Alpine 1/Federal
Final Report - Part 1
Drilling Report

James C. Witcher[1], Larry Pisto[2],
W. Richard Hahman[3], and Chandler A. Swanberg[4]

June 1994

ARIZONA GEOLOGICAL SURVEY
CONTRIBUTED REPORT CR-94-E

Prepared for the
Arizona Department of Commerce
Energy Office
Phoenix, Arizona

[1]Geologist, Southwest Technology Development Institute, New Mexico State University, Las Cruces, NM
[2]Core Division Manager, Tonto Drilling Services, Inc., Salt Lake City, UT
[3]Consultant-Registered Geologist, Las Cruces, NM
[4]Geothermal Consultant-Geophysicist, Phoenix, AZ

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ACKNOWLEDGMENTS

The community of Alpine, Arizona is thanked for their friendliness, hospitality, and assistance to the drillers and geologists. The fax machines, good mail service, good meals, hardware and other vendors, and friendly smiles in Alpine all contributed to a successful drilling project. Personnel at the U. S. Forest Service (USFS), Apache-Sitgreaves Forest, Alpine District Office, provided valuable assistance by providing gate keys, locating an acceptable and nearby site to place drilling fluids, and suggesting a very good access from the highway to the drill site. Bob Dyson of the Alpine District Office is especially thanked. John Sass of the U. S. Geological Survey (USGS) is thanked for providing preliminary heat-flow data and discussions on the thermal regime of the area. Chuck Chapin, Director, and Richard Chavez of the New Mexico Bureau of Mines and Mineral Resources (NMBMMR) are thanked for sending a loading crew and a truck to Alpine to pickup the Tertiary core on loan from Larry Fellows, Director, Arizona Geological Survey (AGS). Informal discussions on the geology of the region with Wes Peirce (AGS-Emeritus), Steve Rauzi (AGS), Andre Potochnik (ASU), Steve Cather (NMBMMR), Richard Chamberlin (NMBMMR), and Clay Conway (USGS) are greatly appreciated. Tonto's outstanding drillers and helpers formed a highly proficient and enthusiastic drilling crew. Mike LaOrange, Tonto Drill Forman, and Larry Pisto, Tonto Core Division Manager, are especially thanked for their close coordination and good communications which assisted the geologists tremendously. The staff, secretaries, and students at SWTDI/NMSU are also thanked for their assistance in various phases of this project. Funding for drilling the Alpine 1/Federal corehole was the Arizona Department of Commerce, Energy Office and the U. S. Department of Energy, Geothermal Division.

1.0 INTRODUCTION

1.1 BACKGROUND

Regional geologic and geophysical surveys, shallow temperature-gradient drilling, and published reconnaissance geothermal studies infer possible hot dry rock (HDR) geothermal resources in the Alpine-Springerville area. This report discusses the results of a State of Arizona and U. S. Department of Energy funded drilling project designed to gather the deep temperature and stratigraphic data necessary to determine if near-term HDR geothermal potential actually exists in this portion of the White Mountains region of Arizona. A 4,505 feet deep slim-hole exploratory well, Alpine1/Federal, was drilled within the Apache-Sitgreaves National Forest at Alpine Divide near the Alpine Divide Camp Ground about 5 miles north of Alpine, Arizona in Apache County (Figure 1).

1.2 PURPOSE AND OBJECTIVES

Hot dry rock (HDR) geothermal energy is a method of mining or extracting the natural heat energy within the earth (Tester and others, 1989). As originally conceived by scientists and engineers at Los Alamos National Laboratory, heat is extracted from relatively impermeable rock by artificially fracturing a hot volume of rock and introducing water into the man-made fracture system with an injection well (Potter and others, 1974). A second well removes or produces the heated water from the fracture reservoir for use

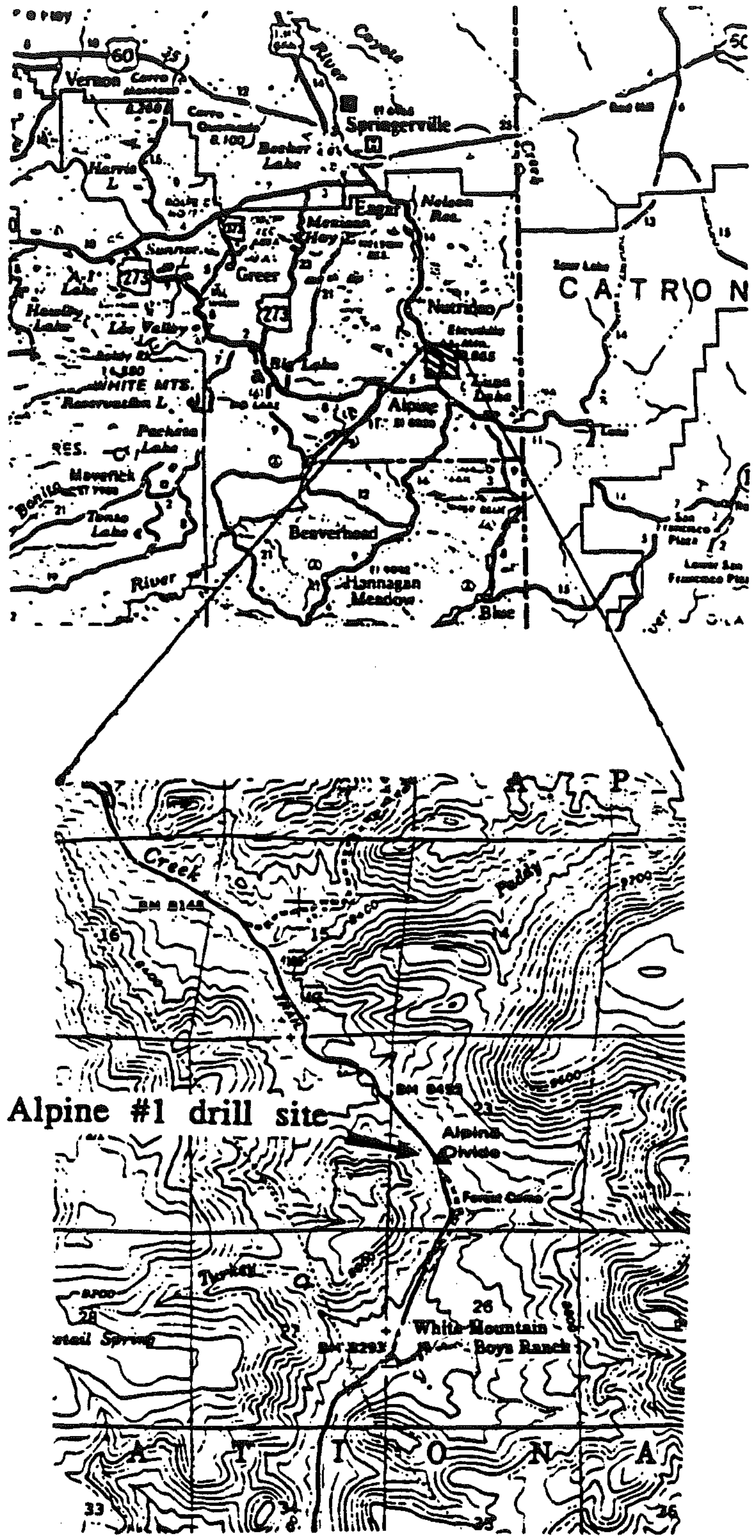


Figure 1. Location map of the Alpine 1/Federal drill site.

at the surface. The concept, as currently field tested, requires a relatively impermeable rock volume with predictable fracturing characteristics. A volumetrically-large, structurally-simple rock body with high temperatures is desired. The crystalline basement rocks (i. e., Precambrian granite) make potentially good hosts.

The types of Precambrian basement rocks beneath the Alpine-Springverville area are not known. Precambrian rocks in most deep wells and in surface outcrops nearest to the area are metamorphic rocks or metasedimentary rocks, not granite. Furthermore, the actual depth to Precambrian crystalline basement can only be inferred from sparse well and outcrop information in the Alpine-Springerville area.

Unusually high temperature gradients have been measured in shallow (<1,200 feet depth) boreholes in the eastern White Mountains region (Minier and Reiter, 1991 and Stone, 1980). Prior to drilling, uncertainty existed as to actual temperatures at greater depth. Flowing ground water in a deep aquifer or significant changes in subsurface thermal conductivity beneath the existing shallow heat-flow measurements could be reflected by drammatically changed temperature gradients at depth. Prior to drilling, regional geological analysis suggested that the Kaibab-Coconino (San Andres-Glorieta) aquifer was missing beneath the area of highest measured temperature gradients at Alpine Divide. However, geologic and geothermal uncertainties in the region required clarification by a deep borehole before a reliable assessment of the HDR potential could be presented.

Table 1 lists the types of information that are useful in HDR assessments.

Table 1. Types data used for an initial Hot Dry Rock evaluation.

