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**INVESTIGATION OF THE GEOKINETICS HORIZONTAL IN SITU
OIL SHALE RETORTING PROCESS**

Quarterly Report for January—March 1980

By
David L. Hutchinson

May 1980
Date Published

Work Performed Under Contract No. FC20-78LC10787

Geokinetics Inc.
Concord, California

MASTER

U. S. DEPARTMENT OF ENERGY

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INVESTIGATION OF THE GEOKINETICS
HORIZONTAL IN SITU OIL SHALE
RETORTING PROCESS

QUARTERLY REPORT

JANUARY, FEBRUARY, MARCH, 1980

by

DAVID L. HUTCHINSON

GEOKINETICS INC.

280 Buchanan Field Road
Concord, CA 94520

Date Published - May 1980

PREPARED FOR THE UNITED STATES DEPARTMENT OF ENERGY
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SUMMARY

Geokinetics Inc. (GKI) continued the recovery of shale oil from Retort #18. The retort produced 3,479 barrels of oil during the quarter for a total of 4,528 barrels to date. The burn front advanced at a rate of 0.8 feet per day. A persistent leak developed from a surface fracture near the air injection wells and required constant sealing and tamping to minimize gas leakage.

Chromatographic analyses of Retort #18 shale oil by the GKI analytical laboratory indicated some variation in the oil from the wells near the air-in end of the retort and oil from the air-out end of the retort; samples from the air-out end are lighter oil than those from the other end. This is probably due to condensation of light oil mist through the retort.

Representatives of GKI, the U.S. Department of Energy/Laramie Energy Technology Center (DOE/LETC) met to discuss the use of shale oil at Plateau's Roosevelt refinery. Shale oil has been blended with Altamont crude (the refinery's normal feedstock) in concentrations of 0.1 to 1.0 percent shale oil by volume. The distillation, API gravity, pour point, flash point, Naptha and Cat Gas were not affected by the shale oil. The diesel off the crude unit changed from water white to yellow, however and a fine grayish-brown precipitate formed. Preliminary arrangements were made for Plateau to conduct additional blending using GKI shale oil; DOE/LETC will then analyze a sample of the feedstock and all products. Efforts to develop methods for eliminating the precipitate will continue.

Substantial effort went into the preparation of applications for various environmental permits. GKI worked closely with VTN Consolidated to finalize the Prevention of Significant Deterioration (PSD) permit application. GKI worked with the State of Utah and consultants to develop plans and permit applications needed for deep-well disposal of retort wastewater. Design of a large evaporation pond to handle wastewater from Retort #24 is also underway.

Re-entry drilling was performed on Retorts #21, #22 and #23 during the quarter; tracer tests were run by Sandia Laboratories on Retorts #19, #21, #22 and #23. Blasthole drilling began on Retort #25.

GKI met with DOE/LETC, Sandia Laboratories and blasting consultants to discuss instrumentation and finalize plans for Retort #25. The retort will be similar to Retort #24, with refinements to improve breakage in the lower portion of the retort. The Retort #25 blast design incorporates an increase in the overall powder factor, a modified delay between initiation round and "W" row detonation and bottom priming instead of top priming in blastholes.

Arrangements were made by DOE/LETC for the loan of two 700 kilowatt (KW) electric generators from the U.S. Department of Defense (DOD). These larger generators are necessary for the five-fold scale-up to commercial prototype Retorts #24 and #25. The generators are expected to be delivered to the field site during the next quarter.

STATUS OF MAJOR TASKS AND SIGNIFICANT ACCOMPLISHMENTS

SITE PREPARATION:

Locations and depths for re-entry holes on Retorts #21, #22, #23 and #24 were determined. Air-in, air-out, production and observation wells on Retorts #21, #22 and #23 and three production wells on Retort #24 were surveyed and flagged for re-entry drilling. Retort locations are shown in Figure 1.

The coordinates and elevations for the post-blast core holes on Retort #24 were determined by survey during the quarter. The core hole locations are shown in Figure 2.

The ground for Retort #25 was cleared of brush. Blasthole locations for Retort #25 were surveyed in and a detailed level survey was completed. Collar elevations of the blastholes and elevations of intermittent and surrounding surface grid points were determined. The completed pre-blast topographic map was then forwarded to blast consultants for use in blasthole depth calculations.

No exploratory geological work was conducted during the quarter and no exploratory core holes were drilled or assayed.

DRILLING AND BLASTING:

Evaluation of the blast of Retort #24 continued during the quarter, as did design work for the blasting of Retort #25. A major difference between Retorts #24 and #25 is an average of 10 feet of additional overburden on Retort #25. Sandia Laboratories will instrument the Retort #25 blast and continue to work with GKI to prepare for the blast.

Blasthole drilling on Retort #25 began in March. The drilling is being performed by GKI personnel using the Chicago Pneumatic CP-650 drill rig. The location of Retort #25 is shown in Figure 1.

