PEDRO MOUNTAIN DRILLING PROJECT, CARBON COUNTY, WYOMING

BENDIX FIELD ENGINEERING CORPORATION
Grand Junction Operations
Grand Junction, Colorado 81501

GEOLOGICAL SURVEY OF WYOMING

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CARBON COUNTY, WYOMING

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SUMMARY

The Pedro Mountain drilling project, which consisted of drilling a core hole to a depth of 2,197 feet in granite in Carbon County, Wyoming, was completed in May 1976. The major objective of this cooperative project between the U.S. Energy Research and Development Administration and the U.S. Geological Survey is furtherance of the evaluation of the Granite Mountains area as a potential source of the large uranium deposits in Tertiary sandstone in adjacent sedimentary basins.

The hole, with a planned depth of 2,500 or 3,000 ft, was drilled by Himes Drilling Company, the subcontractor, during the period from March 10 to May 7, 1976. Because of difficult drilling conditions, the coring was done in three stages - HQ to 75 ft, NQ to 1,974 ft, and BQ to 2,197 ft. Total core recovery was excellent, averaging 94.4 percent.

It was hoped that the hole could be drilled entirely in granite but altered diabase was encountered just beneath the alluvium and was the dominant rock type in the upper 122 ft. From 122 to 141 ft the hole penetrated pink to red granite. At 144 ft there was a transition to light-pink to light-gray granite, which persisted to 1,173 ft where altered diabase was cut. The hole remained in the diabase to 1,566 ft where it again penetrated granite, which was predominant to the bottom of the hole. Preliminary studies of the cores suggest that uranium leaching has occurred to total depth.

Geophysical logging was preformed by four organizations: Birdwell Division, Seismograph Service Corporation; Bendix Field Engineering Corporation - Advanced Technology Division; U.S. Geological Survey - Water Resources Group; and U.S. Geological Survey - Geophysical Group. Seventeen different logs were run in the hole and are now being studied. Preliminary indications are that the KUT (spectral-gamma) log is the most useful in evaluating holes of this type.

INTRODUCTION

LOCATION

The Pedro Mountain No. 1 core hole (PM-1) is approximately 53 miles southwest of Casper, in SE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 17, T. 27 N., R. 83 W., Carbon County, Wyoming (Fig. 1). Pedro Mountain is the name applied to the extreme eastern end of the Granite Mountains, a low range of hills composed primarily of granite of Early Precambrian age.

The site is on public domain in the Medicine Bow Resource Area of the Rawlins District of the Bureau of Land Management (BLM). Grazing rights in the area are under lease to Wheatland Farms.

PURPOSE

This cooperative project between the U.S. Energy Research and Development Administration (ERDA) and the U.S. Geological Survey (USGS) for the coring of granite in the Pedro Mountains is the outgrowth of an on-going USGS project: Uranium Source Rocks Studies -- Granitic Rocks. This project had concentrated its efforts in the Granite Mountains, Wyoming. The Pedro Mountains, an eastward extension of the Granite Mountains, are composed of Early Precambrian alkalic granite.

These Precambrian granitic rocks have been proposed as a source for uranium ore in the Crooks Gap, Gas Hills, Powder River Basin, and Shirley Basin uranium districts. Indirect evidence supporting this suggestion includes (1) proximity of the granite to the uranium districts, (2) indications that the granite was the source for the sedimentary rocks that form the hosts for the ore, and (3) uranium-lead isotopic data that demonstrate a uranium loss from the granite of approximately 20 g/ton or 80 percent since Cretaceous time.

PREVIOUS WORK

Previous work in the Granite Mountains has included analyses of cores from two drill holes (GM-1 and GM-2) near Jeffrey City. These drill holes penetrated biotite alkalic granite, a partly assimilated metamorphic xenolith, and thin zones of albitized granite. Several surface samples of alkalic granite and silicified-epidotized granite were also analyzed. There is isotopic evidence for uranium mobility for each analyzed rock type. Most samples have lost uranium, but a few portions of the core have gained significant amounts of uranium. Even the deepest samples (1,326 ft, 404.3 m) taken from the assimilated xenolith exhibit evidence of uranium loss.