TYPE DATA	METHOD
lithology (type of rock)	core
rock mechanical properties	core
rock permeability and porosity	logs and core
structure (fractures, faults, and joints)	logs and core
rock thermal properties	core
heat production	core
in situ stress	logs or borehole
temperature	logs
nature of basement fluids	water samples

The main objectives of the Alpine1/Federal drilling project were to drill at least 100 feet into crystalline Precambrian basement, determine subsurface temperatures, temperature gradients, and heat flow. Based upon sparse regional geologic information, the target depth was selected at 4,500 feet below the surface at the Alpine Divide site (see Appendix 1). Overall, the primary mission of the drilling project was to obtain the data necessary to determine subsurface temperatures deep into the Precambrian basement and assess the HDR geothermal energy potential of the eastern White Mountains region.

1.3 SITE SELECTION

The Alpine Divide site was selected as the best site to evaluate the geothermal potential of the region. This site easily ranked as the highest in terms of geothermal potential. The subsurface temperatures at this location were highest for two important reasons. First, the depth to Precambrian basement is greater and the sediments that act as thermal blankets have greater thickness. With the same heat flow, this translates into higher temperatures because intervals with low thermal conductivity sediments have higher temperature gradients than intervals with high thermal conductivity rocks. Second, the site is known to have the highest measured temperature gradients (and heat flow) in the area (71 °C/km) (Stone, 1980). Prior to drilling, regional geologic relationships suggested that the cavernous Kaibab (San Andres) limestones may be missing or thinned considerably below an unconformity at this site (see section 7.3 Part 2 of this report). Therefore, from a drilling standpoint this site ranked the highest because the Kaibab (San Andres) Formation has serious potential for drilling problems. Access to the site was very good as the site was immediately adjacent a paved highway. In addition, the subsurface geology was known to depth over 1,000 feet. This insured that cementing of the surface casing and testing of the blowout prevention equipment (BOP) proceeded smoothly prior to deep exploration drilling and that safety equipment was well anchored for safe deep drilling. Appendix 1 summarizes the attributes and drawbacks of candidate sites for the Alpine1/Federal borehole.

1.4 PARTICIPANTS

The Alpine Geothermal Project was administered by the State of Arizona Department of Commerce, Energy Office, Phoenix with procurement through the Arizona Procurement Office, Phoenix. Funding was a grant from the U. S. Department of Energy, Geothermal Division, Washington, D. C. to the State of Arizona with a matching contribution from Arizona's share of the Petroleum Violation Escrow Funds. U. S. Department of Energy oversight of the project was through the DOE Albuquerque Field Office. In addition, the State of Arizona Department of Commerce, Energy Office, formed a Geothermal Evaluation Committee to provide assistance in project direction and procurement (see Appendix 2).

Prime contractor to the State of Arizona for the Alpine Geothermal Project was Tonto Drilling Services, Inc., Salt Lake City, Utah. Well site geotechnical services, permit coordination, and reporting were subcontracted by Tonto to the Southwest Technology Development Institute (SWTDI/NMSU) at New Mexico State University. The U. S. Geological Survey (USGS), Geothermal Division, an invited participant, contributed equipment and personnel toward heat-flow studies of the Alpine1/Federal borehole. Appendix 2 also lists some of the major suppliers for the drilling project.

1.5 PERMITS

All operations conformed to the regulations, permitting and operational procedures administered by the USFS, the U. S. Bureau of Land Management (BLM) and the Arizona Geological Survey (AGS), Oil and Gas Administrator. All access and surface issues were closely coordinated with the USFS. All drilling was in compliance with federal Geothermal Resources

Operational Orders (GROO's), directives of the USFS, BLM, AGS, and stipulations of the permits. Prior to commencing any operations, specific details were submitted to the USFS, BLM, AGS through the Applications for Permits to Drill (APD's) or Sundry Notices. Access to the drill site road from the highway was permitted with the Arizona Department of Transportation (ADOT). As operator, Tonto Drilling Services posted a Plugging Bond with the AGS and a Compliance Bond with the USFS/BLM.

Daily communications (as needed) and weekly communications with Federal and State regulators was maintained throughout the project. The U. S. Forest Service assisted in locating an acceptable drilling mud disposal site very close to the drilling location.

1.6 SCOPE

This report, Part 1, Drilling Operations, on the Alpine1/Federal geothermal test hole details the drilling operations at the Alpine Divide site. This report provides a brief case study of a successful slim-hole drilling operation. Second, because drilling rates, procedures, and problems are usually a consequence of subsurface geological conditions, the initial discussion of drilling operations provides a suitable springboard to detail subsurface stratigraphy encountered in the Alpine1/Federal hole. The subsurface geology in the Alpine1/Federal borehole is discussed and interpreted in Part 2, the companion to this report. In addition, Part 2 interpretes the subsurface temperature regime of the Alpine-Springerville area and discusses the near-term potential for HDR in the area.

2.0 DRILLING AND SITE OPERATIONS

2.1 DRILL SITE LAYOUT

The Alpine1/Federal borehole is adjacent to temperature-gradient hole SJ-116 in the southwest quarter of section 32, Township 6 North, Range 30 East, 1,153 feet from the west section line and 2,122 feet from the south section line at an elevation of 8,556 feet at Alpine Divide on the north side of U. S. Highway 180/191/666 (Figure 1). The drill site is located on U. S. Forest Service land within the Apache-Sitgreaves National Forest. Access to the drill site is via a former logging road which intersects U. S. Highway 180/191/666 about 1,500 feet north of the site. A locked gate at the highway provides controlled entry on to the all-weather gravel logging road. Approximately 250 feet of gravel was laid down from the logging road for temporary all-weather final egress to the drill site.

Minimal dirt work included preparing a level substructure pad and the digging of a small 'U' shaped mud-pit on the southside of the drill rig (Figure 2). The blowout prevention (BOP) controls (accumulator), water tanks, and mud-mixing tank were installed on the north side of the drill rig. Overall layout provided for efficient water, mud, and equipment resupply, drilling operations, and well site geotechnical operations.

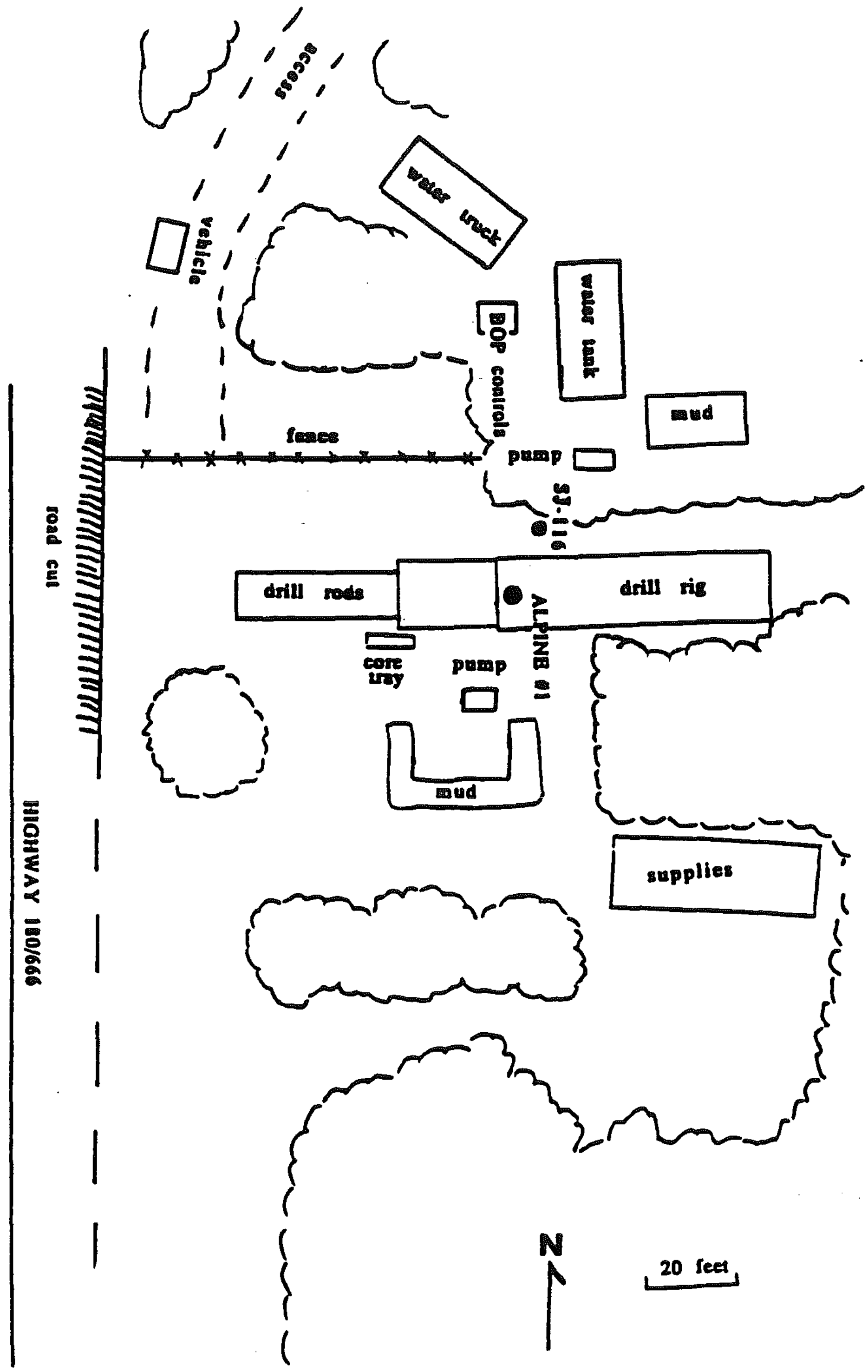


Figure 2. Layout of the Alpine 1/Federal drill site.