RE-ENTRY DRILLING:

Two observation wells were drilled on Retort #19 for use in tracer tests by Sandia Laboratories. The wells were designated OB-Tracer #1 and OB-Tracer #2 and were drilled to depths of 95 feet and 100 feet respectively. Both wells were cased with 6-5/8 O.D. steel casing which was perforated from the bottom of the hole to 35 feet from the surface. The locations of these tracer observation wells are shown in Figure 3.

Retort #19 production well PW-6 was improved in January to enable the use of a two-inch working barrel. The casing was pulled and the well was redrilled to a depth of 92.6 feet. The 9-1/2 inch diameter hole was then recased with 6-5/8 inch O. D. steel thinwall casing. The bottom 15 feet of casing had four columns of six-inch perforations spaced

six inches apart. A packer was placed five feet above the top of the perforations. The same procedure was planned for PW-5 on Retort #19, but the casing could not be removed so another production well was drilled. The new well, designated PW-5A, was cased in the same manner listed above for PW-6. The locations of the production wells on the retort are shown in Figure 4.

Re-entry drilling was also performed on Retorts #21, #22 and #23 during the quarter. The CP-650 drill rig was used to drill the eight-inch holes. The air-in (AI), observation (OB), and production (PW) wells were drilled and the respective hole depths are listed below:

<u>Retort #21</u>		<u>Retort #22</u>		<u>Retort #23</u>	
AI-1	59.2 feet	AI-1	55 feet	AI-1	68.4 feet
AI-2	58.4 feet	AI-2	55 feet	AI-2	67.8 feet
PW-1	69.5 feet	AI-2A	56 feet	PW-1	79.1 feet
PW-2	76.2 feet	AO-1	70 feet	PW-2	86.9 feet
OB-1	66.3 feet	AO-2	70 feet	OB-1	76.1 feet
OB-2	69.3 feet	PW-1	70 feet		
		PW-1A	68 feet		
		PW-2A	76 feet		
		OB-1	61 feet		
		OB-2	67 feet		
		OB-3	67 feet		
		OB-4	73.5 feet		

Re-entry air, production and observation well locations for Retorts #21, #22 and #23 are shown in Figures 5, 6 and 7, respectively. The above re-entry holes will facilitate water level drawdown and tracer studies by Sandia Laboratories, and the holes were completed to Sandia's specifications.

An air-flow increase of 78 percent was achieved at Retort #22 air-in well AI-1 as a result of well stimulation efforts in February. The casing in AI-1 was raised 1.2 feet with the use of a bulldozer and then sprung with a small explosive charge. Examination of the well bore using a Sandia Laboratories down-the-hole camera showed an enlarged cavity at the bottom of the hole with a large vertical notch two feet off the bottom. Similar attempts to improve air flow at AI-2 were less successful.

RETORT PROCESS FACILITIES:

Net air flow at Retort #18 air-in wells AI-1 and AI-2 was increased by 14 percent in February. Both wells were sprung with two sticks of dynamite and blown out using a 750 scfm air compressor to remove ash, drill cuttings and other loose sediment. The holes were then sprung again using four sticks of dynamite. Retort #18 air, production and observation well locations are shown in Figure 8.

Later in the quarter, a down-the-hole casing ripper was constructed to perforate (slot) air hole well casings in order to increase air

flow. The device was used successfully on Retort #18 air-out wells AO-4 and AO-6.

The wiring of Retort #18 thermocouples into the WestAq data recording system was completed during the quarter. Retort #18 thermocouple well locations are shown in Figure 10. The system has functioned properly and plans were made to interface Retort #19 thermocouples with the data recorder.

Design of the thermocouple data recording equipment for Retort #19 was nearly complete by the end of the quarter. Thermocouple lengths and distribution on the retort were calculated based on the expected burn front configuration. Re-entry instrument well locations on Retort #19 are shown in Figure 3.

An improved air-out manifolding system for Retort #19 was designed. The system utilizes less piping and materials, yet provides for increased mist collection capability.

Fabrication and installation of Retort #19 process facilities began in January. Six production pumps were set in place and retort dewatering was initiated. Fluid level monitoring was conducted to assess drawdown rates, void distribution and fluid communication in the retort. Later in the quarter production wells PW-5 and PW-6 were sprung with small explosive charges in order to increase fluid communication between the retort and well bores. Success was more evident for PW-5 than PW-6. The locations of Retort #19 re-entry air, production and observation well locations are shown in Figure 4.

Air injection and mist elimination equipment for Retort #19 were constructed and blowers were mounted on skids for placement on the retort.

Significant air flow increases were achieved at Retort #19 air-out wells after well casings were slotted with the down-the-hole casing ripper in February.