Two distinct events, at the western end of the Granite Mountains, have been identified from whole-rock Rb-Sr and U-Pb geochronology: (1) formation of metamorphic rocks about 2,900 m.y. ago and (2) intrusion of the granite about 2,600 m.y. ago. Scant data for rock-mineral geochronology suggest another event at approximately 1,400 to 1,800 m.y. ago, but consistent ages have been obtained

R.03W.

Figure 1. Location map, Pedro Mountain No. 1 drill hole.

only at the eastern end of the Granite Mountains in the vicinity of the Pedro Mountains. These samples also have the largest percentage and amount of Cenozoic uranium loss. From this coincidence it may be inferred that Precambrian events influenced the apparent recent uranium mobility.

Several samples with widely varying thorium contents (1 to 70 ppm) have been analyzed in this study, but there is no well-defined relationship between percent uranium loss and present-day thorium content. However, there is a strong correlation between original thorium and original uranium contents. As a consequence of this relationship and the nearly constant percent uranium loss, there seems to be a strong correlation between a high thorium content and a large amount of uranium loss. Many surface samples from the Pedro Mountains contain more than 100 ppm thorium, but they were too intensely weathered to be useful for the detailed isotopic studies to test the amount of uranium loss.

The cooperative drilling project in the Pedro Mountains was proposed to provide material suitable for investigating (1) the maximum depth of uranium mobility, (2) the existence of an event 1,400 to 1,600 m.y. ago and its effect on current uranium mobility, and (3) the amount of uranium mobility in a granite with a high radioelement content. In addition, it was hoped that the drill hole would provide samples from which the original uranium distribution could be determined, and that the hole could be used as a test locality for calibration and interpretation of geophysical logs in crystalline rock.

HISTORY

Proposals to core as much as 3,000 ft of NQWL hole were sent out to prospective bidders on January 19, 1976. Bids were returned on February 10, 1976, and the contract was awarded to Himes Drilling Company of Grand Junction, Colorado, on March 5, 1976. Geophysical logging was conducted from May 10 to May 16, 1976, by U.S. Geological Survey, Bendix Field Engineering Corporation (BFEC), and Birdwell Division, Seismograph Service Corporation.

Site cleanup and rehabilitation was completed and inspected as satisfactory by Bureau of Land Management personnel on May 24, 1976.

ACKNOWLEDGMENTS

The project geologist was John Stuckless, U.S. Geological Survey; and the project engineer was T. J. Price of BFEC. U.S. Geological Survey geologists Myron Smith and Norman Lewis and BFEC geologists Scott Hesse and Joseph Dunagan were present throughout the project. The BFEC logging effort was evaluated by Michael Callihan; all data were collected by Robert Young.

DRILLING

One objective of this report is the description of the drilling procedures used in the Pedro Mountain project. The general procedures and problems involved are discussed below. Details such as bit size, mud pump pressure, casing type, hole deviation, and drilling mud characteristics are tabulated in Appendix A.

PRE-CORING PHASE

Move In and Setup

The rig left Grand Junction at 7:30 a.m., March 8, and arrived at the drill site at 11:30 a.m., March 9. The drill setup was completed at noon, March 10. The rig is shown on location in Figure 2.

Site Preparation

Leveling of the drill site was unnecessary. Two earth-type mud pits, each 5 ft wide, 12 ft long, and 8 ft deep, were dug with a backhoe.

Spud-In and Surface Casing

On March 10 at noon, the hole was spudded with a 6-3/4-in. tricone rock bit, drilling open-hole through the surface soil. At a depth of 11 ft, bed rock was reached and 11-1/2 ft of 4-in. I.D. casing was set.