2.2 WATER

Water for drilling operations was obtained from Luna Lake, located east of Alpine and approximately 7 miles from the drill site, with Tonto's 3,500 gallon capacity water truck. With approval of the Arizona Department of Game and Fish and the New Mexico State Engineers Office, two acre-feet (~700,000 gallons) of water was purchased from the Luna Irrigation District, Luna, New Mexico to cover all possible drilling contingencies. Actual water consumption by the Alpine1/Federal drilling operations was less than 150,000 gallons. About half of the water consumption occurred during the drilling of lost circulation zones in the lower 1,200 feet of the hole.

2.3 DRILL RIG AND SPECIFICATIONS

A truck-mounted and removeable Universal Drill Rig 1500 (UDR1500) cored the Alpine1/Federal hole. Table 2 lists important specifications for the UDR1500 drill rig. The UDR1500 is a top drive rig that is specifically designed for deep continuous wireline diamond core drilling and shallow rotary drilling. The UDR1500 utilizes hydraulic drives for the drill motors, pumps, and hoist, allowing excellent variable controls for difficult and critical drilling situations. The rig hydraulics are powered by a 230 hp at 2,100 RPM 6-71N Detriot diesel engine. A 52 foot long mast permits 40 feet rod stands for efficient tripping.

Table 2 Specifications for the UDR-1500 drill rig.

category	subcategory	specification
TONTO RIG	rig number	020002 w/12 ft, 6 inch steel substructure
DEPTH CAPACITY		
	HQ	5,400 ft
	NQ	6,560 ft
DIMENSIONS		
	length	52 ft, 6 in
	width	8 ft, 2 in
	height	11 ft, 6 in
	weight	42,900 lb
MAST/DERRICK		
	length	52 ft, 6 in
	rod pull capacity	40 ft rod stands
	angle	vertical to 45 degrees
	safe working capacity	50,800 lbs force
MAIN WINCH/HOIST		
	drive	hydraulic-driven, mounted at the top of the mast
	maximum pull	50,800 lbs force
	brake	fail-safe hydraulic brake
	variable pull or lowering speeds	
		0- 281 ft/min at 10,290 lbs force
		0-66 ft/min at 44,900 lbs force
WIRELINE WINCH		
	drive	hydraulic-driven, mounted on the rear side of mast
	wireline	6,560 ft of wire rope (0.3125 in diameter)
	maximum pull	10,110 lbs force
	infinitely variable line speeds	0-1,410 ft/min
HYDRAULICS		
	three circuit hydraulic system	
		main
		mudpump
		cylinder
	hydraulic oil filter system	10 micron
POWER		
	Detroit diesel GM 6-71N	
		238 hp at 2,100 rpm
		noise shielded
		264 gal fuel tank (1,000 liter)
	electricity generator	110 volt, 8kw
ROTATION		
	variable speed hydraulic top drive	0-1,500 rpm
	travel distance/feed length	24 ft
	pull back force	32,000 lbs
	pull down force	15,700 lbs
	swivel	floating spindle with mud swivel
	lubrication	filtered-jet lubricated gears
SLIPS/FOOTCLAMP		
	drive	hydraulic-driven
	breakout and makeup tool	torque up to 13,500 lbs
PUMP		
	hydraulic-driven FMC Bean L1122B	40 gpm at 1,000 psi

At the drill site, the UDR1500 was mounted on a 12 feet tall heavy steel substructure to allow clearance for BOP equipment and to provide a stable drilling platform. Depth capacity with HQ coring is 5,400 feet and about 6,560 feet, the total length of the wireline, with NQ coring. Table 3 lists the size parameters for HQ and NQ core.

Table 3 HQ and NQ core specifications.

CORE SIZE	PARAMETER	SPECIFICATION
HQ CORE		
	CORE DIAMETER	2.50 inches
	HOLE DIAMETER	3.85 inches
	HOLE VOLUME	58.3 gal/100 ft
	ROD OD	3.5 inches
	ROD ID	3.0625 inches
	ROD WEIGHT	77 lb/10 ft
	ROD VOLUME	38.2 gal/100 ft
NQ CORE		
	CORE DIAMETER	1.875 inches
	HOLE DIAMETER	3.040
	HOLE VOLUME	36.3 gal/100 ft
	ROD OD	2.75 inches
	ROD ID	2.375 inches
	WEIGHT	52 lb/10 ft
	ROD VOLUME	23 gal/100 ft

2.4 WELL CONTROL

In the event that pressured fluids, gas, or rapidly boiling or flashing super-heated water entered the Alpine1/Federal borehole, several steps were taken to insure that well discharges would be controlled. Well control consisted of blow out prevention (BOP) equipment, a choke manifold, a drill string safety valve, an auxillary water tank with a minimum of 275 bbls (11,550 gallons) of water on site, and the monitoring of bottom-hole temperatures (BHT) and mud return temperatures. The BOP stack consisted of a double-gate ram and a 1,000 psi annular preventer installed on a 7 1/16 inch well head with flow (choke) and kill line ports (Figure 3). H and H Oil Tool provided the BOP stack for the Alpine1/Federal project. An optional rotating head is shown in Figure 3. However, the rotating head was not actually installed. The kill line port was connected to the auxillary water tank via a pump. The flow port was connected to an API 2M manifold choke valve that was securely anchored in place at the mud pit. The drill string safety valve was kept in an easily accessible location on the drill floor with the valve in an open position. The BOP stack, manifold choke valve, and drill string safety valve were all tested to 1,000 psi for 30 minutes. The pressure tests were witnessed by Steve Rauzi, AGS Oil and Gas Administrator and John Haas, BLM. The drive for the actuating system that is used to instantly close the pipe ram, the blind ram, the annular BOPs consisted of a hydropneumatic accumulator.

2.5 HYDROGEN SULFIDE MONITORING

Tecton Geologic of Healdsburg, California provided industry standard automatic hydrogen sulfide continuous-monitoring detectors with visual and audio alarms. Hydrogen sulfide detectors were installed at suitable locations to include on the drill floor, below drill floor on the substructure near the BOP equipment, and at the flow-line discharge or choke manifold, near the mud pit. Alarms were set to trigger at 20 ppm hydrogen sulfide. A wind sock was also installed at a location visible to all site personnel.

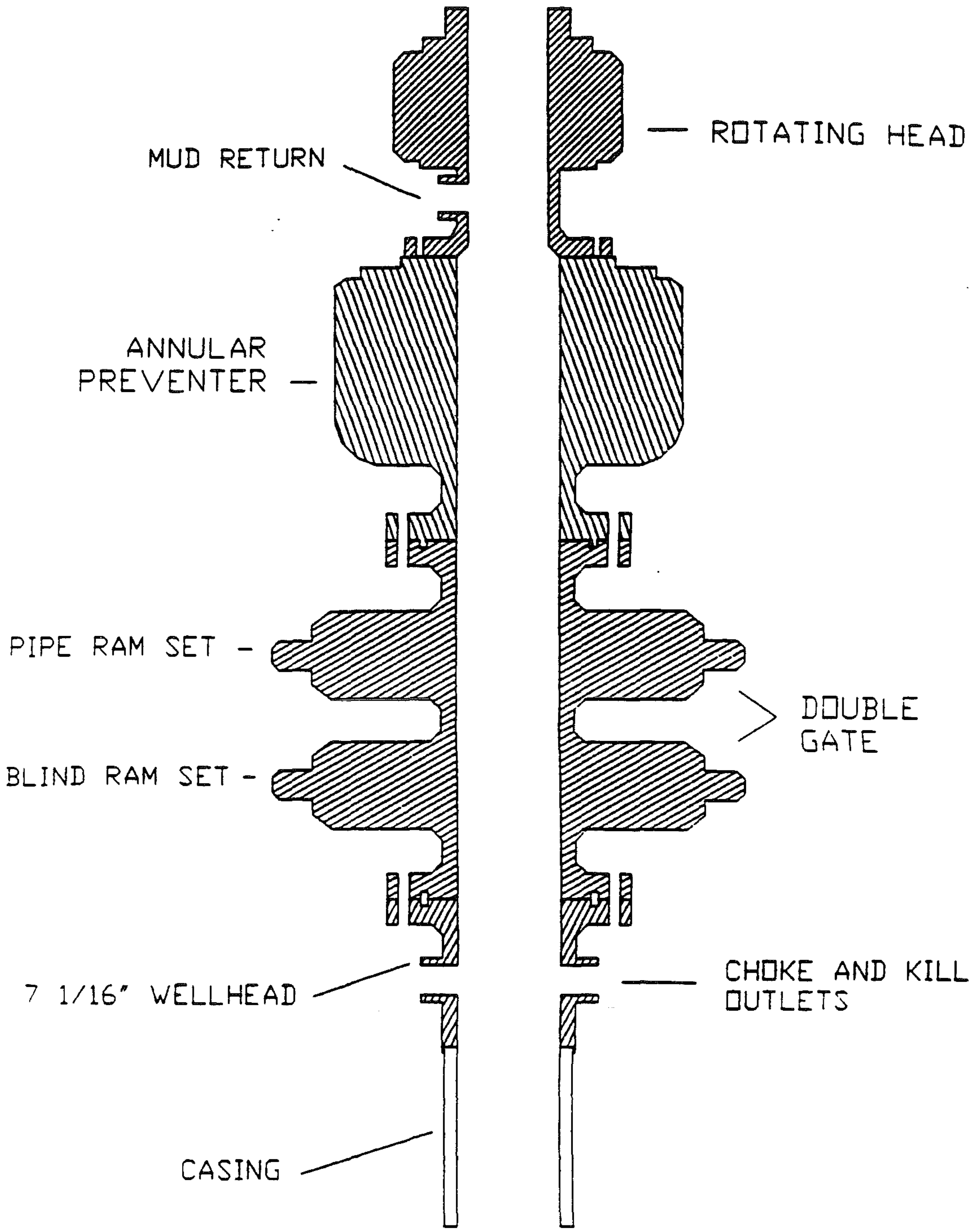


Figure 3. **Diagram of blow out prevention (BOP) equipment for the Alpine 1/Federal borehole.**