Preparation of Retort #22 and related process equipment continued during the quarter. Pumps were installed in production wells and activated to dewater the retort for Sandia's tracer tests, so air flow tests could be run and to allow observation of fluid drawdown characteristics. Retort #22 production well locations are shown in Figure 6.

In addition, Retort #22 well flanges were welded, blowers mounted on skids and orifice runs and bypasses were installed on the blowers. Construction of an afterburner for the retort was also underway.

A used 300 horsepower (HP) blower and three 75 HP blowers were purchased and received during the quarter. These blowers will enable testing of higher air flows on the larger retorts.

RETORT BURN:

Retort #18 continued to burn throughout the quarter and had burned for 140 days at the end of March. Re-entry well locations and the retort surface facilities are shown in Figures 8, 9 and 10.

During this quarter Retort #18 burned 91 days. The burn front advanced approximately 75 feet during the quarter, from the third row of thermocouples in January to 45 feet from the air-out wells at the end of March. Thermocouple data indicated some tonguing of the burn front along both sides (the north and south edges) of the retort.

The Retort #18 oil production rate increased by 27 percent and water production decreased by five percent in January after air injection rates were increased by 25 percent early in the quarter. Air injection blowers were operated at full capacity from January 8 through January 24, 1980. At that time two additional blowers were temporarily installed on Retort #18 air-in wells AI-1 and AI-2 to test higher air injection rates. Air injection rates were increased by 20 percent but did not result in a corresponding production increase.

Increases in the Retort #18 oil production rate and fire front advance rate were observed in March. These increases appeared to be related to improved air-out vacuum capability achieved after air-out wells AO-4 and AO-6 were slotted with the down-the-hole casing ripper in February; air-out flow was increased by approximately 180 percent. The air-out flow increases likely resulted in a faster rate of fire front advance and the corresponding increase in the oil production rate.

It was noted in March that gases from Retort #17 (the burn of which ended December 10, 1979) were apparently being drawn into Retort #18 as a result of increased air-out vacuum. The analytical laboratory had been measuring the hydrogen sulfide (H_2S) concentration in retort off gas to determine the amount of sulfur entering the atmosphere from the burner. Coinciding with the increased air-out vacuum at Retort #18 air-out wells, a definite increase in H_2S concentration was noticed. There was no increase in oxygen (O_2) in the off gas or any other change that should have increased the sulfide concentration.

The H_2S concentration of the gas within adjacent Retort #17 was measured and found to vary from 1-1/2 percent to four percent depending on the location within the retort. The high sulfur content of the gas in the spent retort was due to retorting by residual heat in the absence of air. It was suggested that gas was being pulled from Retort #17 to Retort #18 through cracks in the rock between the two retorts by the increased suction at Retort #18 air-out wells. To check this possibility, gas samples were taken from Retort #18 air-out wells AO-4, AO-5 and AO-6 and measured for H_2S concentration (AO-4 being closest to Retort #17 and AO-6 being further away). The test showed concentrations as listed below:

RETORT #18

A0-4	1,960 ppm	H ₂ S
A0-5	1,220 ppm	H ₂ S
A0-6	630 ppm	H ₂ S

These figures provide evidence that the excess sulfide measured at Retort #18 was indeed being pulled from Retort #17 through cracks between the two retorts. If the communicating cracks are close together, the H₂S concentration would be expected to decrease sharply as the fire front passed the cracks. Later analyses confirmed this as H₂S concentrations declined to normal levels as the burn front advanced.

Representatives of GKI, DOE/LETC, Sandia Laboratories and Lawrence Livermore Laboratory (LLL) met in March to discuss GKI retort operations, research results and ongoing tests, and plans for future retorts including data collection and analyses.

Recent shale oil testing and evaluation by LLL was summarized. Oil may be lost due to coking, cracking and combustion. For in situ retorts, cracking loss is small, while coking and combustion losses may be high. The local oil yield is equal to the product of a coking factor and a combustion factor. The coking factor is inversely proportional to the 1-alkene/n-alkane ratios (C₈-C₁₂). The combustion factor is inversely proportional to the NC₁₁+NC₁₂/naphthalene ratio. Using this method, LLL calculated a production of 55 percent for Retort #17. This agrees well with the 50 percent actual recovery from Retort #17. The measurements were done on five shale oil samples provided to LLL for analysis. The samples were taken at approximately one month intervals, and analysis was performed using a gas chromatograph with a capillary column. The GKI analytical laboratory could conduct this type of oil analysis with a gas chromatograph fitted with a capillary column, which would be useful to evaluate changes in oil recovery with retort operating parameters.

Using the gas analyses from Retort #17, LLL calculated a 44 percent oil recovery and reported that the ethene/ethane ratio works well as a retorting indicator at high SGV, but loses accuracy at low flow rates.

The following suggestions were made by LLL personnel at the meeting:

1. Using computer interface to handle data from Retort #22 (which will be instrumented by Sandia). LLL would then manipulate the data stored on the computer tape.
2. Analysis of shale oil with respect to time, in order to observe changes in retort operation with amount of retort burned.

