan: Jack...
 170:29:44 Schmitt: Let me have your camera to put in the ETB). Go ahead (and talk). (Noticing that Gene is about to throw the hammer) Oh, the poor little...Let me throw the hammer.
 170:29:48 Cernan: Okay.
 170:29:49 Schmitt: Let me throw the hammer? Please.
 170:29:50 Cernan: It's all yours.
 170:29:51 Schmitt: You got the gravimeter
 170:29:52 Cernan: You deserve it. A hammer thrower...You're a geologist. You ought to be able to throw it.

[Schmitt emerges from behind the LM, moving a ways north,]

170:29:56 Schmitt: You ready?
 170:29:57 Cernan: Go ahead.
 170:29:58 Schmitt: You ready for this? Ready for this?
 170:30:00 Cernan: Yeah. Don't hit the LM. Or the ALSEP.
 (Pause)

[Jack throws the hammer with a discus motion. It is visible against the sky for a long time. Gene's picture of Jack, AS17-143-21941 may have been taken just after he threw the hammer.]

170:30:07 Cernan: Look at that! Look at that! Look at that!
 170:30:12 Schmitt: Beautiful.
 170:30:14 Cernan: Looked like it was going a million miles, but it really didn't.
 170:30:17 Schmitt: Didn't it?

[Because of the Rover's location east of the LM, none of the following close-out activities are visible.]

170:30:19 Cernan: Okay, here, this is an ETB.
 170:30:20 Schmitt: Let me make sure that that's all cinched up.

170:30:22 Cernan: Okay. And then start on up. We got to get going here.
 170:30:27 Schmitt: Yeah. Unfortunately, their little plan didn't count for the fact that it's hard to pack the ETB with the film magazines in it.
 170:30:34 Cernan: And I'll try and get the big bag here cinched up.
 170:30:38 Schmitt: That is a major task.
 170:30:39 Cernan: Yes, that's going to be...Oh, is it heavy. Is it heavy. Something in that core tube you put in there?
 170:30:45 Schmitt: Yes, sir.
 170:30:46 Cernan: Okay.
 170:30:47 Schmitt: Don't tell anybody, though, because they'll get mad at me.

[Schmitt - "I grabbed one of the unused core tubes, grabbed hold of the strut, and leaned on it underneath the LM, just behind the strut, and pushed it in as far as I could. And I think it went in about two-thirds of the way, and then I capped it."]

170:30:49 Cernan: Oh, man, is that (big bag) heavy. Holy smoley. Oh! (Pause; static)
 170:31:03 Schmitt: (Garbled) 252 has about three-quarters of a core - hand pushed (into the ground) - (taken about) half a meter inside the plus-Y (north) footpad.
 170:31:24 Parker: Okay; copy that.
 170:31:29 Cernan: Okay, Jack, how's that ETB coming so you can get going?
 170:31:31 Schmitt: Fine.
 170:31:32 Cernan: Okay, I've got to...
 170:31:33 Schmitt: I've got to put it on the strap, though.
 170:31:37 Cernan: I can get that. This is all cinched up. I think it'll hold. Why don't you start on up? Then I'll start dusting you.
 170:31:47 Schmitt: Okay. (Pause)
 170:31:52 Cernan: Okay. Very good.
 170:31:54 Schmitt: Anything fall out?
 170:31:55 Cernan: Nope.
 170:31:56 Schmitt: Okay. Oh...
 170:31:58 Cernan: Let me dust you. Set that down, and I'll hand it all to you.
 170:31:59 Schmitt: Okay, you'll have to hand stuff...
 170:32:01 Parker: Okay; and, 17, a reminder. We need you inside in 10 minutes.
 170:32:07 Cernan: Okay, Bob. (To Jack) I'll get your front real quick. (Long Pause)
 170:32:24 Schmitt: I'll do a lot of jumping up here in a minute.
 170:32:25 Cernan: Your back is clean.
 170:32:29 Schmitt: I'll get the legs as best I can.
 170:32:30 Cernan: Okay. Why don't you get me here before you do that?

170:32:33 Schmitt: Okay. And while I'm doing that, will you take this...

170:32:35 Cernan: (Garbled)

170:32:36 Schmitt: I'll get it.

170:32:37 Cernan: Okay. (Pause)

170:32:45 Schmitt: Boy, you got dirty today. I think we're just going to have to live with it. (Pause)

170:32:57 Cernan: Get my top. I can kick a lot of that stuff off my legs. (Pause) How do I look in back?

170:33:06 Schmitt: Terrible. (Long Pause) Okay, turn. Oh, man. (Pause) You're going to have to...Your legs are really filthy. Not much I can do about it.

170:33:35 Cernan: Okay, I'll get them off. Why don't you start back...

170:33:36 Schmitt: Just kick them against each other when you go up.

170:33:37 Cernan: Okay. Start on up.

170:33:41 Schmitt: You might shake the bags.

170:33:42 Cernan: Okay.

170:33:45 Parker: And don't forget your PLSS an...

170:33:49 Schmitt: (Responding to Parker) No.

170:33:51 Cernan: Do what?

170:33:52 Schmitt: PLSS antennas.

170:33:53 Cernan: Okay.

170:33:55 Schmitt: Although it doesn't make much difference anymore.

170:33:59 Cernan: That's to get them out of the way. The big bag didn't stay closed very long.

170:34:04 Schmitt: I don't know how we're going to get that in.

170:34:06 Cernan: Well, I can hand it to you.

170:34:08 Schmitt: It never had a very good closure on it...

170:34:12 Cernan: That Velcro won't hold.

170:34:13 Schmitt: ...but it can be closed.

170:34:14 Cernan: I had it over the top. The latch was closed, but...

170:34:19 Schmitt: Oh, it won't hold with all that weight in there. Okay, I got your antenna.

170:34:22 Cernan: Okay, let me get a high...Got to close this. You don't want that in your way.

170:34:27 Schmitt: I can't close it.

170:34:29 Cernan: Oh. (Chuckles) Okay. (Pause)

170:34:39 Schmitt: You might try. (Pause)

170:34:45 Cernan: Get all your flaps? (Pause) Okay, hold your head down. (Pause) No.

170:35:02 Schmitt: Won't go, huh?

170:35:03 Cernan: No. Will that bother you getting in?

[Gene has been unable to get Jack's antenna tied down. Here, they are deciding to leave it up.]

170:35:04 Schmitt: I can probably make it.

170:35:05 Cernan: Okay, head on up. (Pause)

170:35:10 Schmitt: (Missing the rung) Oops. Try that again. Okay, why don't you hand me the neutron flux, and I'll put it...
 170:35:20 Cernan: Okay, neutron flux.
 170:35:21 Schmitt: ...on the platform. (Pause) Okay.
 170:35:27 Cernan: Why don't you start in, and I'll get some of these bags (the full SCB's) out of the way.
 170:35:30 Schmitt: Well, I just...(Pause) You don't want to hand them to me up here?
 170:35:38 Cernan: Okay.
 170:35:41 Parker: And, Jack, for your thoughts, we've agreed that you can delete the tracking light. We'd like to get you guys in as soon as possible. Seven minutes now. And we'll delete the tracking light test.

[Jack is on cuff checklist page LMP-32. Gene is on CDR-34.]

[Cernan - "Jack was supposed to turn the tracking light on so that I could see if it was blinking. Ron needed to track us visually. Parker was getting quite worried about us getting in, because I remember that I told him, 'Don't worry, we're doing it.' Jack and I felt like we had our act together. We weren't pushing against oxygen starvation or anything like that. I can see the guys back here in the MOCR saying, 'Get 'em in, get 'em in. They're down to mission-critical oxygen, a mission rule,' or what have you. But this is a time when we really felt we had it together. We knew what we were doing, we knew what we had to do. We'd been in and out of that hatch three or four times already."]

[Schmitt - "It looks like I got in in two and a half minutes."]

[Cernan - "It looks like you got in awful quick."]

170:35:51 Cernan: Okay. (Pause)
 170:35:57 LM Crew: (Garbled) (Pause)
 170:36:09 Schmitt: Okay, that's all I can handle up here. One more and I can put it up here.
 170:36:15 Cernan: Watch the cover on this one. (Pause) Got it?
 170:36:19 Schmitt: Got it.
 170:36:20 Cernan: Stand it up, because the cover won't hack it. (Long Pause)
 170:36:43 Cernan: Okay. Soon as you get on in, I'll come up to the porch. (Long Pause)
 170:37:29 Schmitt: Where's that EVA pallet that's always in my way?
 170:37:33 Parker: I think we aren't going to have one of those (an EVA) tomorrow, Jack, so we did away with that. (Pause) We hope we're not going to have one of those tomorrow.
 170:37:41 Cernan: Bob, we're maximizing our efforts, so just bear with us. Jack's going to be in about 30 seconds,

and I'm on the ladder hauling some stuff up now. (Light static starts)

[Gene is on CDR-35.]

170:37:56 Parker: Roger. "Don't panic."
 170:38:02 Cernan: Well, we're not. I just don't want you to.
 170:38:05 Parker: I never panic there, guys. (Pause)
 170:38:14 Schmitt: (In the cabin by now) Got some stuff for me?
 170:38:16 Cernan: Yes, sir. (Pause) This is not the time to rush. It's the time to do it nice and slow and right.
 170:38:26 Schmitt: Oh, we're all right.
 170:38:27 Cernan: Okay. (Pause) You're not going to like this (big bag), but I'm going to give you this one first because I've got it in my hand.
 170:38:38 Schmitt: Either one. (Pause)
 170:38:48 Schmitt: Oh, hang in there...I've got it! Oh, that's a heavy bag.
 170:38:53 Cernan: That is heavy, babe. Let me tell you, that's heavy. (Pause)

[Schmitt - "I wouldn't be surprised if we had almost a hundred pounds in that big bag. I think that all the big rocks were in there. But it's strange, that's still not a lot of weight. We must have been feeling the mass more than the weight."]

[The actual weight of the big bag, as reported at 171:36:39, is 71 terrestrial pounds or 12 lunar pounds. This is nearly half of the 137 pounds of samples they collected during this EVA.]

[Cernan - "Relatively, I guess it was heavy. We didn't pick up a hundred pounds of stuff very often. We picked up the Rover together; but everything else we picked up - relatively speaking - was a lot lighter than that."]

[Fendell points the TV at the ground. This is a somewhat to be a risky thing to do, considering that the Flight Director probably would not be eager to have Gene spend five minutes to go out and fix it.]

170:39:06 Schmitt: Okay; next.
 170:39:08 Cernan: Can you reach that one? If not, I'll shove it in further.
 170:39:11 Schmitt: I got it. (Pause) Okay.
 170:39:22 Cernan: One more coming at you.
 170:39:23 Schmitt: Okay.
 170:39:24 Cernan: Tilting up right now.
 170:39:26 Schmitt: Go ahead. (Long Pause)

[Fendell is looking at Earth.]

170:39:39 Schmitt: Okay, next.
 170:39:41 Cernan: Okay, tilting up at you.

170:39:42 Schmitt: Got it.
 170:39:44 Cernan: Okay? (Pause)
 170:39:48 Schmitt: Okay, next. Okay, Bob, we've got...
 170:39:53 Cernan: Oh, here...
 170:39:55 Schmitt: Big bag, three SRC's (means "SCB's") and a neutron flux.
 170:39:59 Parker: Okay, and we gather an ETB coming up with two cameras in it.

[The ETB is hanging near the ground from the lanyard. Gene is pulling it up by hand.]

170:40:04 Schmitt: ETB's next. (Pause) (To Gene) Got an ETB? Yeah. (Pause) ETB has two cameras.
 170:40:19 Parker: Okay. And as you guys say farewell to the Moon, we're looking up to the Earth (with the Rover TV camera) down here where you guys are returning pretty soon.
 170:40:29 Cernan: (To Jack) Okay.
 170:40:30 Schmitt: You're going to have to push that.
 170:40:31 Cernan: Okay, let me get it.
 170:40:33 Schmitt: That's all right. I'll wait until you're ready.
 170:40:36 Cernan: Okay? Can you make it?
 170:40:40 Schmitt: Yeah, I've got it.
 170:40:42 Cernan: Okay, let me get that other thing (garbled). (Pause)

[Fendell points the TV at the LM.]

170:41:00 Cernan: Bob, this is Gene, and I'm on the surface; and, as I take man's last step from the surface, back home for some time to come - but we believe not too long into the future - I'd like to just (say) what I believe history will record. That America's challenge of today has forged man's destiny of tomorrow. And, as we leave the Moon at Taurus-Littrow, we leave as we came and, God willing, as we shall return, with peace and hope for all mankind. "Godspeed the crew of Apollo 17."
 170:41:55 Parker: Roger, Geno. Thank you very much. (Pause)
 170:42:01 Cernan: Bob, I am up on the ladder and I'm going to be going through the hatch. (Long Pause)
 170:42:18 Schmitt: Gene, I've got to get out of your way.
 170:42:20 Cernan: Yup. (Long Pause; static)

[Here, Jack is closing the hatch so that he can get behind it and give Gene room to get in the cabin.]

170:42:42 Schmitt: Okay.
 170:42:43 Cernan: Okay, let me... (Pause) Okay, babe, here I come.
 170:42:51 Schmitt: Come on in.
 170:42:53 Cernan: Hatch look good to you?
 170:42:54 Schmitt: Well, it's dirty.

170:42:56 Cernan: Okay.
 170:42:57 Schmitt: Keep her down. Buttons. (Pause) Come towards me a little. There you go. (Pause) Okay, you've got it.
 170:43:15 Cernan: Okay, I'm inside the hatch.
 170:43:18 Schmitt: Okay.

[Fendell points the TV at the ground again, possibly for thermal reasons.]

170:43:19 Cernan: Let me look at that hatch once more.
 170:43:21 Schmitt: Okay.
 170:43:24 Cernan: That's the last time we want to have to open that.
 170:43:27 Schmitt: Caught in the same way again (on the DSKY).
 170:43:28 Cernan: Yep. Let me just...I can see down there.
 170:43:30 Schmitt: I can see (the hatch seal)...
 170:43:31 Cernan: Does it look good to you?
 170:43:33 Schmitt: It's clear.
 170:43:34 Cernan: Okay.
 170:43:36 Schmitt: There is a little bit of dust but it's all in the...I don't think the seal's affected.
 170:43:38 Cernan: Roger.
 170:43:42 Schmitt: There you go.
 170:43:43 Cernan: If I can turn around.
 170:43:44 Schmitt: Yes, I've got to get out of your way.
 170:43:46 Cernan: Yup, I'll wait for you. (Long Pause)
 170:44:31 Cernan: Yeah, now I can.
 170:44:33 Schmitt: Okay. Let me get my hand over here.
 Okay, I'm out of your way.
 170:44:39 Cernan: Okay. And...
 170:44:44 Schmitt: Close the hatch.
 170:44:46 Cernan: Hatch is closed. Let's see if I can lock it.

[They are now on Surface Checklist page 7-1.]

170:44:50 Schmitt: Then we've got to turn our H2O off. Oh, we've got to turn our...Let's turn our water off first, before you lock it (the hatch).
 170:44:59 Cernan: Well, it's locked now. Can you get your own water? If not, I'll get it.
 170:45:02 Schmitt: I doubt it. Haven't been able to before.
 170:45:07 Cernan: Okay, I'll get it.

[Schmitt - "I don't remember exactly where the shutoff was, but I just never could reach it. Maybe not even in training. With his longer arms, Gene could handle it. I was probably standing facing the rear - which would have made it easy for him to get to the shut off. Or, maybe I was facing inboard helping him with the door. It would have been a whole lot easier with more room in the LM; of course,

(laughing) the suit probably would have expanded to fill it. Parkinson's Law applied to lunar modules.

"It disturbs me that I did training for this for over a year and it didn't get permanently imbedded in long-term memory. I wonder if actors remember their scripts? Probably not. It's probably all short-term stuff, except for pieces. But still, I trained for Apollo 15 - the same procedures. So it was 30 months and, God knows how many of these (rehearsals) we really did in that period of time. We never memorized the checklist - never tried to. The fact is, that would have been a bad thing to do, to work from memory. You'd be taking a risk of forgetting something. That's why you had the cue cards. But it's strange; why would I not remember having that difficulty (with the feedwater shutoff)."]

[On Apollo 12, Pete Conrad and Al Bean tended to work from memory rather than the cue cards and forgot steps on a couple of occasions. In each instance, they had to use the cue cards to backtrack and take care of all the necessary steps.]

170:45:08 Schmitt: Have you got yours?

170:45:10 Cernan: Let me see. (Pause) Mine's off. No, wait a minute. (Pause) Mine's off. (Pause)

170:45:24 Schmitt: No, I can't get it.

170:45:27 Cernan: Okay. I'll get it for you. Not now. Before you move any more, let me get over here out of the way.

170:45:32 Parker: Okay. And pay attention here, 17, when you come on, we'd like you to leave Press Reg A which is the one that's been Off...We'd like to leave that closed.

170:45:41 Cernan: (To Jack) Turn around.

170:45:41 Parker: Just use Press Reg B (garbled).

170:45:44 Cernan: Okay, Bob.

170:45:47 Schmitt: Get it, Geno?

170:45:48 Cernan: Turn some more, I can almost reach it. Another...

170:45:49 Schmitt: Okay. (Pause)

[The three PLSS water controls - the feedwater diverter valve and the primary and auxiliary On/Off levers - are located on the lower, right, front corner, with the diverter valve being at the corner and the other two being in board from it on the front edge. The levers have dramatically different shapes so that they can be easily distinguished by feel.]

170:45:54 Cernan: Okay. Your Aux water is Off.

170:45:55 Schmitt: Okay.

170:45:56 Cernan: Okay, Bob...

170:45:58 Schmitt: No, no. The Prim(ary) water.

170:46:00 Cernan: Okay. (Pause)

170:46:03 Schmitt: (Garbled).

170:46:08 Cernan: Standby. (Pause) Your Prim water's Off.

170:46:10 Schmitt: Is your Prim Off?
 170:46:13 Cernan: Yep. It's Off. Okay. (Pause) Okay.
 (Reading) PLSS Prim water closed. Forward hatch Closed and
 Locked. Okay, I've got to get the upper (dump) valve, Jack.
 Move in.
 170:46:25 Schmitt: Okay. (Pause) How's that?
 170:46:29 Cernan: Oh, that ought to do it. (Pause) It's
 Auto and I've got the lock on it. (Pause) Okay. Now, Bob,
 say again which Reg A you want left.
 170:46:51 Schmitt: Reg A left closed, I got it.
 170:46:54 Parker: That's affirm, Jack.
 170:46:56 Schmitt: Go ahead.
 170:46:57 Cernan: Okay, dump valves are both Auto...Cabin
 Repress, Auto.
 170:46:59 Schmitt: Cabin Repress, Auto.
 170:47:01 Cernan: Okay, and I've got plenty of (PLSS)
 oxygen so we're in good shape for an Auto Repress.
 170:47:04 Cernan: Cabin Repress breaker Closed on 16.
 170:47:07 Schmitt: Okay, Cabin Repress, Closed.
 170:47:12 Cernan: Come on, baby, there it comes. Half a
 psi. Okay, it is increasing. (Repress becomes audible) You
 can go to Cabin on the regulator.
 170:47:24 Schmitt: Reg B.
 170:47:27 Cernan: Yeah, just the one regulator your using.
 (Pause) 1.5 (psi).
 170:47:33 Schmitt: Reg B is in Cabin.
 170:47:35 Cernan: Okay, she's coming up. There's 2.0.
 Your next move will be to get your PLSS 02, Off. (Pause)
 170:47:51 Cernan: 2.5 (psi). Okay, get your PLSS 02, Off.
 (Pause) Mine's Off. Get it? We'll be soft-suited shortly.
 (Pause) Just get around. I'll get it for you.
 170:48:13 Schmitt: I think that I've got it. (Pause) There
 I got it.

[The oxygen control is on the chest-mounted RCU.]

170:48:17 Cernan: Okay. "Verify cabin pressure stable at
 4.6 to 5.0." We'll watch it here.
 170:48:23 Schmitt: I'm watching. (Pause) Five (psi).
 Cernan: Okay. 5.0.
 Schmitt: 5.0.
 Cernan: Boy, it got hot in here, didn't it? Okay,
 purge valve to Depress; verify your circuit breakers.
 Schmitt: Say again, that last one.

[Schmitt - "When Gene gets business-like, he sometimes
 talks too fast."]

170:48:38 Cernan: You don't need your (garbled) Depress
 (garbled) but you don't need it.
 170:48:40 Schmitt: Oh, yeah. No.

[They are now at the top of the righthand column of
 Surface 7-1. According to plan, they should be at 169:40]

minutes into the mission and are, therefore, still about an hour behind, as they were at the start of the EVA. The planned start of the rest period is at 174:39 and they will actually start it at about 175:20, having gained back about a half hour. Because their work load between wake-up and launch is fairly light, they are in very good shape.]

170:48:41 Cernan: Verify your circuit breakers...White Dots out plus EVA decals.

170:48:45 Schmitt: No White Dots (in). (Pause)

170:48:57 Cernan: Okay, I'm squared away there. (Pause)
(Are you) squared away?

170:49:03 Schmitt: Standby.

170:49:04 Cernan: Okay.

170:49:05 Schmitt: Looks good.

170:49:06 Cernan: Stay at (circuit breaker panel) 16 now, ECS Suit Fan 2, Closed?

170:49:08 Schmitt: Suit Fan 2's Closed.

170:49:09 Cernan: Suit Fan Delta-P, Closed.

170:49:10 Schmitt: Closed.

170:49:11 Cernan: Caution lights are on, that's good.

Until the Sep(arator)...Wait, ECS Caution...They'll go out when it (the Separator) winds up. Doff gloves, stow on comm panel. Oh, oh! Sweet music to my ears.

[Schmitt - "This sounds like Gene's hands were bothering him. Whatever he might have said later, he was happy to get those gloves off."]

170:49:26 Schmitt: Going to have to put them on again, in a few minutes.

170:49:28 Cernan: I know. It's still sweet music.

170:49:32 Schmitt: Come on, now.

[Once they get hooked up to the LM ECS and get their PLSS's off, they will put their gloves back on so that they can depressurize the cabin, open the hatch, and jettison the PLSS's and other un-needed gear.]

170:49:34 Cernan: I have never seen so much dirt and dust in my whole life. Ever. (Pause) Ron's not going to be able to see through either one of these helmet visors. (Laughs) Yes, he will.

[Schmitt - "There was dust on everything we wore. Gene succeeded in falling and I did too - several times. The helmets had a lot of dust on them, and I suspect we got them pretty badly scratched. I don't remember the scratches very well, but we did talk about it a couple of times. However, the dust we brought in was almost all on the floor; it didn't come up and permeate the LM until we went weightless after liftoff. And then there was a lot of it. After the EVA's, there was dust flying around because, at least on the first EVA, I had a reaction to breathing it; but I don't remember

there being a noticeable film of it on the instruments or anything else.

"What Gene was saying about Ron is that we had to take one of the helmet covers (that is, one of the LEVA's) up to him so he could use it on his EVA to retrieve the film packets from the Scientific Instrument Bay (in the Service Module). Ron would never have admitted to anything (like a scratched visor) that would have kept him from doing his EVA. That was the next big thing; that's what he was really looking forward to."

[Cernan - "Once we got to orbit, I don't think the dust was as bad as I was afraid it would be. We were concerned and were thinking about wearing our helmets to keep the dust out through the whole liftoff and rendezvous. We did wear them for liftoff, but I don't think we did for rendezvous."]

170:49:52 Cernan: But they sure do get scratched, if you're not careful. (Pause) Okay. (Long Pause) I think it's harder getting them (the gloves) off, these days, than it is getting them on. (Pause)

170:50:35 Schmitt: Ah, I did it! Patience. Maximum effort. (Pause)

170:50:48 Cernan: There's one. (Long Pause)

170:51:02 Schmitt: Okay, (my) gloves are off.

170:51:05 Cernan: My gloves are off. We're right there (on the cue card). (Pause)

170:51:10 Schmitt: Okay, "verify safety on the dump valve". I'll do that. (Pause) Okay, I verify that, there. (Garbled).

170:51:20 Cernan: We want to take a double look at something down there.

170:51:24 Schmitt: (Garbled). It's locked.

[They have been using the overhead valve and what may be happening here is that Jack first checked the safety on the overhead valve and is now verifying the safety on the hatch valve.]

170:51:29 Cernan: Uh-huh. (Pause) Happy?

170:51:35 Schmitt: Yep. Okay, Descent H2O valve, Open.

170:51:44 Cernan: Okay, "Descent H2O valve, Open."

170:51:46 Schmitt: That's Open.

170:51:47 Cernan: "Remove purge valves, stow in purse." (Pause)

170:51:57 Schmitt: Okay.

170:52:00 Cernan: Okay, "disconnect OPS hose." (Long Pause) Oh boy! That lock/lock is just tight on there, Jack.

170:52:26 Schmitt: It is. (Pause) Got it.

170:52:39 Cernan: Your's off?

170:52:40 Schmitt: Yeh.

170:52:41 Cernan: Okay. "Connect LM hoses, red to red, and blue to blue." We've got to do that this time, because we've got to dump the PLSS's. Okay?

170:52:49 Schmitt: Okay. Let me turn around here.

170:52:51 Cernan: Let me get out of your way.
 170:52:52 Schmitt: I'll get back in here.
 170:52:54 Cernan: Okay, I'm out of the way now.
 170:52:57 Schmitt: How would you like to get off the PLSS water and get some spacecraft water, too?
 170:53:02 Cernan: Oh, that's the next thing. Suit Isol(ation valve) to Suit Flow (valve), On; and then we'll put PLSS pump and fan Off. Then we'll disconnect the PLSS water and connect spacecraft water. (Pause)

[The switches for the PLSS pumps and fans are on the chest-mounted RCU's. After the second EVA, Gene and Jack had commented, apparently, about the RCU's being hot.]

[Schmitt - "Driving back from Station 5, the RCU's would have been facing into the Sun. Driving back from Station 9, they would be shaded. So you probably won't find that comment here. I don't remember if I've mentioned this but, on the long drive coming back from Station 4, I noticed the warmth on the Sun penetrating the suit on my forearm. I would ride with my forearm more or less across my chest. There was a shoulder detent that let you do that so that you could work out in front of your chest. Riding in the Rover I'd just rest my right arm in that detent. So, during the drive back into the Sun from Station 4 to Station 5 and then on to the LM, I noticed the warmth - finally - penetrating the seven layers of mylar and warming that forearm. And it really felt good - a little therapy for those sore forearm muscles. I was probably using my left had to take pictures and wouldn't have had that arm in the detent."]

[Cernan - "I know what Jack's saying, but I think that "detent" is the wrong word. There was enough friction (in the cabling) that you could put your arm in certain places and it would stay there, but I don't think there were any detents."]

[Joe Kosmo, a suit expert at NASA Johnson agrees that there were no detents. In detail, there was a pair of cables - one for the right arm and one for the left - which were attached at the center of the chest and ran over to the arm pit, then through a tube that ran up over the shoulder blade and down onto the back, and then over to a tie down at the center of the back. Friction between the cable and the tubing let them maintain a desired arm position without having the work against the internal pressure of the suit.]

170:53:15 Schmitt: You might unhook that stuff up there so you can get to your hoses.
 170:53:19 Cernan: I can't reach it though.
 170:53:21 Schmitt: Oh, okay. I can get it, I think.
 170:53:23 Cernan: I can get it. (Pause) Okay, I got them. (Pause) Okay, we want red to red and blue to blue. (Pause) We got to verify these, too, because...
 170:53:42 Schmitt: Yep.

[They want to make sure that they have the hoses hooked up properly before they depressurize the cabin for the jettison.]

170:53:50 Cernan: Bob, you still with us?
 170:53:53 Parker: You bet, I wouldn't leave for the world.
 170:53:58 Cernan: Okay.
 170:54:02 Schmitt: Okay, I'm hooked up and locked.
 170:54:04 Cernan: Okay.
 170:54:05 Schmitt: You want to verify? And I'll do it for you, if you want.
 170:54:07 Cernan: Okay, see if you can't find this one. See it?
 170:54:13 Schmitt: Yeah.
 170:54:14 Cernan: Here, verify the red one. Okay.
 170:54:20 Schmitt: In and locked.
 170:54:20 Cernan: Got the red one, locked. (Pause)
 170:54:27 Schmitt: Locked.
 170:54:26 Cernan: Okay. Let me take a look at yours. (Pause) Locked. (Pause) Locked.
 170:54:42 Schmitt: Okay.
 170:54:45 Cernan: Okay, now...
 170:54:45 Schmitt: Ready for Suit Flow?
 170:54:46 Cernan: Yes, sir; Suit Flow on both of them.
 170:54:50 Schmitt: Okay.
 170:54:51 Cernan: Oh man, it feels great!
 170:54:52 Schmitt: Yes, sir.
 170:54:53 Cernan: PLSS pump Off and PLSS fan Off.
 170:54:55 Schmitt: PLSS fan's Off; pump's Off.
 170:54:57 Cernan: Okay. Disconnect PLSS water from PGA. Connect the LM water. Boy, I never thought air could feel so cool.
 170:55:05 Schmitt: Yeah.
 170:55:06 Cernan: Okay, the PLSS water is disconnected. I think that's mine. Yeah, that's mine. Spacecraft water. (Pause) Okay. Mine's connected. (Pause)
 170:55:33 Schmitt: How about pushing on that (spacecraft water hose to seat it in the connector)?
 170:55:35 Cernan: Okay.
 170:55:37 Schmitt: Get it?
 170:55:40 Cernan: Yeah, but I want to see it first. (Pause)
 170:55:44 Schmitt: Watch your helmet. You're going to scratch it.
 170:55:47 Cernan: Got it.
 170:55:48 Schmitt: You don't have your visor down. Neither do I.
 170:55:49 Cernan: Okay, connect...Okay, PLSS mode 0. Bob, we're both going off the air. We'll get on LM comm.
 170:55:56 Parker: Okay. We'll be waiting for you. We're here.

[They are about to start the steps on Surface 7-2.]

170:56:00 Cernan: Okay, go "O", Jack.
 170:56:03 Schmitt: How about some cooling?

[Schmitt - "Between here and about 171:01, it sounds like there was some recovery in my voice from the let down of getting back in and struggling to get the LM configured and pressurized and stuff like that. By 171:01, I sound much more business like."]