Self-contained breathing equipment (Scott Paks) were placed for emergency use at three different locations to include the briefing areas. Two briefing areas were designated at the drill site. These areas were situated to provide one briefing area that would be upwind of the hole at any given time.

2.6 WELL SITE GEOLOGY AND OPERATIONS MONITORING

Well site geotechnical operations included making field geologic logs of core and cuttings and curating core for storage and future study. Appendix 3 details the core marking procedures for the Alpine1/Federal test hole. After the core was boxed, marked and described, the core was taken to Alpine to be photographed and placed in temporary storage. After the core was photographed, 3-to-6 inch pieces of core at approximately 50 intervals were selected and removed from the core boxes for thermal conductivity measurement. Appendix 8, Part 1 contains the field geologic log. Core boxes 1 through 301 with HQ core from 500 feet to 3,265.5 feet, the Tertiary stratigraphic section, are stored at the New Mexico Bureau of Mines and Mineral Resources, at Socorro, New Mexico. In addition, 4 to 6 inch pieces of core at ten feet intervals, generally selected at the end or beginning of a core run, from the 500 to 3,265.5 feet interval are also stored at the Arizona Geological Survey at Tucson, Arizona. Core boxes 302 through 432 with HQ and NQ core from 3,265.5 to 4505 feet, the Mesozoic and Paleozoic stratigraphic section, are stored at the Arizona Geological Survey. Core photography, as color slides, is on file at the Arizona Geological Survey.

Starting at 2,244 feet depth, bottom-hole temperatures (BHT) were taken at approximately 50 feet intervals with a maximum thermometer that was sealed in a water-tight container. The thermometer container was attached to the wireline overshot that was used to retrieve the core tube and core at the end of a coring run. In addition to the BHT measurements, periodic readings were taken of the mud return temperatures at the manifold valve discharge into the mud pit. Mud return temperatures were begun at 854 feet depth.

Operations monitoring included keeping a core log, daily report log, and a well history log. A summary of the core log is listed in Appendix 4. The core log was used to track penetration rates, daily footage rates, time between core runs, core recovery rates, and footage depth. The daily report log was used to document footage per shift, BHT and mud return temperature measurements, all drilling activities, materials used in drilling, and hours worked by SWTDI/NMSU personnel. A well history log complemented the daily report log. The well history log was used to record chronologically important events at the well site such as visitors, drilling milestones, or any other events not recorded by the core log and daily report log. Appendix 5 is a summary of important information contained in the daily report log and the well history log.

2.7 DRILLING SUMMARY AND PENETRATION RATES

Award of the Alpine 1/Federal drilling contract was given on 1 April to Tonto Drilling Services of Salt Lake City, Utah. In coordination with Tonto and the Arizona Department of Commerce all permits from Federal and State agencies were acquired and a Plan of Exploration Operations and a Geologic Logging and Core Marking Plan were prepared by Tonto's geotechnical subcontractor, Southwest Technology Development Institute, New Mexico State University, Las Cruces, New Mexico, between April and July. The Tonto drill rig began moving on to the site on 1 July (day 0, Figure 4) (also see Table 4 and Appendix 5). However, drilling start-up was delayed by the refusal of a subcontracted truck driver to unload the substructure and mud tank on location. The truck driver claimed that the first turn on the access road from the highway was too narrow. However, other trucks of the same size and the drill rig managed to negotiate the turn on this former logging road with no problem. Start-up was also delayed by the failure of Tonto's crane on 3 July (day 2, Figure 4) just before the 4th of July. On 7 July (day 6 Figure 4) the borehole was spudded. By 13 July, 500 feet of surface casing was cemented and the blowout prevention equipment (BOP) nippled-up and tested (Figure 4 and Appendix 5).

Some initial problems with rig hydraulics were experienced; however, the hydraulics problems were solved by Tonto field crews in the first few days. An occasional problem with the core catcher in the core tube resulted in minor core slippage. However, core recovery for the Alpine 1/Federal hole exceeded 99.5 percent (see Appendix 4).

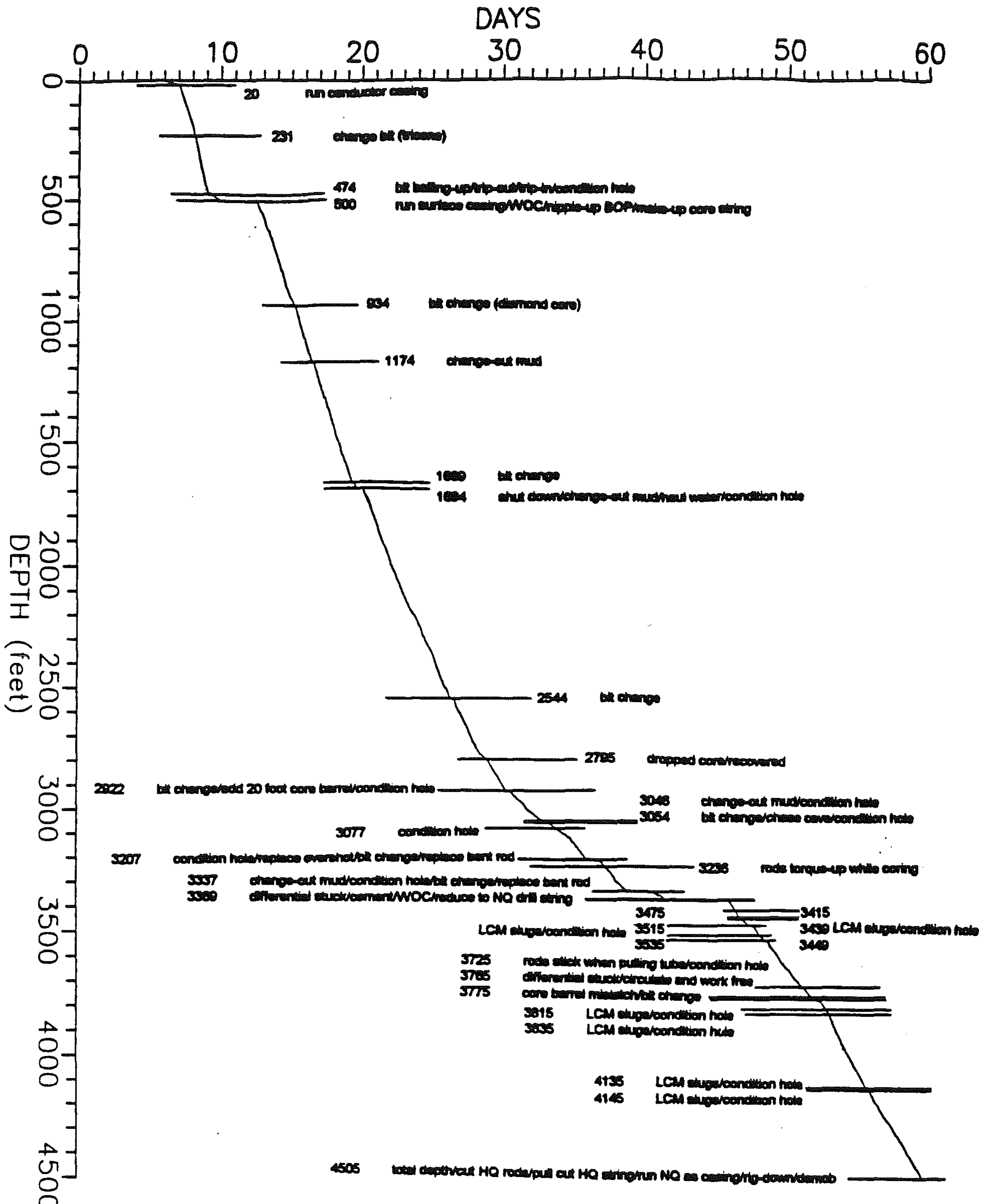


Figure 4. Drilling history of the Alpine 1/Federal borehole.