CORING PHASE

First-Stage Coring

HQ coring (2.5 in. core diameter) was started at 11 ft in a closely fractured diabase, which caused frequent blocking of the core bit and resulted in some very short core runs. Because of the unstable nature of the formation, some of the side wall of the hole collapsed each time the core barrel was removed for bit change. This necessitated reaming the hole to the bottom with each new core bit, which commonly resulted in damage to the inner gauge of the bit. After an unsuccessful attempt was made to ream the hole with the 6-3/4-in. rock bit to enable 4-in. casing to be set through the highly fractured formation, the hole was cemented and rereamed to the original depth. This method worked satisfactorily and enabled the HQ coring to proceed to a depth of 75 ft, where the rock was less fractured; the HQ drill rod was then set as casing (3.065 in. I.D.) to a depth of 75 ft.

Second-Stage Coring

After the HQ casing was set, the core size was reduced to NQ (1.875 in.) and coring continued. Some drilling fluid was lost between 75 and 190 ft

Figure 2. Drill rig on location.

where a total loss occurred. Unsuccessful attempts were made to stop fluid loss by mixing wheat bran and drilling mud. Although circulation was lost, the core cuttings were carried out of the hole and into the fractured rock, thereby eliminating the possibility of a tight hole upon cessation of pumping. Progress was slowed by two fractured zones at 500 to 700 ft and 1,300 to 1,600 ft. In these intervals, the intensely fractured rock frequently blocked the core barrel, causing very short core runs.

Due to unstable hole conditions, drill-rod torque gradually increased to the point that a twist-off situation was possible. To stabilize the hole and regain circulation, the HQ casing was reamed to 175 ft, and the hole was cemented from 1,200 to 1,520 ft. As a result, hole conditions were improved, but all drilling fluid still was lost. NQ coring continued to 1,924 ft, where loose gravel-size granite fragments were intercepted. These fragments did not remain in place after being cored and fragments tended to fall into the hole during the coring operation with sufficient pressure to severely score the outside of the core barrel. To eliminate this problem, the hole was cased through this zone with the NQ drill rod (2.375 in. I.D.).

Third-Stage Coring

Following the setting of the NQ casing at 1,924 ft, the core size was reduced to BQ (1.43 in.) and coring continued to 1,936 ft. The hole was then reamed to the new depth and full circulation was regained. Coring was then resumed and continued without problems to 2,183 ft, where another altered zone was crossed. Here, the fractured granite deteriorated to rubble during drilling and made coring difficult. During this coring operation the hole was collapsing, which caused extreme drill-rod torque and excessive mud-pump pressure. At 2,190 ft, a white, very fine-grained material, which consisted almost wholly of montmorillonite and quartz squeezed up the hole for 5 to 10 ft when the drill rods were pulled for bit change. At 2,197 ft, no further progress could be made; therefore, the decision was made to abandon the hole.

OTHER CONSIDERATIONS

Work Schedule

Normal work schedule consisted of operating 24 hours per day, two shifts, for 10 days followed by 4 days break.

Weather

Temperature ranged from 0° to 30°F during the first two weeks with winds of 10 to 20 mph. Snow flurries occurred periodically throughout the project. The coldest chill factor during the project was estimated at -45°F.

Water Supply

Water was purchased from the Bureau of Reclamation representing the North Platte River Project, actual owners of the water resources of the North Platte River drainage system.

Geothermal Study

Dr. E. R. Decker, Associate Professor of Geology at the University of Wyoming, is performing a geothermal study. He requested the use of the core hole at completion of drilling and asked permission to install 1-1/4-in. pipe to the total depth for the purpose of taking temperature measurements during the next several months. His request to use the core hole and have the drilling subcontractor install the pipe was granted by Eugene W. Grutt, Jr., manager of ERDA, Grand Junction Office. The casing was cemented in place by Halliburton Oil Well Cementing Co. The 4-in. surface casing was cemented in place, and a screw-on locking cap was installed.

Completion

Cleanup and rehabilitation of the drill site was completed on May 22. A final inspection was made by the Bureau of Land Management May 24 and affirmative approval was given.