170:56:04 Cernan: Okay, zap me with it, and go "O", and then put your audio breaker, Open; and connect the LM comm. Then an audio breaker Closed. Okay? (Long Pause)
 170:56:56 Cernan: You read me, Jack? (No answer) You read me? (No answer; Long Pause) Read me?
 170:57:42 Schmitt: (Faint) You're loud and clear.
 170:57:43 Cernan: Okay. Next thing, VHF B...Wait a minute. You get the audio breaker, Open...Closed...Okay...VHF squelch B LMP. Okay, noise threshold, plus one and a half. (Pause) Yeah.
 170:58:03 Cernan: Okay. Audio, both panels. VHF A, Receive, and B, Off. (Pause) A, Receive and B is Off here. Okay, mode ICS/PTT (Intercomm System, Push-to-Talk)

[Comm Break]

171:01:09 Schmitt: Okay, Houston. We're back on LM comm.
 171:01:12 Parker: Roger, 17. We copy you loud and clear on LM comm. (Long Pause)
 171:01:45 Parker: And 17. Jack and Gene, we have a couple of - in fact, we have three - records here to read out to you guys. On Apollo 17, two of them. One, the longest single EVA, 7 hours 37 minutes and 22 seconds. The longest total lunar surface EVA time 22 hours 5 minutes and 6 seconds. And a summary: the total lunar surface EVA time for the Apollo Program, 80 hours 44 minutes and 8 seconds.
 171:02:10 Cernan: That's quite a tribute to the people who made it possible. I'll tell you. Thank you, Bob.
 171:02:15 Parker: Roger, Geno. And I can't speak as authoritatively as some people have tonight, but for all of us around me, I'll say thank you, also.
 171:02:30 Cernan: Your words are well taken. You know how I feel. (Long Pause)

[Bob Overmyer takes over briefly as CapCom. Throughout the Mission, he has been one of the Command Module CapComs. Houston has said good night to Evans, who is near LOS on his 42nd orbit.]

171:02:56 Overmyer: Hey, Gene and Ron, this is the CSM CapCom. Thought you might be interested. Your buddy (Ron Evans) up above you there is chugging on and about ready to bed down himself, right now. And he did take a good look at the landing site through binoculars tonight and took a good look at Shorty Crater there, and plotted out some variations in color that may be the same color changes you saw - that orange soil and that. We're trying to match it all up. And Farouk (al Baz) and Ron are working it out. We're trying to match it all up and see if we can get a comparison there.
 171:03:32 Schmitt: Excellent. Tell him we'll see him tomorrow.
 171:03:35 Overmyer: Yeah, he's counting on it. (Pause)

[Evans is now about 20 minutes into his rest period. His observations of Shorty were made at 166:17.]

[CapCom: Are you getting the landing site into view now?]

[Evans: I got it in window 2. (Pause) Okay. I've got Shorty in the picture. It looks like a sharper crater than any of them in the pentagon complex. The other one that looks sharp, just like that one, is F crater. (Pause) Back to the other window. Did they kind of find that orange stuff on the north side of it?]

[CapCom: Let me check on that, Ron. I'll be back with you in a second.]

[The phrase "pentagon complex" is one that only Evans uses and, apparently, refers to a pentagonal pattern of craters around the target point. Looking from the east, the base might be formed by East Trident and the unnamed crater north of the SEP, then Holden on the north arm, an unnamed

doublet between Powell and Camelot on the south, and Camelot, itself, forming the west apex of the pentagon. There are many other possibilities in the area, but this one has the advantage of being symmetric around the CSM ground track.]

[CapCom: I don't think so; their stop was at...Station 4 was on...]

[Evans: (Garbled) I'll get (garbled)]

[CapCom: ...Station 4 was on the south side of it. Just go ahead with what you see and...]

[Evans: I'd say they just barely got into the stuff, then, becau(se)...But it...But it looks like...Kind of the north rim of it has more of a...a tint of a different color to it. I (garbled) my pictures.]

[CapCom: Is the color differentiation concentric around the crater or is it just in...in splotches?]

[Evans: No. It's just in the...kind of the north side of it.]

[CapCom: What would you say the color is, then? Is it one of the "different" tans?]

[Evans: Yes, the color...(Chuckles) Yes, it's kind of a different...Would you believe kind of an orangish tan through these binocs? I got to take another look at that when I go by the next time.]

[CapCom: Roger, I'm with you. (Pause) Ron, when you get back...when you get done with this, we'd like you to sketch - when you get a chance - the color variations... just some thoughts on where the color splotches are with respect to Shorty, in particular.]

[Evans: Okay. I'll do that when I finish up here.]

[A few moments later, Evans reports seeing a "sharp crater" in the area "from Tacquet on down to Menelaus or Melinor" that had "an ejecta almost the same color as the stuff around Shorty". Then, at 166:48 after he has crossed the terminator into lunar night, he has the following conversation with Houston.]

[CapCom: Farouk just came out and said "a really good show". He's really excited about what you saw there; and we're really pleased with it.]

[Evans: I think I said north and as I look at the map - the orange distribution goes generally about a crater diameter to the north, but it essentially starts...Well, if you cut on a 60-degree angle from (map coordinate) Dog Sierra at 63...cut a 60-degree angle there and then make that go around about a crater diameter.]

[CapCom: Okay, to the north at Dog Sierra at 63? Yeah, I've got it.]

[Evans: On TL-50. And, if you're looking at the thing from the bottom (from the east), the right (north) side is 0...go up 60 degrees. You're 60 degrees up from the horizontal and 30 degrees down from the vertical. It'll be something like that.]

[CapCom: Okay.]

[Evans: It had kind of a brownish-orange tint to it.]

[CapCom: Ron, I guess one of the things that at least goes through Stu (Roosa)'s and my mind on that Shorty Crater - and I think you dispelled it when you said it goes out like a 60-degree angular cone away from it. But the question we'd really like to be thinking about...Is that concentric coloring around there? Like it might have been just a layering from a flap ov(erturn)...(correcting himself) you know, a turned-over flap or something like that, or whether it just seems to be some sort of a...I don't want to say "flow", but something that would give it the 60 degree direction like that.]

[Evans: Yes, I see what you're saying. And it almost looked to me like it was gradational, as you went away from the crater. In other words, more...more orangish...more orangish closer...closer to the crater than as you got away from it.]

171:03:41 Cernan: How's (Command Module) America looking to you, Bob?

171:03:45 Overmyer: Well, I'll give an update. It's working perfect. No problems at all and we got good SIM bay data on everything. The UV, the IR, the lunar sounder. And every data point we can see is just great. It's just hardly any anomalies at all. Everything is just wonderful.

171:04:05 Cernan: Outstanding! (Pause)

[Schmitt - "At the recent - 1991 - Lunar Science Conference, a paper was presented on taking a new look at the Lunar Sounder data. And, basically, when they tried to analyze the original data, they found they really didn't have the capability to analyze it very well. Some of the digitized data that was produced here on Earth after the film data came back has disappeared. The film data is still refrigerated and in the NASA archives. There was some holographic data - and I don't understand what that means with regard to this data - and another look is being taken at it. It looks like there still some very interesting stuff in it about large-scale layering in the lunar mare. But the sad thing is that some of the digitized data was not retained in the archives. Hopefully, somebody is going to put some effort into redoing all that. We'll see. The Lunar Sounder was the granddaddy of the SIR system (Side-looking Imaging Radar) that flies on the Shuttle and looked at the Sahara, for example, and saw all those old water courses."]

171:04:22 Overmyer: Gene, about the total limit of any problem up there is - and it's not a problem - is we're just having to stir those H2 tanks manually because of that limiting cycle on the pressure switch there. We could go back to Auto but it's easier to go Manual.

171:04:43 Schmitt: I'll be back up there tomorrow and I'll stir them for you.

171:04:48 Overmyer: Roger.

[Schmitt - "On the way out to the Moon, I started doing some exercises in which I would lie underneath the couch and grip a cross strut and run in place against the back wall of the lower equipment bay and try and get my heart rate as high as I could - just for exercise. And the flight controllers responsible for the cryogenic tanks (in the Service Module) found that the vibration was causing the tanks to stir without turning on what they called the "fan" inside of it.]

[Parker rejoins Overmyer at the CapCom Console.]

171:04:50 Parker: And Jack and Gene, let me make a note here for you guys. There will be a series of references to this throughout the checklist; but there's a general thing and you might even put a piece of tape across it if you want to or something - rather than go through (the checklist) and call out (changes at) all the locations. We'll leave Press Reg A closed for the rest of the time. Might just keep that in mind.

171:05:14 Cernan: Okay, Bob, I think we'll handle that one okay. (Long Pause)

[This is a reference to a slow leak in Pressure Regulator A noted during the post-EVA-2 period.]

171:05:52 Overmyer: Gene, there's one thing you may be interested in as the Commander. We're going to have to do two burns tomorrow on America. The mascons didn't deteriorate the orbit as much as everybody thought it was, so there's going to be an RCS (Reaction Control System) burn about an hour prior to the LOPC (Lunar Orbit Plane Change) burn.

[The Moon's gravity field is fairly irregular due to the presence of high density regions under some of the lunar mare. The detailed distribution of these "mascons" was not well known, particularly beneath the Farside track of America and the mission planners could only assume an average behavior based on what had happened to the Lunar Orbiters and the other Command Modules. After separating from Challenger prior to the descent, Evans fired the CSM engine to put himself in a 70 by 54 nautical mile orbit which was then expected to decay into a 60-mile circular orbit. As Overmyer says, the mascons did not cooperate and Evans will have to change the size of his orbit before the plane-change burn which will line him up with the planned ascent path of the LM.]

171:06:19 Cernan: That's interesting, Bob. Are you going to do a DOI 3, huh?

171:06:24 Overmyer: Well, yeah, I guess that's what it'll be. It's going to be an RCS burn at about 11 foot per second. It'll drop the...It'll circularize the orbit and then we'll do the plane change burn. (Pause)

171:06:40 Parker: Okay, and 17, we'd like you to press on reasonably diligently tonight. You're just about on schedule but if we can turn off this Marine (Overmyer), we'd like you guys to press on. We're looking at a nominal launch time and we've used up, of course, all the MCC (Mission Control Center)-H conference but we think you're within a few minutes of being right on. If you can press on like you did last night we'll be in great shape.

171:07:09 Cernan: Okay, Bob. I never stopped doing what I wanted to do anyway even though a Marine was talking.
(Pause)

[Schmitt - "Apparently, the MCC-H Conference was just a 60 minute pad they built into the flight plan in case we had to talk about liftoff or a LM problem of something like that."]

171:07:24 Schmitt: Okay. CDR's OPS 6100 (psi); LMP, 6500.

[Comm Break. They are performing the OPS checkout step near the middle of the righthand column of Surface 7-2.]

171:09:33 Schmitt: Okay, Houston this is the LMP. LMP's OPS is regulating at 4.25.

171:09:45 Parker: Okay, I copy that.

[They are checking the OPS's to see if they produce a proper regulated pressure. Each contains oxygen bottles pressurized at greater than 6000 psi and that pressure needs to be regulated down to the 3.8 psi that the suit is designed to handle. Jack's OPS is regulating at a pressure that is slightly higher than normal. Previously, Gene described plans for using the OPS's in case he and Jack were unable to dock with the Command Module and had to make a suited EVA transfer. If one or both of the OPS's fails this check of the regulators, they will keep one or both of the PLSS's rather than jettisoning them.]

[Schmitt - "I don't remember the back-up plan for an EVA transfer and, as we were listening to this, I thought we were checking out the OPS's so that we could take one of them up for Ron to use for his EVA."]

[Cernan - "We did use an OPS as a backup for Ron's EVA. But Ron wore hoses for his EVA and was pressurized off of spacecraft oxygen. We would never have let him go out on the OPS alone. But, we had to bring the OPS's up any way, for our EVA contingency. We'd already paid the weight penalty to bring it up to orbit, so it made sense to use one as a backup for Ron. He was out there and exposed. He could have ripped his suit or a hose could have popped off."]

[Schmitt - "There was also a plan for using one of the OPS's if we had to hot-wire the LM. This last-ditch procedure was to take a line out to the batteries in the Descent Stage to the Gene's circuit breaker panel to open the

propellant valves. You didn't make the connection to the circuit breaker panel right away; because, as soon as you did, the valves would open and you'd be on your way. So you'd come back in (after connecting the wire to the batteries) and then, when you were finally ready to go, you'd touch the circuit breakers and hot-wire the hypergolic valves in the Ascent Stage. I think we went through that drill once to know where the batteries were."]

[Cernan - "It would have been a last ditch effort. The hatch would have been open and the wires would have ripped off."]

171:09:46 Schmitt: And the CDR's is 3.9.

171:09:51 Parker: Okay that.

171:09:52 Schmitt: That might be ...I started...Let me bleed it off and let me see what it regulates at next time. I didn't have my hose locked, Bob, and it came off the first try. (Pause)

[Schmitt - "To check the regulator, you had to have the hose blocked off and I was saying that I may not have done that. As I recall, there was a place you locked the hose in to seal it off; and then you opened the valve to see how it regulated into the hose. I interpret what I said here to mean that the hose wasn't locked down and that there was some flow out. But that would have given a lower regulated pressure; so, I don't understand this. Getting the check to come out right was important because, if you had to keep a PLSS, you might have to throw away some rocks!"]

171:10:09 Cernan: Bob, we'll take another OPS check later on when we stow them. We're pressing on. (Pause)

[Cernan - "Obviously, if didn't concern us. If it was regulating at 4.25 it would have made you suit harder, but it still would have been okay. If it been regulating at 2.0, it would have been something different."]

171:10:26 Parker: Jack, they're saying we better do that (second check) before you throw out the PLSS's because we have to verify a good one before you dump the PLSS's.

171:10:36 Cernan: Okay, we'll do that.

[Long Comm Break]

171:15:16 Schmitt: Okay, Houston, we rechecked the LMP's OPS and it's regulating at 4.25, again.

171:15:27 Parker: Is that a steady 4.25, Jack?

171:15:32 Schmitt: Yeah, it's done that twice now. (Pause)

171:15:41 Parker: Okay, and it's steady once you do a check, right?

171:15:47 Schmitt: Right. It's open now. We've been watching it for about a minute, now.

171:15:50 Parker: Okay, we'll go with it then, Jack.

171:15:56 Schmitt: Okay.

[Comm Break. Houston has decided that Jack's OPS is acceptable as is. Once they get the OPS's stowed and get the PLSS's positioned for the jettison, they will weigh the sample containers, just in case they have hauled in too many rocks and have to jettison some of the rocks along with the PLSS's.] They are moving to the tasks on Surface 7-3.]

171:17:38 Cernan: Okay, Bob, we're going to start the (sample) weighing process here...
 171:17:43 Parker: Okay we're ready to copy...
 171:17:44 Cernan: ...It might take a couple minutes to get things squared away.
 171:17:46 Parker: Okay give us a call. We're ready to copy the weights.
 171:17:49 Cernan: Okay. (Long Pause)
 171:18:30 Schmitt: Bob, sample (bag) 15 Echo has a bunch of dust that gradually accumulated in my (shin) pocket.
 171:18:40 Parker: No fair, Jack! You can't go collecting samples after the EVA's over!

[Comm Break]

171:20:49 Schmitt: Say Bob, right now I can't find the sample containment bag number 5. Number 5 collection bag will be in (containment) bag 3.
 171:21:00 Parker: Okay, we note that. Thank you. Very good. (Long Pause)

[Checklist page Surface 7-7 contains a line "Stow Collection Bags in Covers" which suggests that these containment bags - which Jack had gotten out of the MESA at the end of EVA-1 - are thin, outer covers for the SCB's, presumably for dust control. This agrees with impressions that Jack and Gene have of how they did the stowage.]

171:21:49 Schmitt: Okay, and we're going to cross out "3" on the bag, and put a "5" on it.
 171:21:56 Parker: Okay, or I think we could keep track of it otherwise; but that's fine.
 171:22:03 Schmitt: That's for our reference too.

[Very Long Comm Break. During this break, they are weighing the sample containers.]

[Cernan - "Each pound mattered. I'm not saying that we would have thrown out a pound of rock. There were margins. But, weight translated into less Delta-V(elocity) and into fuel."]

171:36:33 Cernan: Okay, Bob, you ready?
 171:36:34 Parker: Roger. We're ready. (Pause)
 171:36:39 Cernan: Okay, bag 7 is 32 (pounds), bag 4 is 31.5, bag 5 is 21, the big bag is 71, the ISA is 22. (Pause)

[These are terrestrial weights, including the containers. The Interim Stowage Assembly (ISA) is a set of bags that normally hung behind Gene on his wall-mounted PLSS. Of course, when Gene was donning or doffing his PLSS or when the rockboxes were being mounted on the wall in its place, the ISA was put somewhere convenient, usually against the hatch or aft of the engine cover, or was hung on the forward bulkhead over the DSKY. For launch, it will be attached to the aft bulkhead.]

171:37:05 Parker: Okay, we have those five weights there, Geno. We have 32 for number 7, 31.5 for number 4, 21 for number 5, 71 for the big bag, and 22 for the ISA.
 171:37:27 Schmitt: That's affirm, and we're standing by for your Go for jettison. (Long Pause)
 171:37:44 Parker: Okay 17. Challenger, we are ready for jettison.
 171:37:53 Cernan: Roger. Understand.

[Comm Break. They will now assemble the equipment for jettison - as listed at the bottom of the lefthand column of Surface 7-3 - and then don their gloves, pressurize the suits, and perform a pressure integrity check before depressurizing the cabin.]

171:39:03 Parker: Okay and 17, we'd like...
 171:39:04 Cernan: How do you read, Bob?
 171:39:06 Parker: Loud and clear, 17. And Challenger, we'd like to keep out the original BSLSS bag, the one that you launched with. We think we're going to need that to stow samples in.
 171:39:19 Cernan: Okay, it's out (of the jettison bag)
 171:39:21 Parker: Okay. Or, it's in (the spacecraft), we hope.
 171:39:23 Schmitt: (To Gene) I've got it over here.
 171:39:27 Cernan: Okay. (Pause) (Engineering data)
 Recorder, On.
 171:39:29 Schmitt: Whichever way.

[They are near the top of the righthand column of 7-3.]

171:39:30 Parker: We want it (the BSLSS bag) kept in the cabin, right.
 171:39:32 Schmitt: Recorder's, On.
 171:39:37 Cernan: Okay, don EV gloves. Let me...

[Each of them has two pair of EV gloves, but have only been using one pair. As we will see at 171:54:54 and 174:52:48, they will jettison the unused pair, a departure from the checklist which doesn't call for any glove jettison. After repress - as called out in the checklist - they doffed their used gloves and stowed them on the comm panel. Now, they have re-donn'd the used gloves in preparation for the

depress. Apparently, they have also gotten the unused gloves out of storage - an action not called out in the checklist - but have not put them on.]

171:39:38 Schmitt: Okay, the recorder's not giving us any recording though.

171:39:43 Cernan: ...see if I can't get a little grease, yet, out of some of these things. (Pause) Don your gloves, Jack, if you're...

[Gene wants to put some lubricant on his hands.]

171:39:54 Schmitt: Why isn't the recorder recording?
(Pause)

171:39:57 Cernan: Oh.

171:40:00 Schmitt: Are we out of tape? (Pause)

171:40:05 Cernan: (Should) be 8 hours on it. (Pause)

171:40:10 Schmitt: I don't think I left it on. (Pause)
Might have left it on. (Pause) I probably did, if it's on now. (Pause) I thought I read it in the checklist though.
(Pause) Don Arabian will never forgive me!

[Schmitt - "Don ran a group of contractor representatives who were outside the Mission Control Building in the tall building to the west. I can't remember the building number. And they were there to support any engineering data analysis that had to be done. This recorder, I gather, was gathering a lot of LM engineering data. I remember the recorder but I can't tell you why it only had eight hours of tape on it. But I must have left it on when we went out."]

171:40:40 Parker: Shall we save ourselves some ascent weight?

171:40:47 Schmitt: (Laughs)

[Schmitt - "Knowing Parker, I think he was saying that we should jettison me! Don was not going to be pleased."]

171:40:50 Parker: Unfortunately, Owen wasn't listening.

[Schmitt - "This was a reference to Owen Morris, the head of the Lunar Module Project Office. Aaron Cohen watched over the Command and Service Module for George Low and Owen worked on the LM."]

171:40:52 Schmitt: Well it was okay up until...It was just this EVA, if it was on, Bob.

171:41:03 Parker: Okay.

171:41:05 Schmitt: Because it was working when we prepped, I'm sure of that.

[According to the checklists, the recorder was supposed to be on during flight and during the hatch opening for each

of the EVA's and equipment jettisons. Specifically, Jack was to turn the recorder on during the comm check that preceded helmet donning and then turn it off just before following Gene down to the surface. For each of the EVA's, the instruction to turn the recorder off was printed on the cuff checklist and, obviously, he missed the step at the start of this third EVA.]

171:41:08 Cernan: Okay. You can don your EV gloves. And we'll check each others connectors again.

171:41:14 Schmitt: I'll take my cuff checklists off. (Pause)

171:41:23 Cernan: Needless to say, you don't have to put your dust covers on, Jack. If that makes you feel better. (Pause) Oh, boy!

[Cernan - "The dust covers went over the wrist rings and were added to the program fairly late, I think, and maybe even for our flight. As I remember, they were a pain in the butt and I was adamantly against them. I was not happy about having one more piece of gear; and I remember that I got in some disagreements with some people about even having to carry them. But they wanted them to be part of the uniform and we did use them. And I will eat a little crow, because they did work better than I thought they would. Considering the amount of problems we had with dust, they did serve a good purpose."]

171:41:47 Schmitt: Dirt's just as...

171:41:48 Cernan: Bob, how long were we out today, 7 what?

171:41:53 Parker: Stand by, we got it here someplace. 7 hours (pause while somebody in Houston finds the number) 7 hours 15 minutes and 31 seconds.

171:42:09 Cernan: How many kilometers did we put on the Rover?

171:42:12 Parker: We have an approximate total of about 36.1. (Pause)

171:42:20 Schmitt: Boy, this one (glove) is really getting stiff.

171:42:27 Cernan: Probably another 1/2 kilometer on that (total) when the Nav wasn't working.

[The Rover Navigation system wasn't in operation until after the initial drive out to the ALSEP. That drive plus Gene's 200 - 300 meter test drive out to the east and back would have added the half kilometer to his total.]

171:42:36 Parker: Yeah; since we didn't get distance readouts all the time, we sort of interpolated those distances there, Gene.

[For the next minute or so, they seem to be struggling with one of Jack's gloves.]

[Cernan - "Generally, we each put on one of our own gloves and then helped the other guy with his second glove.

Although it was possible to get both of your own on, it was generally easier with the buddy system."]

171:42:44 Schmitt: (To Gene) Push on the button.
 171:42:45 Cernan: Are you opening or closing?
 171:42:47 Schmitt: Closing; trying to.
 171:42:49 Cernan: You don't have to push on the button to close it.
 171:42:51 Schmitt: Well, yeah...

[Cernan - "There were a couple of buttons that you had to push down at the same time to unlock the wrist ring; but, to get the glove on, you just had to push it in and it snapped over. And then we had lock-locks on those gloves to make sure."]

171:42:53 Cernan: They're not locked.
 Schmitt: Now I know why I brought you.
 Cernan: Jack, did you put those gloves on?
 Schmitt: I don't know. I was listening to you for one thing. Boy, it is stiff though. Never get it off.
 171:43:28 Cernan: I (garbled) this thing down there so it doesn't...
 171:43:30 Schmitt: Wait a minute.
 171:43:31 Cernan: ...tangle. (Long Pause)
 171:43:51 Schmitt: Okay.
 171:43:52 Cernan: I just don't want to (garbled). (Pause)
 All we need. (Long Pause) (Garbled).

[They may be leaning forward in the suits as they work on the gloves and aren't always triggering the voice-activated audio circuits.]

171:44:21 Schmitt: Good. (Pause) Okay.
 171:44:31 Cernan: (Garbled) hang down that.. (Pause)
 Okay, EV gloves are donned. Let's check our PGA connectors. Do you want to check mine?
 171:44:43 Schmitt: That's locked. (Pause) That's locked. Okay.
 171:44:48 Cernan: Okay?
 171:44:51 Schmitt: Helmet shouldn't have changed.
 171:44:53 Cernan: Okay. That's locked; locked; locked; locked. (Pause) Over, I can't see. Locked.
 171:45:09 Cernan: Okay, "Suit circuits shall not be maintained at elevated pressure greater than 5 minutes". Okay, we want to do an integrity check here. And we're not going to use Reg(ulator) A at all.
 171:45:16 Schmitt: Right.
 171:45:17 Cernan: Okay, Suit Gas Diverter, Pull Egress, verify.
 171:45:20 Schmitt: Pull Egress.
 171:45:22 Cernan: Now you can verify all that other stuff. Can you get it back there? Cabin Gas Return, Egress, verify.
 171:45:26 Schmitt: Verified.

171:45:28 Cernan: And Suit Circuit Relief (valve) is a Close. Close it.
 171:45:32 Schmitt: Okay, it's going Closed. (Pause) Closed.
 171:45:36 Cernan: Okay, Pressure Reg...Okay; let's leave A Off, and Pressure Reg B to Direct 02. (Garbled) 4.0, and then go to Egress, and we'll check on decay.
 171:45:51 Schmitt: Okay, go on to...
 171:45:53 Cernan: Wait a minute (garbled), I should have (garbled).

[Gene probably wants to unlock the hatch before pressurizing his suit.]

171:45:57 Schmitt: Yeah. (Pause)
 171:46:01 Cernan: Okay, it's unlocked. Okay. (Garbled)
 171:46:06 Schmitt: (Garbled) Direct 02.
 171:46:08 Cernan: Okay. (Long Pause)
 171:46:26 Schmitt: How high do they want the suit?
 171:46:29 Cernan: 3.7 to 4.0 (on the) cuff gage.
 171:46:30 Schmitt: Okay. (Pause) Want some (drinking) water?
 171:46:38 Cernan: It's coming up, slowly. (Pause) Yeah, you can give me some water. (Long Pause)

[We had some trouble deciding whether Jack was offering Gene some drinking water or whether he was offering to turn the LCG pump on. The water gun is behind Jack near the floor, while the LCG pump breaker is on the panel to his right. However, by opening the pump breaker, Jack would have been departing from the checklist and probably would have been less casual about his offer. Hence, I conclude that he had the water gun in hand.]

171:47:02 Schmitt: Off the peg (on the pressure gage).
 171:47:05 Cernan: Okay, I'm off the peg. (Pause)
 171:47:20 Schmitt: There, you're coming up on 3.5.
 171:47:24 Cernan: Okay, when you hit 3.7. I'll be with you. So you can...
 171:47:25 Schmitt: Okay 3.7.
 171:47:29 Cernan: Okay. Mark it. One minute.
 171:47:30 Schmitt: Okay.
 171:47:34 Cernan: You did go Egress (on Press Reg B), right?
 171:47:35 Schmitt: Yep.
 171:47:36 Cernan: Okay. (Pause) (Garbled) it out?
 171:47:46 Schmitt: (Laughs) (Pause) Well, it's suppose to be possible to do.
 171:47:57 Cernan: Hope so, (garbled). (Pause)
 171:48:16 Schmitt: There.
 171:48:18 Cernan: Get it?
 171:48:19 Schmitt: Yeah.

[They are watching the suit pressure decay in the usual manner, looking for less than a 0.3 psi decrease over one minute.]

171:48:21 Cernan: Okay, we've got another 15 seconds to go. (Long Pause) Okay, Mark it. One minute. You can go to Suit Circuit Relief (Valve), Auto.

171:48:42 Schmitt: Okay, suit...Watch your ears.

171:48:44 Cernan: Okay.

171:48:46 Schmitt: There.

[They are now setting the Suit Circuit Relief Valve to Auto - it was closed - and will feel the pressure adjustment as the suit circuit and the suits come into equilibrium.]

171:48:49 Parker: And 17, we're watching you, and you look good to us. You're Go.

171:48:55 Schmitt: Okay, I had about two tenths (psi pressure decay).

171:48:58 Cernan: And I had two tenths. 3.7 to 3.5. Okay, let's make sure we got everything. You went to 4.0, then you went to Egress then we monitor. Suit Circuit Relief, Auto; pressure is decaying at 4.8. Okay, that's good. Okay. We're GO for cabin depress.

[They are now on Surface 7-4.]

171:49:16 Parker: Roger. Roger, you're Go from Houston.

171:49:27 Cernan: Okay, (on circuit breaker panel) 16 ECS Cabin Repress, Open.

171:49:21 Schmitt: Okay, Repress coming Open. Circuit breaker's open.

171:49:25 Cernan: Okay. This time I think I'll get this valve down here.

[Gene is saying that they can use the hatch dump valve rather than the overhead valve. Without the PLSS's on, they have a great deal more freedom of movement.]

171:49:28 Schmitt: They want this left in Auto?

171:49:30 Cernan: Huh?

171:49:31 Schmitt: Leave this in Auto?

171:49:34 Cernan: All you want is...

171:49:36 Schmitt: ...circuit breaker.

171:49:37 Cernan: ...16 Cabin Repress, Open.

171:49:38 Schmitt: Okay.

171:49:40 Cernan: "Overhead or forward dump valve Open and then Auto at 3.5."

171:49:44 Cernan: Get that one down there, now.

[Jack will open the forward dump valve while Gene watches the pressure gage.]

171:49:47 Schmitt: Okay, you ready?

171:49:48 Cernan: Okay, go ahead. I'll give you a call at 3.5. (Pause) Circuit relief was Auto, right?

171:49:57 Schmitt: Yep.

171:49:58 Cernan: Had to...Okay. (Pause)

171:50:06 Schmitt: Okay, going Open.

171:50:09 Cernan: Okay, it's coming down. I want you (to go) Auto at 3.5, I give you a call my suit is going up. (Pause) Mark it. Okay, you're 3.5. "Verify cabin 3.5 and LM suit circuit locked up at 4.3 and decaying." Okay, it's about 4.6 and decaying. (Pause) How's it look to you, Houston?

171:50:33 Parker: Looks good to us, 17.

171:50:38 Cernan: Okay, Jack. Overhead...(Correcting himself) Make it the forward dump, Open. And I'll verify we lock up (garbled). (Pause) (Garbled) is decaying, the Auto's working. (Pause) Locking up, and the cabin's at 1. (Pause)

171:51:31 Cernan: Okay, hatch opening. Downward. (Pause)

171:51:43 Cernan: Jack, when I get the hatch partially opened, you can go to Auto on that valve. (Pause)

171:51:56 Schmitt: Still no good words about the gravimeter (the LSG), huh, Bob?

171:52:00 Parker: No, there's an outside chance that it's been a little cold. And they're hoping that if it warms up, that it may take care of itself; but, no, everybody's very sad about that.

171:52:15 Schmitt: Well, I could have sprinkled dirt on it, maybe. (Pause)

[The idea is to make the gravimeter darker so that it would warm up by absorbing more sunlight.]

171:52:22 Cernan: Let me go after the hatch, Jack. (Pause)

171:52:37 Schmitt: Still about 0.2. (Pause) Okay, you want that in Auto?

171:52:43 Cernan: I can get it (the dump valve on the forward hatch) from here.

171:52:44 Schmitt: Okay. (Pause)

171:52:55 Cernan: And the lock/lock's on. Turn around over here. Boy I wish it'd take some of that dust out. (Garbled) it.

171:53:02 Schmitt: Gotta turn. Wait (garbled). (Pause)

171:53:07 Cernan: The hatch is open, Houston.

171:53:10 Parker: Copy that.