TABLE 4 Footage of important activity, events, and milestones of the Alpine1/Federal hole.

depth ft	activity
0	mobilization/rig-up
20	run conductor casing
231	change bit (tricone)
474	bit balling-up/trip-out/trip-in/condition hole
500	run surface casing/WOC/nipple-up BOP/make-up core string
934	bit change (diamond core)
1174	change-out mud
1669	bit change
1694	shut down/change-out mud/haul water/condition hole
2544	bit change
2795	dropped core/recovered
2922	bit change/add 20 foot core barrel/condition hole
3046	change-out mud/condition hole
3054	bit change/chase cave/condition hole
3077	condition hole
3207	condition hole/replace overshot/bit change/replace bent rod
3236	rods torque-up while coring
3337	change-out mud/condition hole/bit change/replace bent rod
3369	differential stuck/cement/WOC/reduce to NQ drill string
3415	LCM slugs/condition hole
3439	LCM slugs/condition hole
3449	LCM slugs/condition hole
3475	LCM slugs/condition hole/haul water
3515	LCM slugs/condition hole
3535	LCM slugs/condition hole
3725	rods stick when pulling tube/condition hole
3765	differential stuck/circulate and work free
3775	core barrel mislatch/bit change
3815	LCM slugs/condition hole
3835	LCM slugs/condition hole
4135	LCM slugs/condition hole
4145	LCM slugs/condition hole
4505	total depth/cut HQ rods/pull cut HQ string/run NQ as casing/rig-down/demob

The daily footage rate averaged about 137 feet per day for the period between 13 July and 31 July (Table 5). Footage rates for the period 14 July to 19 July averaged 178 feet per day and dropped to 131 feet per day between 21 July and 28 July. Between 29 July and 31 July the daily footage rate decreased to 74 feet per day as the Baca Formation was penetrated.

TABLE 5 Daily footage log of the Alpine1/Federal hole.

date	footage feet/day	remarks
7/13	67	coring HQ/10 foot core barrel
7/14	190	
7/15	170	
7/16	190	bit change
7/17	170	
7/18	180	
7/19	180	
7/20	60	bit change
7/21	155	
7/22	153.5	
7/23	131.5	
7/24	110	
7/25	130	
7/26	135.5	
7/27	104.5	bit change
7/28	130	
7/29	76.5	
7/30	91.5	
7/31	54	bit change
8/1	50	
8/2	38	bit change
8/3	42	chase cave
8/4	59	
8/5	52	rods torque-up/bit change/dented rod replaced
8/6	29	chase cave/rod torque-up
8/7	72	
8/8	29	pull back and condition hole/chase cave
8/9	1	bit change/dentedrods replaced/chase cave
8/10	14	
8/11	17	HQ string differential stuck/unable to free rods
8/12	0	cement/WOC/reduce to NQ string
8/13	0	WOC/drill-out cement
8/14	0	re-cement/WOC
8/15	30	drill-out cement/core NQ
8/16	76	lost circulation/LCM slugs/condition hole
8/17	40	lost circulation/LCM slugs/condition hole
8/18	70	lost circulation/LCM slugs/condition hole
8/19	70	
8/20	70	
8/21	50	differential stuck/worked free/core barrel mislatch/bit change
8/22	80	lost circulation/LCM slugs/condition hole
8/23	120	
8/24	110	
8/25	110	lost circulation/LCM slugs/condition hole
8/26	89	
8/27	91	
8/28	100	
8/29	30	total depth (4505 feet)

Core penetration decreased substantialy during the first half of August as compared to the rates in July. Rates were generally less than 50 feet per day, compared to more than 100 feet per day in July. Depth of drilling played some role in the rate decrease; however, the nature of the lower Baca Formation was the primary cause of penetration rate reduction. Drilling rates increased dramatically after the NQ reduction and the bad formation in the lower Baca was cemented behind the HQ rods. NQ core rates for the lower 750 feet of the Alpine 1/Federal averaged about 100 feet per day. A 100 feet per day rate of coring at depths below 3,500 feet is generally regarded as excellent, especially considering the time to pull the core tube, retrieve the core, and then send the tube back to bottom in order to resume coring.

2.8 BIT PERFORMANCE

Core bit performance for drilling the Alpine 1/Federal hole was generally very good (Table 6). In 2,869 feet of formation coring, seven HQ bits and 3 HQ reamer shells were used. Also, two NQ bits and 2 NQ reamer shells were used for 1,136 feet of formation coring. An additional "used" NQ bit was used to core out cement. A ten foot core barrel was employed except for the 2,922 feet to 3,369 feet interval (447 feet), where a 20 foot core barrel was used. All core bits were diamond bits except for the HQ-3 bit which was a carbide bit.

Table 6 Core bit performance.

bit	top ft	bottom ft	footage ft	S/N	shell	remarks
HQ1	497	934	437	3Q30126	3R940	10' core barrel
HQ2	934	1,669	735	L12627	3R951	10' core barrel
HQ3	1,669	2,544	875	20241	3R940	10' core barrel/carbide bit
HQ1	2,544	2,922	378	3Q30126	3R951	10' core barrel/bit reused
HQ4	2,922	3,054	132	L20078	3R940	20' core barrel
HQ5	3,054	3,207	153	32214/11	3R951	20' core barrel
HQ6	3,207	3,337	130	32214/12	3R948	20' core barrel
HQ7	3,337	3,369	32	1Q16424/4	3R948	20' core barrel/left in hole
NQ1				7557	3R1819	used bit/core-out cement
NQ2	3,369	3775	406	L20966	3R1819	10' core barrel
NQ3	3,775	4,505	730	28145-1	3R823	10' core barrel

Where the formation held up well the HQ diamond bits averaged 775 feet. The NQ bits averaged 568 feet of footage. From 2,922 feet to 3,369 feet depth, HQ bits 4 through 7 averaged only 112 feet of footage. While a 20 foot core barrel was used during drilling with these bits; the lower footages are attributed to bad formation. The Baca Formation drilled in this interval contained very hard resistant gravels in a matrix of clay and sandy clay. The clays tended to swell and washout easily, releasing gravel, "cave" into the borehole. Washed out clay and sand contributed to downhole drill string torque and bent rods. The resistant gravel as "cave" contributed to much uneven bit wear.

The carbide bit had a footage of 875 feet. A carbide bit was selected because the formation drilled by the carbide bit had much fine-grained silt and clay-rich strata, which can polish or plug a diamond bit face.

Figure 5 is a penetration diagram for coring of the Alpine 1/Federal bore hole. The penetration rate is a function of many variables. Among the more important are formation properties and bit type. Between 500 and 1,669 feet (bits HQ-1 and HQ-2), penetration time ranged from 4 to 8 min/ft. The carbide bit penetration from 1,669 to 2,544 feet depth, ranged from 4 to 12 min/ft. The greater variability is probably a function of changing rock types of an interbedded claystone, siltstone, sandstone sequence. The interval from 2,544 to 2,922 with the HQ-1 bit shows a general decrease in penetration from 6 to 12 min/ft. A generally increasing penetration time with depth in this interval is attributed to formation changes, rather than bit wear. Penetration of the 2,922 to 3,369 feet interval, bits HQ-4 through HQ-7 is highly variable with penetration times generally greater than 15 min/ft. Rates exceeding 30 min/ft were common.

Rates for NQ-2 (3,369 to 3,375 ft) are also highly variable and generally range from 8 to 16 min/ft. Penetration for NQ-3 is relatively steady and averages about 7 min/ft from 3,775 feet to about 4,250 feet. From 4,250 feet to 4,505 feet depth, the penetration is about 10 min/ft and is somewhat variable between 8 and 15 min/ft. A total depth of 4,505 feet was reached on 29 August and the hole was completed as a temporary observation hole by 31 August. The NQ rods where left in the hole to function as temperature observation tubing and to provide a contingency for re-entry to deepen the Alpine 1/Federal to Precambrian basement