SUMMARY OF CORE LITHOLOGY

Immediately upon recovery, the core samples were studied and described. A preliminary description is presented below and summarized in Plate 1.

Drill hole PM-1 was collared in alluvium and intersected bed rock at a depth of 11 ft (3.4 m). From 11 to 121 ft (3.4 to 36.9 m) core samples are dominantly chloritized and intensively fractured diabase. Some short intervals of pink to red, coarse-grained biotite granite were recovered with the diabase. From 122 to 141 ft (36.9 to 43.0 m), the core samples consist of pink to red, strongly fractured biotite granite, similar to that recovered within the diabase. Both the red color and intense degree of fracturing of all granite recovered in the upper 141 ft (43.0 m) seem to be related to the intrusion or alteration of the diabase.

The character of the granite changes gradually in the interval 141 to 143 ft (43.0 to 43.6 m). The color changes from red to light pink and light gray; it remains coarse grained, but fractures become rare. This lighter colored competent granite persists from 143 to 199 ft (43.16 to 60.17 m). The amount of alteration of the granite increases again in the interval from 199 to 233 ft (60.17 to 71.0 m), and most granite recovered in that interval is strongly fractured and stained with limonite. The general appearance is similar to weathered granite with brassy biotite.

From 223 to 363 ft (71.0 to 110.7 m), the granite is generally light pink to light gray in color, coarse grained, and only slightly fractured. Minor amounts of finer grained biotite granite and a few thin pegmatites were also recovered. Some narrow zones near the bottom of this interval contain large (>1 cm) crystals of magnetite.

From 363 to 435 ft (110.7 to 132.6 m), core samples consist of medium- to coarse-grained chloritized diorite. Most core is intensely fractured and friable. Limonite staining is common. This dioritic zone is transitional with the granite at the top and bottom and therefore is interpreted

tentatively as a partly assimilated xenolith. From 435 to 524 ft (132.6 to 159.8 m), the core samples are dominantly medium- to coarse-grained biotite granite that is only slightly fractured or altered. One section of the core from 450 to 452 ft (137.2 to 137.8 m) contains more than 50 percent magnetite. The interval from 524 to 611 ft (159.8 to 186.3 m) consists of a mixture of strongly fractured diorite and granite. Chloritic alteration and limonite staining are common throughout this interval.

From 611 to 1,173 ft (186.3 to 357.6 m), the light-pink to light-gray biotite granite is generally coarse grained. In this interval, the granite consists of zones of moderately fractured fresh rock and zones of intensely fractured altered rock. Chlorite and biotite were noted in both zones, but chlorite is dominant in the closely fractured, limonite-stained samples. A few mafic segregations were recovered from this interval, and in some places the granite is somewhat pegmatitic. High concentrations of magnetite were also noted in a few pieces of core.

At 1,173 ft (357.6 m), the drill hole intersected a diabase dike at an angle of 10°. Core recovered to 1,566 ft (477.4 m) consists of altered diabase that is strongly fractured and chloritized. In a few places, the chloritized diabase contains small amounts of pyrite and veins of calcite.

From 1,566 to 1,994 ft (477.4 to 607.9 m), core samples generally are moderately fractured and consist of medium- to coarse-grained biotite granite that has minor chlorite and limonite staining. A few thin, heavily fractured and altered zones were intersected in this interval, as well as a thin zone of mafic gneiss and a few thin granitic pegmatites. A biotite gneiss with some calcite veins was also recovered from the interval between 1,994 to 2,008 ft (607.9 to 612.2 m).

Core samples recovered between 2,008 and 2,197 ft (612.2 to 669.8 m) are strongly altered medium- to coarse-grained biotite granite. The alteration seems to be of two types, possibly having two distinct ages. Some samples have been albitized, which may represent alteration at the time of the intrusion. At the bottom of the drill hole, most feldspar has been replaced by montmorillonite, which may have formed later in response to near-surface conditions.