171:53:12 Schmitt: Okay. (Pause) Okay. (Pause)

171:53:20 Cernan: And Danny's not out there to hand us in the lightweight PLSS's!

[This is another reference to the mock-up PLSS's used during training and to suit engineer Danny Schaeiwitz.]

[Schmitt - "The PLSS's were handed in for egress training and we may not have had PLSS's in the cabin, just to protect the equipment."]

171:53:24 Schmitt: Okay. Here goes the old...Whose PLSS is this now?
 171:53:28 Cernan: Well, look at it, if you want a memory.
 171:53:31 Schmitt: That must be yours; it's red. No, that's mine...No, it's yours. Here goes the old Commander's PLSS.
 171:53:39 Cernan: Okay, baby thanks for doing a good job. And that was a backup PLSS too.

[Cernan - "The PLSS's were all the same but, for some reason, the decision was made quite late on to use my backup. I don't know what happened to the primary.]

171:53:43 Schmitt: Well, that wasn't very good.
 171:53:46 Cernan: It walked down the ladder.
 171:53:49 Schmitt: It went down as gracefully as you did.

[Schmitt - "I was leaning over the hatch and pushing the PLSS out with my hands. Gene was probably watching out the window. I don't think I could see down the ladder and just saw it bounce a little bit."]

171:53:51 Cernan: Look at that. Okay, what's next?
 171:53:55 Schmitt: Well, I can give you some of these.
 (Pause)
 171:54:00 Cernan: Here hold...Okay.
 171:54:02 Schmitt: Everything is in here.
 171:54:04 Cernan: Okay. That's the first thing.
 171:54:09 Schmitt: Okay. (Pause) Okay. (Pause)
 171:54:24 Cernan: (Garbled)...(Pause)
 171:54:32 Schmitt: Beautiful gloves.
 171:54:33 Cernan: Well, Houston, I think we ought to probably just mention, anyway. We are jettisoning two sets of EVA gloves. I think that's worth mentioning. Because they did their job!
 171:54:49 Schmitt: Just like everything else did its job. Let me jettison mine.
 171:54:54 Cernan: Okay. (Pause)

[As indicated by a discussion at 174:52:48, they are both wearing their used EV gloves and have just jettisoned their unused gloves. The checklist does not call for any glove jettison. It does, however, call for boot jettison, which they seem not to have done.]

171:54:58 Schmitt: Ooops, we didn't get them clear.
 (Laughs)
 171:55:07 Parker: Okay, we copy two sets of EVA gloves to the surface for the last time.
 171:55:07 LM Crew: (Garbled)
 171:55:09 Cernan: They're very reluctant. (Laughs) What else have you got there?
 171:55:12 Schmitt: ISS?
 171:55:13 Cernan: (Garbled) together.
 171:55:16 Schmitt: The other ISS. (Pause)

[The only reference we have been able to find to an ISS - other than Inertial Sensor System, which doesn't make sense in this context - is on page 7-3 in the surface checklist where the crew is instructed to "Remove ISS, Wrap & Tie the Following: Lunar Boots (4), RCU's (2), Armrest (1), Yo-Yo's (2)" and then on page 7-4 where they jettison the ISS along with the PLSS's. Gene and Jack think ISS may be Interim Stowage Shelf, perhaps a part of the Interim Stowage Assembly.]

171:55:25 Schmitt: Nope, one more.
 171:55:28 Cernan: That it?
 171:55:28 Schmitt: Got one more thing.
 171:55:30 Cernan: PLSS.
 171:55:31 Schmitt: No wait.
 171:55:33 Cernan: Oh, is there something (garbled)?
 171:55:37 Schmitt: Watch it.
 171:55:39 Cernan: (Garbled) this, I'll get it. (Long Pause)
 171:56:00 Cernan: Okay, let's get this out.
 171:56:04 Schmitt: Okay, the old LMP's PLSS.
 171:56:08 Cernan: (Garbled) that OPS stays where it is.
 171:56:15 Schmitt: Okay. (Pause) Okay, get it down there and then put your foot against it and it'll probably go. (Pause) The only geologist's PLSS on the Moon. (Pause) (To Gene, who is kicking the PLSS out the hatch) Good boy. Have fun PLSS. Ooh. (Pause)

[Cernan - "I remember that one of the PLSS's sort of got hung up on the porch and I had to get way out with my leg to get it unstuck. You didn't have room to throw them out; you just had room to push them out."]

171:56:42 Cernan: That'll stay there. Okay, we got everything else?
 171:56:46 Schmitt: Okay...

[AS17-145-22196, 22199, and 22211 show the jettisoned PLSS's. These photographs will be taken after Gene and Jack get out of their suits.]

171:56:47 Cernan: Hatch seal clear.
 171:56:51 Schmitt: Pretty good.
 171:56:52 Cernan: Pretty good from here.
 171:56:54 Schmitt: Too bad we don't have a broom (to sweep the dust out).
 171:56:57 Cernan: Is that everything else? Nothing else here to go. Nothing behind you. Nothing here. (Pause) Okay! (Pause)
 171:57:07 Schmitt: Hatch going closed. (Pause) Get to do this again tomorrow.

[They will do a very brief trash jettison in the morning.]

171:57:12 Cernan: I know it. Okay, forward hatch closed. Let me see if I can't lock it. (Long Pause) Okay, it's locked. (Pause)

171:57:38 Schmitt: Okay, "Cabin Repress, Dump valve, both Auto, verify."

171:58:41 Cernan: They all are auto and locked.

171:58:45 Schmitt: Okay.

171:58:46 Cernan: "Cabin Repress, Auto. Verify."

171:58:48 Schmitt: Verified.

171:58:49 Cernan: "On 16, Cabin Repress, Closed."

171:58:52 Schmitt: Repress going Closed.

171:58:53 Cernan: "Master Alarm and Cabin Warning Light (should come) on." There it is. (Pause) Cabin's coming up. (Pause) Okay, it's increasing and you go to Cabin on that one reg.

171:59:13 Schmitt: Reg Bravo. Cabin.

171:59:21 Cernan: Okay. (Long Pause) Okay, cabin's coming. It's about 5 (psi). Okay, (warning) lights are off. Repress stopped. Cabin pressure stable. (Pause) Okay, Houston, Challenger; we're going to take off our gloves. (No answer; pause)

172:00:33 Schmitt: Hello, Houston. How does it look?

172:00:35 Parker: Roger. You look stable, and...Stand by. (Pause) Okay, you're Go to unsuit there, guys. (Pause)

172:00:58 Cernan: Speaking of suits. These things perform super! (Long Pause)

172:01:42 Cernan: Okay, and we can get our helmets off.

172:01:45 Schmitt: If I can ever get unsuited. (Pause) (Garbled; laughs) That's my hand. Let me try the other one.

172:01:57 Cernan: Oh, let me get it for you. I'm free here. No sense...Yeah, but I'm...(Both laugh) There. Okay.

172:02:05 Schmitt: The right one went easy last night. I think they're all really getting (dusty)...

172:02:11 Cernan: Oh, and the helmet is off, and I'm stowing it in the BRA! (Pause) Well, there's no changing our minds now (about a fourth EVA), the PLSS's are going to be hard to retrieve. (Pause) But you could if you had to, though.

[Both Gene and Jack have the impression that the BRA was hung in the back of the cabin. Charlie Duke joins the conversation.]

172:02:36 Duke: Challenger, Houston. From the old backup crew that followed you every step of the way, super job on EVA you guys.

172:02:53 Cernan: (Thinking he's talking to John Young) Thank you, John. Appreciate the words, Jose. But we also appreciate your helping us get it this far.

172:03:05 Duke: (Retaliating) Roger, Neil.

172:03:12 Cernan: Hey, you know, and all those things you tell people... (Hearing Charlie's "Neil") Was that Charlie!? I haven't heard your voice since down... You know all those good things you tell us about dust and all those other things: you know, you believe them all just like everybody else does, but you've just got to come out here and experience it for yourself to really be a believer.

172:03:29 Duke: Yeah, well I take it back about it all looks the same.

[Schmitt - "Charlie thought that all parts of the Moon looked just like all other parts of the Moon. And I think the TV of Taurus Littrow changed his mind. He and John were in a pretty desolate, unscenic place at the Descartes site."]

172:03:35 Cernan: Hey, it really doesn't, Charlie; but all those physical things you get handicapped with... There's a lot of easy things as far as 1/6 g, but all those other things (you've got to experience). You know there's nothing like doing it to be a believer.

172:03:50 Duke: Well, you guys did it great.

172:03:56 Schmitt: Charlie, it may all look the same, but Taurus-Littrow, mark my words, has some variety.

172:04:03 Duke: Yeah, we could tell that, Jack. Great job.

172:04:10 Schmitt: Thank you, Charlie; and thank you for all the help.

172:04:15 Cernan: Hey, Charlie, remember a long time ago when I said something about being down among them. I didn't know what it was until we got here.

[Cernan - "Charlie was CapCom on Apollo 10. When Tom Stafford and I went down in the Lunar Module over the top of the Apollo 11 landing site, I said 'Boy, we are down among 'em,' meaning that it seemed like we were going right down over the mountain tops."]

172:04:27 Parker: Challenger, we have a good word from the old program manager...

172:04:29 Cernan: (To Jack) Where are we (in the checklist)?

172:04:32 Parker: ...even though you guys were pretty piggy there in bringing rocks back, we're going to let you keep them all. You only busted the red line (that is, are overweight) by 40 pounds.

172:04:44 Cernan: Okay. He's a pretty good guy any way.

172:04:48 Slayton: That assumes your good buddy upstairs gets a good plane change tomorrow.

[If the plane change leaves Evans in less than an optimal orbit for rendezvous, they might have to discard some of the samples.]

172:04:57 Schmitt: Oh, he will; and I'll tell you, Gene and I both have lost 20 pounds a piece on this mission.

172:05:05 Slayton: We can believe that.

172:05:10 Cernan: (To Jack) Verify safeties (on the dump valve locks). Hey, we're on VOX anyway. Let's go to ICS/PTT.

172:05:16 Parker: It's safer that way.

[In a moment, they will switch from voice-activated comm to Push-to-Talk. The safeties were pins with wires on them so that they wouldn't drop off and get lost.]

172:05:21 Cernan: Yeah, specially when you don't know you're talking. (Pause) Okay, we came to the end of the EVA-3 prep and post card.

172:05:41 Parker: Roger. We're following you to the surface checklist.

[They are now starting Surface 7-5.]

172:05:43 Cernan: Hey, Jack and I are going to frame this page 2-3, cut it down the middle and each take half. (Pause)

172:05:58 Schmitt: I'm going to take the front half. Gene will take the back half. (Long Pause)

[Page 2-3 in the Lunar Surface Checklist lists procedures for a One-Man EVA. The reverse side - page 2-4 - is a procedure to follow in the event of a LM repress failure.]

[Schmitt - "We probably never decided who would go out (for a one-man EVA). The back half of the page is something immaterial to the one-man EVA, and this remark suggests that we had had some discussion about who was going to be the one man."]

[Cernan - "It wasn't discussed in that much detail but, if we only had one PLSS, I suppose that - politically - we would have to have had a geologist go out. But, I guarantee you that Cernan would have been out there during part of it. We probably wouldn't have bothered with the Rover, because you wouldn't let one guy get that far away. But we probably would have each done a shortened EVA. A four, five, six hour EVA - whatever we thought we could have done. And then have the other guy go out and do another one and, at least, stay there a couple of days. I don't remember specifically what our plan was; but that was one thing I always dreaded - that we would be faced with only one PLSS. That would have really compromised us. But there was no question that we would have both gone out. I wasn't going to go that far - a second time - and not go out on the surface. Period. But it would have been impractical, as well, not to have Jack go out - being a geologist. That was part of the reason for the whole trip."]

172:06:53 Schmitt: Okay, Roberto, we're going to manage the old batteries.

172:07:01 Parker: Okay, and Challenger we're ready to manage the old batteries.
 172:07:10 Schmitt: The old ED batteries are 37.2. A and B.
 (Pause) (To Gene) I was just going to say I wish we had a broom.

[Comm Break. The following is a discussion about the use of batteries versus fuel cells in the LM design.]

[Schmitt - The early plan, the first design reference mission that Grumman put together, was a fuel-cell vehicle. And what killed the fuel cells were the fuel-cell problems that Gemini ran into. And that scared the managers, so they went to batteries. It's unfortunate, because the Apollo fuel cell was a different fuel cell"]

[Cernan - "We also had a Block II development of solar panels to take with us."]

172:10:18 Parker: Okay, we're happy with your battery management. We're ready for you guys to go to Low (data transmission rate).
 172:10:27 Schmitt: You got Low.
 172:10:29 Parker: Thank you. (Long Pause)
 172:11:01 Parker: (Sounding stuffy and/or tired) And, Challenger, it's Bob. I'm going to turn you over to Casper about now, and let him put you guys to sleep.
 172:11:18 Schmitt: Bob, I'm not sure what you mean. Who's your friendly ghost?

[Casper the Friendly Ghost was a comic book character of the 40's and 50's (at least). "Casper" was also the name the Apollo 16 crew gave their Command Module. Here, Parker is referring to the Apollo 16 Command Module Pilot, Ken Mattingly, who will take over the CapCom console.]

172:11:23 Parker: I bet you can guess.
 172:11:25 Schmitt: He doesn't know anything about the LM. He doesn't know anything about the LM. (Pause)
 172:11:37 Mattingly: It's never too late to learn.
 172:11:43 Schmitt: For you, I'd believe that; for a lot of people, I wouldn't. (Pause) Welcome aboard, Ken.
 172:11:54 Mattingly: You guys make a pretty interesting show to watch. (Pause)
 172:12:05 Schmitt: I hope so. (Long Pause; Jack can hear Mattingly and others in the Control Room) All I can do is hear your breathing, Ken.
 172:12:35 Mattingly: Yeah. Just noticed that.

[The background noise disappears as Mattingly takes his foot off his microphone switch. Long Comm Break.]

172:19:22 Schmitt: Hey, Ken. You can tell your friends off to the left there (at the Surgeon's Console) that I've turned the biomed off.
 172:19:28 Mattingly: Okay. Thank you.

[Long Comm Break. After stowing the OPS's under the instrument panel and getting the ETB, the ISA, and the big bag out of the way, they are emptying the urine bladders in the suit before getting out of the suits.]

172:25:32 Cernan: Hello, Houston; Challenger. CDR's going off the air.

172:25:36 Mattingly: Okay.

[That is, Gene is turning off his audio circuit. They will get him out of his suit first. They are now on Surface 7-6.]

[Very Long Comm Break]

172:36:32 Mattingly: (Faintly) Hey, Jack; Houston. You busy?

172:36:38 Schmitt: Say again, Ken.

172:36:40 Mattingly: (Normal volume) Are you busy? I'm sitting here looking at a couple of questions that they wanted to ask. Whenever it's convenient for you. I'm not sure just how busy you are right now; and just keep in mind I've got a few questions to ask you on the traverses, and give me a call when you're ready to talk about it.

172:37:02 Schmitt: Okay; we're unsuiting, Ken. Let us get unsuited, and then we'll be back with you.

172:37:07 Mattingly: Okay. Just whenever it's convenient for you.

[AS17-143-21943 is a window pan taken after the PLSS jettison. 21960 is the best of the photos taken out of Jack's window and shows the thrusters and an assortment of footprints and Rover tracks. The photos taken out Gene's window - 21961 to 21982 are much better pictures. 21969 to 21972 show the PLSS's and 21973 to 21979 comprise an excellent horizon sequence. AS17-145-22192 to 22222 is another post-EVA window pan taken at some point prior to suit doffing. AS17-145-22223 to 22228 are pictures that Gene and Jack took of each other before taking the suits off. 22225 and 22228 are the best of these.]

[Long Comm Break]

[Cernan - "The pictures speak for themselves. We were pretty happy, pretty tired, and pretty dirty. Look at the faces and you can see the sense of satisfaction. And look at how dirty...look at how filthy we are! And hot. I guarantee you that underwear was soaked."]

[Schmitt - "In all four of the pictures that we took of each other in the cabin, one thing you can see is a prominent vein in the foreheads of both of us. Normally, you don't see it. Sometimes it will show up when you laugh and you get a lot more blood flow into your head. But I don't

think I was smiling hard enough in these pictures for that to happen. Here, it's an illustration of the excess blood volume that goes into the upper body in reduced gravity. Even in 1/6 gravity, even after this long a time, and even after we'd sloughed off a lot of fluid by this time. We'd probably each lost about ten pounds because we'd lost a lot of fluids."]

[The following transmissions were accumulated during a press briefing and times are not readily available.]

172:46:57 Mattingly: Challenger, Houston.

Schmitt: Go ahead.

Mattingly: Hey, how about if we hit a Pro(ceed) on the DSKY and get it into POO and back into Standby? We're worrying about the clock registers overflowing. And we'd like to get that done before 172:50, or somewhere in that neighborhood.

Schmitt: Okay; stand by. (Pause) Is that what you wanted?

Mattingly: Oh, we can't watch it, Jack. If you just tell us that you've got it into POO and back into P06.

Schmitt: That's what happened. (Pause) I thought you watched it the other night.

Mattingly: No, we don't have any high bit rate now.

Schmitt: That do make a difference. That's right.

Mattingly: I understand that you've completed that transition. Is that correct?

Schmitt: Which one?

Mattingly: You did get it out of Standby into POO, and then back. Is that correct?

Schmitt: That's affirm. We completed that.

Mattingly: Okay. Thank you.

Schmitt: Sorry to be so unclear.

Mattingly: Hey, we also are still on your stowage. So when you get on page 7-6, where it says, "Stow Heaviest Collection Bag," down in the right-hand column towards the bottom, why don't you skip that step until after the eat period. And we're still working on the stowage locations.

Schmitt: Okay.

[Very Long Comm Break]

[Schmitt - "We were stowing the bags to optimize the center of gravity and, therefore, fuel consumption - particularly RCS fuel."]

173:02:33 Cernan: Hello, Ken. How do you read Challenger CDR?

173:02:35 Mattingly: Loud and clear.

173:02:38 Cernan: Okay.

[Very Long Comm Break. Gene is now out of his suit and they are probably working on Jack's, now.]

173:19:13 Cernan: Houston, Challenger. How would you feel about this (Lithium Hydroxide) canister being changed now?

[Deke Slayton joins the conversation.]

173:19:18 Slayton: Stand by. (Pause) Okay; change her out, Geno.

173:19:28 Cernan: Okay. (Pause)

[The checklist calls for a changing the LiOH canister after the meal and the one hour schedule padding called "MCC-H Conference" but, since they are running late, the change is coming about on time. Obviously, Gene and Jack are not only paying close attention to the detail of the checklist but understand the rationale for the when and why of each of the steps. Once again, they have beaten Houston to the punch.]

173:19:44 Slayton: For your information, we're trying to negotiate some time for you here. We're about one and a half (hours) down. We know how to pick up one hour of it, but we haven't quite figured out how to gain the other half (hour).

[That is, they can gain an hour by eliminating the MCC-H Conference.]

173:19:58 Cernan: Okey-doke. Well, we're all unsuited now, and we're about ready to talk and eat at the same time, or listen and eat here at the same time. And it won't be long and we'll be ready to hit the sack.

173:20:09 Slayton: Okay; fine. Ken's trying to negotiate the question sessions for you here.

[Schmitt - "What it sounds like is that Deke sent Ken to negotiate a minimum list of questions - which I would have argued against. You want to get information is when it's fresh. And we weren't using the whole eight hour rest period anyway, so you could cut the time out of the rest period (rather than the geology debrief)."]

[Comm Break. AS17-134-20514 to 20532 are photos Gene and Jack took of each other and of the suits and helmets piled on the engine cover. 20514 to 20522 is a series of pictures of Gene. They are all blurred to some degree and 20521 and 20522 are the only acceptable pictures. 20523 to 20525 are good pictures of the suits and helmets. Note the soft-sided stowage bags. 20526 to 20529 are too dark to be useful. 20530 and 20531 are good pictures of Jack. Note Circuit Breaker Panel 16 behind him and, at the right, the ECS controls. 20532 is too dark to be useful.]

173:23:52 Cernan: Canister's changed out, now.

173:23:55 Mattingly: Thank you.

[Comm Break. They are both out of their suits and LCG's and are into their Constant Wear Garments. They are on Surface 7-7.]

173:26:04 Cernan: Okay, Ken, we're on and ready for that (fifteen minute EVA) debriefing. And you should be getting Jack's biomed also.
 173:26:10 Mattingly: Okay. (Pause) Okay. Before we start on those questions, are you prepared to copy some lift-off times in your data book, and that kind of stuff?
 173:26:25 Cernan: Give us about 10 seconds (to get the Data Card book out)..
 173:26:27 Mattingly: All right, sir. (Pause)
 173:26:36 Schmitt: Go ahead, Ken.
 173:26:38 Mattingly: Okay. This is rev 44. Lift-off: 174 plus 13 plus 49. TPI: 177 plus 01 plus 00. Okay; I'll give you just the lift-off times. Excuse me. For rev 45: 176 plus 12 plus 19; 178 plus 10 plus 49; 180 plus 09 plus 20; 182 plus 07 plus 50; 184 plus 06 plus 20. Rev 50 is 186:04:50. Over.
 173:27:38 Schmitt: Okay, Ken. Starting with 44: 174:13:49; 176:12:19; 178:10:49; 180:09:20; 182:07:50; 184:06:02 (sic); 186:04:50. And what's the present rev, please?
 173:28:03 Mattingly: Okay; we're coming up on...In fact, it looks like we're in 44 right now. Okay. (Pause) And, Jack, how about let's confirm that the rev 49 was 184:06:20.
 173:28:30 Schmitt: Oh, I did have that wrong, in the seconds. Two zero seconds.
 173:28:35 Mattingly: That's affirmative. Okay; and we've got your biomed coming through.
 173:28:42 Schmitt: Well, one...(Hearing Mattingly) Am I alive?
 173:28:47 Mattingly: Just barely. (Pause)

[Had they actually done an emergency liftoff 18 seconds early, they would have reached orbit about 30 kilometers ahead of the Command Module. However, given that they would have been in the same orbital plane as the Command Module, the error would have been merely an annoyance. Both spacecraft would have had enough fuel to make the slight velocity adjustment need to close the gap.]

173:28:53 Schmitt: Ken, I'd like to believe that you read that one wrong, because I've gone through 50 copies on that without a mistake (during training).

[Schmitt - "I don't know where I got the number 'fifty', but I'd copied pads a lot of times in training and a lot of times during the mission. There were a lot of them."]

173:29:00 Mattingly: Well, I'll settle that with you when you get back.
 173:29:04 Schmitt: 50 rev.
 173:29:06 Mattingly: All right, sir. And...

173:29:08 Schmitt: Okay.

173:29:10 Mattingly: ...looks like it's about time for an eat period, and I've got these questions for you. But let's keep in mind that that's secondary, and if it ever gets in the way of eating, why holler up, and we'll just drop it right there. We're about an hour and a half behind the time line, and we're going to make up no more than an hour of that.

173:29:36 Schmitt: Okay. (Long Pause) Okay, Ken. We're cutting into the chow and go ahead.

173:30:09 Mattingly: Okay. Would you like for me to just read you all the questions, and let you mull those over before you work on it, or you want to do one at a time?

173:30:22 Schmitt: One at a time's better, Ken.

173:30:23 Mattingly: All right, sir. Number 1. Wanted to know if the blue-gray rocks at Station 6 are similar to those at Station 2? (Pause)

173:30:43 Schmitt: Ken, I think they are. But I think you'll find that the ones at Station 6 are (a) much more metamorphic rock, or recrystallized rock, than the ones we had at Station 2. (Pause) I had the impression that the ones we were sampling at Station 6 were really inclusions in the anorthositic gabbro and had been probably considerably metamorphosed by it being included in it; whereas, the ones we had at Station 2 were a separate rock type apparently, as I recall it, anyway.

173:31:36 Mattingly: Okay; that's good.

[Schmitt - "Because I was using the term 'anorthositic gabbro', it doesn't appear that it had really struck me yet that it (the vesicular Station 6 rock-type) was a partially molten breccia."]

173:31:38 Cernan: Ken, let me just say that my impression is that there was a lot more action in the rocks at Station 6 than 2. I saw a lot more...A lot more was evident, (such as) the inclusions and some of the patterns (and) some of the other things we saw.

173:32:02 Mattingly: All right, sir. Let's go on to the second one, and it said: "Do we understand that there were no breccias at Station 8?" (Pause)

173:32:20 Schmitt: Ken, that parent orthopyroxene plagioclase rock was a breccia in the sense (that) it was fractured and was injected by dark glass. But it would be what we would call a mosaic breccia, in that respect, I think, and we didn't see any Station 6- or Station 2-type breccias there at all. Other than the subfloor gabbro, that orthopyroxene plagioclase rock was the only major rock type I think we saw, unless we picked up some in the rake sample.

[This was the rock that they turned over at Station 8 at 166:56:39. Post-mission analysis confirmed Jack's 'orthopyroxene plagioclase' description made here and in the field at 167:02:30.]

173:33:06 Mattingly: Okay. (Pause) Okay; the third one says: "What are your impressions of the distribution of the familiar subfloor gabbros throughout the EVA-3 traverse?" (Pause)

173:33:38 Schmitt: Well, I think we discussed that a little bit on the traverse - quite a bit, as a matter of fact. The impression I had was that (during) most of the traverse on the plains - with the one exception of Van Serg Crater - we were in block fields or fragment fields that were almost...well, (that) were dominantly subfloor. And, visually from the Rover, I had no impression of any other significant rock type, with the exception of occasional blocks of the gray variety of the subfloor gabbro. I don't know what Gene's impression was. He was driving a lot, but...Pass it on.

173:34:27 Cernan: I think we actually even commented - when we hit the break in slope coming back out of Station 6 and 7, and then coming back down out of 8 - how the terrain features changed. I think that was due principally to what we've been calling the subfloor material (being) evident. And there again, it was, what I would say, particularly mantled, filleted, much like we have here where the LM is; with the exception of Van Serg, where we actually saw fragmental boulders for the most part - a lot less buried - sitting on the surface.

173:35:17 Mattingly: All right, sir. "At Van Serg, some rocks were described as gray breccias, and some contained white fragments. Was there a variety of breccias present?"

173:35:33 Schmitt: I think not, Ken. My impression was that there was a variety only in the degree to which they were fractured. We found and sampled, I think, the two major...One (was a) extremely fractured rock that I said was friable; anyway, it broke into small pieces very easily with a hammer or in your hand, if you worked at it. And the other was a breccia that was much more cohesive than that. It was not fractured or friable at all, but they both were on the rim, and I think they were just varieties, probably, of shock fracturing.

173:36:18 Mattingly: Okay. "Could the Van Serg breccias correlate with the blue-gray material at Cochise?" (Pause)

173:36:31 Schmitt: That's possible, I guess. But my first guess would be that the blue-gray at Cochise was blue-gray subfloor. And...(Thinking it over) Well, I don't know. That's a good question. That's a good question. Maybe with the pictures we have, we can work out an approximate attitude on that contact that I talked about in Cochise, and see if it would project over reasonably to Van Serg. I wouldn't be surprised if it would. That's a good point.

173:37:08 Cernan: To me they looked very similar.

173:37:11 Mattingly: Okay. And you guys sure you're eating?

173:37:15 Schmitt: But...But...Ken, Ken, Ken.

173:37:20 Mattingly: Go ahead.

173:37:24 Cernan: Yeah, we're eating. We're fixing and eating at the same time.

173:37:30 Mattingly: You're mighty efficient. Go ahead. You were starting to say something.

173:37:38 Schmitt: Yeah, Ken. I think (that), from the distance (from which) we saw the blue-gray in Cochise, you couldn't make a definite correlation. But it's a good idea and ought to be considered as one of the possibilities. The other is that we just had a window in the subfloor that coincidentally - I mean (that) one (unit) underneath the subfloor might be that breccia - and, coincidentally, the Van Serg impact hit that window.

[Schmitt - "In this point in my thinking, I hadn't come to the ultimate conclusion that was made; and that was that Van Serg hit into a very deep zone of regolith and that the breccias we were seeing were primarily regolith breccias or what was once called 'instant rock' created by the impact. The reason that the regolith was deep there was that several large craters had superimposed their ejecta blankets in that particular region. So the regolith was probably 30 or maybe more meters thick, in contrast to the five meters out on the valley floor itself.]

173:38:10 Mattingly: Okay. "Can you tell us anything about the cowpie at Van Serg? Was it a clast in the breccia?"

173:38:21 Schmitt: Negative. It was a...Excuse me; I have my mouth full.

173:38:29 Mattingly: It's about time.

173:38:32 Schmitt: It was an aggregate of irregular - looked like - agglutinated glass in (broken) fragments just sitting on the rim of Van Serg. And the reason I said I thought it was "in place" or had fallen there and crystallized (that is, cooled) there, is that there were four or five similar fragments arranged in a small coherent area. (I'm) not making that very clear I don't think; but it looks as if it hit and broke apart upon hitting a little bit but didn't really splatter or break apart in any significant manner.

173:39:28 Mattingly: All right.

[Schmitt - "The material was apparently quite viscous but still hot (when it landed). It didn't shatter but broke. It was probably glassy when it hit, with some crystals in it."]

173:39:30 Schmitt: There are similar things...I tell you what it looks like. If anybody's walked up the rim of Kilauea Iki (on the island of Hawaii) - in the ash out there - and on top of the ash, there are bombs that were fairly clearly molten when they hit, and they had just enough strength to break when they hit. But the individual pieces didn't move very far at all. And you can see that pattern on

Kilauea Iki. And it was the same kind of thing, except that there was no directional aspect of it here.

173:40:10 Mattingly: Okay.

173:40:14 Schmitt: And that's not to say it's volcanic glass. That's just the kind of pattern it was.

[The glass they found at Van Serg was undoubtedly formed in a relatively nearby impact.]

173:40:24 Mattingly: Okay. "Can you tell us if the darker material in the bottom of Van Serg was similar to the collected rim material?"

173:40:38 Schmitt: I think so, except - as Gene pointed out - the clasts were coarser. They were coarser in the bottom than about anything we saw in the rim.

[Schmitt - "I think I wasn't answering the question. I'm not sure, but photographs show that there was dark, fine-grained material streaming down the wall of Van Serg. And I'm not sure I noticed that, except in the photographs. Van Serg was actually a bench crater and the dark material was stopping at the bench. It may be that I described that. We'll see. After the mission, the people who looked at the soil samples found devitrified orange glass spheres. There was probably fire-fountaining along the bounding faults of the valley at the foot of the Massifs. That's the most likely place for the conduits to have developed."]

[This comment was made in a review session that was conducted long before our meeting with Gene in Santa Fe. The answer to Jack's question - did he describe the bench that the termination of the dark material at the bench? - is that, while he didn't notice the dark material, he did describe the bench which, in one sense, is visually defined where the dark streaks stop. The relevant photos are AS17-142-21799 to 21811 which are part of Jack's Van Serg pan.]