3. Analysis of mist oil by gas chromatography as a rapid evaluation of process control.

The meeting provided a method to rapidly assess retort conditions and yield from oil and/or mist analysis. Gas analysis is rapid but so complex that it may only be used for a few retorting parameters (such as oxygen, carbon monoxide, carbon dioxide, hydrogen and nitrogen) and for specific purposes (such as oxygen consumed or carbon monoxide and carbon dioxide produced).

Observations throughout the burn of Retort #18 have indicated the rate of oil and water production changes abruptly during or immediately following a period of snow melt. Water production increased sharply during run-off periods due to the influx of water to the retort. Oil production decreases during periods of increased run-off. This trend may be the result of variations in the elevation of the oil/water interface with the retort. The oil/water interface level should rise as water influx occurs. If the interface level exceeds the elevation of the down-hole pump, the majority of the fluid pumped would be water. This may explain the oil/water production trend during periods of high run-off.

The results of GKI retort off gas analyses and carbon monoxide monitoring were reported monthly during the quarter. A reduction of retort surface gas leakage was achieved after Retort #18 air-out wells A0-4 and A0-6 were slotted in February, resulting in improved vacuum capability. Physical surface sealing techniques (e.g., tamping and mud packing) were implemented when the presence of CO was noted above the retort or when surface leakage was evident. A persistent surface leak developed from a fracture near the air injection well and required constant attention to minimize gas leakage.

OIL PRODUCTION AND HANDLING:

Oil recovery from Retort #18 was 4,528 barrels at the end of the quarter. The retort operation produced 1,239 barrels of oil in January; 974 barrels in February; and 1,266 barrels in March (corrected figures), for a total of 3,479 barrels during the quarter. The daily production rates averaged 38 barrels per day during the three-month period.

Another 3,000 barrel capacity oil storage tank was constructed and put into use. Approximately 5,000 barrels of shale oil were in storage at the end of March. No shipments of oil were made.

Representatives of GKI, DOE/LETC and Plateau, Inc., met during the quarter to discuss the use of shale oil at Plateau's Roosevelt refinery. Shale oil has been blended with Altamont crude (the refinery's normal feedstock) in concentrations of 0.1 to 1.0 percent shale oil by volume. The distillation, API gravity, pour point, flash point, Naptha and Cat Gas were not affected by the shale oil. The diesel from the crude unit changed from water white to yellow; however, and a fine grayish-brown precipitate formed. Preliminary arrangements were made for

Plateau to conduct additional blending using GKI shale oil. DOE/LETC will then analyze a sample of the feedstock and all products. Efforts to develop methods for eliminating the precipitate will continue.

Chromatographic analyses of Retort #18 shale oil samples collected in January were completed by the GKI analytical laboratory. The results are indicated in Appendix A. The analyses of these samples do not indicate any large variations in the composition or ratios of components in the samples from the beginning of the month to the end. There is some variation in the oil from the wells near the air-in end of the retort and oil from the air-out end of the retort. The oils from the air-out end are lighter than those from the other end. This is probably due to condensation of light oil mist through the retort.

GKI obtained the results of gradient elution chromatographic analyses and distillation tests performed on samples of shale oil and Altamont crude sent to the University of Utah by GKI and Plateau in 1979. The results are attached as Appendix B. GKI arranged for the analyses as a part of cooperative efforts to determine the cause of incompatibility when shale oil is blended with Altamont crude.

Shale oil samples were sent to several Utah refineries which may be outlets for the oil. A 20-gallon sample of shale oil was sent to Hydrocarbon Research, Inc., for upgrading studies.

POST-BLAST AND POST-BURN EXAMINATIONS:

Discussions between GKI and DOE/LETC continued regarding a post-burn core sampling program on Retort #16. The DOE/LETC proposed program would operate under an interagency agreement with the U. S. Environmental Protection Agency (EPA). The plan calls for sampling, by coring, to produce 18 or more cores representing the burned horizons plus an exterior core representing the same horizons in an unburned state. In addition, one core will be cut to sample the overburden over the center of the retort. These cores will be logged and described as they are cut, and examined for combustion indicators and fractures as they are recovered.

The cores will be described in detail and examined visually and instrumentally for organic residue to derive flow and burn patterns. Several cores will be selected for mineral profile development by X-Ray diffraction. These mineral profiles will describe the high temperature mineral products which result during in situ combustion of oil shale and will be compared with the X-Ray diffraction mineral profile of the same section in a raw shale core. Part of the cores will be furnished intact to EPA for leaching tests.

GKI has already surveyed and staked the proposed core hole locations and constructed boxes for core sample preservation.

Tracer tests were run on Retort #19 by Sandia Laboratories personnel to assess retort fragmentation and void distribution. Preliminary evaluation of the results indicated breakage and void

distribution as expected in the upper portion of the retort, with fragmentation but limited void in the lower part of the retort.