DISCUSSION

At present it is not possible to assess how well the drilling of PM-1 meets the proposed goals of the project; however, several unforeseen benefits are now obvious. Two units, not found during surface work, were recovered in sufficient quantity to allow detailed geochemical and petrologic examination: montmorillonite-altered granite, and diorite inclusions in the granite. In addition, subsurface samples of diabase were not previously available for study.

The significance of the high-magnetite granite is unknown, but high-magnetite contents have been noted in the granite near the Little Man mine approximately 3 miles to the west. Anomalous magnetite content and associated slight uranium enrichment were also noted in drill hole GM-1. Detailed studies of the magnetite-bearing drill core from PM-1 may yield important clues for uranium exploration in other granitic terranes.

It can be inferred from results of previous drilling and from the strong degree of alteration of the granite from PM-1 that the maximum depth of mobile uranium may not be found. From preliminary analyses, it can be deduced that several zones in PM-1 contain anomalous amounts of thorium and potassium. Analyses of these samples should supply information about uranium mobility in granites that have high radioelement contents.

From megascopic examination of the drill core, it seems likely that much of it should be usable for identifying and evaluating the effect and extent of the postulated 1,600-m.y.-ago event. Furthermore if that event is related to the ubiquitous diabase dikes, the diabase core samples could provide valuable information.

This report is based on a preliminary examination of the cores. The U.S. Geological Survey will publish a more comprehensive report when all available analytical data have been received and evaluated.

GEOPHYSICAL LOGGING

As noted above, one objective of the project was collection of as much data as possible from the drill hole by using a variety of geophysical logging techniques. Both the U.S. Geological Survey and BFEC have logging capabilities, but neither is equipped to run the entire suite of logs deemed necessary for full evaluation. Accordingly, Birdwell was selected as sub-contractor for the additional services. The following logs were run in the hole; most are illustrated as indicated.

Birdwell Division, Seismograph Service Corporation

1. Directional Survey (Pl. 2)
2. Gamma-Ray Neutron (Pl. 3)
3. Density (Pl. 4)
4. Temperature (Pl. 5)
5. Three-Dimensional Velocity (Pl. 6)
6. Electric (Pl. 7)
7. Caliper (Pl. 8)

BFEC - Advanced Technology Division (ATD)

1. Resistivity
2. Caliper (Pl. 9)
3. Spontaneous Potential

4. Gross Gamma (Pl. 9)
5. Neutron-Neutron (Pl. 9)
6. Magnetic Susceptibility (Pl. 9)
7. Spectral-Gamma (KUT) (Pl. 10)

USGS - Water Resources Group

1. Resistivity
2. Resistance
3. Temperature
4. Caliper
5. Gamma
6. Acoustic
7. Gamma-Gamma
8. Spontaneous Potential
9. Epithermal Neutron

USGS - Geophysical Group

1. Induced Polarization

EVALUATION OF GEOPHYSICAL LOGS

KUT (Pl. 10)

The borehole was surveyed with a KUT (spectral-gamma) probe (Pl. 10) from 1,490 ft to the surface. Data were collected in the form of a digital tape, which provided equivalent percent potassium (K), ppm uranium (U), and ppm thorium (T). An analog recording was also made of gross-gamma counts per second. (A 60-ft interval was recorded with a backup KUT probe for experimental purposes and is not included in this report).

As noted above, the diabase and granite found in the borehole have a contrast in potassium content. The potassium (K) portion of the KUT log, when compared with the core description provided by the U.S. Geological Survey and Bendix, reflects this contrast. It can be discerned readily that granite has a relatively high potassium content and diabase a relatively low content. Near the top of the borehole from 10 ft to 110 ft, the alternating diabase and granite layers are graphically displayed on the potassium curve as alternating lows and highs. Farther down the borehole, from 378 to 398 ft, a diorite zone displays a very low potassium content as does the

diabase zone from 1,173 ft to 1,490 ft. The major granite zones, of course, produce the opposite response. It is evident that KUT logs offer considerable potential as a lithologic indicator in igneous rocks.