173:40:51 Mattingly: Okay. "Are there any distinctive features, other than color, to separate tan from blue-gray breccias, such as jointing, or massive nature, continuity, anything of that nature?" (Long Pause)

173:41:17 Cernan: Yeah, we're... (To Jack) Where did we find those tan breccias? (Pause)

[Bob Parker rejoins the conversation.]

173:41:27 Parker: Challenger, this is Bob. I think we were talking about some of them, I think, at Station 1 the first night. We had both natures. In fact, didn't we have two of those in the same rock together?

173:41:41 Schmitt: They were both gabbros.

173:41:43 Parker: Yeah, excuse me...

173:41:45 Schmitt: Bob, they were tan gabbros and blue-gray gabbros.

173:41:47 Parker: Roger. Okay, yesterday...Excuse me, I wasn't reading the question. Okay, the breccias. There were tan and blue-gray breccias yesterday at Station 2, were there not? You had the two types of breccias at Station 2.

173:42:01 Schmitt: Oh well, yeah. Yeah, that's right. And, now as I think back, I guess that's the main difference between the tan rocks at Station 2 and Station 6; because the ones at 6 appear to have an igneous texture or at least a very crystalline texture and inclusion-like masses of other rocks. Whereas, the ones at Station 2, they seem to be fragment breccias, as I recall.

173:42:45 Cernan: That's right.

173:42:47 Schmitt: Although they may have been recrystallized or metamorphosed, they were clearly breccias at Station 2. I just forgot about that.

173:42:54 Parker: Okay, copy that.

173:42:58 Mattingly: Okay, and "can you amplify your description going out to Station 6? In particular were there blue-gray and tan-gray bands on the North Massif?" (Pause)

173:43:13 Schmitt: Rather than bands, there were lines that appeared to be the upper terminus of the source of the boulders that were strewn below that line. And those lines tended to be either...(to) show a blue-gray source or a tan-gray source, if you will. (Garbled for a few seconds) Oh, those (garbled) bags.

173:44:00 Parker: Challenger, if you think you're talking to us, you're breaking up badly.

173:44:08 Schmitt: I just thought you might be interested; we just had a little spurt of dust come up by the window.

173:44:19 Mattingly: Was there a sleigh with it? (Long Pause)

173:44:34 Schmitt: Wise guy. (Pause)

[The date is December 14.. It is about 2:37 a.m. in Houston. Mattingly is wondering if they've had an early visit from Santa Claus.]

173:44:43 Mattingly: Okay. Did you see very much of dust, or was it just one little shot?

173:44:52 Schmitt: One little shot, it was actually just particles. Something we threw out must have popped.

173:45:02 Mattingly: (Returning to the geology questions) Okay. "Do you have any preliminary stratigraphic sequence for the plains?"

173:45:16 Schmitt: For the plains, huh? (Pause) Well, my guess would be that the Van Serg breccias were the oldest rocks. The subfloor gabbro's the next oldest; and the mantling material's the youngest. But the only good clear relationship was mantle on top of the subfloor gabbros. We really don't have a good relationship of the (Van Serg) breccias and I guess I lean towards thinking that Van Serg was a window in the subfloor rather than being a bed of some kind on top of the subfloor.

173:46:02 Mattingly: Okay, and "do you have an opinion on what underlies the Sculptured Hills?"

173:46:13 Schmitt: Well, I think, we said...The rake sample is probably going to have to tell the tale there. My guess is - from the boulders of subfloor around up there that are of gabbro - that maybe the Sculptured Hills are a version of the subfloor rocks. I don't think that the orthopyroxene anorthosite rock was necessarily indigenous to the Sculptured Hills. It was glass-coated and permeated by glass, so I suspect it may have been thrown there by an impact somewhere else.

[Schmitt - "The Sculptured Hills are almost certainly a variety of the ejecta blanket of the Orientale Basin. Why they have a different surface texture, I don't know. I think what was bothering me here is that we were seeing a large number of basaltic fragments up on the side of the Sculptured Hills where we were sampling. How they got there, I don't know. But we weren't too far from Cochise, Henry, and Shakespeare and they may be ejecta from those craters. Those are pretty big craters - as big as Camelot - and Camelot certainly had a lot of subfloor basalt around it. The theory I expressed here probably wasn't very good, except for the comments about the orthopyroxene anorthosite rock. That's good logic."]

173:46:56 Mattingly: All right sir, we've got one last thing for you to clean up. Back on page 7-6 of your checklist, it looks like we may have skipped some steps on the (Cabin) Gas Return Valve, and (we'd) like to make sure that you get that to Auto and the (Cabin) Gas Diverter (Valve) pushed to Cabin before you stow the oxygen hoses. (Long Pause)

173:47:45 Cernan: Okay, Ken, we got Cabin Gas Return, Auto.

173:47:50 Mattingly: Okay, understand Auto and you got the Select to Cabin?

173:47:58 Cernan: Yeah, Gas Diverter's pushed to Cabin and we're drying the PGA's (the suits) out.

173:48:04 Mattingly: All right, sir. (Pause)

173:48:13 Cernan: And I guess if you could go in...My feeling is if you go to the bottom of every one of those large craters like Camelot, and you'd examine some of these fragments on the walls and down into the bottom, I just get a feeling you'd find this blue-gray breccia down there.

173:48:36 Mattingly: All right, sir.

173:48:43 Cernan: I mean in all the big craters like Camelot.

173:48:47 Schmitt: I think maybe that's true; however, we do not see isolated fragments of it very often, if at all, out here on the plains themselves, away from the craters. So if the blue-gray breccia - (correcting himself) the Van Serg breccia - does underlie the subfloor, it's far enough down (below the surface) that the craters we have apparently have

not penetrated and brought up much of that kind of material.

(Pause) Well, that's it.

173:49:32 Mattingly: Okay guys, it's time to press on and finish up chow time and I've got your stowage summaries whenever you're ready for that, to get started on.

173:49:46 Schmitt: Okay, Ken let us finish eating, then we'll go back to work.

173:49:51 Mattingly: Okay, give me a call when you're ready. (Long Pause)

173:50:03 Schmitt: (Inadvertent key) I'll help you (garbled).

[Long Comm Break]

173:54:10 Cernan: Okay. Ken I'd like to go ahead and hear your recommendations on stowage and I'll write it down.

173:54:17 Mattingly: All right, sir. On (Surface Checklist) page 2-2, I've got some numbers to fill in at the bottom under the collection bag stowage. (Pause)

173:54:29 Cernan: Okay, I've got it.

173:54:31 Mattingly: Okay, number 1 with the aft of the engine cover is bag 8. And then the second line, it's bag 7. The third line it's bag 6 left hand and 5 right hand. And the last line is bag 2 and 4. And you can disregard the max. weights.

[The planned maximum weights were 40 pounds aft of the engine cover; 40 pounds in the LHMS (Left-hand Mid-Section) which is a stowage area just aft of the area where Gene's PLSS had been stowed and, now, the rock boxes are fastened to the wall; 40 pounds each in the LHSSC and RHSSC (left- and right-hand-side stowage compartments) which are below the side instrument panels; and 50 pounds in the ISA (Interim Stowage Assembly).]

173:54:58 Cernan: Okay, just so we got it straight: aft engine cover, bag 8; left hand side, bag 7. Left hand plus the right hand side: number 6 left hand and 5 right. And the ISA (Interim Stowage Assembly) bags 2 and 4.

173:55:12 Mattingly: That's affirmative. (Pause)

173:55:22 Cernan: Okay.

[Long Comm Break]

173:58:57 Mattingly: Hey, Jack, the people down here watching things noticed that your Suit Isol(ation) valve is still in Disconnect. If you're trying to dry the suit out, you might check that. It's your option what you want to do with it.

173:59:11 Schmitt: I'm glad somebody is watching things! Thank you.

[Schmitt - "Ken was being very diplomatic."]

[Very Long Comm Break]

174:23:25 Cernan: Ken we're in the process of getting all these bags in the proper places, now.

[Schmitt - "I think there were storage racks on the right and lefthand sides and, if I remember correctly, they had fabric covers."]

[Cernan - "The rock boxes stacked on top of each other where my PLSS had been on the port bulkhead. They were locked in with pins."]

[Long Comm Break. They are doing the tasks in the righthand column of Surface 7-7, apparently not in order. Gene is stowing the rock bags, a task near the bottom of the column and, as indicated by his next statement, Jack is stowing film magazines, a task near the top of the column.]

174:28:03 Schmitt: Ken, this is Jack. Why don't you make a note that mag Bravo (Apollo magazine 134) is empty, with miscellaneous photos since the last report on it.

174:28:13 Mattingly: Okay.

[These are the photos that Gene and Jack took of each other and the helmets. Long Comm Break]

174:31:36 Schmitt: And, Ken, we're stowing mag Nancy (Apollo magazine 143) at a reading (a frame count of) 153.

174:31:44 Mattingly: Okay, copy 153.

[Very Long Comm Break. Jack is stowing the film magazines into the LCG (Liquid Cooled Garment) Stowage Compartment which is below his right-side switch panel. AS17-143-21943 to 21982 is a window pan which they may have just taken. 21960 is the best of the photos taken out of Jack's window and shows the thrusters and an assortment of footprints and Rover tracks. The photos taken out Gene's window - 21961 to 21982 are much better pictures than the ones taken out Jack's window. 21969 to 21972 show the PLSS's and 21973 to 21979 comprise an excellent southwestern horizon sequence.]

174:44:15 Cernan: Houston, Challenger.

174:44:18 Mattingly: Go ahead, Geno.

174:44:23 Cernan: Okay, Ken. All we've got left to stow now is the Buddy SLSS bag and that's in work. And we got all the ETB stuff taken care of. All the other bags are stowed per your recommendation. We'll be configuring the ECS for sleep and putting up the hammocks here shortly; and as soon as we can get cleaned up personally a little bit, we'll be in the sack.

174:44:58 Mattingly: Okay. Sounds great. (Long Pause)

174:45:55 Mattingly: Hey, Geno, the guys are looking at that Buddy SLSS bag and suggested you all make sure that you're going to have room to do the equipment jettison and

get the hatch open and all that. They had planned on stowing it the next day.

[This suggests that they can use the floor space between them for stowage, but only after they are finished using the hatch.]

174:46:14 Cernan: That's a good thought, Ken. Thank you, Ed. The fact is that probably make things more convenient. We were going to be smart and get ahead here but, thank you.

174:46:23 Mattingly: "The faster I run, the behinder I get." (Long Pause)

174:46:42 Cernan: Yeah. You keep forgetting these checklists have been exercised a hundred thousand times.

174:46:50 Mattingly: Yeah, we keep remembering that.

[Long Comm Break]

174:51:06 Mattingly: Challenger, Houston. If you'll just give us a call when you're ready to sack out, we won't bother you. That way we can keep track of what you're doing and when you're about ready to go to bed and we'll get you up at an appropriate time.

174:51:21 Schmitt: Okay, Ken, this is Jack. I guess I have the "duty biomed" tonight, so I'll give you a call when we're turning out the lights.

174:51:30 Mattingly: Okay.

174:51:31 Schmitt: And it won't be too long.

174:51:33 Mattingly: All right. You guys are doing pretty good! You're almost caught up.

[Comm Break]

174:52:35 Schmitt: Hey, Ken, working through this thing, we haven't been able to find instructions for the stowage of the EV gloves. Do your friends back there have any recommendations?

174:52:48 Mattingly: Okay, stand by one and I'll check on that.

[Comm Break. As mentioned at 171:39:37, they each had two pairs of EVA gloves - a fact confirmed when, at the end of the second EVA, Gene asked Bob Parker if "those gloves that you've got packed in the back have got something in them." At 171:54:54, they departed from the checklist and jettisoned two pairs of gloves rather than two pairs of boots. As suggested by the dialog from here to 174:56:09, they jettisoned the unused EVA gloves - which they must have gotten out of storage, another action not in the checklist. Gene says that they had decided to bring the boots home and, perhaps, they decided to jettison a pair of gloves instead. Each of them also has a pair of Intravehicular (IV) gloves.]

[Cernan - "I think we had two pairs of EVA gloves because that was a single point failure to the suit."]

174:54:13 Mattingly: Okay, Jack, we can stick those things on the comm panel for now, and then tomorrow on page 7-14, it's going to have you stow them in the LEVA bags; but, for the time being, if you just stick those up on the panel and set them aside, you'll use them tomorrow (for the jettison).

174:54:35 Schmitt: Okay, Ken, got you. Yeah. They're going to get the inside of the LEVA pretty dirty. (Long Pause)

174:54:59 Mattingly: Well, from what we've seen, Jack, (chuckling) I think everything's going to be about the same color by the time you get through.

174:55:08 Schmitt: Okay, it didn't bother your (Apollo 16) EVA - did it, Ken - to have a little dust in your helmet?

174:55:15 Mattingly: No, no; that's kind of nice to have.

174:55:21 Schmitt: Hey, an experienced fellow like you might have a recommendation on how to get my visor up.

174:55:30 Mattingly: Yeah; give it to the CMP. (Long Pause)

[Deke Slayton rejoins the conversation.]

174:56:00 Slayton: We were just debating down here how come you guys threw away those nice clean gloves and kept the dirty ones.

174:56:09 Schmitt: I wish you hadn't ask that, Deke. (Slayton laughs) We were just debating that, too. (Pause)

[The value of the worn gloves - both from an historical and an engineering point of view is inestimable. I think they made the right choice.]

174:56:23 Slayton: How long are your arms, Jack.

174:56:26 Schmitt: You do all sorts of things...(Stops to listen to Slayton)

174:56:30 Cernan: Hey, they're out on the porch as a matter of fact. That's not too far fetched. (Long Pause)

174:57:08 Schmitt: I guess there's some old friends you just hate to get rid of, Deke.

174:57:12 Slayton: Yeah, that figures. (Long Pause) Yeah, you guys have had some real winners there. Don't change a good thing.

174:57:39 Schmitt: Well, they seemed to do all right for us. I guess that's the way we were half-way thinking, but not thinking very well, as is witnessed in our checklist procedures tonight.

174:57:52 Slayton: Ah, you're doing outstanding.

[Comm Break]

175:00:08 Mattingly: Challenger, Houston. On your comm, your checklist will call for going to Down-voice Backup. And, tonight, we'd rather just leave it in the Normal Voice.

So, if you leave the configuration you have, rather than change it, that would be a good deal for us. (Pause)

[The "Down-Voice Backup step is not to be found in the available version of the checklist neither on Surface 7-7 nor on 7-8.]

175:00:37 Schmitt: Okay, Ken, I only got part of that, I was scrubbing my face here. You want to save the same comm configuration we've got right now. Is that correct?

175:00:45 Mattingly: That's affirmative.

175:00:50 Schmitt: Okay. That's easy.

[Schmitt - "We had some soft cotton towels which we could wet with the water gun."]

[Very Long Comm Break]

175:16:55 Schmitt: Okay, Ken. Gene just stowed the EVA antenna.

175:16:59 Mattingly: Okay.

[This step is near the top of the lefthand column of Surface 7-8.]

[Schmitt - "This was an antenna on the LM for receiving EVA transmissions. The ground could monitor signal strengths and just pick whichever antenna was getting the best strength - either the Rover or the LM."]

175:17:03 Schmitt: And I'll be off comm here just for a few minutes - (correcting himself) (off) biomed - but I'll be back with you when I turn in.

175:17:12 Mattingly: Okay. I may have misled you earlier when I said, we weren't going to lose any time. We can get you 8 hours (of rest) up to about 19 after the hour. After that, we're going to have to start rearranging things to get 8 hours.

175:17:34 Schmitt: Well, Gene's almost in his hammock now. And I will be shortly, so I think we're probably in pretty good shape.

175:17:39 Mattingly: Okay, that's fine. I just...I didn't want to mislead you.

175:17:45 Schmitt: That's all right, you've never misled me before. (Pause) Well, let me think about that.

175:17:56 Mattingly: I was going to say: you catch on awful slow, if that's true.

175:18:05 Schmitt: Right.

[Comm Break]

175:19:14 Cernan: Ken, I'm going to take off my headset here and jump into the hammock. What time (are) we getting up Central Time?

175:19:27 Mattingly: Well, it's going to be roughly 45 minutes past the time listed at 182:39. So...Are you asking for it in local time?

175:19:40 Cernan: Yeah. My watch is set on Houston time. What time will it be?

175:19:44 Slayton: Be about...

175:19:45 Cernan: Eight hours from when?

175:19:46 Slayton: Be about 12:15 (p.m. Central Standard Time), Geno.

175:19:51 Cernan: Okay, that sounds great, Deke. It won't...We're just cleaning up a few minor things and we'll actually probably be asleep in the next 10 to 15 minutes.

175:20:03 Slayton: Okay, sleep good. You had a lovely day. Hope tomorrow's as good.

175:20:06 Cernan: Sorry to keep...(Stops to listen) Thank you, boss. Sorry to keep you up so late. But appreciate it very much.

175:20:14 Slayton: We're enjoying it.

175:20:18 Mattingly: Hey, Gene, before you unplug you might...

175:20:20 Cernan: Okay, I'm going off the air.

175:20:22 Mattingly: ...check the Suit Flow valve. Looks like it's not flowing, if that's the configuration you want. (Pause)

175:20:36 Cernan: Yeah, we've got them both flowing. And we've got good circulation in the cockpit. If it looks good to you down there, we're in good shape up here.

175:20:45 Mattingly: Looks fine. See you later.

175:20:50 Cernan: Okay, we thank you much.

183:29:59 LM Crew: (Sung with occasionally successful harmony) Good morning to you; Good morning to you; Good morning, Dear Gordy, Good morning to you. (Long Pause)

[Schmitt - (Laughing) "You're being overly generous. I didn't hear any successful harmony."]

[My Beautiful Australian Bride, Dianne Jones, a woman of good musical judgement, agrees with Jack. I am outvoted. There was no successful harmony.]

[Cernan - "Can you imagine (the scene) down in the MOCR. They're quietly sitting there watching the systems and figuring out what their going to do next and off the open carrier comes this noise."]

Fullerton: (Music: Thus Spake Zarathrustra by R. Strauss)

183:33:14 Fullerton: Good morning, Challenger and thank you for the vocal rendition from the Moon, there.

183:33:24 Cernan: Well, we thank you for your kind music. We wanted to let you know we were thinking about you this morning, Gordy.

183:33:34 Fullerton: You just beat us to it, but...

183:33:36 Cernan: That was a great song.

183:33:37 Fullerton: ...we decided to play it anyway, because it's such a pretty selection.

183:33:44 Cernan: I think it's very apropos at the moment. I guess I can just wait for "Hail Purdue," huh?

183:33:55 Fullerton: Yeah, just stand by, you'll probably hear it before you get back.

[Gene and Jack had a total of thirteen wakeup calls during the mission. Ten times Houston picked out appropriate musical selections, albeit none of them "Hail Purdue" in honor of Gene's alma mater, Purdue University. There was no music for their first two wake-up calls in space. For the third morning, Houston picked "The Jayhawk Fight Song" in honor of Ron Evans alma mater, Iowa State University. There was no music again for the fourth morning but, for the fifth call, on the day that Gene and Jack made their landing, Houston played John Denver's version of "The City of New Orleans" which features the phrase "Good morning, America, how are you?" in the chorus. "America" is, of course, the name of the Apollo 17 Command Module. For Gene and Jack's first wakeup call on the Moon, Houston picked Wagner's "The Ride of the Valkyries", a tune regular played on mornings of final exams at Caltech, which was Jack's undergraduate school. (Gordon Fullerton and Journal Editor Eric Jones were also Caltech undergrads.) Flight Director Gerry Griffin's alma mater, Texas A&M, was honored the next morning with a rendition of "The Aggie Fight Song". Strauss's "Thus Spake Zarathrustra", which is associated with space because of the Stanley Kubrick/ Arthur C. Clarke film "2001". For the rest of the mission, the selections are: Roberta Flack's rendition of "If Ever I Saw Your Face", presumably a reference to the

Moon below the orbiting spacecraft; the Doors "Come on Baby Light My Fire" , to be played on the day (December 17) that the Apollo 17 crew leaves lunar orbit for the trip home; "Home for the Holidays"; The Carpenter's "We've Only Just Begun", played in the belief that the end of Apollo is not end of humanity's lunar adventure; and, for the morning of splashdown, a dual selection of the Navy's "Anchors Away" and the U.S. national anthem, "The Star Spangled Banner."]

183:34:01 Cernan: Hey, we've been stirring for about 15 or 20 minutes. We're in the midst of a nice hamburger omelet (chuckle) and assorted accessories.

183:34:05 Schmitt: As a matter of fact, it's all over us.

183:34:06 Cernan: And if you'll give me 5 minutes, I'll be ready to go on the PGNS, unless you want to start it sooner. (Long Pause)

[Procedures for powering up the inertial platform and other elements of the guidance and navigation system are printed on checklist page Surface 7-9. They are supposed to perform those tasks before breakfast but, as Fullerton indicates in his next statement, Houston agrees with their decision to start with breakfast. In fact, they have a relaxed schedule for the nearly five hours that remain before launch and won't be facing any time-critical tasks until the later stages.]

183:34:37 Fullerton: Okay. No hurry, finish up and get cleaned up there. And the only change...We have some change in the timing as far as the checklist so we can gain back the time we're behind now, which is actually less than an hour. And the only hardware change other than deletions is that we'd like you to leave Demand Reg A closed at all times. So whenever you come across a place that says Open at Cabin or Egress, we'd like you to leave it Closed.

183:35:20 Schmitt: Okay. Gordy. We've got you on that.

[Cernan - "Here we are, after three days of exploring the lunar surface. We're coming up on an extremely critical portion of the mission - lifting off from the surface - and the conversation is so casual. It just strikes me. We've got food spilled all over; they start playing songs; we're singing to them."]

[Schmitt - "I wonder if, in the journals of other explorers, there is this light-hearted overlay to what was otherwise a stressful adventure. I wonder if there's any sign of the synergistic humor that human beings have among themselves - the kind where, if you read it, it doesn't sound very humorous, but you know it's there."]

183:35:23 Cernan: And, Gordy, could I have a quick status report on America and Challenger?

[Cernan - "This conversation is laid back; and, yet, there is business involved. We ask for the status of the Challenger and so on. But, then, when you read on, Jack's got a poem. It just strikes me that we were confident, confident that we are proceeding along on the plan. I think the mood is worth commenting on and, as I look back on it, I'm proud of it. We weren't stereotypes going bang, bang through the checklist. We woke up, we sang them a song, and we're sitting back and eating breakfast. And you've got to picture what's going on. Jack and I are in our long underwear with our suits piled up behind us - it's like four people in the little lunar module - sitting wherever we can. And they ask for the PGNS and you just reach over and get it. I wish there had been a mini-camera inside the spacecraft. It's the kind of thing you want to relate to other people. We were a quarter million miles away from home; we'd done something unique; we had something extremely significant still to do; and we had to take things in stride, one step at a time. We were feeling pretty good about it. We were ready to take our spoils back home. It might have been a case of rewarding ourselves for what we'd done."]

[Schmitt - "There are photographs of Gene and me in the LM (AS17-134-20521 and 20530) and I think the looks on our faces tell the story. The fact that we took the time to take pictures of ourselves says a lot."]

183:35:31 Fullerton: You bet. America is just as good as gold, just like always. Ron got off the trim burn on the back side followed by a good plane change on the front side. In fact the G&N cut-off was a tenth (of a foot per second) and - or less - in all axes. Didn't even need to trim it. So, he's in about a 62-1/2 circular (orbit), I believe, and waiting for you to come up and join him.

183:36:05 Cernan: Okay, how's his consumables?

183:36:12 Fullerton: Stand by. (Pause) Okay, America's consumables are great and so are yours. There is a possibility we may have to switch to Ascent Water (tank) just prior to lift-off. Everything really is in good shape.

183:36:38 Cernan: Those are good words, Gordy. Thank you.

[They have been using the water supply in the Descent Stage up to this point - primarily to cool the electronics - and have nearly exhausted it.]

183:36:46 Schmitt: Hey, Gordy. In honor of one of your comm handovers last night, and in the tradition of Apollo 8, I've got a paraphrase of a familiar poem for you.

183:37:01 Fullerton: Okay; go ahead.

183:37:03 Schmitt: Well, "It's the week before Christmas and all through the LM, not a commander was stirring, not even Cernan. The samples were stowed in their places with care, in hopes that with you, they soon will be there. And Gene in his hammock and I in my cap, had just settled our brains for a short lunar nap. But up on the comm loop there rose such a

clatter, I sprang from my hammock, to see what was the matter. The Sun on the breast of the surface below, gave the luster of objects, as if in snow. And what to my wondering eyes should appear, but a miniature Rover and eight tiny reindeer. And a little old driver so lively and quick, I knew in a moment, it must be St. Nick. I heard him exclaim as over the hills he did speed. Merry Christmas to all and to you all Godspeed."

183:38:22 Fullerton: Very good.

183:38:27 Cernan: Gordo, that was the first time I heard that and I got to say that is beautiful!

[Cernan - "I still think it's a classic. That's what I meant (a little while ago) about the tone of the moment."]

183:38:33 Fullerton: I agree. Did the LMP get any sleep or did he spend all night composing that?

183:38:43 Cernan: People always said we ought to have a poet in space.

183:38:48 Schmitt: I don't think we've made it yet.

(Answering Fullerton) No, for some reason I really woke up with one of your handovers last night, and that was how I went back to sleep. (Pause) Gordy, that's for the kids. They are the future.

183:39:20 Fullerton: Rog, Jack. (Long Pause)

[Gene thinks Jack may have made some notes and was using them as he recited his creation. Jack has a vague recollection of having used notes.]

[Schmitt - "The Apollo 8 reference is that somebody in the MOCR wrote a paraphrased version of 'The Night Before Christmas' and I read it up to the crew. As a kid I had given recitations of it."]

[On Christmas Day 1968, about 45 minutes after Apollo 8 had a successful engine burn to put themselves on a homeward-bound trajectory, the following conversation was recorded for posterity, starting at 89:59:18.]

[CapCom: Jack's been watching you since LOI (Lunar Orbit Insertion), and he has a few words he wants to give you.]

[Borman: Go ahead.]

[Schmitt: Typhoid Jack here, and we have some good words here that originated at the Cape with a bunch of friends of yours. And it's sort of a paraphrase of a poem that you probably are familiar with. Do you read me, Apollo 8?]

[Borman: You are loud and clear, Jack.]

[Schmitt: Okay. " 'Twas the night before Christmas and way out in space, the Apollo 8 crew had just won the Moon race. The headsets were hung by the consoles with care, in hopes that Chris Kraft soon would be there. Frank Borman was nestled all snug in his bed, while visions of REFSMMAT's danced in his head; and Jim Lovell, in his couch, and Anders, in the bay, were racking their brains over a computer

display. When out of the DSKY there arose such a clatter, Frank sprang from his bed to see what was the matter. Away to the sextant he flew in a flash to make sure they weren't going to crash. The light on the breast of the Moon's jagged crust gave a luster of green cheese to the gray lunar dust. When what to his wondering eyes should appear, but a Burma Shave sign saying "Kilroy was here." (Laughter) But Frank was no fool; he knew pretty quick that they had been first; this must be a trick. More rapid than rockets, his curses they came. He turned to his crewmen and called them by name. Now Lovell, now Anders, now don't think I'd fall for an old joke you've written up on the wall. They spoke not a word, but grinning like elves, and laughed at their joke in spite of themselves. Frank sprang from his couch, to the ship gave a thrust, and away they all flew past the grey lunar dust. But we heard them explain ere they flew around the Moon: Merry Christmas to Earth; we will be back there real soon." Great job, gang.]

[Borman: Thank you very much. That was a very good poem; but in order to win the race, you have got to end up on the carriers (the recovery ship).]

[The cultural references in the poem are to Kilroy, "a mythical soldier of World War II whose name was inscribed in unlikely places all over the world by American soldiers" (Webster's Third International Dictionary, 1968) and to the thousands upon thousands of Burma Shave signs that kept American motorists entertained between 1927 and 1963. As detailed in Frank Rowsome's "Verse by the Side of the Road", the Burma-Vita Company advertised its brushless shaving cream with sets of six, red-and-white signs spaced far enough apart that there were easily read by passing motorists. Each set of six carried either an advertising message or a public service message, usually in funny verse with two or three words per sign and the last sign always saying "Burma Shave". Two examples from the 1960 campaign are "We've Made Grandpa / Look So Youthful / His Pension Board / Thinks / He's Untruthful / Burma Shave," and "Henry the Eighth / Sure Had / Trouble / Short Term Wives / Long Term Stubble / Burma Shave." A combination rising costs, increasing urbanization, the development of the Interstate Highway System, and opposition to roadside advertising killed this much loved piece of Americana.]

183:40:17 Fullerton: Challenger, Houston. One update for the post-sleep procedure. I understand you brought in the LMP's camera, and we want to be sure you get that into the jett bag before the final jettison here. And, by the way, you're Stay for that final jettison.

183:40:39 Schmitt: Okay, Gordy. It's already in the jett bag, thank you. (Pause)

[Cernan - "Obviously, I did not leave the LMP's camera on the Rover pointed at the zenith. But I swear I put something there. It's possible it could have been the 500

lens, because we didn't bring it back and I mentioned it was under the seat. I know that I did something with a camera. Now, it could have been a lens. And I stuck it between the seats, sort of wedged it in somewhere, and pointed the lens toward the zenith."]

[Schmitt - "Houston wanted us to jettison the camera because they didn't want us to take pictures of Ron Evans' EVA. They had decided it was too cumbersome and too risky. But, we were going to ignore them, and we figured out how we could do it. But we needed a camera. Ron had a camera, but it was not EVA-qualified."]

[Cernan - "We had made up our minds we were going to take pictures of Ron."]

[Schmitt - "And we needed a lunar-surface camera to do it."]

[Cernan - "Now, we did put the LMP's camera in the jett bag, so we must have had mine."]

[What is puzzling about Gene's and Jack's memory on this is that Gene's cuff checklist page CDR-33 contains the line "Cam to ETB", indicating that Houston expected them to have that camera on board.]

183:40:52 Schmitt: And, Gordy, you might make some notes that before I put it in there (in the ETB at about 174:31:44), I took a black-and-white window pan with mag Nancy (Apollo magazine 143).

183:41:08 Fullerton: Okay, Jack. Roger.

183:41:13 Cernan: Gordo, on Reg A, you interpret that is just a small leak by the reg? That it would be usable, if you had to.

183:41:28 Fullerton: That's affirmative, Geno. It's a small, slow leak and it is usable if needed.

[That is, if Reg B doesn't work, they'll be able to use Reg A for repressurization following the final hatch opening.]

183:41:38 Cernan: Okay, thank you. In summing up so far, I think that's all the system anomalies we got, isn't it?

183:41:48 Fullerton: That's all I can think of at the moment. I do have revised times for the rest of the Lunar Surface Checklist which, at a convenient time, I can give to you, so that you'll have a how-goes-it as you go on down the line here.