Natural gamma radiation logs were run by Sandia Laboratories on Retort #23 and #24 post-blast core holes and on Retort #24 air-in holes. Retort locations are shown in Figure 1; post-blast core holes in Figures 2 and 11; and Retort #24 air-in holes in Figure 12.

Breakage analysis of Retort #24 using post-blast core data continued during the quarter. A final folded stratigraphic section and a simplified folded breakage section from the core holes were completed. Surface fractures and voids created by the Retort #24 blast were mapped by plane table survey to determine any unique physical characteristics of the surface heave at the initiating round. Retort #24 post-blast heave contours are shown in Figure 13.

SEPARATE EXPERIMENTS:

Retorts #21, #22 and #23 were dewatered for tracer tests by Sandia Laboratories. Fluid levels and drawdown rates were monitored.

Tracer studies were conducted by Sandia on Retorts #21, #22 and #23.

ENVIRONMENTAL RESEARCH:

GKI continued working with VTN Consolidated consultants on the preparation of a PSD permit application for the research program. A pre-application meeting with EPA was held in February and attended by representatives of GKI, VTN, DOE/LETC and EPA. GKI submitted to EPA a document entitled "Emissions Inventory and Preliminary Assessment for Determination of PSD Applicability." The following determinations were made at the meeting:

1. GKI will need a PSD permit before Retort #24 is ignited;
2. The document submitted would suffice as the PSD permit application if GKI includes a cover letter that answers additional questions to be presented by EPA;
3. GKI could use the ambient air baseline data that has been previously obtained for the Federal Prototype Oil Shale Leasing Program Tracts U-a and U-b environmental studies; and
4. Due to low overall emissions, EPA would probably not require GKI to utilize additional control equipment during the R&D program, but would require periodic monitoring of emissions.

Preparation of the application for an Underground Injection Control (UIC) permit continued during the quarter and neared completion in March. If this permit is obtained from the State of Utah, GKI will be allowed to dispose of retort water into a suitable geologic formation

via a waste disposal well. A consulting petroleum geologist assisted GKI in obtaining and interpreting geological baseline data consisting of electric logs and "Scout" tickets of various deep holes drilled by petroleum companies in the vicinity of the GKI operation. The proposed disposal well surface location is underlain by the following, in descending order: the lower portion of the Green River Formation consisting of marlstone, tight siltstones and thin oil shales; the Wasatch Formation which is composed of shales, tight siltstones and lenticular sandstones; the Mesaverde Formation consisting of correlatable sandstones and shales; and the Buck Tongue shale.

The most favorable injection area is a 1,500 foot zone in the Mesaverde Formation with a total of approximately 400 feet of 15 percent porosity sandstone. The base of the zone is approximately 5,300 feet below the surface. The formation is bounded by a thick shale sequence at the base of the Wasatch Formation and the very thick Buck Tongue shale at the base of the Mesaverde Formation. The zone was selected for injection for the following reasons: the average salinity of the formation waters within the zone is well above EPA standards for potable water; the migration trend of the injected effluent water in this zone can be projected with some degree of accuracy because of the correlatability of the sandstones; no contamination of usable potable formation waters would result; and no detrimental effect on known petroleum producing horizons would occur.

Pretreatment of the effluent waters prior to injection will most likely be necessary. This would include the addition of chemicals to prevent corrosion of the injection system, to prevent scaling and bacterial growth which would otherwise result in clogging in the injection formations; and to remove excess emulsified oil and grease which would otherwise clog injection formations. An injection well casing program was devised to protect shallow fresh waters in the Wasatch Formation. The completion of the well will include pressure devices to detect any casing failures or leakage of effluent water through the casing.

A visit was made to observe an operating wastewater injection well. Surface facilities included two 1,500 barrel tanks used for storage and pretreatment; two 250 HP electric pumps; miscellaneous piping; electronic tank fluid level monitoring devices; electronic devices to prevent the accidental injection of oils down the bore hole; injection volume meters; injection pressure devices; and pressure monitoring devices to detect down-hole casing failures. A small evaporation pond had been built to handle any overflows and a building housed the pumps and all data monitoring and recording instrumentation. The aerial extent of the surface facilities was approximately two acres. The estimated cost of the surface facilities, when built several years ago, was \$150,000 - \$200,000.

Design of a large evaporation pond to handle wastewater from Retort #24 is also underway.

GKI met with Utah Division of Environmental Health personnel to discuss air quality, hydrology programs, future research and development plans and related permits. Written confirmation that GKI had met all requirements of Utah State antiquities regulations was received in January.

GKI met with representatives of DOE/LETG to discuss the restructured Environmental Research Plan (ERP) and the ongoing environmental program.