The thorium (T) curve also contributes to lithologic identification in this log. Upper diabase zones between 10 ft and 110 ft are depleted in thorium in contrast to the alternating granite zones. The diabase zone from 1,173 ft to 1,409 ft is also low in thorium, when compared to the thick granite zone lying just above it.

The uranium (U) portion of the KUT log displays several prominent zones of low uranium content, where uranium leaching could have occurred. These zones include 198-210 ft, 218-225 ft, 785-800 ft, 810-823 ft, 860-875 ft, 970-980 ft, and 1,025-1,050 ft. All these zones occur in granite, and none are found in any other rock types. If it is assumed that the radioactive minerals were distributed somewhat homogeneously during emplacement or anatexis of the granite bodies, then these anomalously low uranium values could represent leached areas. However, this determination cannot be made until radiometric and chemical analyses of the core are completed and made available. There is also a significant enrichment in uranium in the 1,175- to 1,200-ft interval, which probably represents addition of uranium to the diabase from the granite.

Caliper (Pl. 9)

The caliper log was run from 1,510 ft to the surface and indicates borehole sizes ranging from 3.1 in. to 8.0 in. These data were used to provide borehole size corrections to the KUT log, and in the future it will be used to correct other downhole logs. The N-N log is particularly susceptible to deviations in hole size. The caliper log is a good indicator of washed-out zones that correlate with fractured zones described in the U.S. Geological Survey-Bendix core description.

Neutron-Neutron (N-N, Pl. 9)

Neutron-neutron data were collected from a depth of 1,502 ft to the surface at 20 K cps maximum scale setting. When evaluating the N-N log, it should be noted that the core description provided by U.S. Geological Survey-Bendix mentions frequent and extensive fracturing of the rocks traversed by the borehole. Also, during the drilling process, circulation could not be maintained virtually from the outset. Because the N-N log responds primarily to the amount of hydrogen in a granite environment, it is a good indicator of the fractured zones where fluid losses resulted in lost circulation. In this regard, the N-N log corresponds very well with the caliper log, which indicates fractured and washed-out sections of the borehole. In each place where the caliper shows an increase in hole size, the N-N shows a corresponding decrease in neutron counts.

Magnetic Susceptibility (MS, Pl. 9)

A magnetic susceptibility survey was logged from 1,502 ft to the surface at a sensitivity of 267 micro-centimeter-gram-second (μ gcs) units per inch.

No negative anomalies are shown on the log but positive anomalies are abundant. The positive anomalies are substantiated by the U.S. Geological Survey-Bendix core description which cites the magnetic zones in detail. Because large amounts of lubricant were used during the core-drilling process, it is not likely that metal contamination is as much of a factor as it has been in past projects.

Gamma-Electric

A gamma-electric survey was run from 1,502 ft to the surface. The gross-gamma portion of the log performed normally and provided data indicative of downhole conditions. However, because of the large amounts of lubricant (Black Magic) that were used during the core-drilling process, a highly resistive environment was artificially produced in the borehole. This effectively rendered the resistivity and spontaneous potential curves useless; therefore they are not included.

Geophysical Instrument Performance

All downhole probes and associated electronic equipment performed admirably during the project and provided data indicative of downhole conditions. The only failure was the magnetic susceptibility probe provided by the U.S. Geological Survey.

CONCLUSIONS

Before a definite conclusion can be drawn, it will be necessary to compare the geophysical data presented here with complete chemical and radio-metric analysis of the core. If the evaluation of the KUT log corresponds with that analysis, the KUT log could be valuable in the evaluation of crystalline (granitic) rocks. Although analysis of the data still must be refined, the KUT log could provide a means for exploring granitic rocks for their potential as uranium source rocks without core drilling. This could be accomplished by refining methods of lithologic determination using potassium and thorium curves and of identifying leached zones utilizing primarily the uranium curve.

The other logs run provided good amplifying information for the KUT log. The magnetic-susceptibility log indicated the presence of magnetite, found only in the granite, thereby offering further lithologic information. The caliper log shows deviations in hole size in possible fracture zones and will be used extensively in the future as a primary log to correct other logs for deviations in hole size.