183:42:05 Cernan: Why don't you give them to us now, Gordy?

183:42:09 Fullerton: Okay, turn to page 7-9. (Long Pause)

183:42:24 Cernan: Go ahead.

183:42:26 Fullerton: Okay, 7-9 LGC/IMU Power-up, change that time from 183:04 to 184:10. The eat period time is now 184:20.

183:42:44 Fullerton: Turn the page (to 7-10), and the "183:59" above "Park Rendezvous Radar" is now 185:05.

183:42:56 Fullerton: Next page (7-11), "don suits" at 185:15. (Pause)

183:43:04 Fullerton: Go to the next page (7-12). "Prep for equipment jettison" is 185:50; and, the same page, "helmet/glove donning" is 185:58.

183:43:22 Fullerton: Next page (7-13), "pressure integrity check", 186:04. "Cabin depress" is 186:08; and "hatch opening" is 186:12.

183:43:43 Fullerton: Next page, 7-14, "cabin repress" is 186:15. "Cabin cleanup for launch" is 186:20.

183:43:59 Fullerton: And on the following page (7-15, we're going to delete the P22 but we'd like you to do all the procedures except those from "Verb 95 Enter," through "POO Enter," inclusive...(That is), the center section of procedures. So you'll still be closing the rendezvous radar breakers, going to LGC, and parking the antenna and copying pads. Over.

183:44:24 Cernan: Okay, we're going to delete everything from Verb 95 through POO on P22. That's the center of the page.

183:44:34 Fullerton: That's affirmative and then the next page, "cabin prep for ascent" is 186:45, and instead of 39 minutes we're going to have you do that in 3 minutes. And you should have a little more time than that, since you got up early. That puts you right back with time line, at lift-off minus 1 hour and 15, at 186:48. Over.

183:45:06 Cernan: Okay, top at 7-15 where we pick up what was going to be the beginning of the P22? Have you got a time up there?

183:45:14 Fullerton: I guess we'll just have to work that in with the cabin cleanup time. We had deleted that whole time block but you do have to catch those procedures.

183:45:31 Cernan: Okay, and then the times on the top of 7-10, for P22, are not applicable, and I guess you can give us an update for our P57 lift-off time.

183:45:47 Fullerton: That's affirmative. We might...There's a couple more changes coming at me here but let me make sure I got them straight and I'll call you later. Go ahead with whatever you were doing.

183:46:01 Cernan: Okay. (Long Pause)

183:46:26 Cernan: (Coughs) Gordy, if I get ready for the "LGC/IMU power up, I'll give you a call even though it comes earlier; but I'd like to get that started, as soon as we're ready to start it.

183:46:39 Fullerton: Okay. We concur with that. (Pause)

183:46:52 Schmitt: Hey, Gordy, as far as the food, medication, and sleep goes...(We took) no medication. Gene had 5 hours of good sleep, I had probably around my usual 6, in spite of my poetic inclinations.

[Schmitt - "Our rest period was normally eight hours, and we were usually a little late getting started."]

[Cernan - "We'd sit around and talk and Jack'd stick his finger in the rock bag."]

183:47:05 Schmitt: And the food...We continue to do well, I believe. We've eaten a wet pack apiece last night. We got one this morning. We've eaten our scrambled eggs and sausage yesterday, and we've run out of juices and tea. And which is somewhat of an inconvenience I might say. And if you've got any specific questions, I can fill you in on it; but, I think, foodwise we've done pretty well.

[Schmitt - "The wet packs were the original form of the Army's irradiated Meal-Ready-To-Eat."]

[Cernan - "They were cold, not warm."]

[Schmitt - "We had four kinds, as I recall: peanut butter, a hamburger, wieners..."]

[Cernan - "Ham in a kind of gravy, and roast beef."]

[Schmitt - "Maybe there were five, then. And there was a fruit cake, too. And it was really pretty good. They were our best meals."]

[Cernan - "It was a good change from eating all the rehydrated food."]

183:47:43 Fullerton: Can you give us a feel on the fluid intake?

183:47:50 Schmitt: Well, that's what I was trying to do when I said we'd drunk all the juices and tea. Plus, Gene, in particular, takes water from the hose.

183:48:02 Fullerton: Okay, Jack, fine. Sounds good.

[Very Long Comm Break. They've already had breakfast, a bit out of sequence, and will now power-up the inertial platform and other elements of the navigation system. During this LM Comm Break, Houston has AOS with Evans, who is on his 49th orbit.]

183:57:32 Cernan: Okay, Gordy, it's PGNS (Primary Guidance and Navigation System) power up time.

183:57:36 Fullerton: Okay, Geno. And I've got a couple more items to completely clean up the checklist whenever you can get to that.

183:57:53 Cernan: I'll let Jack give you a call. I'm going to start on the PGNS, if you're ready. (No answer; Long pause) Gordy, you ready for the PGNS?

183:58:23 Fullerton: That's affirmative, finally got you a Go to start it as per checklist.

[They are about 54 minutes behind schedule and will catch up easily.]

183:58:33 Cernan: Okay there's the Pro; I did get the Restart. (Pause) I got the No Att, the DAP, Gimbal Lock light, and a Program Alarm light's on.

183:58:48 Fullerton: Roger. (Long Pause)

183:59:37 Cernan: Mark it. The gimbal operate breaker is Closed.

183:59:39 Fullerton: Roger. (Pause)
183:59:46 Cernan: That's the IMU Operate breaker. And I'll stand by for 90 seconds (until the corresponding lights go out.
183:59:50 Fullerton: And we're ready for a Power Amp, Primary; and High Bit Rate. (Pause)
184:00:08 Cernan: Okay. You got it.

[Long Comm Break]

184:04:35 Cernan: Okay, Gordo, self-test is complete and it's Go; and I'll give you an E-memory dump.
184:04:40 Fullerton: Okay, we're ready, standing by for it. And while it's coming, I could give you the update for the next page. (Pause)
184:04:55 Cernan: Okay, it's coming at you and you can go with the updates on the next page.
184:04:59 Fullerton: Okay. Page 7-10, your P57 lift-off time, upper right corner, is 188:01:43.85. Over.
184:05:16 Schmitt: Okay, Gordy, P57 lift-off time 188:01:43.85.
184:05:23 Fullerton: That's affirmative. And then we'd like you to delete all the steps below that lift-off time, from the A/T-3 data star info box through the Verb 32 after "for the remaining data stars" and after last star. In other words, just delete all between the box and up to circuit breaker AOT Lamp, Open. And, of course, there'll be no P22 time, over.
184:05:59 Schmitt: Okay. Delete all the data star information between the start of that box and, "after last star, Verb 34 Enter, 00 Enter."
184:06:12 Fullerton: That's correct and then turn to page 7-15. We're changing...Looking here a little closer, we find that radars are already in good position, so you can delete all procedures on page 7-15, except "Copy Ascent pads, CSI pad, and LM DAP weight." (Pause)
184:06:48 Schmitt: Okay. We've deleted everything but the last three lines on that page.
184:06:53 Fullerton: Okay. On page 7-12, back up a couple pages. In the lower right corner there, in the blank space, you might jot down 185:58, VHF check with Command Module. And that'll be according to the procedures on 7-15 in the box. You might just parenthesis 7-15 to remind you where the procedure is. But the comm check will come during that time when you're prepping for equipment jettison, or right around there. (Pause)
184:07:37 Cernan: Okay. We got that.
184:07:39 Fullerton: Okay. That's all we got for you, and we have the E-MOD dump okay.
184:07:48 Cernan: Okay.

[Comm Break]

184:09:00 Cernan: (Now on 7-10) Gordy, we're on POO in Data and we're standing by for your up-link, and how long does that AOT Heater breaker have to be open? I pushed it in at 184:08.

184:09:11 Fullerton: Okay. I'll get an answer for that, and I think we'll be coming with the up-link here shortly.

(Long Pause)

184:09:56 Fullerton: Gene, no time constraint on that AOT breaker; except, if it (the telescope sight)'s foggy, it hasn't been in long enough.

184:10:08 Cernan: (Laughing) Thank you, Gordy. (Long Pause)

184:11:05 Fullerton: Challenger. Here comes your up-link.

184:11:11 Cernan: Okay.

[Comm Break. They are getting state vector information from Houston.]

184:14:58 Fullerton: Challenger, it's your computer. You have a state vector, a time increment, and an RLS.

184:15:01 Cernan: Thank you, Gordy.

[Schmitt - "RLS was probably the REFSMATT Landing Site."]

[Cernan - "I haven't heard that word for years. It was the coordinates of the landing site so that we would know where we were lifting off from."]

[Comm Break]

184:17:44 Cernan: Well, it (the computer) likes the command module's orbit.

184:17:49 Fullerton: That's good.

[Very Long Comm Break. Because of slight deviations of the CSM orbit from the planned path, liftoff will be 1 minute, 10 seconds early. Evans has done a power-up test of the CSM vacuum cleaner in preparation for the arrival of the surface crew. Next, Gene and Jack will perform a check of the platform alignment using gravity and a sighting on the bright star Vega.]

184:34:35 Fullerton: Okay, we see that.

184:34:36 Schmitt: Houston, there's a Noun 05.

184:34:39 Fullerton: Doesn't look like the Challenger shifted around much in the last 3 days. (Pause)

184:34:52 Schmitt: Well, at least it always settles back to the same spot. (Long Pause)

184:35:47 Fullerton: Okay. You're clear to torque those.

[Long Comm Break.. They have just done a gravity alignment and, as per instruction, will now skip the stellar alignment and prepare to don their suits.]

184:39:58 Schmitt: Say, Gordy, are we clear to jettison the Buddy SLSS bag, now?

184:40:03 Fullerton: That's affirmative, Jack. We've determined you won't need it for rock stowage. And along the same line, John Young suggested that you might check your checklist pockets on your suits, when you get to that point. His were full of dirt. You might want to take those off and discard them, if that's the case, so that it won't fly up and get you at insertion.

184:40:28 Cernan: Yeah, we already did that, Gordy. They were a mess, and we took them off. They're in the jettison bag now.

184:40:34 Fullerton: Okay. (Pause)

[Cernan - "We had some strap-on thigh pockets. I think we called them our 'checklist pockets' because we could slip our checklists in them. (Chuckling) And you know, we were ahead of the ground on a lot of things."]

[Schmitt - "But it's nice to have them thinking for you."]

184:40:41 Cernan: We're going to take time out for about 15 or 20 minutes of mandatory housekeeping here.

184:40:50 Fullerton: Okay, understand.

184:40:54 Cernan: That's prior to suit donning.

184:40:59 Fullerton: Roger.

[Cernan/Schmitt - "We needed to take a leak (urinate) before we donned the suits."]

[Very Long Comm Break as they get out of the Constant Wear Garments and into the LCG's. Because of the low residue diet, neither of them had to defecate while they were on the Moon.]

184:58:18 Schmitt: Gordy, this is Jack. I just went off biomed briefly.

184:58:22 Fullerton: Okay, Jack.

184:58:28 Schmitt: And Gene will be on biomed shortly.

184:58:31 Fullerton: Roger. (Long Pause)

184:58:54 Cernan: Gordy, I'm back up.

184:58:57 Fullerton: Okay.

[Very Long Comm Break while they get Jack into his suit. Houston is estimating that the descent water supply will run out at 186:40 plus or minus one hour. Gene and Jack will switch to ascent water, if necessary, prior to liftoff. In fact, they will make the switch to ascent water at the normal time of 187:43.]

185:17:16 Schmitt: Okay, Houston. This is the LMP, suited. How do you read biomed and voice?

185:17:21 Fullerton: We're copying your ticker (that is, his heart beat) loud and clear. Also your voice.

185:17:30 Schmitt: Okay.

[Comm Break]

185:18:38 Cernan: Gordy, Gene. I'm going off the air.
185:18:42 Fullerton: Okay, Geno.

[Very Long Comm Break while they get Gene suited. Once they get done, they will report their PRD (Personal Radiation Dosimeter) readings. This activity is near the top of the righthand column of Surface 7-12 and was scheduled for 184:59. They are now only about 32 minutes behind schedule.]

185:31:33 Cernan: Okay, Gordo. This is CDR. You ought to have me all back up on the comm and biomed now. (Pause)
185:31:42 Fullerton: Okay, Geno. Looking good. (Long Pause)
185:32:06 Cernan: CDR's PRD is 17045.
185:32:14 Fullerton: Okay; got that. (Pause)
185:32:27 Schmitt: LMP is 24150.
185:32:32 Fullerton: Okay.

[Long Comm Break as they get all of the gear they will need for the jettison within reach and everything else out of the way. Their next call was scheduled for 185:07. They are still just a bit over a half hour behind schedule.]

185:42:16 Cernan: Okay, Gordo. We're ready to don the helmets and gloves.
185:42:20 Fullerton: Okay. (Long Pause)
185:43:00 Cernan: Okay, Gordo. We're going to press on, but don't let us miss 185:58 for the VHF check (with Ron Evans), will you?
185:43:07 Fullerton: Sure won't. We're watching them.
185:43:12 Cernan: Okay.

[Comm Break]

185:46:02 Fullerton: Challenger, Houston. We're getting close to the bottom on descent water. We're expecting to have to switch to ascent water sometime in the next hour. We'll give you a call.
185:46:17 Cernan: Okay, Gordy. (Long Pause)

[They switch to voice-activated comm and we pick them up in the middle of a conversation.]

185:47:13 Schmitt: Okay. (Long pause)
185:47:29 Schmitt: I cleaned them up for you. What more could you ask?
185:47:35 Cernan: (To Fullerton) Hey, Houston. We're VOX now.
185:47:40 Fullerton: Okay; and loud and clear on VOX.
185:47:41 Cernan: Is the recorder on, Jack?

185:47:43 Schmitt: Well, the (LM data) recorder's on, but I don't think it's going to work. (Chuckles)
 185:47:47 Cernan: See if I've got anymore juice in here (in the suit drink dispenser).
 185:47:52 Schmitt: I owe Don Arabian something. (Long Pause)

[Schmitt - "I think the original LM data recorder was to record engineering data that they didn't put on the telemetry. And then, for having screwed that up (by not turning the recorder off before going outside for EVA 3), I said I owed Don something. He sort of honchoed the third or fourth tier of industrial people that were watching over the missions. And it would be the kind of data they were interested in."]

185:48:34 Schmitt: Wristlet covers. Don wristlet covers. (Long Pause)
 185:49:39 Schmitt: Okay; my right glove is on and locked. Verified. (Long Pause)
 185:49:54 Cernan: Oh, I just came to the end of my grease. Probably a good time, because if everything goes the way it's supposed to, I shouldn't put on these EV gloves anymore.
 185:50:04 Schmitt: Don't you use that in your IV (gloves)?
 185:50:05 Cernan: No, I don't need it with my IV. (Long Pause)

[At this point in the review, we realized that Gene's grease is hand cream, not lubricant for the wrist rings.]

[Schmitt - "Gene decided he liked that better, and I decided I liked the nylon liners. Neither one of them kept us from getting abraded and bruised."]

185:50:30 Cernan: Mine are all on and verified. Locked. Back in Suit Flow. (Pause) Okay, we got 8 minutes to the comm check, so let's press on. (Pause) Hate to get in the middle of the integrity check...Oh, we can do it. This won't take long. Let me know when you (garbled) with your glove.
 185:51:05 Schmitt: I will.
 185:51:06 Cernan: Okay.
 185:51:08 Schmitt: Certainly sluggish today. (Pause)
 185:51:17 Cernan: Turn that off?
 185:51:19 Schmitt: Well, I did once, Gene, and I...Didn't help, and I started to run out of air. There.

[The times of the following transmissions are lost under the Public Affairs Commentator.]

Cernan: Doublecheck. You sure they're locked?
 Schmitt: Yes, they're locked.
 Cernan: Okay.
 Schmitt: Okay. Gloves are Go.

[They will now begin the Pressure Integrity Check, which is on Surface 7-13. they have actually lost a little time in getting the gloves on and are 38 minutes behind schedule.]

185:51:43 Cernan: Okay; stay facing that way. Pressure integrity check. "Suit shall not be maintained at elevated pressure greater than 5 minutes." Okay; Suit Gas Diverter, Pull to Egress. Verify.

185:51:52 Schmitt: Okay; that's verified.

[For the jettison operation, they will pressurize the suits by setting pressure Regulator B in the Direct O2 mode. In Direct O2, they added oxygen at a slow, but unregulated, rate. The five minute limit may have to do with Houston's ability to detect out-of-range leaks in this ECS configuration.]

185:51:53 Cernan: Cabin Gas Return (valve), Egress. Verify.

185:51:55 Schmitt: Egress, verified.

185:51:56 Cernan: Suit Circuit Relief, Close.

185:51:58 Schmitt: Going Closed.

185:52:00 Cernan: Okay; we will leave Pressure Reg A, Close.

185:52:03 Schmitt: Yes, sir.

185:52:05 Cernan: Pressure Reg B, Direct O2, and we'll go up to 3.7 or 4.0 on the cuff gauge, and then you want to go to Egress on it.

185:52:12 Schmitt: Okay.

185:52:15 Cernan: Okay; you can go on up.

185:52:17 Schmitt: I'm in Direct O2. (Long Pause)

185:52:32 Cernan: Okay; the suit circuit's coming up.

(Long Pause) Okay; suit circuit's about (3.)72 now. (Cuff pressure gage) should be coming off the peg shortly.

185:53:03 Schmitt: I'm off the peg.

185:53:04 Cernan: And I'm off the peg. (Pause) You can stop it on your cuff gage...

185:53:08 Schmitt: Yes, I will.

185:53:09 Cernan: ...at 3.7. (Pause)

185:53:20 Schmitt: That's 3.0 (pause), 3.5 (pause), 3.7.

185:53:29 Cernan: Okay; go to Egress.

185:53:31 Schmitt: I'm in Egress.

185:53:32 Cernan: Okay. Mark it.

185:53:35 Schmitt: Okay. 3.75.

185:53:38 Cernan: And CDR was 3.75. (Pause) Gots (sic) about 4 minutes for VHF. (Pause) My suit's going to be good.

185:54:12 Schmitt: That's the whole circuit.

185:54:14 Cernan: Yeah, I know.

185:54:15 Schmitt: It's about the same. (Pause)

185:54:23 Cernan: Got about 10 seconds to go. (Pause)

Okay. Mark it. CDR dropped from 3.75 to 3.60. (Pause)

185:54:42 Schmitt: Okay?

185:54:44 Cernan: Okay; "Suit Circuit Relief, Auto."

185:54:47 Schmitt: Hold your ears. (Pause) Auto.
 185:54:52 Cernan: "Suit circuit pressure decays to 4.8."
 Coming down. (Pause) Okay. Jack. The next thing is
 depress, but before we do that, I think we ought to get this
 VHF check. It's only about 3 minutes away.
 185:55:11 Schmitt: Let's do it. (Pause) I got a scratch on
 my helmet!
 185:55:16 Cernan: Okay, Gordo. We're going to configure
 for the VHF here. Standing by for a call from the CMP.
 185:55:23 Fullerton: Okay; sounds like a good idea.

[The steps for the VHF comm check are in the box at the
 lower left on Surface 7-15.]

185:55:28 Cernan: And we'll press on after that. Jack, you
 better make sure your volume's up.
 185:55:34 Schmitt: You're Receive B, huh?
 185:55:35 Cernan: We're A, Off and Receive, B on the Audio.
 185:55:40 Schmitt: Hey, what do we do once we hear him?
 185:55:42 Cernan: Okay; when you hear him...
 185:55:43 Schmitt: Go to...
 185:55:44 Cernan: Probably answer him is the first thing.
 And then VHF...
 185:55:46 Schmitt: ...A to T/R.
 185:55:47 Cernan: No. Then you want...
 185:55:48 Schmitt: A to T/R, yeah.
 185:55:49 Cernan: You want A, Transmitter, Voice/Range,
 then A to T/R, and A Transmitter, Off...after conversation.
 185:56:00 Schmitt: Okay.

[Evans will do doppler ranging using the voice carrier.]

185:56:05 Cernan: So as soon as you hear him, you want the
 VHF A Transmitter to Voice/Range.
 185:56:08 Schmitt: Yeah, I'll do that. (Pause) He's going
 to try to lock up on us I guess, huh? (Pause) They've got
 us VHF Ranging, so we'll have to be quiet once we get
 established. (Pause)
 185:56:43 Cernan: It's like home in these suits.
 185:56:48 Schmitt: Yep. (Long Pause)
 185:57:36 Fullerton: Challenger, about 30 seconds to the
 comm check.
 185:57:42 Cernan: Okay. Thank you, Houston. (Long Pause)
 185:58:20 Schmitt: (Hearing Evans VHF carrier as he comes
 over their horizon) There he is.
 185:58:21 Cernan: Yeah. (Pause) Talking in VOX. (Pause)
 185:58:31 Schmitt: Okay; I'm going to go Voice/Ranging, I
 guess.
 185:58:33 Cernan: Wait...No, wait until he gives us the
 call.
 185:58:34 Schmitt: Okay. (Pause)
 CapCom: Ron, will you please give your LM guys a call
 there, please. They're calling you.

Evans: Oh, okay. Hey, Challenger. This is Sea Monster. How do you read? (Laughing) This is America, really.

185:58:39 Schmitt: Hey, Houston; we're reading CMP on VOX.

185:58:44 Fullerton: Roger.

185:58:46 Cernan: Hey, Captain America, this is Challenger. You're loud and clear. (To Jack) Go to T/R.

185:58:54 Schmitt: Okay, Ron. You're loud and clear. How do you read us?

Evans: Hey, read you loud and clear.

Schmitt: Okay; you were very good on B on T/R. (On A) you're in the mud a little bit.

185:59:09 Evans: Okay. I'm just transmitting duplex Bravo.

185:59:11 Schmitt: Oh, okay. That's better. You must have turned away from your mike. How are you doing?

185:59:15 Evans: Okay. I'm doing great. Standing by now for you and going to do a little landmark tracking when I go over this time.

185:59:23 Schmitt: Okay.

[This is Evans' last pass over the landing site prior to lift-off. Landmark tracking will allow Houston to check the CSM orbit.]

185:59:24 Cernan: Okay. Are you in Voice/Range, Jack?

185:59:25 Schmitt: Yes, I am.

185:59:28 Cernan: Ron, are you going to do any ranging at all?

185:59:32 Evans: Negative on the ranging.

185:59:34 Cernan: Okay. Gee, you're loud and clear. How's America looking to you?

185:59:39 Evans: Hey, outstanding! I'll tell you. It's a beautiful bird.

185:59:43 Cernan: Yeah, we got a beautiful bird down here. We'll see you up there shortly.

185:59:49 Evans: Okay, you're kind of fading out a little bit.

185:59:52 Cernan: Hang in there and keep your (docking) probe extended!

185:59:57 Evans: Okay.

186:00:00 Cernan: Okay; we're going to go VHF, Off.

186:00:03 Evans: Okay. We'll see you just prior to liftoff, then.

186:00:08 Cernan: Okay. Jack, VHF A Transmitter, Off.

186:00:12 Schmitt: A is Off.

186:00:13 Cernan: That's all you need to do. Outstanding!

186:00:16 Fullerton: Okay, Challenger,...

186:00:16 Cernan: (Garbled).

186:00:17 Fullerton: ...you have a Go from us for depress.

[They go back to Surface 7-13, to the top of the righthand column.]

186:00:24 Cernan: Okay; stand by one. (Pause) (To Jack) I doubt it. You might be able to (see the CSM as it goes overhead). It's awful glary though. He'll be well sunlit up there. (Pause) I doubt it.

186:00:40 Cernan: Okay; we have a Go for depress, Jack. On 16 ECS, Cabin Repress (circuit breaker), Open.

186:00:45 Schmitt: Cabin Repress coming Open. Open.

186:00:48 Cernan: Why don't you watch your gage, and I'm going to...

186:00:51 Evans: (Faintly) I guess I can turn my VHF off if their's is off.

186:00:54 Cernan: Okay. I'm going to open the forward dump to Auto to 3.5.

186:01:00 Schmitt: Okay; I'll watch.

186:01:03 Cernan: (Garbled) call. Okay, coming down.

186:01:11 Schmitt: Okay; that's 5; 4.5; 4. Stand by. Mark. 3.5.

186:01:24 Cernan: Okay. "Verify suit circuit lockup at (greater than) 4.3 and decaying."

186:01:30 Schmitt: Okay; it's 4.5. Stand by for the decay. (Pause)

186:01:39 Cernan: Oh, man, I got to go get that Water Sep(arator) Select.

186:01:42 Schmitt: Pull the 2, huh?

[They are on page 7-13 of the Surface Checklist. The instruction to switch to Water Separator 2 is a late addition.]

186:01:45 Cernan: Oh, boy.

186:01:45 Schmitt: Want me to get it?

186:01:46 Cernan: No. I got longer arms, I guess.

186:01:52 Schmitt: I can reach back in there.

186:01:53 Cernan: Okay. If you can get back there.

186:01:55 Schmitt: I think. (Pause) Now, they want it?

186:02:01 Cernan: Yeah, now. Pull the 2.

186:02:04 Schmitt: Okay. Pull the 2. Okay.

186:02:07 Cernan: Happy with the suit circuit?

186:02:09 Schmitt: And, yeah, we got a decay in the suit loop.

186:02:12 Cernan: Okay. (Pause) Okay; verify suit circuit lock's up. I'm dumping all the way.

186:02:20 Schmitt: Okay. (Long Pause) (Suit) circuit's 4.2. (Long Pause)

186:03:05 Schmitt: Okay, you're at 0.7 in the cabin and 4.1 in the suits. (Long Pause)

186:03:34 Schmitt: About 4.0, and the cabin is 0.3. (Long Pause)

186:03:51 Cernan: Okay; let me see if I can jar it (the hatch).

186:03:55 Schmitt: Okay; I guess we're Go for EVA-4.

186:03:59 Cernan: Five, isn't it?

186:04:00 Schmitt: Five this time?

[EVA 4 was the PLSS jettison prior to the last rest period.]

186:04:02 Cernan: Oh, man, I got it open. If I could bleed that pressure. Oh, boy! Let me hold it here for a minute. (Breathing heavily, but chuckling) There's a lot of psi on that hatch. (Pause) Okay; that'll hack it. Let me go to Auto here.

[Cernan - "You get the pressure in the cabin low enough that you can get the hatch open; but there's still a tremendous force on it and I had to hold it open to get it all the way down."]

186:04:21 Schmitt: Save our (surface) checklist (from blowing out the hatch). (Pause) Make it...Oops, that's closed.

186:04:30 Cernan: That's Auto, and the lock/lock is on. (Pause) Okay. (Pause) Hatch is open all the way. Where are we?

186:04:49 Schmitt: Why is that still waving in the breeze? Don't understand that.

186:04:57 Cernan: There's a solar wind in here. We're on (page) 7-dash-something here.

[They are still on Surface 7-13.]

186:05:07 Schmitt: Not still venting, are we? Houston, how's our cabin configuration? Seem's to still be a little breeze going out the hatch.

186:05:24 Fullerton: All the numbers look good here, Jack.

[Schmitt - There were all kinds of nooks and crannies in the LM, now. Not just the ordinary nooks and crannies, but we had bags that had gotten pressurized and, so, everything was venting. It didn't happen instantaneously. I don't remember thinking about that at the time, but that's probably what it was. There were just lots of sources of oxygen."]

186:05:29 Cernan: Okay, hold that (hatch), Jack.

186:05:31 Schmitt: Okay.

186:05:34 Cernan: Okay. Ready?

186:05:33 Schmitt: Okay. (Pause) Partially open; that's good. (Garbled) "Forward hatch...jettison the jett bag!"

186:05:41 Cernan: Here goes Santa Claus...

186:05:43 Schmitt: Here you go, Santa Claus.

186:05:44 Cernan: ...Santa Claus' bag.

186:05:45 Schmitt: Another bag of goodies. (Pause) Give it the old... There you go.

186:05:50 Cernan: 3-point kick (a reference to a 'field goal' in American football)..

186:05:52 Schmitt: Nice. Beautifully done!

[Cernan - "A lot of things we would just set down in front of the hatch and - pop - just kick them out. It was easy enough to do that. Kick them far enough to clear the porch."]

186:05:54 Cernan: Just where we wanted it. All clear of the ascent stage. (Pause) Need the...
 186:06:08 Schmitt: Okay; clear. (Pause) Good boy! Now, for your next act. Watch it. (Pause) No.
 186:06:21 Cernan: No. No. Never mind.
 186:06:22 Schmitt: Don't even think about it.

[We have no idea what is going on here. One possibility is that Gene has started to turn around, pretending that he is going to get out for an EVA or to get the clean gloves.]

186:06:23 Cernan: (Laughing) Okay. (Laughs)
 186:06:24 Schmitt: (Laughing) Okay?
 186:06:26 Cernan: "Jettison bag. All items are clear of ascent stage." Ready to close hatch?
 186:06:29 Schmitt: Looks like it.
 186:06:30 Cernan: Short EVA-5.
 186:06:34 Schmitt: (To Houston, joking) Are we Stay/No Stay for hatch closure?
 186:06:39 Fullerton: You have a Go for closing the hatch.
 186:06:44 Schmitt: (Laughing) Okay. (Pause)
 186:06:50 Cernan: Okay. The hatch is closed. Boy, is it easy to get around in here without a PLSS on.

[They now turn to Surface 7-14.]

186:06:58 Schmitt: Okay; your Dump Valve verified in Auto?
 186:07:03 Cernan: Yes, sir, and locked.
 186:07:04 Schmitt: Okay. (Pause) Cabin Repress. Okay.
 186:07:08 Cernan: Okay. Verify it's Auto?
 186:07:10 Schmitt: It's Auto.
 186:07:12 Cernan: Okay; on (circuit breaker panel) 16, Cabin Repress, Closed?
 186:07:15 Schmitt: Okay; Cabin Repress going Closed.
 186:07:16 Cernan: And the hatch looked clear when I sealed it. Clear when I closed the hatch.
 186:07:20 Schmitt: Okay. Closed.
 186:07:21 Cernan: There's the Master Alarm. (Pause) And the cabin is coming up. (Pause)
 186:07:33 Schmitt: Lots of 02.
 186:07:35 Cernan: (Sound of repress begins) Okay; cabin is increasing, and you can go to Cabin on Pressure Reg B (Pause)
 186:07:42 Schmitt: It's in Cabin.
 186:07:44 Cernan: Okay. Cabin warning light will go off here shortly. (Pause) And my suit's coming down.
 186:07:55 Schmitt: Mine, also. (Pause) Okay. We're just about to go through 50 percent, Descent 02 (remaining).

(Pause) We're there. (Pause) Okay. Cabin's almost at regulating pressure.
 186:08:34 Cernan: And Cabin light's still on. Next thing we'll do when it stabilizes, we'll doff our gloves, doff our helmets...
 186:08:41 Schmitt: Locked up.
 186:08:42 Cernan: Okay
 186:08:43 Schmitt: 5.0.
 186:08:44 Cernan: Okay. You can doff your gloves. (Pause)
 186:08:51 Schmitt: Let me watch that pressure a minute.
 (Pause) Well, it looks like it's stable at five. Okay.
 (Pause) How's the cabin look, Houston? Looks good here.
 186:09:14 Fullerton: Okay; it looks good here.