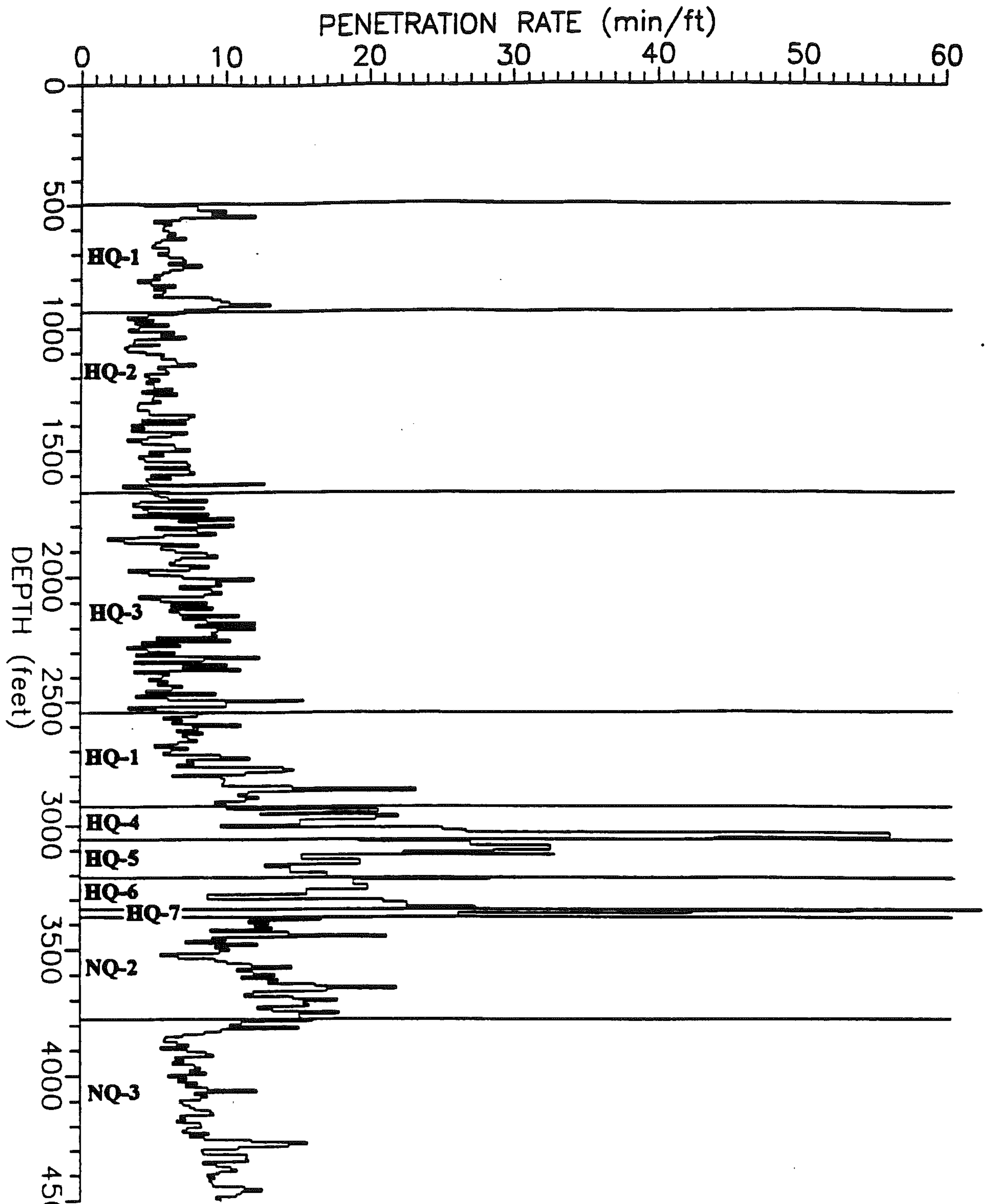


Figure 5. Core penetration rate versus depth for the Alpine 1/Federal borehole. Core bit footage is also shown. Bit labels correspond to labels in Table 6.

2.9 DRILLING MUD PROGRAM

Summit Drilling Fluids, Denver, Colorado provided drill mud supplies and services for the Alpine 1/Federal borehole. Summit's mud engineer, Mr. Kevin Buchanan of Tucson, Arizona, periodically tested the drilling mud and made recommendations for the drilling mud program.

Maintenance of proper drilling fluids is important in lubricating the hole, cleaning the hole of cuttings, stabalizing cored formations, and preventing lost circulation. Table 7 shows the measured properties of the drilling mud at various depths during drilling. An ideal mud for the Alpine 1/Federal borehole has a weight of about 8.4 lb/gal, a viscosity of 30 to 40 s/qt, a trace percentage or less of sand, and less than 1.5 percent solids. The interval from 3,076 to 3,338 feet shows deviation from ideal mud conditions. Formation washout and clay addition to mud was difficult to control in this interval even with frequent mud and hole conditioning.

Table 7 Drilling mud properties for the Alpine1/Federal borehole.

date	depth ft	circ volume gal	viscosity s/qt	weight lb/gal	mud gradient psi/ft	filtrate cm^3/30 min	wall cake API	pH	hardness mg/l Ca	Cl mg/L	sand % vol	solids % vol
7/14/93	634	1245	54	8.4	0.4368	12	1	10	40	300	0	1
7/15/93	805	1311	35	8.5	0.4420	14.2	1	9	80	240	tr	1.5
7/20/93	1689	1652	37	8.5	0.4420	11	1	8.5	40	300	tr	1.5
7/29/93	2779	2067	39	8.5	0.4420	7.4	1	8	20	400	tr	1.5
8/3/93	3076	2187	41	8.6	0.4470	7.6	1	8.5	40	500	0.75	2
8/4/93	3098	2196	47	8.6	0.4470	7.2	1	8.5	40	500	1	2
8/10/93	3338	2289	61	8.6	0.4470	7.4	1	8.5	40	500	0.5	2
8/16/93	3447	2297	42	8.5	0.4420	11	1	9.5	tr	400	tr	1.5
8/18/93	3535	2320	58	8.4	0.4368	11.8	1	9.5	tr	400	tr	1
8/23/93	3935	2424	51	8.4	0.4368	18.6	1	9	tr	400	tr	1
8/25/93	4145	2479	48	8.4	0.4368	11.6	1	8.5	20	500	tr	1

Appendix 6 provides brief descriptions and shows consumptive use of the drilling mud additives and related materials for the Alpine 1/Federal borehole. Table 8 is list of registered product names. Cement use was confined to cementing surface casing and HQ rods at 500 and 3,360 feet, respectively.

Table 8 List of drilling products with registered names and trademarks.

product	company
DRISPAC	Drilling Specialities Company, Inc.
SDF K-LA LUBE PLUS	Summit Drilling Fluids, Inc.
SDF RING FREE L PLUS	Summit Drilling Fluids, Inc.
SDF 2000	Summit Drilling Fluids, Inc.
SDF SUPER GEL	Summit Drilling Fluids, Inc.
TORKEASE	Drilling Specialities Company, Inc.

Use of drilling detergent to stabilize clay began below 3,000 feet depth. Use of *Drispac Plus*, a drilling polymer, was fairly constant except for the lower 1,000 feet when usage doubled. *K +La Lube Plus*, a biodegradable liquid lubricant, had a useage decline between 2,000 and 3,000 feet depth. Rod grease, used to reduce formation sticking, was used only below 3,370 feet depth. *Ring Free*, used to reduce mud viscosity and clean mud rings, was used regularly from 2,000 feet to total depth. *SDF 2000*, a drilling polymer, had decreased use between 1,500 and 3,370 feet depth. Use of soda ash increased below 3,000 feet to control pH and calcium content of the mud.

Anhydrite and limestone are abundant below 3,000 feet in the Alpine 1/Federal borehole. *SDF Super Gel*, a bentonite drilling mud, was used mainly to rotary drill the upper 500 feet of the hole and to build wall cake and control circulation losses between 3,370 and 3,850 feet depth (interval is mostly the porous Dakota and Glorieta/Coconino Sandstones).

2.10 LOST CIRCULATION

Three major lost circulation zones were encountered in the San Andres/Glorieta (Kaibab/Coconino), and Yeso (Supai) Formations. However, full and partial returns were maintained during most of the drilling through these intervals. Where circulation was lost, the hole was conditioned with lost circulation material (LCM) slugs. The LCM slugs were circulated after the drill string was pulled back at the end of a core runs. Figure 6 shows borehole depth versus LCM with a pre-equilibrium temperature log superimposed. Negative spikes in the temperature log indicate formation cooling effects that result from loss of drilling fluids. Major cooling spikes match the depths where LCM was used.

Lost circulation was almost entirely due to open fractures; although significant intergranular porosity was evident in the Glorieta (Coconino) Formation. Intergranular porosity was indicated by selective drill mud sieving (i.e. mud buildups on outer core surfaces where grain cementation is low).