APPENDIX A. ADDITIONAL DRILLING DATA

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APPENDIX A. ADDITIONAL DRILLING DATA

Additional information pertaining to the drilling operation in the Pedro Mountain No. 1 hole are presented below:

OPERATING TIME

46 days drilling and coring

7 days logging

22 days break

AVERAGE BIT LIFE

44.83 feet

BITS USED

1 - 3-3/4 in. tricone roller rock bit

2 - HQ diamond bits

38 - NQ diamond bits

9 - BQ diamond bits

TYPE AND SIZE BITS

6-3/4 in. tricone roller rock bit

HQ (2.5 in. I.D. x 3.78 in. O.D.)

2 step

40 carats per bit

40 stones per carat

standard water course

NQ (1.875 in. I.D. x 2.98 in. O.D.)

5 step

25 carats per bit

60 stones per carat on the face

APPENDIX A. (continued)

TYPE AND SIZE BITS (continued)

40 stones per carat on the step
standard water course
BQ (1.43 in. I.D. x 2.36 in. O.D.)
4 step
15 carats per bit
60 stones per carat on the face
40 stones per carat on the step
standard water course

BIT PRESSURE

HQ - 2.5 lbs. to 5 lbs. per stone (1,600 stones/bit)
NQ - 4 lbs. to 12.5 lbs. per stone (1,250 stones/bit)
BQ - 5 lbs. to 13.5 lbs. per stone (750 stones/bit)

MUD PUMP PRESSURE

85 to 150 P.S.I.

REAMER SHELLS USED

1 - HQ
2 - NQ
1 - BQ

REAMER SHELL SIZES

HQ - 16.5 carats per reamer
25 stones per carat
NQ - 11.5 carats per reamer
25 stones per carat

APPENDIX A. (continued)

REAMER SHELL SIZES (continued)

BQ - 7.5 carats per reamer

30 stones per carat

CASINGS USED

15.5 ft, 4 in. I.D. (surface pipe cemented in place)

175 ft HW

1936 ft NQ

CASING SHOES USED

1 - HQ

1 - NQ

CASING RECOVERED

175 ft HW

1936 ft NQ

DRILLING MUD AND ADDITIVES

American Mud Products

Red Devil Gel

Mud Lub Drill Aid 405

Surf drill

Amvois (drill-rod lubricant)

Black Magic

APPENDIX A. (continued)

CORING

<u>Depth (ft)</u>	<u>Date (1976)</u>	<u>No. Core Runs</u>	<u>Core Recovery (%)</u>	<u>Drift (degrees)</u>
Start	3/10	..	..	..
0-100	3/14	29	95	1
100-200	3/15	17	96	1.5
200-300	3/16	16	94	1.5
300-400	3/17	13	88	1.5
400-500	3/18	19	89	2
4-day break	3/18-3/21			
500-600	3/22	26	94	2.5
600-700	3/25	24	97	4
700-800	3/26	18	95	4
800-900	3/27	17	89	4.5
900-1000	3/28	15	96	3.9
1000-1100	3/29	17	95	4.5
1100-1200	3/30	14	96	5.75
1200-1300	3/31	20	98	5
4-day break	4/2-4/5			
1300-1400	4/6	25	98	5
1400-1500	4/8	24	98	5.5
1500-1600	4/14	33	95	5.5
4-day break	4/16-4/19			
1600-1700	4/20	24	91	6
1700-1800	4/21	20	98	6
1800-1900	4/23	18	97	7.5

APPENDIX A. (continued)

CORING (continued)

<u>Depth (ft)</u>	<u>Date (1976)</u>	<u>No. Core Runs</u>	<u>Core Recovery (%)</u>	<u>Drift (degrees)</u>
5-day break	4/26-4/30			
1900-2000	5/2	21	92	7.5
2000-2100	5/4	21	95	8
<u>2100-2197</u>	5/7	26	<u>91</u>	
Average			94.4	