[Public Affairs reports a 60 second EVA from hatch open to hatch close. By the normal definition of 3.5 psi to 3.5 psi, this was a six-minute EVA.]

186:09:21 Cernan: Okay. (Lost under the PAO commentator).
 186:09:25 Schmitt: I hope so. Physics says it should have been.
 186:09:28 Cernan: There's an experiment. (Pause) Not really, since we do that with our PLSS and everything else.
 (Pause) Okay. Take your helmet off. (Pause) Boy, that was painless enough. (Pause) Jack, I'd wrap that thing around it like (garbled).
 186:09:58 Schmitt: Wait a minute. (Garbled) take our helmets (garbled).
 186:10:02 Cernan: Not yet. We (garbled) obviously. Stow them on the engine cover. Okay.

[Comm Break. After doffing the helmets and gloves, they will stow the LEVA's and EVA gloves and, in general, get things out of the way in preparation for launch.]

186:13:40 Fullerton: Challenger, Houston. Just a reminder. Before you stow the right-hand (that is, Jack's) OPS on the floor, you need to attach the floor hole cover.
 186:13:54 Cernan: Okay; we're...Jack's down there cleaning up the floor now, and I'm working on the visors.
 186:14:00 Fullerton: Okay.

[Cernan - "We had some indentations in the floor to hook (the tethers) onto, so there must have been some adapter we had to put in."]

[Long Comm Break]

186:18:53 Fullerton: Challenger, Houston. We have a copy of an update on the rock stowage that was given to you last night. We're not sure if they read one part of it to you, and that was concerning using some contingency webbing to reinforce the tiedown of the bag that goes on the Z-27 (aft)

bulkhead. If you did get that update, forget it. We do not need any extra tiedown other than the normal tiedown. Over.
 186:19:25 Cernan: Okay, Gordy. That's for the Buddy SLSS bag, I guess, and we did not get it (the update). But we haven't quite stowed that yet anyway, so we will forget it.
 186:19:34 Fullerton: Okay. (Pause)
 186:19:39 Cernan: Are the Rover batteries still alive?
 186:19:45 Fullerton: I'll check with the back room, here. Stand by.

[Very Long Comm Break. After tidying up the cabin, they will copy data for the ascent, as per the last three lines on Surface 7-15. Fullerton gave them updates to the checklist concerning this and other sections at 183:42:26.]

186:40:58 Fullerton: Challenger, Houston. I'm standing by with a pad any time you're ready.
 186:41:05 Schmitt: Okay, Gordy. I'll be ready in just a minute.

[Long Comm Break]

186:45:04 Schmitt: Okay, Gordy; go with the ascent pad.
 186:45:09 Fullerton: Okay, Jack. This is the direct ascent pad. Tig (Ignition Time) is 188:01:35.93; Noun 76 is 55408, 0032.0, minus 0005; DEDA 047 is plus 37430, minus 72507, plus 58669; plus 56907, plus 0032.0, plus 05359; and TPI time is 188:55:5700. LM weight 10900 (pounds); and HA is 629; HP 622. One remark; your Tig for one rev late is 190:00:18. Go ahead (with the readback). (Pause)
 186:47:00 Schmitt: Okay, Gordy, here's your readback. Direct rendezvous is 188:01:35.93; 55408, 00320, minus 0005, plus 37430 minus 72507, 58669, 56907, 00320, 05359; 188:55:5700; 10900; 629; 622. Remark: one rev late Tig is 190:00:18. Over.
 186:47:56 Fullerton: Okay, that was a good readback. Now I have a co-elliptic ascent pad. Tig is 188:04:14.00; 55390, 00380, minus 0005; plus 37430; minus 72507; 58630; 56907; 00380. Rest of the pad down to LM weight is NA. (NA = not applicable) Your LM weight is 10900, and the HA and HP are NA. Over. (Pause)
 186:49:16 Schmitt: Okay, Gordy, co-elliptic readback: 188:04:14.00; 55390, 00380, minus 0005; plus 37430; minus 72507; 58630; 56907; 00380; rest of pad is NA except for LM weight, 10900. Over.

[Schmitt - "These were all contingency pads and there was only a limited amount of information that could be stored in the computer."]

186:49:57 Fullerton: Okay, that's a good readback. Turn to page 10 (of the LM DATA Book); I have the CSI pad, co-elliptic.

186:50:11 Cernan: And, Gordy, I'm starting to pick up the breakers on panel 11.

186:50:15 Fullerton: Okay, Geno. (Pause)

[The circuit breaker configuration is shown of Surface 8-2. Gene has probably verified the switches listed on 8-1.]

186:50:25 Schmitt: Okay, Gordy, CSI on page 10.

186:50:29 Fullerton: Okay. Tig is 189:01:53.81. Tig at TPI is 190:55:00.00. Noun 81 is 0539; and Delta-VY is a plus all balls (that is, all zeros). 373; 05419, 06550; plus 0539; plus all balls; and plus 0012.

186:51:27 Schmitt: Okay. CSI pad: 189:01:53.81; 190:55 all zeros; plus 0539; plus all zeros; 05419; 06550; plus 0539; plus all zeros; plus 0012. Over.

186:51:55 Fullerton: Okay. That's a good readback. That's all I have for you.

186:52:01 Schmitt: Okay.

[Comm Break. During this break, Houston has LOS with Evans on his 50th orbit. Gene finishes his circuit breaker check on Surface 8-2 and Jack does his on Surface 8-3.]

186:54:36 Cernan: Okay, Gordo, we're on the top of (page) 8-4.

186:54:38 Fullerton: Roger, Geno.

[Comm Break. They have just finished a check of their circuit breaker configuration. And are about to perform a radar "self" test.]

186:55:55 Cernan: Okay, Gordo. The rendezvous radar looks a little warm. I'm reading about 90 degrees.

186:56:01 Fullerton: Okay 90. (Pause)

186:56:14 Schmitt: Okay, Gordy, are you ready for AGS Status to Operate?

186:56:19 Fullerton: Let me check. (Pause) We're ready, Jack; go ahead.

[Comm Break. Jack is at the top of the righthand column of Surface 8-4.]

186:58:32 Cernan: Okay, Gordo. Noun 72, R2 is not varying. I've got both shaft and trunnion and crosspointers varying.

186:58:43 Fullerton: Okay, Geno. We copy that. (Long Pause)

186:59:26 Cernan: Okay, Gordy. On the radar test, everything is Go. Everything is within limits. The only anomaly is the one I just reported.

186:59:33 Fullerton: Okay, Geno. In 20 seconds here, on the hour even, we'll have a site handover to Goldstone (from Madrid).

186:59:44 Cernan: Okay.

[Long Comm Break. Note that this site handover comes about an hour before launch, rather than at launch as Jack suggested in his comment at 121:30:03. See the discussion at 188:01:39.]

187:04:12 Fullerton: Geno, Houston. You can go ahead and park the radar at 0 and 30.

187:04:19 Cernan: Yeah. It's going there right now, as a matter of fact.

187:04:23 Fullerton: Okay.

[Comm Break]

187:06:14 Schmitt: Okay, Houston. The AGS gyro calibration is complete and looks pretty good. I guess Z's a little...No, that...Yeah, Z's a little more than you'd expect, I guess.

187:06:30 Fullerton: Okay, Jack. (Long Pause)

[This step is at the bottom of the righthand column of 8-4.]

187:06:58 Fullerton: Challenger, Houston. Words on the radar. When you parked it there, we saw it go to the proper places. From all our indications, the interface between the radar and the PGNS is okay. And our best guess is some kind of self-test problem.

187:07:19 Cernan: Okay, Gordy. Thank you. (Long Pause)

187:08:01 Schmitt: Rate gyros are good.

187:08:05 Fullerton: Roger.

[Comm Break. They have now finished the items on Surface 8-5.]

187:09:24 Schmitt: Okay, Gordy. I'm going to go to Auto (tracking) on the S-BAND (the high-gain antenna), if you want it. (Pause)

187:09:40 Fullerton: Okay. We're Go. And go ahead with the check. (Pause)

187:09:49 Cernan: Okay, Gordy. I'll give you a call before I fire, but we're in the process of getting ready for the RCS.

(This will be a "hot" test firing of the Reaction Control System, the small steering rockets on the LM.)

187:09:56 Fullerton: Roger. (Long Pause)

187:10:20 Cernan: Okay, Gordo. Here we go.

[Comm Break]

187:11:39 Cernan: Gordy, the AGS check looked good.

187:11:42 Fullerton: Roger. (Pause) It looked good here also. (Pause)

187:11:57 Schmitt: Okay; System A, Quad 4 talkback still sticky.

187:12:01 Fullerton: Roger, Jack.

[Comm Break. The test using PGNS, which comes up next, is near the bottom of Surface 8-6.]

187:13:05 Cernan: Okay. Here we go on the PGNS, Gordy.

187:13:07 Fullerton: Okay, Geno. (Long Pause)

187:13:47 Cernan: Looked good here, Gordy. (Pause)

187:13:52 Schmitt: And, you've got Data and P00.

[Jack has now configured the computer to accept uplinked data from Houston. They are on 8-7, just above the line of asterisks.]

187:13:57 Fullerton: Okay. Your up-links are coming. We'll give you a vector and zero the pos/neg cells. Your RLS is okay.

[Comm Break]

187:16:00 Fullerton: Challenger, Houston. We'd like you to put the Ascent Batteries, On, according to the procedures on the next page, 8-8, just a little early because of pre-conditioning noticed before descent. And we checked your RGA's during the hot fire, and your hot fire itself, and they both looked good.

187:16:23 Cernan: Thank you, Gordo.

187:16:28 Fullerton: And, Challenger, it's your computer now.

187:16:31 Schmitt: Thank you.

[Long Comm Break. Next, they will recheck the platform alignment as per the procedures on 8-7 and 8-8.]

187:19:57 Cernan: Gordo, did you ever get any word on the Rover batteries?

187:20:04 Fullerton: No. I sure haven't. I haven't heard on that one.

187:20:10 Cernan: It's not important. I just wondered whether those things were going to be working back there (to give TV of liftoff).

187:20:15 Fullerton: Okay. We've got no reason to believe they won't. When you get down to parking the rendezvous radar antenna after this P57 (platform alignment program), give me a call. We're going to change the parking position.

187:20:30 Cernan: Okay. (Pause) Why don't you just give me the numbers now?

187:20:43 Fullerton: Okay. Do as the checklist shows (bottom left on 8-8), except do a Verb 41 Noun 72 to 0 and 30 degrees. Go to Slew, and then delete the "manual slew for 3 seconds." They want to leave it there for temperature

purposes. This will be a cooler position for it during ascent.

187:21:08 Cernan: Okay. Understand. That's 0 and 03000.

187:21:14 Fullerton: That's affirmative. (Pause)

187:21:21 Cernan: And the first 01...(correcting himself) first (Noun) 04 was 0.01.

187:21:27 Fullerton: Roger. We got that.

[This is a gravity check of the platform alignment, as indicted at the top of Surface 8-8.]

[Comm Break. TV on. Fendell plays with tracking he will use to follow the launch.]

187:24:28 Fullerton: Challenger, Houston. We've got you on television now. We have a good picture.

187:24:38 Cernan: Glad to see old Rover's still working.

[Comm Break]

187:28:59 Fullerton: Okay. We got your Noun 5. (Long Pause) Go ahead and torque them.

[Comm Break. They have just done an alignment check using the bright star Vega. Gene's next transmission indicates that they are on Surface 8-9.]

187:33:14 Cernan: Okay, Houston. P12 looks good, and the PGNS is in Auto.

187:33:19 Fullerton: Okay, Challenger. There's no change to 047 and 053. I do have a K-factor for you. (Pause)

187:33:34 Schmitt: Go ahead.

187:33:35 Fullerton: Okay. It's 179:59:59.82. Over.

187:33:51 Schmitt: Okay; 179:59:59.82.

187:33:56 Fullerton: That's right, Jack.

[Comm Break. Next they will perform a check of switch positions, as detailed on Surface 8-10 and 8-11.]

187:35:25 Fullerton: Challenger, Houston. I have a couple of PIPA bias updates for the PGNS. (Pause)

187:35:39 Cernan: Okay. Go ahead.

187:35:41 Fullerton: Okay, with a Verb 21 Noun 01, load address 1452 with 03045, and load address 1454 with 05246. Over.

187:36:06 Cernan: Okay. That's 1452 with 03045; and 1454, 05246.

187:36:13 Fullerton: Readback's good. (Long Pause)

187:37:02 Cernan: Okay. They're in, Houston.

187:37:03 Fullerton: Okay. Look good to us. (Long Pause)

[Evans is just re-emerging from his lunar farside pass. A single comm channel will be used for both spacecraft through launch.]

187:38:09 Evans: Hey, Houston; America.
 187:38:15 Fullerton: Roger, America. This is Houston.
 You're loud and clear.
 187:38:21 Evans: Okay, Gordo. Got my suit on.
 187:38:25 Fullerton: Okay, Ron. We gave you the wrong
 skinny (slang for "information") on the comm configuration
 last rev. We're actually, now, in a full MSFN relay mode.
 We'd like you to stay off of VOX. Over.
 187:38:44 Evans: Can do. I'm off VOX. (Long Pause)
 187:39:18 Fullerton: Challenger, Houston. When you get
 to a break point, I have some words on what you can expect in
 the way of guidance steering. Over.
 187:39:27 Cernan: Stand by. (Long Pause)
 187:40:05 Cernan: Okay, Gordy. You can go ahead and talk
 while we're putting our helmets and gloves on.

[Gene and Jack are now at the top of 8-12.]

187:40:10 Fullerton: Okay. We never got around to
 debriefing you on PDI, but the out-of-plane indications you
 saw on the AGS during descent were proper (that is, correct).
 We had changed your vector slightly just prior to PDI, so the
 AGS was navigating and indicating properly. We just ran the
 present ascent targets in the LMS (Lunar Module Simulator)
 with the half-a-mile crossrange as shown on the pad, and
 you're going to be steering south. That's the way the
 steering direction goes. (Partly joking) That's to your
 left, for Geno's benefit. And the crosspointer indicated a
 maximum of about 13 feet-per-second out-of-plane velocity at
 about ignition plus 3 minutes and 50 seconds, and then came
 on back to zero. Over. That velocity was AGS velocity.

[Schmitt - "The AGS used what they called strapdown
 gyros. It integrated accelerations from those gyros to give
 three-axis velocities. It carried its own state vector, but
 much less precisely."]

187:41:15 Cernan: Okay, Gordo. That's good information to
 have. (Pause to listen to Fullerton's last sentence)
 Understand the AGS on that one. Okay.

[Comm Break]

187:42:43 Evans: Okay, Houston. America maneuvering to
 attitude.
 187:42:45 Fullerton: Roger, America. (Long pause)
 187:43:00 Evans: Also, I'll start pumping up the cabin,
 Direct 02.
 187:43:02 Fullerton: Okay.

[Cernan - "I think he pumped the cabin up because he had
 to use oxygen out of the Command Module to pressurize the

tunnel, so he wanted to build up the pressure so that he could vent it into the tunnel once we were docked."]

187:43:05 Schmitt: Ascent Water is Open, Houston.

187:43:07 Fullerton: Roger.

[Comm Break. This is the normal switch-over time. Jack's call indicates that they now have their helmets and gloves on.]

187:44:24 Cernan: Okay, Houston. We're at lift-off minus 17 minutes, and Verb 47 ' going over.

187:44:29 Fullerton: Roger, Challenger.

[Comm Break. They have reached the bottom of Surface 8-12.]

187:45:45 Fullerton: America, we see your cabin at 5.5.

187:45:52 Evans: Okay, thank you. (Pause) Direct 02's Closed.

187:46:10 Cernan: Houston, the Descent Batts are coming Off.

187:46:13 Fullerton: Roger. (Pause) America, it looks like, to us here, your maneuver's stopped. Maybe you hit the stick.

187:46:33 Evans: You roll around in this suit, you knock the thing off of lock. (Long Pause)

187:46:56 Fullerton: Challenger, we're recommending PGNS direct rendezvous.

187:47:02 Cernan: Roger, Gordo; understand. PGNS direct rendezvous for Challenger. (Long Pause; static)

187:47:58 Fullerton: America; OMNI Delta, please. (Long Pause: static disappears after 30 seconds) America, this is Houston; voice check.

187:48:43 Cernan: Okay, hold... (Hears Fullerton; Long Pause)

[As Gene's next transmission indicates, they have finished with the tasks on Surface 8-13 and have performed the pr-launch circuit breaker reconfigurations on Surface 8-14 and 8-15.]

187:49:02 Cernan: Hello, Houston; Challenger. Circuit breakers are configured. We're on the top of 8-16.

187:49:09 Fullerton: Challenger, Houston. Okay; sounds good. (Pause)

187:49:17 Cernan: And we're standing by for lift-off minus 10.

187:49:20 Fullerton: Roger. (Long Pause)

187:49:35 Cernan: And, Houston, are you in relay now?

187:49:39 Fullerton: We lost high gain on America, so we inhibited the down-link. We're not in relay, no.

187:49:50 Cernan: Okay.

187:49:52 Fullerton: We're actually in a one-way relay. Ron should be able to hear you, but not vice versa.

[Comm Break; Jack is not on VOX, so we only hear Gene's half of the following conversation.]

187:51:01 Cernan: Okay, Houston; coming up on 10 minutes. And we're ready to pressurize the APS (Ascent Propulsion System).

187:51:05 Fullerton: Okay; you're Go to pressurize the APS (Ascent Propulsion System).

[In the following procedures, they are firing small explosive charges which open the valves on the helium tanks which, then, provide pressure to the propellant tanks. Readers may want to note the Emergency Launch procedures listed in the box at the right side of Surface 8-16. If the crew had found a leak in either of the tanks in the Ascent Stage, they could have launched almost immediately to take advantage of as much of the propellant as possible.]

187:51:13 Cernan: Okay. The Master Arm is coming On. I've got two good lights. (Pause) Tank 1 is selected. Okay, Ascent Helium Press(urize) Tank 1, Fire. Ready; 3, 2, 1. Mark it. We got a squib fired, Houston.

[That is, they could feel the vibrations caused by detonation of the charge.]

187:51:35 Fullerton: Roger. (Long Pause) Challenger, you're Go for Tank 2.

187:51:56 Cernan: Okay, understand; Go for Tank 2. (To Jack) Ready? Okay. 3, 2, 1. Mark it. Tank 2. We got the squib. (Pause)

187:52:21 Fullerton: Okay, Challenger. Both tanks look good.

187:52:22 Cernan: Wonder why they didn't balance off?

[Schmitt - "On our gauges, the pressures for the two tanks were different, and they should have been the same. Down below (187:54:07), Gordo will tell us that they think there's a transducer problem.]

187:52:24 Cernan: Okay. Master Arm is coming Off, and the lights are out. (Pause) Okay, Jack. System A, Ascent Feed 2, Open. (Pause) Okay, monitor your...Okay. System A Main SOV (Shut Off Valve) Closed.

[For the first part of the ascent, they will use Ascent Fuel for the RCS (Reaction Control System, the small steering jets) and save the RCS Fuel supply for final maneuvers - hence the closure of the shut-off valves. See Gene's comment at 187:56:26.]

187:52:51 Cernan: How does it look to you? Okay; B Ascent Feed 2, Open. (Pause) I can feel them (the valve charges) in the floor when they go. Okay; and B Main SOV, Closed. Check your manifold pressures. Are you happy? (Pause) Okay, Houston. We got Ascent Feed.

[They are now at the bottom of Surface 8-16 and are waiting for permission to launch. Details of the launch are given in the LM Timeline Book, which is not reproduced here. See Surface 8-17.]

187:53:14 Fullerton: Roger. And America, can you read Houston? Over.
 187:53:20 Evans: America. Roger. Loud and clear.
 187:53:23 Fullerton: Okay, Ron. You're loud and clear. (Pause)
 187:53:35 Cernan: Okay. We're standing by for 5 (minutes to lift-off). (Pause) Houston, Challenger is Go for lift-off. We're at 7:54 (prior to liftoff) and counting.
 187:53:45 Fullerton: Roger, Challenger. You're Go for lift-off.
 187:53:53 Cernan: Roger. Understand. Challenger is Go for lift-off. (Pause)
 187:54:07 Fullerton: Challenger, Houston. We think the transducer in tank 2 has shifted. We want you to monitor tank 1 for APS helium (pressure). Over.
 187:54:19 Schmitt: Roger. We were looking at that, and we'll monitor 1.
 187:54:23 Cernan: (To Jack, who is back on VOX) What of this do you want?
 187:54:24 Schmitt: I need the big one there, with the cards in it. (Long Pause)

[This card contain the final checklist items.]

187:54:51 Cernan: Here you go.
 187:54:53 Schmitt: Thank you.
 187:54:54 Cernan: That's all right.. (Pause) Okay. (Long Pause)
 187:55:27 Cernan: Okay. Let's go over the APS burn card.
 187:55:29 Schmitt: Okay. My Display/Engine Override Logic breaker is In; circuit breakers Stab(alization)/Control all Closed on panel 11, except AEA and DECA Power.
 187:55:39 Cernan: Okay. Stab/Control breakers are all Closed, except AEA and DECA Power.
 187:55:43 Schmitt: Okay. Logic breaker's In.
 187:55:45 Cernan: Logic breaker's In.
 187:55:46 Schmitt: And all of mine are Closed except Descent Engine Override. Logic's In.
 187:55:51 Cernan: Okay.
 187:55:52 Schmitt: Rate Scale, 25 Degrees per Second.
 187:55:53 Cernan: 25.
 187:55:54 Schmitt: Attitude/Translation, 4 Jets.
 187:55:55 Cernan: 4 Jets.

187:55:56 Schmitt: Balance Couple, On.
 187:55:57 Cernan: On.
 187:55:57 Schmitt: Dead Band, Min.
 187:55:58 Cernan: Dead Band in Min.
 187:55:59 Schmitt: Abort/Abort Stage, Reset.
 187:56:00 Cernan: Abort/Abort Stage are Reset.
 187:56:01 Schmitt: Attitude Control, three, to Mode Control.
 187:56:05 Cernan: Attitude Control, three, on Mode Control.
 187:56:07 Schmitt: Okay. And you're going to be in Auto and Att Hold.
 187:56:12 Cernan: PGNS is Auto, and AGS is Att Hold.
 187:56:13 Schmitt: Stop pushbuttons are reset, and...
 187:56:14 Cernan: Reset here.
 187:56:16 Schmitt: ...And you're in Jets.
 187:56:17 Cernan: And I'm in Jets.
 187:56:19 Schmitt: Okay. (Pause)
 187:56:22 Cernan: Okay, let's take a swing around the systems.
 187:56:26 Schmitt: I just did. Everything looks good. The propellant pressure is holding up. We're tied to the ascent tanks on the RCS (Reaction Control System).

[Cernan - "We had two sources of propellant for the RCS systems. One was their own tanks and, for the other, we could crossfeed and utilize ascent propellant. We did that during the ascent phase to save the RCS fuel for rendezvous. We had a margin in the ascent tanks to cover that."]

187:56:34 Cernan: Okay; 5 minutes and my...
 187:56:38 Schmitt: That EC...
 187:56:39 Cernan: Rendezvous Radar breaker is Closed.
 (Pause) And let's go to the timeline book.
 187:56:48 Schmitt: Got it.
 187:56:49 Cernan: Make sure of everything in here. (Long Pause) Okay. At 2 minutes, I'll get the Master Arm. We already are VOX. You'll get 400 plus 1. (Pause)
 187:57:21 Schmitt: Okay. And I'll get the (16 mm sequence) camera and...
 187:57:24 Cernan: (Sounding very relaxed) Okay. At 10 seconds I'll hit the Abort Stage, followed by the Engine Arm to Ascent. (Pause) You get the Pro(ceed). I'll backup the start. If we don't get a start, I'll go Guidance Control to AGS. I'll wipe out the thrusters. I'll go AGS Auto. And if we don't get a start, we'll back off. (Pause) Okay?
 187:57:51 Schmitt: Okay. (Pause)

[Cernan - "In listening to this, it's obvious that we were pretty confident. I know how prepared we were and I'm still impressed. I'd have to go back and study and learn this all over again. I sounds to me like we knew exactly what we were going to do in the event of a no-light. You get to a point where you hope it never happens but you almost dare something to fail. Because you know that, if it does, you're prepared to handle it." I don't specifically remember

why I was going to wipe out the thrusters (by rotating the control through all thruster positions), but I think we had to reinitialize something - maybe zero the AGS."]

187:58:00 Schmitt: Houston, we have an awful lot of noise coming up (the comm circuit).

187:58:06 Fullerton: Okay, Challenger. I understand.

187:58:10 Schmitt: I think we can read you, Gordy. You sound pretty good now.

187:58:15 Fullerton: Roger.

187:58:22 Cernan: That's VHF noise, Jack. (Pause) (Go to) VHF B. (Pause)

[They are hearing the Command Module. Because Evans is in a 60 mile orbit, he 'rises' over the LM horizon about 6 minutes prior to passing overhead. They will launch prior to his overhead pass.]

187:58:35 Schmitt: Okay. I can cut it out with a high squelch (setting) on Bravo.

187:58:43 Cernan: Okay, Houston. Challenger's at 2 minutes and 50 seconds (prior to launch).

187:58:49 Fullerton: Roger, Challenger...

187:58:50 Cernan: We're Go for PGNS...

187:58:51 Fullerton: Everything looks great down here.

187:58:52 Cernan: ...direct (ascent)... (Responding to Fullerton) Okay. (Pause)

187:59:07 Schmitt: I'm not going to be able to squelch him (Evans) out any more.

187:59:10 Cernan: Okay. Turn the volume down a little bit. (Pause)

187:59:22 Cernan: (Responding to Evans, who is talking to them directly) Reading you loud and clear, America. This is Challenger. We're coming up on 02:10 from lift-off.

187:59:37 Cernan: (To Evans) We'll be with you shortly. Okay, Jack. Double-check your Logic Power breaker.

187:59:43 Schmitt: Checked.

187:59:44 Cernan: Okay, Master Arm is On. I've got two good lights.

[These lights indicate that the explosive bolts which they will fire to separate the Ascent Stage from the Descent Stage are ready to fire.]

187:59:47 Schmitt: Okay. I've got 400 plus 1 in.

187:59:50 Cernan: Okay. (Pause)

187:59:57 Schmitt: My watch is reset (as a backup to the event timer.) (Pause)

188:00:06 Cernan: Okay. You got 367. You want to pick up the (16 mm sequence) camera just before I hit Abort Stage. (Long Pause)

188:00:34 Schmitt: One minute coming up, Gene.

188:00:38 Cernan: Take your final look at the valley of Taurus-Littrow, except from orbit. (Pause) Okay, one minute, Houston. We're 50 seconds now, and we're Go.
 188:00:51 Fullerton: Roger. You're looking good here.
 188:00:55 Schmitt: I'll get that (camera) at 30.
 188:00:57 Cernan: Okay. (Pause)
 188:01:10 Schmitt: Camera's not going to run without me holding it.
 188:01:20 Cernan: Okay. Average g, 20 seconds.

[Cernan - "This was a routine in the PGNS to start recording data from the accelerometers."]

188:01:23 Schmitt: Ah, shoot!
 188:01:25 Cernan: Okay. Now, let's get off. Forget the camera. (Garbled)...
 188:01:27 Schmitt: Ten seconds.
 188:01:28 Cernan: ...10 seconds.
 188:01:29 LM Crew: Abort Stage.
 188:01:30 Cernan: ...pushed. Engine Arm is Ascent.
 188:01:32 Schmitt: Okay. I'm going to get the Pro. (Pause)
 99 Proceeded 3, 2, 1...
 188:01:39 Schmitt: Ignition.

[Schmitt - "As I recall, at the moment of ignition, all we had was static - loud static. And I was looking to see what happened, to see if I'd lost lock."]

[Cernan - "Jack spent half of the liftoff trying to get comm back."]

[Schmitt - "And I remember somebody telling me that what had happened was that they had a site handover scheduled right at liftoff! And nobody caught it."]

[Jack's memory is not quite accurate, although the problem was, in part, due to procedures on the ground. The following has been extracted from the Apollo 17 Mission 5-Day Report: "On lunar module ascent, two-way lock with the lunar module transponder was lost. This resulted in a 4-minute loss of uplink voice, and tracking data during ascent. It was necessary to have the Command Module Pilot pass comments from the ground to the lunar module crew during this period. The initial loss of lock was attributed to attenuation by the lunar module (engine) plume. Communications should have been re-established in less time (than 4 minutes). A review of data indicates that a normal re-acquisition by Goldstone should have been attempted earlier. Approximately 4 minutes after lunar module lift-off, a normal re-acquisition was accomplished."]

188:01:40 Cernan: We're on our way, Houston!
 188:01:43 Schmitt: Rates are good. AGS saw it (that is, the ignition)... (Pause)
 188:01:48 LM Crew: Pitchover!
 188:01:51 Fullerton: Roger. You have good thrust.
 (Pause)

[After launch, Fendell successfully tracks the LM for 26 seconds. He finds it again, very briefly, at 45 seconds and, a minute later, points the TV back at the descent stage. The flag is still standing, as is the SEP pallet Gene had leaned against the north landing strut.]

188:01:58 Schmitt: Okay, 30 seconds; 308 is your number.
 188:02:02 Cernan: Okay, coming through 1500 feet.
 188:02:03 Schmitt: And H-dot looks good.
 188:02:05 Fullerton: Roger. We've lost data right now, but we'd like Aft Omni. Aft Omni, please.
 188:02:16 Cernan: Okay; coming up on 40 seconds. And we're Go. Coming right over the top of Camelot.
 188:02:25 Cernan: Awful lot of static, Jack. We break lock?
 188:02:28 Schmitt: Yeah.
 188:02:29 Cernan: Why don't you get it on an Omni, or something?
 188:02:31 Schmitt: Yeah, I got it. It's on the Omni.
 188:02:32 Cernan: See if you can get comm back.
 188:02:33 Schmitt: Hello, Houston. How do you read?
 188:02:35 Fullerton: Roger, Challenger. You're loud and clear, and both systems look good. You're right on the line.
 188:02:38 Schmitt: Okay. Should be about 145 and minus 47.

[These are pointing angles for the high-gain antenna.]

188:02:47 Cernan: See if we can get comm.
 188:02:48 Schmitt: I will. (Long pause)
 188:03:10 Cernan: 01:30, Houston. We're in the blind, and we're Go.
 188:03:14 Fullerton: Roger. We'd like the AGS to Auto.
 188:03:16 Schmitt: Okay. I got good lock...(Still not hearing Houston) No. (Pause) Trying to hold.
 188:03:25 Cernan: Okay, Houston; coming up on 2 minutes...
 188:03:30 Fullerton: Challenger, Houston. You're Go at 2 minutes. We'd like AGS to Mode Control, Auto. Over.
 188:03:31 Cernan: ...Challenger is Go and coming through 14K' (fourteen thousand feet). (Pause)
 188:03:42 Schmitt: Okay. You watch the table, Geno.