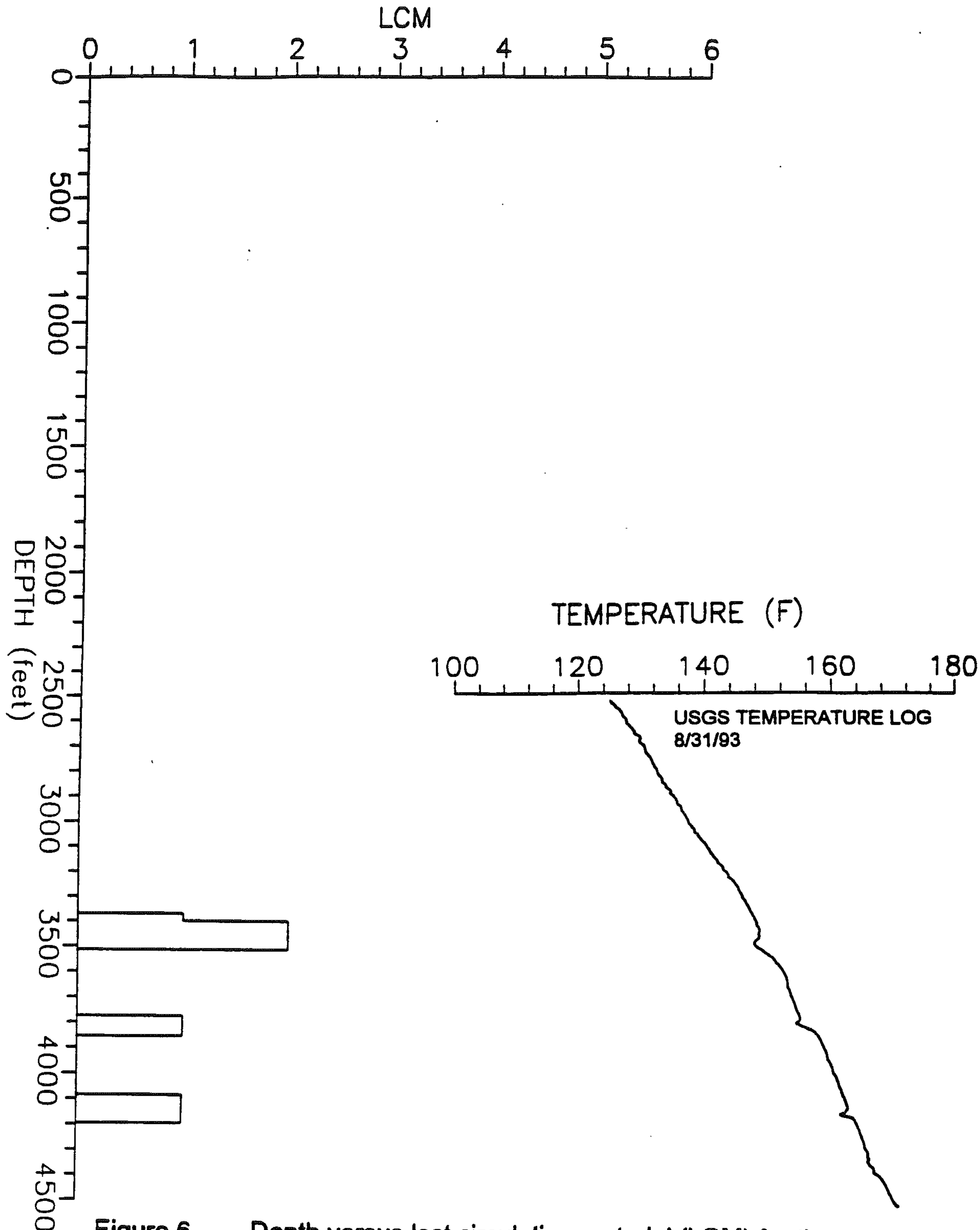


Figure 6. Depth versus lost circulation material (LCM) for the Alpine 1/Federal borehole. The inset graph shows temperature versus depth across the interval of lost circulation one day after drilling stopped.

2.11 FORMATION PROBLEMS AND DIFFERENTIAL STICKING

Starting at 2,700 feet depth, maintenance of proper drilling mud became increasingly difficult and penetration rates slowed (Figure 7) The sandy clay and clayey sand in matrix-supported conglomerate and gravels in the basal Baca Formation were easily eroded from the borehole walls. As a result, the drilling fluids became more viscous and sandy. Formation washouts also left loose gravel behind that fell into the hole and contributed to drill string sticking. Figure 8 shows depth intervals for the application of the drilling mud additive, *TorkEase*, which was used to reduce drill string friction. The sticking and wedging resulted in bent drill rods on two occasions (see Figure 4). Rather than reduce from HQ to NQ coring at the base of the Baca and place the bad formation behind cement and the HQ drill string, Tonto decided to continue carefuly and slowly coring HQ to insure against premature drill string reduction to NQ size drill string. Prior to actual drilling, the Permian San Andres/Kaibab and Glorieta/Coconino Formations were identified as potential problem zones for drilling that could require reduction from HQ to NQ core (see Appendix 1). A reduction from HQ to NQ core was forced because the drill string became differential stuck.

Differential or hydraulic stuck is a term used to describe a condition where the drill string is unable to be turned and/or be withdrawn or advanced without snapping the rods. This results when differential hydraulic pressures push the drill string into the hole wall and friction prevents rod movement.

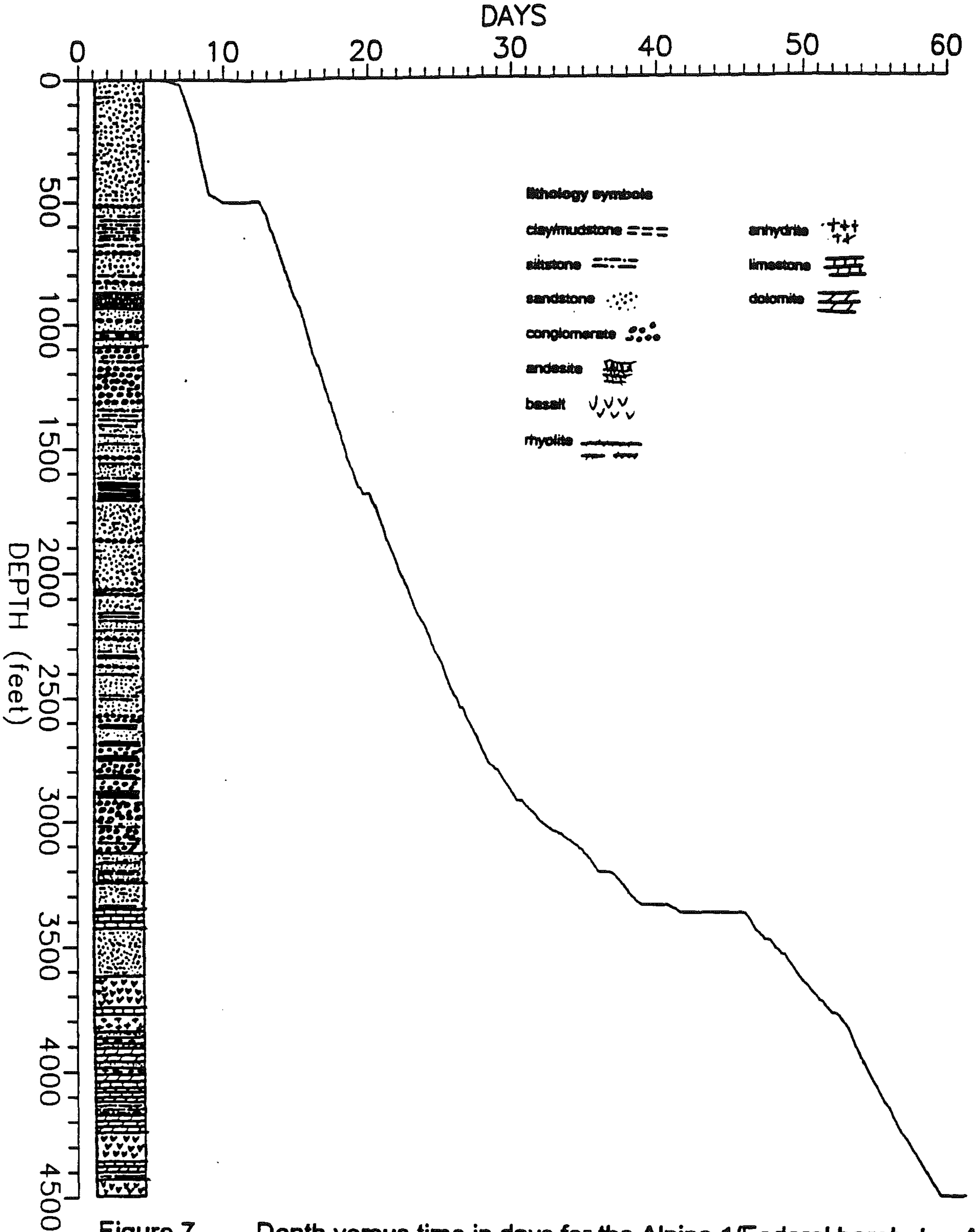


Figure 7. Depth versus time in days for the Alpine 1/Federal borehole. A summary stratigraphic column is shown for comparing geology with daily drilling progress.