GKI reviewed the draft report prepared by Monsanto Research Corporation on the Retort #17 process stream characterization study conducted for ten days in the summer of 1978 under an EPA contract. A letter outlining GKI's comments on the draft was sent to Monsanto and EPA-Cincinnati.

The sixth set of quarterly water samples from wells peripheral to Retort #15 was collected in January. Five samples were collected for analysis by the GKI analytical laboratory. The Retort #15 hydrologic wells shown in Figure 14 have been sampled every three months since the retort burn terminated in July, 1978. Preliminary assessments of the data indicate a trend for the water surrounding Retort #15 to return to the quality of unaffected native groundwater.

A newly revised native groundwater sampling study was initiated in January, and three samples were collected for analysis by the GKI analytical laboratory. The wells sampled were blown dry 72 hours prior to sampling. Native groundwater samples will be collected six times yearly, once every other month, utilizing wells located at least 200 yards from any retort that has been blasted. This program is expected to provide 18 valid native groundwater samples during 1980 and provide data for additional characterization of native groundwater existing directly above the mahogany oil shale zone. The second suite of 1980 native groundwater samples was collected in March.

Emissions of sulfur dioxide (SO₂) and nitrogen oxide (NO_x) from Retort #18 were calculated from hydrogen sulfide (H₂S) and ammonia (NH₃) concentrations in the retort off gas during the quarter. Emissions of carbon monoxide (CO), hydrocarbons (HC) and ozone were determined from stack gas sampling. The following table shows the results obtained:

<u>EMISSIONS</u>					
	SO ₂	NO _x as NO ₂	CO	HC	Ozone
Low lbs/day	237	11			
High lbs/day	1,200	330			
Average lbs/day	538	168			
Average lbs/MSCF	0.266	0.083			
Total lbs/qtr	48,972	15,317			
Total lbs/1980	48,972	15,317			
Average Concentration			70 ppm	< 20 ppm	< 0.01

Routine meteorological data collection and equipment maintenance was conducted during the quarter.

GKI hired another environmental engineer who will begin work in April.

KAMPSITE:

Routine maintenance of Kamp facilities continued during the quarter. Snow removal and road maintenance were performed. A ditch was constructed to direct run-off water away from the water well. Dust control efforts were initiated later in the quarter.

SUPPORT ACTIVITIES:

Discussions with DOE/LETC continued regarding the electrical power requirements of the project for 1980-1981. DOE/LETC has made arrangements with the Department of Defense (DOD) for the loan of two 700 KW generators which should be delivered to the field site in the next quarter.

Installation of an overhead crane in the shop was completed.

A mechanic and a welder were hired in March to replace employees who terminated employment with GKI.

Routine equipment maintenance and repair work continued throughout the quarter.

ENGINEERING AND ADMINISTRATIVE (includes Health and Safety):

GKI met with representatives of DOE/LETC at Kamp Kerogen to discuss blasting, the retorting process, environmental programs and permit requirements, reporting procedures and electrical power concerns.

Representatives of GKI and Sandia Laboratories met in Albuquerque, New Mexico, to discuss Retort #24 instrument and post-blast core data and plans for Retort #25. Later in the quarter representatives of GKI, Sandia, DOE/LETC and blasting consultants met in Concord, California, to plan for Retort #25.

GKI and the other oil shale companies met with Utah Power & Light Company to discuss future shale industry power needs and the use of retort off gas for generating electricity.

James M. Lekas presented a paper at the DOE/LETC sponsored Third Annual Oil Shale Conversion Symposium in Denver, Colorado, detailing GKI's research progress. Program history, achievements and objectives were summarized.

A mobile instrument trailer was set up near the Kamp offices to house the Digital Equipment Corporation PDP-11 computer system. There are plans to interface a magnetic tape reader with the system.

to enable retorting and environmental data to be stored and used with increased efficiency. Sandia Laboratories personnel have assisted in debugging the system.

GKI continued discussions with a Grand Junction, Colorado, drilling engineering firm regarding the development of improved blasthole and re-entry drilling techniques and the testing of new down-hole equipment.

Safety meetings were held regularly during the quarter. Subjects covered included safe working practices, fire prevention and waste management.

GKI arranged to participate in a grant administered by the Utah Technical College (UTC) Safety and Health Programs which provides consulting and assistance to small businesses for the development and improvement of safety programs. The UTC coordinator of the grant toured GKI operations in March, taking pictures for use in a slide presentation on good safety practices at the field site. The slides will be shown on a subsequent visit. Well-placed signs and fire extinguishers were mentioned as contributing to the overall effectiveness of the GKI Safety and Health Program.

SECOND QUARTER 1980 FORECAST:

SITE PREPARATION:

None.

DRILLING AND BLASTING:

Retort #25 will be blasted.

RE-ENTRY DRILLING:

Re-entry drilling will continue on Retort #24.

RETORT PROCESS FACILITIES:

Process equipment for Retort #24 will be fabricated and installed.