[Cernan - "We had a table of altitude, attitude, and rate of climb. That was a manual backup that told us if we were on our trajectory or not - and a manual backup to tell us that the PGNS was doing what it was supposed to."]

188:03:43 Cernan: I'm watching it. Just get comm, if you can.
 188:03:50 Fullerton: Challenger, Houston. How do you copy Houston?
 188:03:56 Cernan: (Not hearing Houston) Okay, Houston. Challenger's Go; coming up on 02:30. We're through 19K.

188:04:03 Fullerton: Roger, Challenger. We need a 623 plus 10,000 in the AGS. Over.
 188:04:14 Schmitt: (To Gene) Well, those are the angles.
 188:04:15 Cernan: How about an omni...
 188:04:17 Schmitt: I've got...I tried it. I've got...
 188:04:26 Fullerton: Challenger, Houston. Aft Omni, please. Would you relay, America? (Pause)
 188:04:31 Cernan: Okay, Houston. Three minutes, and Challenger is Go. We're through 25K.
 188:04:38 Schmitt: (To Evans) I tried it...I tried it, Ron, and it doesn't hold.
 188:04:44 Cernan: Try Aft Omni again, Jack.
 188:04:45 Schmitt: It doesn't help.
 188:04:46 Fullerton: America, Houston. Tell Challenger...
 188:04:49 Schmitt: All my comm breakers are in.
 188:04:51 Cernan: Try Aft Omni again.
 188:04:51 Fullerton: ...that they're right on the money on trajectory; both systems are Go. Over.
 188:04:54 Cernan: Okay, Houston. In the blind, Challenger's Go; coming up on 03:25 and at 30K.
 188:04:59 Schmitt: Okay, there's Aft. How do you read, Houston?
 188:05:04 Fullerton: America, would you relay to Challenger to go Aft Omni?
 188:05:10 Schmitt: (To Evans) We are Aft Omni. How do you read?
 188:05:12 Evans: (To Houston) Okay, they are in Aft Omni right now.
 188:05:15 Fullerton: Okay, America, tell Challenger...
 188:05:16 Schmitt: And we're reading Houston.
 188:05:16 Fullerton: ...we're reading them 5 by. (Pause)
 188:05:22 Schmitt: Okay. We're reading you, Houston.
 188:05:23 Fullerton: Okay, Jack...
 188:05:24 Evans: Okay, Challenger, America....
 188:05:25 Cernan: (Garbled)
 188:05:27 Evans: ...Yeah, you got them.
 188:05:28 Fullerton: ...we need a 623 plus 10,000. Jack, give us a 623 plus 10,000.

[This is an AGS update in case the PGNS fails and they have to use it.]

188:05:33 Cernan: Okay, 4 minutes. Challenger's Go. We're through 37K.
 188:05:38 Fullerton: Roger, Challenger. You're looking good here.
 188:05:40 Schmitt: Okay, that (623)'s in.
 188:05:43 Cernan: Noun 37 says we got about a 07:16 burn, Jack.
 188:05:50 Cernan: Okay, at 04:30, I'll be about 282 coming through 41K.
 188:05:58 Schmitt: Okay, 04:30. 282 is great; 41K is great, 73 is good; AGS and PGNS are right together.

188:06:10 Cernan: Okay, Houston. Challenger is Go. We're now through 43.5 (thousand feet).

188:06:21 Fullerton: Challenger, Houston. We'd like to terminate Ascent Feed now.

[Cernan - "As I remember, the time to get fuel out of the ascent tanks (for the RCS) was when we had a g-force because, once we were in zero-g, we could not have gotten any even if there was some left. Now they've decided that we've taken enough of the ascent fuel for the RCS. They don't want to get the ascent fuel any lower because they want it for the ascent engine, itself. So, the RCS is now going on it's own tanks - which are full at this point, and that's important. Well, they're not full, because we didn't cross feed on the descent."]

188:06:29 Schmitt: Okay, Main SOV (Shut-Off Valve) is going On.

188:06:32 Fullerton: And the reason is the mixture ratio problem....

188:06:34 Schmitt: Ascent Feed, Closed.

188:06:35 Fullerton: ...That's just to be conservative and safe. Over.

188:06:40 Cernan: Understand. And we're going 5 (minutes), and we're now out of 48K.

188:06:49 Schmitt: Okay, the (sequence) camera's stopped.

188:06:51 Cernan: Okay, burn time's going to be about 18 or 19. 07:18 or 07:19, Jack.

188:06:55 Schmitt: Okay.

[I asked Gene and Jack if, like Conrad and Bean, they experienced a significant amount of LM 'wobble' RCS firing during the trip up from the surface. Neither remembered anything notable.]

188:07:00 Schmitt: Okay. The AGS has us just about in plane.

188:07:03 Cernan: PGNS and AGS are looking good.

188:07:04 Schmitt: A little bit north.

188:07:07 Cernan: Okay, Houston, 05:40. Challenger's coming through 52K. And PGNS says 126 on the H-dot. We're Go.

[They are gaining altitude at the rate of 126 feet per second.]

188:07:14 Schmitt: AGS likes the plane.

188:07:15 Fullerton: Roger, Challenger. Your trajectory is right on the money. Both systems are Go.

188:07:26 Cernan: Get a good shutoff time now.

188:07:27 Schmitt: Okay.

188:07:28 Cernan: Okay, it'll be 20...7:20 (into the burn) on the shutoff.

188:07:29 Schmitt: Okay, we've already terminated Ascent Feed. You got 1300 (feet per second horizontal velocity) to go.
 188:07:34 Cernan: Okay. Let's doublecheck everything now.
 188:07:39 Schmitt: You got that; you want...
 188:07:39 Cernan: Next move is at 200 feet (per second).
 188:07:40 Schmitt: Engine Arm, Off with 200 to go. AGS and PGNS are right together.
 188:07:45 Cernan: We got about another minute to go, Houston. And we're coming up on 57K.
 188:07:54 Fullerton: Roger. And we agree with the...
 188:07:55 Schmitt: 900 to go.
 188:07:55 Cernan: (Garbled) out nicely. Okay, H-dot is rounding right out to the target.
 188:08:03 Schmitt: 700 to go.
 188:08:03 Cernan: Coming up...
 188:08:03 Fullerton: Okay, normal shutdown and normal trim procedures.
 188:08:04 Schmitt: Mark it.
 188:08:10 Cernan: Roger. Normal shutdown, normal trim. Give me a hack at 200 (fps horizontal velocity to go), Jack.
 188:08:18 Schmitt: Okay, it's 500 now...
 188:08:20 Schmitt: Mark it, and the ascent feeds are already terminated.
 188:08:21 Cernan: Okay. Very good.
 188:08:25 Cernan: Seven minutes, Houston. And we're passing 59K.
 188:08:30 Schmitt: 300; stand by. 200 to go.
 188:08:34 Schmitt: Mark it.
 188:08:37 Cernan: Okay, Engine Arm is Off.
 188:08:39 Schmitt: Okay, stand by for shutdown; 80, 50...
 188:08:44 Schmitt: Shutdown!
 188:08:45 Cernan: Okay, Auto Shutdown...
 188:08:47 Schmitt: Auto Shutdown.
 188:08:47 Cernan: ...Houston, Auto shutdown!
 188:08:49 Fullerton: Roger.

[Cernan - "As I remember, my intent was to let the PGNS shut it down and, if it didn't within a second afterwards, I was going to. I think I shut it down anyway. I wasn't going to let it send us into orbit around the Sun. But I was less concerned about the shutdown than the start. I was told that, at liftoff, I beat the PGNS start by some micro-cosmo of a second."]

188:08:55 Cernan: Okay, no trim, Houston; no trim.
 188:09:00 Fullerton: Roger. We're reading the DSKY.
 188:09:01 Cernan: We're showing a 50 (mile) by 9.1 (mile elliptical orbit).
 188:09:07 Fullerton: Roger. (Pause) And MSFN confirms that orbit (with tracking from Earth).
 188:09:13 Schmitt: Okay. AGS got a little bit of out-of-plane. Dispersion was 0900.

1 4 0 2 1 3 1 0

188:09:25 Cernan: Okay, Engine Stop is Reset. Get in the attitude for the tweak. Okay.

[That is, Gene is positioning the LM for a slight correction burn (or, "tweak"), using the RCS.]

188:09:44 Schmitt: Okay, AGS says it's 9.1.

[This is the low point of the orbit they have just entered.]

188:09:46 Fullerton: Challenger, Houston. There will be a tweak. Stand by for it.

188:09:52 Schmitt: 48 (mile high point) by 9.1; 49 by 9.1.
(Long Pause)

188:10:05 Cernan: Okay, that's our attitude. We're in attitude for the tweak.

188:10:08 Fullerton: Okay, Challenger. Here is your tweak. Ignition is at 12 plus 12; VX is a minus 4.0 (feet per second); Y, minus 9.0; and Z, plus 1.0. That's at 12:12; minus 4; minus 9; and plus 1.

188:10:35 Schmitt: Roger. That's at 12:12; minus 4; minus 9; and plus 1.

188:10:40 Fullerton Roger, that's a good readback.

[Cernan - "That was exciting! I hadn't gone through that for a long time. Eric and I did the descent alone and I sort of relived it all. But it's more fun to relive the ascent with Jack."]

Apollo Lunar Surface Journal, Part 19

The Trip Home

The Ascent burn lasted about 7 minutes and 18 seconds and it put the Challenger crew into an elliptical orbit with a low point of 9 nautical miles above the Moon and a high point of 50. It was a nearly perfect burn. At 12 minutes 12 seconds after launch, Cernan did series of RCS (Reaction Control System) firings - called "tweak burns" - to fine tune the orbit. Compared with their 5500 foot-per-second (fps) orbital speed, the velocity change that Cernan wanted - 4 fps aft (down through the ascent engine bell), 1 fps out the plus-Z axis (out the windows), and 9 fps left (toward Gene's side of the spacecraft) - was trivial in the extreme. However, they wouldn't be rendezvousing with Evans for another hour and a half - not until they'd gone around the backside of the Moon and were in radio contact with Earth again - and a net speed change of 10 feet per second meant the difference between a perfect rendezvous and a miss of several kilometers. Better to do the tweak now, with a small engine burn, rather than later with a bigger one.

Because the required velocity change was so small, Cernan actually did three separate RCS firings - one for each of the three spacecraft axes. With Schmitt watching the AGS (Abort Guidance Computer), Cernan fired the thrusters associated with the x-axis - which ran up through the Ascent engine bell to the overhead hatch - until the AGS told them that they had made the desired 1 fps velocity change. Then he did the z-axis change - the z-axis runs from the rear of the cabin forward toward the hatch - and, finally, the y-axis (left/right) change. By the time they were done, they were 125 miles behind and below the Command-and-Service Module (CSM).

The LM crew was flying in an orientation such that, when they got close enough, they would have a clear view of their sister ship. About 18 minutes after the launch, Cernan got his first visual sighting of the CSM. He and Schmitt had just passed through the sunrise terminator into darkness and, although Evans was still out in front of them, he was high enough that he was still in sunlight. Moments later, Evans also passed into darkness and, once his eyes adjusted to the lower light levels, he spotted the tracking light on Challenger.

The two spacecraft were now about 112 miles apart, engines quiet and following paths which, through the magic of orbital mechanics, would soon bring them together. Fifty minutes after launch, Challenger and America disappeared behind the Moon and, by the time they reappeared, forty-five minutes later, they were only 0.8 miles apart and were closing at a stately 30 fps. Cernan and Schmitt had their backs to the Moon and were looking almost straight up at Evans in the CSM. Evans, too, had a good view. He had his TV camera was mounted in one of the CSM windows so that Houston and the rest of the world could watch Challenger as

it seemingly rose up from the lunar surface. Gradually, Cernan slowed his approach and, at a separation of only 100 feet, he stopped. Then Evans did a slow rotation of the CSM so that the LM crews could do a visual examination of the ship that would take them all home.

As the two ships passed over the landing site for the first time since liftoff, Cernan and Evans maneuvered into docking attitude and then, ever so slowly, Cernan inched closer. There was no need to hurry. They were going to spend the next two days in lunar orbit, gathering more data and adding to the wealth of visual observations that Evans had already provided. Fifteen minutes after they started to maneuver, the two spacecraft were docked and, in a few minutes more, they were sure that all the latches were secure. They had a hard dock and could open the hatches, clear the connecting tunnel and begin to transfer the precious lunar samples.

Minutes after the two spacecraft were hard docked, CapCom Gordon Fullerton read to the crew a statement from the Nixon White House. "As the Challenger leaves the surface of the Moon, we are conscious not of what we leave behind, but of what lies before us. The dreams that draw humanity forward seem always to be redeemed, if we believe in them strongly enough and pursue them with diligence and courage. Once we stood mystified by the stars; today we reach up to them. We do this not only because it is man's destiny to dream the impossible, and to do the impossible; but also because, in space, as on Earth, there are new answers and new opportunities for the improvement of and the enlargement of human existence. This may be the last time in this century that men will walk on the Moon, but space exploration will continue, the benefits of space exploration will continue, and there will be new dreams to pursue, based upon what we have learned. So let us not mistake the significance or miss the majesty of what we have witnessed. Few events have ever marked so clearly the passage of history from one epoch to another. If we understand this about the last flight of Apollo, then truly we shall have touched a 'many splendored thing'. To Gene Cernan, Jack Schmitt, and Ron Evans, we say God speed you safely back to this good Earth."

Cernan made a gracious statement of thanks and then Schmitt and Evans added brief thanks of their own. But, inside, Schmitt was steaming. Apollo was ending, but there were still 27 years left in the decade and he hated the thought of an American President telling a whole generation that they would have no chance to do their own lunar exploration. But there was nothing Schmitt could do but suppress his anger and, in the mean time, there was some more exploration that he and the others could do before they headed home.

Once the hatches were open and the tunnel was cleared, Evans passed over the vacuum cleaner and Cernan and Schmitt got busy with the worst of the dust. LOS (Loss-of_signal came about forty minutes after the docking and, by the time

Apollo 17 re-emerged three quarters of an hour later, Cernan and Schmitt were handing sample containers over to Evans. With his own interests in mind, Evans also made sure that they had all the helmets and gloves and other gear that they would need for his EVA. Once they had left lunar orbit and were on their way home, Evans was going to go outside, secured with a tether, to retrieve film canisters from the SIM (Scientific Instrument Module) Bay. The EVA promised to be the highlight of the mission for Evans and he didn't want to lose out on his chance by leaving a helmet or a glove behind in the LM.

By now, Challenger had almost completed its mission. The rocks and the helmets and gloves were all safely aboard America and, indeed, the Command Module was so full of rocks and astronauts that the only way they were going to get a little elbow room was to get rid of a jettison bag that Evans had been filling for the last three days. Consequently, just before they closed the LM hatch for the last time, the astronauts tossed the bulging jett bag into the now empty cabin of the LM. Challenger had once last mission to accomplish. She was headed back down to the Moon for a planned impact on the eastern flank of the South Massif, a final sacrifice to the gods of seismology; and, as Challenger made her last trip down to the lunar surface, she also had the unglamorous - but necessary - job of carrying the trash.

(In writing these words, I am reminded that, whenever I mention these jettisoning operations in a talk about Apollo, someone in the audience will later ask why the astronauts were so carelessly littering the Moon. Why didn't they bring their trash home? As Jack Schmitt mentions in his commentary, when we go back to the Moon to build a permanent base, trash will truly be treasure. The cost of bringing things up from Earth is high enough that anything that could possibly be reused will be stored and cataloged. However, during Apollo, fuel margins were so precious that there it was a simple choice of bringing back geology samples or trash. The choice was simple.)

Because of the precision that was hoped for Challenger's impact, the jettison operation was carefully choreographed. The crew got their suits on and did a pressure check. Then they pressurized the connecting tunnel and, at about 194 hours into the mission, released the latches so that the pressure in the tunnel could gently push the two spacecraft apart. For another half hour, the flight controllers made sure that they could control the LM attitude; and then, at the proper moment, at 195 hours 38 minutes into the mission, they did a long firing of the LM's RCS thrusters. At launch from Earth, the LM was carrying 630 lbs of RCS propellant and, because things had gone so smoothly throughout the flight, there were still 450 pound left when the LM was released for it's final descent. During the long, 1 minute 56 second burn, another 270 pounds of propellants was expended, enough to trim 213 feet per second off the orbital

speed of the 5277 pound Ascent Stage and send it toward impact with the South Massif.

Nobody saw the impact.

Because there were only 40 hours left before the crew was scheduled to leave lunar orbit, the instrumentation in the SIM Bay were still busily gathering data. There wasn't going to be another opportunity to gather close-up lunar data for a long time and a visual observation of the LM impact was of lesser importance than proper orientation of the Command Module for data gathering. Consequently, the crew was looking back along their ground track at the moment of impact and, because the LM was flying in a lower orbit, they were not yet over the landing site when it hit.

Down on the lunar surface, the TV camera on the Rover was still in good working order and, as the moment of impact approached, Ed Fendell pointed it at the planned impact point high on the eastern slope. But there was a question. Because there was only a limited amount of tracking data that could be acquired in the 17 minutes between the end of the deorbit burn and the impact, predictions of the impact point were uncertain by about 10 to 15 kilometers. Fendell could look at most of the error ellipse if he pulled back on his zoom; but, with a wide field, he would have limited resolution would lower his chances of seeing anything. For several minutes, he played with the zoom and adjusted his pointing. However, in the end, he went to maximum zoom and aimed at the planned point and hoped for the best. Given the relatively poor resolution of the camera - even at maximum zoom - there wasn't much chance of success and, even though the LM did hit the mountain within a mile of the planned spot, nothing was seen by the eager audience in Houston. The seismometers that Schmitt had deployed at the ALSEP site saw the impact, but there was nothing to be seen on the TV.

The orbiting Apollo 17 crew had a bit better luck. Three minutes after the impact, Ron Evans had the South Massif in view.

"Hey, Houston, I can see a bright spot on the South Massif. On the top of the South Massif."

Down in Houston, Parker had been listening to another conversation and asked Evans to repeat what he'd said.

"Okay, this is America. I can see a bright spot on the top of the south Massif and - let me see - (text omitted) I guess if you come from the east, it's the second ridge from the east, and right on top of the ridge is a bright spot. I don't know how big a crater it should make."

(The LM impacted with a speed of about 1.5 km/s and with a mass of 2400 kilograms. The impact energy was, therefore, 2.7×10^{16} ergs. Get an estimate of the crater size.)

Moments later, Evans dug out a suitable map - Landing Site 204 in a book of photomaps he had been using for visual observations - and described the location in more detail for Parker. "If you draw a line from Shorty to that Reseau mark that's on the top on the South Massif, and then extend about a little better than one-eighth of an inch toward Shorty from

that Reseau mark...somewhere right in there...That's a bright spot on the top of the Massif that I hadn't noticed before in any of the observations going by there...You know, that bright spot might already (have been) there; but I don't think so. I don't remember seeing it."

(Initial estimates of the impact point based on the time of the first seismic arrival indicated that the impact had been within 15 miles of the planned point, but revise this text based on the literature.)

Now that Challenger's mission was done, Cernan and Schmitt got down to the serious business of getting cleaned up. And it took a while. At the end of the next Farside pass, it was Cernan who answered Houston's call with a cheery "This is your friendly commander, clean and happier, back up (on comm)."

"Roger, Geno," Parker replied. "We're glad to hear you're clean again."

"Well, I'm not really clean, but it's a major step in the right direction." As he recalls in his commentary, Cernan even had lunar dust that had worked its way under his fingernails and it was a long time until the growth of his nails pushed it all out.

Once they were clean, Cernan and Schmitt were ready to join Evans in some sightseeing. And there was plenty to see. As they passed over the landing site for the first time since the LM impact, Evans took a series of pictures (AS17-151-23250 to 23255). And then, a short while later, Schmitt reported that, in "passing over the the Hadley Appennines site from Apollo 15, we noticed that, at their landing point, there's the same slightly or distinctly brighter area as there is at Taurus-Littrow site." then, in thinking about what he'd seen at the surface, Schmitt added that "as we walked along the surface - and this was true at Hadley also - you stirred up a a darker zone, albedo-wise. When you look at it from orbit, the area around where the LM landed (is) a distinct bright spot on the surface of a fairly uniform, gray-albedo plain. And both sites look just alike."

The crew was in a light-hearted mood. They were back in orbit and it had all gone beautifully. Thanks to a warning from Gordon Fullerton, the liftoff CapCom, they knew that it was Parker's birthday and, at a quiet moment just before saying good night, they broke into a three-part rendition of "Happy Birthday."

Never one to let his crew get the upper hand, Parker reacted by saying, "Well, all I can say (is that) it might be appropriate, but it's not very musical." His instant review drew a laugh from the crew and then, after Parker added a "thank you", Cernan responded with "Epic, Bob. Epic. At least you know it's from the bottom of our (pause) hearts."

"And just to let you guys know," Parker replied, "that I'm not easily swayed and made soft by such shows of sentiment, I want to remind the CDR and the LMP that they're going to start collecting their urine from now on." The experimenters were still at work, and an ill-timed urine dump

would play havoc with the UV camera and the other gear. After three days in a gravity field, Cernan and Schmitt were going to have to re-adapt to the intricacies of zero-g hygiene.

On their final full day in lunar orbit, the crew of Apollo 17 was going to spend most of their time doing out-the-window geology and the wake-up music was Roberta Flack's "The First Time Ever I Saw Your Face." During the day, Schmitt, the professional geologist, and Evans, the seasoned lunar observer did most of the talking.

Because of the discovery of orange soil at Shorty Crater at the landing site, they spent a lot of time looking for color at various places where they and the geologists in the Backroom thought that they might find other pyroclastic deposits. As they passed over the landing site, Evans noted that the orange coloration at Shorty was no longer visible but, a bit further west, in the Sulpicius Gallus area in southwestern Mare Serenitatis, both he and Schmitt described numerous features that not only showed prominent orange, but also reds and reddish browns. Eventually, Schmitt saw enough that he was ready to offer an explanation of the colored layers.

"Gordy, my impression from Shorty the other day, and also from seeing these craters that seem to have orange around them (and) that look very much like impact craters from orbit, it may be that - if that is an alteration phenomenon - that it's being localized around the structure created by the impact. But, in this latter case, it looks as if the impact itself penetrated into a zone of that color."

And a few minutes later, in describing a feature that Evans had just pointed out to him, he added, "There's a gouge just south of the Sulpicius Gallus ridge. The gouge (is) a rimless depression and, streaming down from the upper portion of that depression are not only our old friend the orange-grays, but some that would be a red-brown gray. Verry, very clear coloration in this light...My goodness. there's another crater we'll have to look at."

"Yes," said Evans, "there's a whole bunch of them down there."

"Yes, but that's something in the wall of it in that area. Yes, it's starting..(chuckle)..Man, we're seeing an orange Moon now. this whole dark mantle in here around Sulpicius Gallus...they are scattered craters with a variety of orange to red-brown hues. And they all - except for that large, rimless depression, which looked as if it was exposing some layers which were streaming that colored debris down its walls. All the other craters seem to be small impacts that apparently are penetrating just far enough into the dark mantle material to tap this zone of orange to red-brown material."

"And just north of that elongate depression," Evans added "there is another circular crater. And it also is penetrating down through this mantle stuff. And it had the reds and the browns and oranges dipping down it, too."

For most of the day, the astronauts described what they were seeing out the window. The large, mare-filled, Farside crater Tsiolkovsky was of particular interest and so, too, was Mare Symthii near the eastern rim. Schmitt, of course, tended to talk in terms of comparisons between the various features he was seeing and, at one point provided a lengthy discussion of the so-called "wrinkle-ridge" systems which bound the various mare. Jack was truly in a geologist's paradise and, at one point, Fullerton jokingly told the crew that a requested change in the comm configuration was being done "so that the secretaries that are transcribing the air-to-ground can catch up with Jack."

Banter between the crew and the CapComs was an important part of the mission. It was the voice of a friend, a comrade-in-arms who had an office down the hall and who had been through training with you. It was certainly not a faceless voice a quarter of a million miles away.

It was Gordon Fullerton's turn at the CapCom console and he had a question for Ron Evans. Readers will recall that, prior to the landing, Evans' scissors had turned up missing. The scissors were a vital piece of equipment, mostly because the food securely packaged in tough plastic bags, and Evans had endured quite a bit of ribbing when his turned up missing. Cernan and Schmitt each had a pair and it was only with mock reluctance that they agreed to leave a pair behind so that he wouldn't starve while they were down on the surface.

"Say, we've got a question for Ron," said Fullerton. "We've got large teams of engineers trying to locate the missing scissors, and we haven't asked you in a while whether you might have found them. That might save them a lot of effort down there."

"No, I haven't found them yet," replied Evans. "And there's a lot of room underneath these CO2 absorbers (as) I found out the other night because I lost my flashlight. But it (the flashlight) kind of floated out, and I saw it every once in a while. And we found the flashlight and got it back, but I still haven't the slightest idea where the scissors are."

At this point, Cernan joined the conversation. "Gordo, you might have someone hide them (that is, a pair of scissors) in the CSM (mockup) and send a backup crew down to the Cape and see how long it takes them to find them."

"Okay," agreed Fullerton. "I'll get an airplane scheduled up right away."

While the crew was doing geology and bantering with the CapComs, the science teams back in Houston were busy with their own work. At one point in the proceedings, Fullerton read up a science summary for the crew. While Cernan and Schmitt were on the surface, NASA had attempted to launch a small Aerobee rocket from the White Sands Missile Range in New Mexico. The rocket was carrying a UV spectrometer designed to obtain a solar spectrum that could be used to calibrate the data being acquired from the Command Module.

That first launch had failed; but, as Fullerton reported to the crew, a second attempt was successful. He also reported that the infrared radiometer back in the SIM Bay was getting excellent data and mentioned, for example, that during CSM orbit 33 (when Cernan and Schmitt were back in the LM cabin after EVA 2), the crater Kepler C showed up as a 132-degree kelvin hotspot superimposed on a 94-degree background after 11.6 days of the lunar night. The implication was that the ejecta blanket was retaining heat better than the surrounding surface. Down on the surface at Taurus Littrow, the heat-flow probes were nearly equilibrated and the PI (Principle Investigator) was confident that they were going to get a good measurement. The Lunar Surface Gravimeter, an experiment designed to detect gravity waves and a source of considerable frustration to everyone involved, still wasn't working. The Seismic Profiling Experiment was returning good data, having seen both the LM ascent and the impact on the South Massif. Transit times of signals across the array were indicating propagation velocities in the regolith very close to those of the Apollo 16 site, and analysis of the LM impact signals indicated that the impact had occurred close to the target point. Fullerton reported that the first of the seismic charges had been fired and, in addition, that an analysis of the temperature history of the SEP recorder suggested that some good data was obtained.

Fullerton told the crew that the Traverse Gravimeter - an elegantly designed experiment that gave a high return for a small investment of crew time - had proved to be a "spectacular success". among other things, a preliminary analysis of the gravity readings obtained during the traverses indicated that the valley fill material was considerably denser than the Massif material and, indeed, the measurements were consistent with a thickness of 3 to 4 kilometers of dense, basaltic rock.

The crew was quite happy for the news. As Cernan said, "It's satisfying to have put in that much time in and come out with some meaningful results. That makes us all feel good." And, of course, not only did they have the satisfaction that most of the surface experiments were living up to expectations, but there was also the considerable contribution they were making from orbit.

In all, the crew of Apollo 17 put in a full eight-hour day of visual observations - and probably with a good deal more that was done without report to Houston. Because they were following pretty much the same ground track on every pass, they had a chance to think about what they were seeing, make hypotheses, and then, on the next pass, see if the hypotheses made sense. Repeated passes over the landing site gave them a chance to see the gradual fading of the orange coloration around Shorty - presumably an effect of changing lighting conditions - and to compare what they were seeing at Shorty with related features in the Sulpicius Gallus region. From time to time, too, Houston could test its own hypotheses and have the crew examine specific features. As

an example. there were some small craters west of the landing site which bore some resemblance to Shorty but which, on close examination, did not appear to be remarkable. Clearly, while it was possible to do good geology from photographs - particularly high resolution photographs of the sort taken by the Lunar Orbiters spacecraft in 1966 - there was no substitute for a well-trained pair of eyes. Like the other J-mission CMP's Ron Evans did some first-rate out-the window geology. However, even to a casual reader of the orbital geology transcripts, Jack Schmitt's background and his freshly-minted experience on the surface raised the art to a new level. If, as Cernan and Schmitt mentioned in their mission commentary, NASA management was less than enthusiast about having them spend an extra day in lunar orbit, it was a risk that, once taken, paid off handsomely.

But, eventually, the day had to end. For the last couple of hours before starting their rest period, the crew was pretty busy getting themselves and America ready for their last sleep period in lunar orbit. Just before LOS on Rev 67, Houston said goodnight and, indeed, Parker - who had taken over from Fullerton at the CapCom console, told the crew that, while the were sleeping, "the old Orange Team will be sitting around the fireplace here and they'll all be singing Christmas carols." It was December 16 and it was time to go home.

The wake-up music in the morning was the Doors' "Light My Fire". It was a great choice and the amazing thing about it was that Ron Evans slept right through it, despite the fact that he was "on watch" and was wearing the ear piece. Cernan suggested that Houston play the song again but, before that could be done, Evans woke-up, sounding very, very groggy. Just for his benefit, Houston went ahead with the replay

Wake-up came just a few minutes before LOS and, by the time the crew re-emerge, they were eating breakfast. CapCom Bob Overmyer read up a summary of the day's news. Former President Harry S Truman - who had been in the crew's thoughts throughout the mission - was still in serious condition. He died on the day after Christmas. When it was their turn to talk, the crew reported that they had all slept well - once they got to sleep - and got about 5 hours a piece.

The TEI (Trans Earth Injection) burn was done aover the Farside about eight hours after wake-up. During their final hours in lunar orbit, all three of the astronauts passed along miscellaneous geology observations, but the burn was the main event and, when they emerged from behind the Moon for the last time, Cernan was able to report a nearly perfect, 1/2 g burn. "America has found some fair winds and flowing seas," he said, "and we're on our way home." Indeed, once Houston got enough tracking data, they found that the velocity error was so small that the mid-course correction would only have to be 0.3 fps (10 cm/s) and there was talk of deleting the burn.

After the burn, America climbed rapidly away from the Moon and, indeed, the increased altitude meant that AOS came more than 13 minutes early than it would have without the burn. the climb out from the Moon also gave the crew some new perspectives and they shared the view with Houston, especially a sepctacular TV tour of the crater Tsiolkovsky. By the time the landing site came into view, they were 2000 miles out and they were beginning to lose detail. Schmitt said that he could see the landslide area at the base of the South Massif but, soon, even he had to give up. Before long, they settled into the routine of the flight home and, as Schmitt told Houston, there really wasn't much to do. Evans was experiencing some gastric distress and, for the first time in the mission, Houston set up a private comm channel so that he could talk to the doctors without the world listening in. The last five hours of the day passed slowly.

The highlight of the following day was to be Ron Evans' EVA and, this time, although it was Cernan who first responded to Houston, there was no grogginess in Evans' voice when he joined the conversation.

The wake-up music was Jerry Vale's "Home for the Holidays" and, to underline the message, Houston reported to the crew that they had just passed the point where the pull of Earth became dominant over the Moon's. Cernan, of course, wanted to know how fast they were going at the crossover and Houston came back with a figure of 3851 fps - roughly a very modest 1 km/s.

While Cernan's attention was focused on their progress and the status of the spacecraft - and the happy reminder that this day was the 69th anniversary of the Wright Brothers' first flight - Schmitt was still thinking about the Moon. He called down to Houston and asked CapCom Bob Overmyer if there was anyone still in the Backroom. No, he was told. They'd all gone home.

"That's all right, Bob. I just want you to pass on a thought. I had a little trouble getting to sleep last night - and they've probably already thought of it - but it has to do with Van Serg (crater)."

"Go ahead, I'll copy it down."

"No, just ask them if they've thought about the possibility that those Van Serg breccias might be the old indurated regolith over the subfloor."

During the stop at Van Serg toward the end of the third EVA, Cernan and Schmitt had been surprised and puzzled that this fairly sizeable impact out in the middle of the valley was not the basaltic rocks that they had come to expect but, rather, some very fragile rocks that looked to be breccias - rocks made up of fragments of other rocks fused together by an impact. On the drive back to the LM, Schmitt had speculated that Van Serg had, by chance, hit a "window" in the basalt and had dug up underlying breccias but, he remembers not being very happy with the hypothesis. Because Van Serg is only a few tens of meters deep, the "window" hypothesis would require that, elsewhere in the valley where

they did see basaltic rocks, the basaltic layer not be very thick. Consequently, Schmitt thinking during the night may have been influenced by the report from Fullerton that the Traverse Gravimeter was indicating that the basaltic valley fill was three or four kilometers thick and, therefore, the Van Serg breccias had to be made from something that was lying on top of the basalt at that location. Perhaps they were actually clods of soil which had been highly compressed - turned into a fragile "instant" rock - in the impact.

"That's an alternative," Schmitt continued, "that, in the heat of battle did not occur to me at the time. It should have, and it may have occurred to some of them (in the Backroom)."

Overmyer wanted to make sure that he understood what Schmitt was saying. "Okay. that's as opposed to being a window to the subfloor, which is what you suggested the other night."

"Yes, sir. I think I like the regolith (breccia) better. I think it makes sense from a lot of points of view; the size of the crater, the fact that we should have expected to see something but hadn't up to that time."

"Okay. I got that."

"And the breccias, thinking back on it, could very easily have been soil breccias and just getting coarser as you got closer to the top of the subfloor, which is that we were looking at down in the bottom of the crater."

And, indeed, when the Van Serg breccias were examined back in Houston, they proved to be soil breccias - larger, more competent versions of the instant rock that Cernan and Schmitt saw at the rims of smaller craters at several places in the valley.

About five hours after wake-up, the astronaut began preparations for Ron Evans' EVA. They put all the miscellaneous trash they'd accumulated since saying goodbye to Challenger and removed the center couch so that they'd have room for Evan's to get out and for Schmitt to stand in the hatch and take pictures. (The jettison bag would drift off only slowly as they continued their journey and, once it hit the top of the atmosphere, would quickly burn up.)

Because they didn't have a lot of elbow room and, as well, weren't in any great hurry, preparations for the EVA took about two and a half hours. but, eventually they were all suited and had done pressure integrity checks and were ready to open the hatch. As they were depressurizing the cabin, Cernan, who was a veteran of a zero-g EVA on Gemini XI, advised Evans to be sure that, once he had made his way back to the SIM Bay, he got his feet firmly planted in the footholds before he did anything else. During his own "spacewalk", which was only the third which had ever been done and the first in which an astronaut attempted to do real work outside the spacecraft, Cernan was hindered by a lack of hand and footholds. When he tried to use a wrench to turn a bolt, it was he who tended to turn and, coupled with the inadequate cooling capability of the Gemini suit, he had a

very frustrating and tiring time of it. For later, Gemini EVA's hand and footholds were added to the outside of the spacecraft and, back at the Apollo 17 SIM Bay, there was a pair of good footholds for Evans' use.

'Okay, babe,' said Cernan as they prepared to depress. 'When you get out there, just take it nice and slow and easy. You got all day long.'

'Yes, that's right,' said Evans. 'It's not like the zero-g airplane (which gave only about a half minute of zero-g at a time).'

'Feel yourself around, and it's nice and easy to get around. Just don't let your body start moving too fast down there. Okay. Side hatch (dump valve) is coming open slowly.'

'Nice day for an EVA, Ron,' said Schmitt as they got down toward zero pressure. Go out and have a good time.'

Evans got his visors down. It made it hard for him to see while he was still in the cabin; but both Cernan and Schmitt assured him that he would need the protection once he got out in the full Sun. And then they opened the hatch.

A felt-tipped pen drifted out, but no scissors. And then Evans followed.

His first job was to mount a pole on the side of the spacecraft and then mount the TV camera on the pole. Some of the paint on the side of the spacecraft was blistered, he noticed; but, otherwise, it all looked to be in great shape. Gradually, he made his way back to the SIM Bay, laughing and humming as he went. At first, he had a little trouble forcing his feet into the restraints but, eventually, he was securely in place and, just to show everybody that he was, he let go with his hands.

He was having a great time. 'Hey, this is great,' he said, laughing as he did. 'Talk about being a spaceman, this is it!. Okay, back to work.'

His next job was to hook a tether on the lunar sounder data cassette so that, when he pulled the cassette out, it wouldn't float away if he accidentally lost his grip. Once the tether was in place, he pulled on the cassette. 'Okay, let's try the old cassette. We'll push down on it until it (the locking mechanism) goes past center. Ah-ha! I think that was more than two pounds of force to come out, but it came out.'

A moment later, after he'd gotten out of the foot restraints so that he could bring the cassette back to Schmitt at the hatch, Evans caught a suit pocket on the spacecraft and, when it broke loose, the sudden force threw his feet up into the air. He was able to control himself with his hands, but he noticed that, as he used his wrists to rotate his feet back down toward the spacecraft, it was hard to stop them again and avoid having them bounce right back out. 'See, you twist yourself down there, and then you got to stop or you hit the end and you bounce back up in the air again.'

After a successful hand-off to Schmitt, Evans made his way aft again to get the pan camera film cassette. Once he

had it out and tethered, he discovered that the easiest thing to do was to let the cassette float on the tether so that he could get a good grip with both hands while he got his feet out of the restraints. "I think I'll just kind of let that thing go and hang on with both hands...Okay, it's just kind of floating around up there. both feet are free. Okay. It's just kind of coming along with me. I'll just let here do that...Okay. Coming. she's still coming. Must be back behind me. That's good. Nice and slow. Because you don't want that thing banging around too much up here, I don't think. Ahhh, there it is! Delivered it right to you. That's the way it ought to be done, isn't it?"

Evans was having a ball and, at one point when he was taking a brief rest and looked toward the hatch and noticed the TV camera, he said "hi" to his mother and to his wife and their two boys. And then, all too soon, it was time to end the EVA. It took a minute for Schmitt to get out of the way so that they could get Evans and his umbilicals back into the spacecraft. As he got the TV camera down off the pole, he gave Houston a look at the Moon, but the ground was eager for him to get back in. Once he'd handed the TV in, he stuck his own feet down in through the hatch and, with Cernan and Schmitt to guide him, got in without any difficulty. "Man, it's dark in here," he said.

Three hours before splashdown, Cernan gave America a nudge of 2.1 feet per second to fine tune his trajectory. Considering how far and how long they had traveled since the TEI burn, this miniscule burn was a testament to the men and women who and designed, built, and flown the Apollo spacecraft. 301 hours 51 minutes and 59 seconds after the launch from the Cape, America landed in the Pacific, 1.3 miles from its target. Crammed into the spacecraft with the crew were more samples and more frames of exposed film than any other crew had brought back to Earth and, although the splashdown marked the end of Apollo, it was a grand and fitting finale.

The Apollo 17 Lunar Surface Journal, Part 20
Epilog: When might we go back to the Moon?

For much of the 20th Century, humanity has been getting used to the idea of people traveling through space and, eventually, living and working on worlds other than Earth. During the first half of the century, pioneers like Konstantin Tsiolkovsky, Robert Goddard, Werner von Braun and others thought and wrote about space travel and slowly worked out some of the basic technologies that would make it possible. Science fiction writers extrapolated even farther into the future and, long before anyone actually worked out the details of building a spaceship, the fiction writers put cities of the imagination on the Moon and Mars and filled the spaceways with passenger ships and cargo vessels busily engaged in interplanetary commerce. For some people, acceptance of these outlandish notions was out of the question; but, by the time Yuri Gagarin made the first spaceflight in 1961, a sizable fraction of the literate world had been exposed, at least, to the dream of space as a frontier. Although interplanetary commerce will have to wait for the 21st century, by the late 1950's the dream had become familiar enough that, when John Kennedy proposed a lunar landing as a technological feat to impress mankind, almost everyone involved - those who would do the work, those who would pay for it, and those whom Kennedy sought to impress - understood the symbolism. Here was a big, bold step into the future.

Unfortunately, Apollo was so bold a step that the pace could not be sustained. Into the late 1960's, the space community had high hopes that Apollo would lead directly to the construction of a permanent base on the Moon and, sooner rather than later, to the first voyages to Mars. Von Braun and his collaborators had sketched such projects in a series of articles published in Collier's Magazine in the early 50's; and, once the big rockets were actually being built and the first lunar landings were at hand, there were moments when it almost seemed as though the Moon Base and Mars were in reach. But it was not to be; and, indeed, hindsight suggests that, because of economic and political factors, there was no real chance of sustaining Apollo beyond a handful of landings.

The main reason why Apollo ended as quickly as it did was simply that it was very expensive. The Space Age began during a period of intense rivalry between the United States and the Soviet Union and, during the four years that led up to the Apollo decision, America was subject to one humiliation after the another. Russian leader Nikita Khrushchev had bid the political value of dramatic space "firsts" so high that, in response to the Gagarin flight, President Kennedy had to find a way of achieving a clear, unambiguous, final victory in what had become the "Space Race". What was required was an undertaking "so expensive

and so difficult to accomplish" that the Russians would have little chance of keeping pace. So Kennedy committed the United States to a giant step forward. However, Apollo was so expensive and so difficult that it could not continue for very long. America's political will to win the Space Race could not be translated into political and financial support for sustained lunar operations, not to mention voyages to Mars. At it's peak in 1965, the annual cost of Apollo was about 0.8 percent of the U.S. Gross Domestic Product and, as more recent history suggests, there is political support for a program only a quarter that size.

The evidence of the years since Apollo ended is that the United States and many other nations are committed to space, partly as an investment in the development of new technologies, partly in the interest of attracting talented young people to engineering and the sciences, partly in the interest of participating in the long-term economic gains that space is expected to produce, and also, in large measure, because there are few other things now within human reach that are quite so fascinating. In the United States, political support for space development currently translates into a funding of about 0.25 percent of the Gross Domestic Product. In the early 1990's, the NASA budget was about 15 billion dollars: enough to support the operation of a four-vehicle Shuttle Fleet, the development of a Space Station, and the conduct of a variety of scientific and engineering programs, but not enough to include a lunar program as well.

Clearly, it was only the extraordinary political circumstances of the 1960's that made Apollo possible. For a brief time, whatever money NASA needed to achieve the promised first landing was made available. However, once the major pieces of the Apollo engineering work were finished, funding began to shrink. The United States was willing to spend what was needed to beat the Russians; but, once the Space Race was decisively won, the country's political leaders decided that the cost of a continuing lunar program was more than the country could afford. The space budget even shrank to the point that NASA had to cancel three Apollo missions for which flight vehicles had already been built.

Over time, of course, economic expansion makes projects like a Moon Base more affordable and, sooner or later, we will be able to undertake a lunar program without having to spend an Apollo-like fraction of the nation's wealth. During the past century and more, the American GDP has doubled in real terms about once every twenty-five years and there is every reason to believe that growth will continue for a long time to come. Economic expansion comes largely as a result of gains in productivity and, certainly, the limits to our creative use of new machines, new processes, and new resources are nowhere in sight. As the wealth of the nation grows and, indeed, as other nations acquire spaceflight capabilities, the total level of space activities will expand - albeit with ups and downs superimposed on the overall trend - to the point that construction of a permanent lunar base

will become feasible. If, for example, we assume continued investment at about 0.25% of the growing GDP and we also assume that we could conduct a space program that included both a space station and a lunar base for about 30 billion 1990 dollars, then we might see a resumption of lunar operations - preceded by a decade or more of preparatory work - in about 2015.

Of course, if the NASA budget allotment were to grow more quickly than the economy as a whole, we could build the lunar base sooner than 2015.

During the 70's, it was sometimes difficult to believe that the space program hadn't suffered a fatal setback, that some ill-defined "window of opportunity" hadn't closed. By the mid-70's, NASA's budget had stopped shrinking and, measured in constant dollar terms, even grew at a modest pace; but, after the glory years of Apollo, the increments seemed far too small to bring the Space Station, the Moon Base, and the Mars missions much closer to reality. Small increments were too easily overwhelmed by the rising costs of doing business. However, for a number of years following the 1986 Challenger accident, there was a noticeable change in the national commitment. The accident - and the public reaction to it - convinced Washington that the country wanted to spend more in order to have a respectable and productive space program; and, for a number of years after the accident, NASA received hefty, annual budget increases. More recently, the demands of social programs have come into direct conflict with the space program and, as I write these words in April 1994, there is a fierce debate raging in Washington over what has become the international space station.

The space program and its supporters have been on a financial and emotional roller coaster virtually from the beginning. The debate over funding is sure to continue until the time comes that most of our activities in space are self-supporting and public funding is no longer required. The issue at the center of the debate is, of course, the relative value of the space program and, as we have discussed, the perception of space as a technology driver - coupled with the fact that plenty of people still want to rub elbows with astronauts and plenty of kids still want to grow up to be one - generates funding at a level of about one quarter of one percent of the GDP. If the rules of the game were to change, of course, then increased levels of funding might well be in the cards. If, for example, people began to think that there was a real possibility of a substantial, near-term economic return, then new funding might well become available. The space community talks hopefully about asteroid mining, about solar power satellites, and about Helium-3 mining on the Moon but, unfortunately, they been unable to convince anyone but the faithful that the technological risks are low enough - and the potential payoffs large enough and soon enough - to warrant spending large sums of public or private money.

Alternatively, the development of significantly cheaper transportation systems would make it possible to do more at

the current levels of funding and, at the same time, would make a broader array of space activities attractive. However, technical innovation is only part of the answer to cheaper transportation. Of even great importance is the ability to build many copies of a new vehicle and to fly them frequently and efficiently. That is, economies of scale are crucial and, to achieve them, we will probably have to rely on increases in space activities to produce increases in demand and, therefore, decreases in unit costs.

And, finally, we might hasten our return to the Moon if we become a bit less cynical, a bit more mindful of the old maxims about preparing for tomorrow, and, in the process, manage to rediscover our old fascination with the frontier.

We shall see.

Whatever happens over the next few decades, the obstacles in our path are almost all financial and political. Given money and a mandate, it shouldn't - but might - take more than a decade to pick up where we left off with Apollo. The simple fact that six Apollo crews landed on the Moon and brought back a treasure trove of samples, data, and experiences means that the lunar base designers will have to deal with far fewer uncertainties than did the Apollo team. However, thirty-plus years - from the end of Apollo in 1972 to a restart in, say, 2002 - is a long time and, even if we wanted to reuse Apollo-era technology, little of it is left on the shelf.

We will need to redesign much of the flight hardware and surface equipment - partly to take advantage of the engineering advances of the 70's, 80's, and 90's, and partly to prepare for a very different mode of lunar operations. Apollo was designed to meet a challenging deadline for landing a first crew on the Moon. Cargo capacities were extremely limited and none of the crews stayed for more than three days. For the lunar base era, vehicles will have to be designed so that there can be regular deliveries of supplies and equipment and in quantities sufficient that crews can stay on the Moon for months at a time and learn how to put local resources to use.

Lunar base operations will be far more complex than those that were undertaken during Apollo but, if history is any guide, by building on the Apollo experience and by taking advantage of the considerable engineering advances of the intervening years, getting ready shouldn't be as difficult or expensive as Apollo.

As an example, we might note that, between 1937 and 1945, Von Braun and his coworkers spent approximately 2 billion US Wartime dollars designing and testing the V-2 rocket for the German Army. Although the V-2 wasn't much more effective than the Russian-designed Scud missiles fired by Iraq during the 1991 Persian Gulf War, the cost of developing the V-2 was surprisingly close - in inflation adjusted dollars - to the cost of developing the Apollo Saturn V. In addition to the intrinsic expense of developing any new technology, one very important cause of the high cost

of V-2 development was the simple fact that, at the time, there was no practical way to make more than a few basic measurements on any one test flight. When something went wrong - as it inevitably did in the years before engineers could use computers and sophisticated ground-test facilities to check out subsystems ahead of time - a series of test flights had to be conducted to pin down the source of a problem and to verify a fix. In all, the Von Braun team conducted several hundred test launches, most of them spectacular failures. Twenty-five years later, when Von Braun's team was designing the Saturn V, engineering design procedures and the art of telemetry had advanced to the point that only fifteen test flights (ten Saturn I's, three Saturn IB's, and only two Saturn V's) had to be conducted before the vehicle could be certified as safe enough to carry a human crew. Significantly, despite the enormous increase in complexity over the V-2, all of the test flights were successful; and, as well, the constant-dollar development cost was only about fifty percent greater than what Germany had spent on the V-2. Time brings new technologies and fresh insights and makes difficult engineering tasks far more tractable. going back to the Moon should be easier than going the first time - assuming that we haven't choked the space program in red tape before we can get started.

As I said at the beginning of this epilog, for much of the 20th Century humanity has been getting used to the idea of people traveling and working and, eventually, settling in space. For fully a fifth of that century, we have been slowly sifting through the things that we learned as a results of Apollo and, in the long run, it may be that we needed time to think about it all. Because of the extraordinary circumstances of the Cold War, Apollo was undertaken on a crash schedule and, as Arthur C. Clarke noted in an essay published the week of Apollo 11, too much happened too fast for anyone to properly appreciate what had been done and where all of it might lead. Had the space program developed more along the lines that von Braun outlined in the early 50's, by the time we were ready to go to the Moon, the program might have reached a stage of relative maturity comparable to, say, the state of aviation in the post-Lindbergh/Earhart years. As with the early stages of the Air Age, the Space Age was bound to have had a period of public fascination with "firsts". But once that phase had passed and the space program had settled down to a more-or-less orderly program of development, it might have been possible, then, to think of a lunar program as a natural next step - a lunar program complete with plans for a permanent research station of the Antarctic type and, most importantly, complete with modest expectations and a commitment to the long haul.

Instead, the first lunar landing came only eight years after Gagarin and, because it had all been so expensive, few saw a point in continuing. Most people were thinking in the

short term - about firsts and about races and about oldest rocks - and not about the long-term value of the Moon. Lunar operations were too expensive to continue, so why think about the long term?

Eventually, we will go back to the Moon to build a permanent base and to begin the crucial task of how learning how to "live off the land" and, later on, develop products and industries that will make lunar operations self-supporting. And, if Apollo was, perhaps, a step taken out of sequence, the important point is that we did have six successful landings and accumulated a wealth of samples, data, and experiences.

Because of Apollo, we know what most of the Moon is made of and have developed some ideas about how lunar materials could be put to use - first as a way of making lunar base operations more efficient and less expensive and, then, as raw materials for the construction and operation of space-based industries. And we know, as well, some of the tricks and some of the pitfalls involved in getting work done on the Moon.

We have a great deal to learn and great deal to do. But we have been to the Moon and can put that experience to good use as we prepare, sooner or later, to go back.

The Apollo 17 Lunar Surface Journal, Part 21 Acknowledgments and Bibliography

Many people contributed time, knowledge, skill, and support to this project, and I am pleased to acknowledge their contributions.

Janet Kovacevich, Joey Kuhlman, and David Portree of the NASA Johnson History Office introduced me to their collection of Apollo material even before Jack Schmitt and I began the review; over the years, they have provided answers to a number of obscure questions. Judy Allton, who works for the Lunar Sample Curator at NASA Johnson, provided essential information of the Apollo tools. Her little book is an key resource and, as well, the day we spent at Johnson looking at tools and crawling around the publicly-displayed Rover was a great help. Joe Kosmo, also at NASA Johnson, provided access to a cut-away version of an Apollo backpack and also gave me an opportunity to make a close inspection an Apollo suit that was being refurbished for public display.

Independently of the Journal project, Larry Haskins of Washington University undertook the monumental task of producing VHS copies of the Apollo video tapes and it was my great good fortune that Larry completed his work just about the time that the Journal was getting underway. Diana Ryan of the NASA Johnson Audio Office prepared a set of Apollo audio tapes for use in this review; and Carolyn Ng and the people of the photo group at the National Space Science Data Center at the NASA Goddard Spaceflight Center were of great help in assembling a collection of Apollo photographs. Except for those pictures taken during training, most of the original photographs were, of course, taken by the astronauts. The Team Leader for Apollo photography was Dr. Frederick J. Doyle. More recently, Paul Cohen and Gary Sealoff at Johnson used the imminent publication of the Apollo 17 Lunar Surface Journal as an excuse to begin scanning the Apollo photo collection and, with help from Kevin Marsh, graciously provided a complete set of the resulting digital data. Other individuals who provided information about Apollo 17 were Joe Allen; Max Ary; Ed Brisson; Ed Fendell; Terry Neal; Al Rochford; Lee Saegesser; Lee Silver; and John Young. Apollo 17 EVA CapCom Bob Parker helped clear up a number of mysteries. Claire Johnson, who is Gene Cernan's able assistant, contributed both encouragement and the vital information in her phone files. Dick Bull, a former test pilot, helped me puzzle out the checklists during the early stages of my education. Dorothy Uherka read an early draft of the introduction and made some valuable and much appreciated suggestions. Gerry Griffin, who served as Flight Director during the Apollo 17 EVA's read a final draft of the annotated transcript and help us correct a number of errors.

Permission to reprint the Joe and Willie cartoon was graciously given by Bill and Chris Mauldin.

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In the initial stages of the project, I simply could not have gotten started without the help of Kay Coen who got the optical scanner up and running and who then got me up to speed with the word processing programs with which the journal has been edited. Kay and Jody Heiken created a design for the text in the days when we were still thinking in terms of print publication; Yolanda Martinez did much of the optical scanning work; and Helen Smith did some of the interview transcription. Geri Martinez, Janet Harry, and Carol Mahan provided secretarial help with skill and enthusiasm. Mary Ann Olson helped with paste-ups of the panoramic sequences.

Andy Chaikin - who, in the process of researching his book, "Man on the Moon", had become a fellow aficionado of the detail - spent countless hours on the phone with me swapping war stories and tidbits. Andy saved me from numerous errors of fact and interpretation.

The success of Apollo was due entirely to the contributions of the thousands and thousands of people who worked on the program. Gene Cernan, Jack Schmitt, Ron Evans and the other Apollo astronauts insist that they were representatives of all of those people. Indeed, it is only because of the collective efforts of the entire Apollo team that we now know so much about the Moon and about living and working there. In part, Gene and Jack have devoted an extraordinary amount of time to the Journal because they believe that the long-term value of Apollo will be realized only to the extent that the experiences of the missions are accessible. Twenty-plus years after the fact, we all regret that time to do a journal was not taken long ago, when memories were fresher than they are now. However, we have found that, with the help of documentary material preserved and assembled over the years and with the help of other people who were intimately involved in the conduct of the mission, there are relatively few sequences in the transcript that still defy explanation.

The success of the Journal owes much to the patience that Gene and Jack showed when confronted with my ignorance. Repeatedly, they pointed out and explained subtleties in the dialog which I had missed. On occasion, research showed that they had mis-remembered certain facets of the mission; and they were always willing to re-examine those issues and to

make an honest effort to distinguish real memories from after-the-fact hypotheses. In most cases, we were able to resolve discrepancies to our mutual satisfaction and, always, it was their eagerness to thoroughly document the mission that gave us a chance to get it right. Without doubt, errors remain. However, we believe that, on the whole, the Apollo 17 Lunar Journal is an accurate record of the three days that Gene and Jack spent on the Moon. The Journal would have been much less than it is without their support, encouragement, and active participation.

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(Entries marked with an initial asterisk are background documents included in this CD-ROM publication of the Apollo 17 Lunar Surface Journal)

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*Apollo 17 LM Lunar Surface Checklist, Manned Spacecraft Center, Nov. 6, 1972, which contains the detailed checklists used by the crew while they were on the Moon but inside the Lunar Module. This checklist, together with the EVA cuff checklists, proved essential to an understanding of what was happening on a minute-by-minute basis.

*Catalog of Apollo Lunar Surface Geological Sampling Tools and Containers, Judith H. Allton, JSC-23454, March 1989, which contains photographs and detailed descriptions of the equipment used by the Apollo crews in collecting geologic samples.

*Apollo Stowage List, Mission J-3, CM-114/LM-12, Apollo 17, un-numbered NASA document issued by the Manned Spacecraft Center, December 14, 1971, which contains a detailed list of all items stowed on board both the Command Module and the Lunar Module.

*On the Moon with Apollo 17: a Guidebook to Taurus-Littrow, Gene Simons, NASA document EP-101, December 1972, which is a pre-flight introduction to the landing site and to the scientific activities that the crew planned to conduct.

Apollo 17 Cuff checklists - get the proper title et al
Lunar Sourcebook: A user's guide to the Moon, edited by Grant H. Heiken, David T. Vaniman, and Bevan M. French, Cambridge University Press, 1991, which is a collection of authoritative articles on the geology, geochemistry, and geophysics of the Moon.

Where No Man Has Gone Before, William David Compton, NASA SP-4214, 1989, which is an excellent, book-length history of Apollo, with special emphasis on the interactions - and sometimes conflicts - between engineers and scientists over the planning and conduct of Apollo.

To A Rocky Moon: A Geologist's History of the Moon, Don E. Wilhelms, University of Arizona Press, 1993, which is a history of lunar exploration told from the perspective of a geologist who participated in the pre-Apollo telescopic and robotic lunar mapping efforts, in the Apollo site selection process, in the astronauts' geology training. A well-written, fascinating book.

The Apollo Spacecraft: A Chronology (Volume IV), Ivan D. Ertel and Roland W. Newkirk, with Courtney G. Brooks, NASA SP-4009, 1978, which is a detailed chronology covering the design and construction of the Apollo hardware during the period January 21, 1966 to July 13, 1974.

Apollo: Expeditions to the Moon, edited by Edgar M. Cortright, NASA SP-350, 1975, which is a collection of articles outlining the history of Apollo and written by senior managers of the Apollo program and by some of the Apollo astronauts.

Others?

Apollo 17 Introduction, Part 22

Background Material and Supporting Documents

As mentioned previously, this CD-ROM publication of the Apollo Lunar Surface Journal contains an audio track and sufficient number of photographs, drawings, maps, video clips, and background documents that someone who is new to the Apollo experience can understand the rich detail of the mission.

Sharon: I presume that we can do a hypercard-type set up here where, if they want, they can go directly to the files of background material. It also occurred to me that, with regard to the audio tracks, we could have the software fill in an appropriate amount of dead air-time, and provide an icon that would allow the reader to skip directly to the next transmission. These icons would also allow readers to scroll forward in the text to the next spot that interests them and, once there, cue the appropriate audio.

70-mm Hasselblad still photographs

The Apollo 17 crew used 23 magazines of 70-mm film, of which 15 contain images taken on the lunar surface by Cernan and Schmitt. These 15 magazines contain 2396 images, including blanks, overexposed frames and 160 images taken by the crew in orbit.

Include my catalog of frames, with click-able icons so that they can call up images directly from the catalog and some sort of notation for the frames we don't include on the disk

Apollo 17 Video tapes

Unlike the first few missions, the Apollo 17 TV camera was stowed away until the crew deployed the Rover and mounted the TV camera on the vehicle. As on Apollos 15 and 16, this good-quality camera was operated remotely by Edward Fendell in Houston. This mode of operation allowed Houston to watch one or the other of the astronauts as they went about their activities or to do a television pan of a particular site. A total of over 12 hours of television transmissions were recorded during Apollo 17 and, recently, were collected together and converted to VHS format by Larry Haskins of the Department of Earth and Planetary Sciences at Washington University, St. Louis. Include over an hour of clips on this CD-ROM.

Include my catalog of the clips and provide icons so that the clips can be called up directly from the catalog.

Apollo 17 Lunar Surface Checklist

This checklist contains detailed procedures used by the crew while they were on the lunar surface in the LM.

Include an abbreviated catalog of the pages with icons that allow flipping through the checklist from the catalog

Apollo 17 Cuff checklists

These checklists were worn by the crew while they were out on the surface and contain procedures, sketch maps, and

general descriptions of the geologic tasks they were to perform during the EVA's. The checklists were bound with a spiral metal spine which, in turn, was attached to an aluminum wrist band. When an astronaut turned one of his checklist pages, the spiral binding held the page open against the metal wrist band.

Include an abbreviated catalog of the pages and include callable icons.

Apollo 17 Mission Report

This "quick look" summary of the mission was issued in March 1973 - about three months after the flight. It contains summaries of the surface activities and of spacecraft and surface equipment performance, a biomedical assessment, and engineering discussions of instances where individual pieces of equipment failed to operate as planned.

Include a table of contents from which a reader can call up mission report chapters

On the Moon with Apollo 17: A Guide Book to Taurus-Littrow

This pre-mission NASA publication was written by Gene Simmons, a former Chief Scientist at the Manned Spacecraft Center (now the Johnson Space Center) in Houston. At the time the mission, Simmons was a Professor of Geophysics at the Massachusetts Institute of Technology. The Guidebook contains a description of the landing site and of the Rover and the scientific equipment that the astronauts were to deploy. It also contains a summary of the science activities that Ron Evans was going to perform while orbiting the Moon and, as well, a summary of what was known about the Moon prior to Apollo 17.

Table of contents with callable icons

Catalog of Apollo Lunar Surface Geological Sampling Tools and Containers

This excellent compendium was written by Judith Haley Allton who, at the time of this writing in March 1994, was on the staff of James Gooding, the Lunar Sample Curator at the Johnson Space Center. Judy's tool book contains descriptions, drawings, and photographs of all the geology tools used by the Apollo crews and is essential to an understanding of the sampling operations.

Table of contents with callable icons

Descriptions of other background documents included in the CD-ROM