RETORT BURN:

The burn of Retort #18 will be completed.

OIL PRODUCTION AND HANDLING:

None.

POST-BLAST AND POST-BURN EXAMINATIONS:

None.

SEPARATE EXPERIMENTS:

None.

ENVIRONMENTAL RESEARCH:

Application for PSD permit and UIC permit will be submitted to the appropriate regulatory agencies.

KAMPSITE AND SUPPORT ACTIVITIES:

Routine maintenance will continue.

ENGINEERING AND ADMINISTRATIVE:

None.

Figure 1
GEOKINETICS INC. FIELD SITE

FIGURE 2
RETORT #24
POSTBLAST CORE HOLE LOCATIONS

NOTE:
CORE HOLES B
AND D ARE
DRILLED ON A
45° ANGLE.

SCALE: 1" = 50'

○ CORE HOLE

GEOKINETICS INC.

1/6

Figure 3

RETORT #19
REENTRY INSTRUMENT WELL LOCATIONS

Figure 4

RETORT #19
REENTRY AIR, PRODUCTION AND
OBSERVATION WELL LOCATIONS

Figure 5

RETORT NUMBER 21
REENTRY AIR, PRODUCTION AND
OBSERVATION WELL LOCATIONS

-19-

LEGEND

- ⊕ PRODUCTION WELL
- AIR-IN WELL
- OBSERVATION WELL

SCALE: 1" = 20'

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1/6

Figure 6

RETORT NUMBER 22
REENTRY AIR, PRODUCTION AND
OBSERVATION WELL LOCATIONS

-20-

SCALE: 1"=20'

LEGEND

- PRODUCTION WELL
- ⊗ AIR-IN/AIR-OUT WELLS
- ⋯ OBSERVATION WELL

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KG

Figure 7

RETORT NUMBER 23
REENTRY AIR, PRODUCTION AND
OBSERVATION WELL LOCATIONS

-21-

- PRODUCTION WELL
- AIR-IN WELL
- OBSERVATION WELL

SCALE: 1" = 20'

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Figure 8

RETORT #18
RE-ENTRY AIR, PRODUCTION & OBSERVATION WELL LOCATIONS

Figure 9

RETORT NUMBER 18
REVISED SURFACE FACILITIES LAYOUT

Figure 10

RETORT #18
RE-ENTRY INSTRUMENT
WELL LOCATIONS

SCALE: 1"=20'

LEGEND

⊙ CORE HOLE

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6/6

Figure 11
RETORT #23
CORE HOLE LOCATIONS

Figure 12
RETORT #24
AIR-IN WELL LOCATIONS

⊙ AIR-IN WELL
 67.7' DEPTH

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Figure 13
RETORT #24
HEAVE CONTOURS

LEGEND
HEAVE CONTOUR

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6

• WELL EXTENDING INTO RETORT LEVEL

⊙ WELL EXTENDING BELOW RETORT LEVEL

MAP I.
SPECIFIC LOCATIONS OF
HYDROLOGIC MONITORING
WELLS

APPENDIX A
RESULTS OF RETORT #18 SHALE OIL CHROMATOGRAPHIC ANALYSES
BY GEOKINETICS ANALYTICAL LABORATORY.

Complex kerogen molecules break down under pyrolysis and produce oil, gas and water. The composition of the oil and the gas changes with the retorting temperature and also with heating rate. Analyzing the oil using a gas chromatograph to determine composition provides information as to the conditions under which the oil was produced from the kerogen.

Three parameters are listed: oil volume percent by carbon number, 1-alkene/n-alkane ratios, and a total volume percent n-alkanes.

The oil volume percent by carbon number serves as a simulated distillation. This gives an idea as to whether the whole oil is being recovered, just the light ends or a combination somewhere in the middle (the usual case). This parameter can also indicate the general quality of the oil.

The 1-alkane/n-alkane ratio provides an index as to the retorting temperature that produces the oil. Generally speaking, the greater the number, the higher the temperature.

The C₁₇ and C₁₈ isomers (thought to be pristane and phytane) are recorded to observe trends. These two components are of biological origin and will be destroyed by excessive heat.

The total volume percent n-alkanes is an index as to the quality of the oil. Within limits and very generally, the greater the percent of n-alkanes, the better the oil quality.

RESULTS OF RETORT #18 SHALE OIL CHROMATOGRAPHIC ANALYSES
BY GEOKINETICS ANALYTICAL LABORATORY

Date Produced:	1-02-80	1-02-80	1-07-80	1-21-80	1-21-80	1-21-80	1-21-80	1-28-80
Sample Point :	PW-3	PW-4	PW-3	PW-1	PW-2	PW-3	PW-4	PW-1

Volume Percent

≤C8	0.30	0.37	0.47	0.24	0.49	0.75	2.09	0.89
C9 -C10	2.58	3.19	3.66	3.36	3.93	4.42	6.44	3.48
C11-C12	9.70	10.64	11.73	9.57	10.22	10.34	11.92	10.16
C13-C14	15.17	16.81	17.52	14.25	16.42	14.31	14.84	10.51
C15-C16	15.44	15.56	15.89	15.81	15.78	15.83	14.90	17.63
C17-C18	17.26	16.67	16.50	16.90	17.58	16.94	15.62	16.46
C19-C20	12.98	12.30	13.60	11.51	10.01	14.00	12.73	14.62
C21-C24	12.94/ 10.11	11.90/ 10.36	7.42	12.08	4.95	8.22	9.22	9.31
C25+	2.51	2.20	1.45	2.65	1.96	1.50	1.48	2.17

1-alkene/
n-alkane

C6	-	-	-	-	-	-	-	-
C7	-	-	-	-	-	-	.265	-
C8	.354	.336	.303	-	-	-	.370	.301
C9	.745	.713	.655	.524	.510	.494	.491	.509
C10	.557	.570	.566	.681	.695	.684	.720	.674
C11	.279	.274	.263	.348	.335	.334	.330	.346
C12	.525	.525	.395	.544	.519	.533	.522	.518
C13	.417	.417	.460	.392	.328	.338	.373	.334
C14	.702	.606	.267	.447	-	.467	-	-
C15	-	-	.559	-	-	-	-	-
C17	-	-	1.524	1.409	1.337	1.450	1.416	1.517
C18	-	-	1.415	1.600	1.538	1.721	1.684	1.848

Total
n-alkanes

40.18	38.93	39.543	48.81	47.48	48.01	45.80	47.77
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APPENDIX B

RESULTS OF SHALE OIL AND ALTAMONT CRUDE ANALYSES
PERFORMED BY THE UNIVERSITY OF UTAH

The University of Utah performed gradient elution chromatographic analyses and distillation tests on samples of Geokinetics shale oil and Altamont crude. The samples were analyzed for GKI and the Plateau Refinery in Roosevelt, Utah, in conjunction with efforts to determine the cause of incompatibility when shale oil is blended with Altamont crude.

TABLE 1
Gradient Elution Chromatographic Analysis
Shale Derived Liquid
Geokinetics Inc.

<u>Fraction Identification</u>	<u>Weight Percent</u>	<u>Fraction Appearance</u>
Saturates	11.7	white crystalline solid suspended in colorless liquid
Mononuclear and Dinuclear Aromatics	41.0	lime colored solid; liquifies slightly above room temperature (35-40°C)
Polynuclear Aromatics	0.1	light yellow solid
Soft Resins	15.9	dark brown liquid
Hard Resins	3.8	dark brown semi-solid at room temperature
Polar Resins	2.4	black-brown solid
Asphaltenes (Eluted)	24.0	black-brown semi-solid at room temperature
Asphaltenes (Non-eluted)	1.2	-----
	<hr/> 100.1	

F. V. Hanson
3 April 1980

Table 2

Gradient Elution Chromatographic Analysis
Altamont Crude Sample
Roosevelt Refinery
Plateau, Inc.

<u>Fraction Identification</u>	<u>Weight Percent</u>	<u>Fraction Appearance</u>
Saturates	79.0	milk white paraffin wax; solid at room temperature; liquid above 36°C (96.8°F); readily soluble in n-hexane
Mononuclear and Dinuclear Aromatics	14.7	straw yellow solid at room temperature; liquid at temperature slightly above room temperature; sparingly soluble in paraffinic solvents; readily soluble in aromatic solvents
Polynuclear Aromatics	0.2	light yellow solid
Soft Resins	2.8	light reddish brown; solid at room temperature
Hard Resins	0.6	light brown solid at room temperature
Polar Resins	0.2	dark brown solid at room temperature
Asphaltenes (eluted)	0.8	brown-black solid at room temperature
Asphaltenes (benzene eluted)	1.2	brown-black solid at room temperature
	<hr/> 99.5	

F. V. Hanson
3 April 1980

F. V. Hanson
3 April 1980

TABLE 3
 Simulated Distillation Analysis
 Altamont Crude
 Vs.
 Geokinetics Shale Derived Liquid

Fraction Boiling Range (°F) IBP	Altamont Crude 154°F (Wt.%)	Shale Derived Liquid 275°F (Wt.%)
IBP-290	4.9	0.4
290-400	6.9	2.7
400-650	19.3	33.7
650-1000	31.6	46.8
1000+	<u>37.3</u>	<u>16.5</u>
	100.0	100.1

Francis V. Hanson
 3 April 1980

FIGURE 2
DISTILLATION FRACTIONS
ALTAMONT CRUDE
GEOKINETICS SHALE DERIVED LIQUID

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FIGURE 3
DISTILLATION CURVES
ALTAMONT CRUDE
GEOKINETICS SHALE DERIVED LIQUID

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