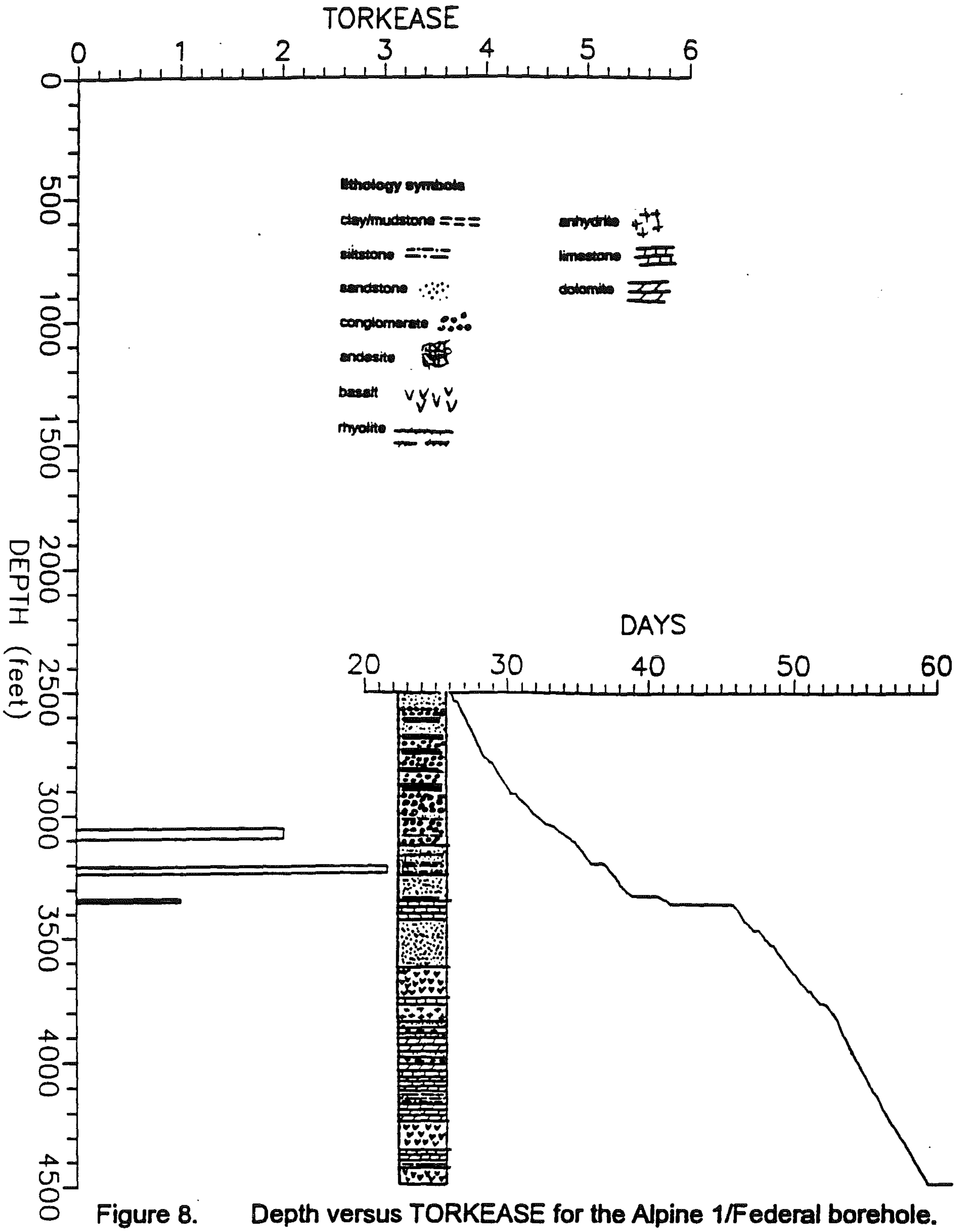


Figure 8. Depth versus TORKEASE for the Alpine 1/Federal borehole. The inset graph shows the stratigraphy and daily drilling progress for the lower portion of the hole.

Drilling detergent is circulated to loosen the mud and sand cake along the hole wall while carefully working the rods back and forth. If this fails to unstick the drill string when the wireline continuous core drilling method is used, drilling resumes through the larger and stuck drill string with a reduced size drill string. When rotary methods are used, it is necessary to back off and retrieve the string above the stuck interval and use jars and fishing tools to fish the remaining string from the hole. A fishing job can be very expensive and is sometimes unsuccessful, resulting in loss of the hole.

In the Alpine1/Federal hole, the drill string became differential stuck, with circulation returns at 3,360 feet, after pulling back from 3,369 feet to pull the core tube. Because the bit was not on bottom, the Tonto elected to cement the the lower part of the HQ string in place when detergent and working the rods for 36 hours failed to free the string. The cement job insured that the HQ reamer shell and HQ bit would stay in place during later drilling with the NQ string. Two cement jobs with a total of 22 sacks of cement were used to cement the HQ string in place. Coring with a reduced NQ string resumed on 16 August. Good penetration rates returned. The NQ drill rods became differential stuck at 3,765 feet depth on 21 August. Circulation of detergent and working the rods for 1 hour successfully freed the drill string. The core barrel mislatched on the the next core run from 3,765 to 3,775 feet depth, resulting in the only significant loss of core in the Alpine1/Federal borehole. No more significant drilling problems were encountered.

2.12 DRILLING MUD TEMPERATURES

Two types drilling mud temperatures were measured during drilling operations. Both measurements are primarily intended to insure safe drilling and comply with federal Geothermal Resources Operations Orders (GROOs), especially where very high temperatures may be encountered. Figure 9 shows mud temperatures measured periodically at the surface after reaching the maximum depth of the adjacent SJ-116 temperature gradient hole. Very little systematic variation occurs. The decrease in mud temperature below 3,500 feet depth is attributed to different heat transfer between the formation and the smaller NQ drill string which has drill fluid circulation rates similar to the larger HQ string. Figure 10 shows mud temperatures measured down the hole at the end of core runs. These bottom hole temperatures (BHT) measurements are taken with a maximum thermometer placed inside a sealed bomb that is placed on the overshot. Readings are taken for 10 minutes after the wireline lowers the overshot to pickup the core tube. The BHT measurements were run at approximately 50 feet intervals after temperatures reached 100 F. In general, the BHT measures can roughly mimic the natural temperature gradient. The BHT measurements are lower than actual temperature values of the formation. Spuriously high measurements from 2,400 to 2,600 feet are the result of bomb leakage and downhole pressure squeezing of the glass mercury thermometer.

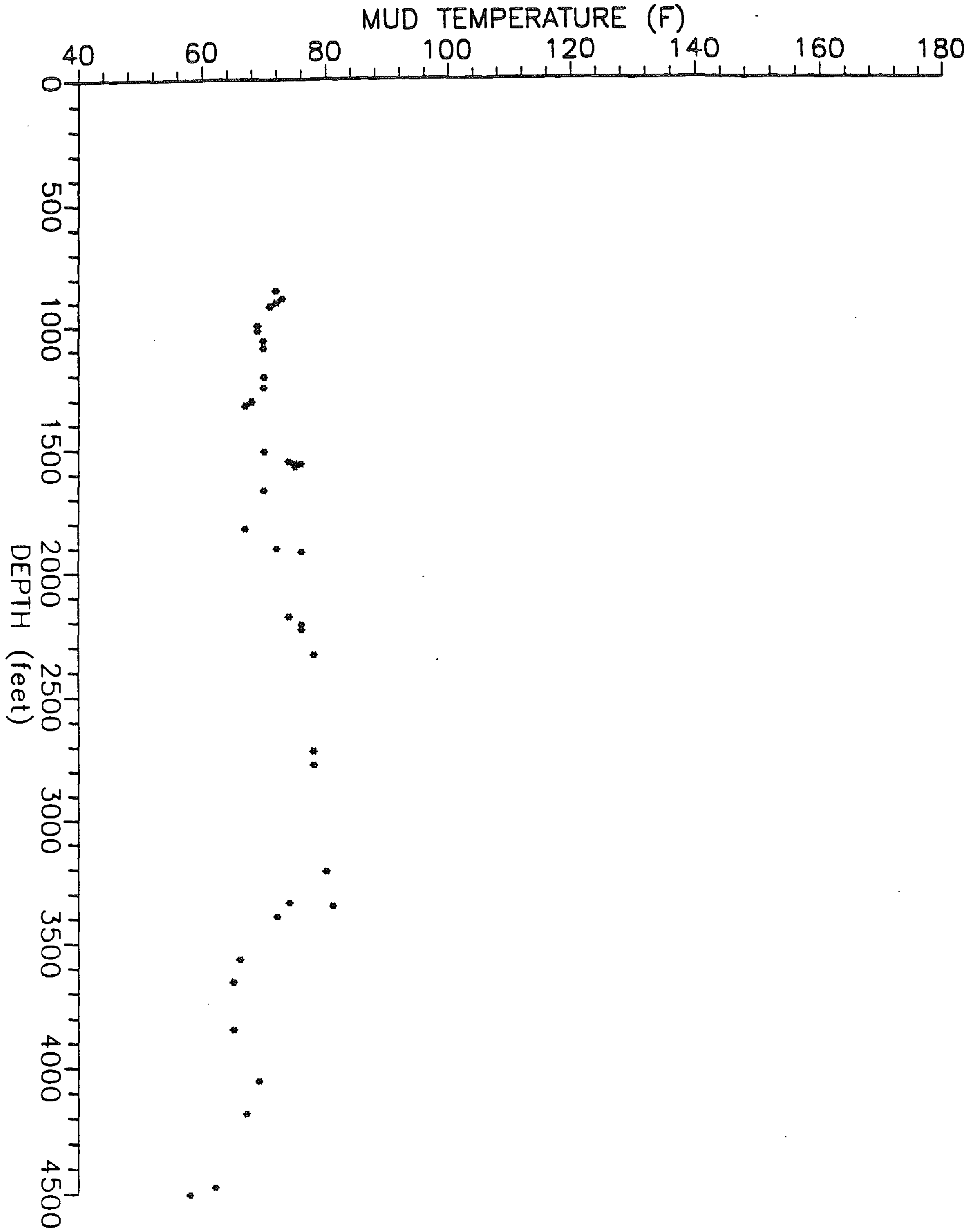


Figure 9. Surface mud temperature versus drilling depth.

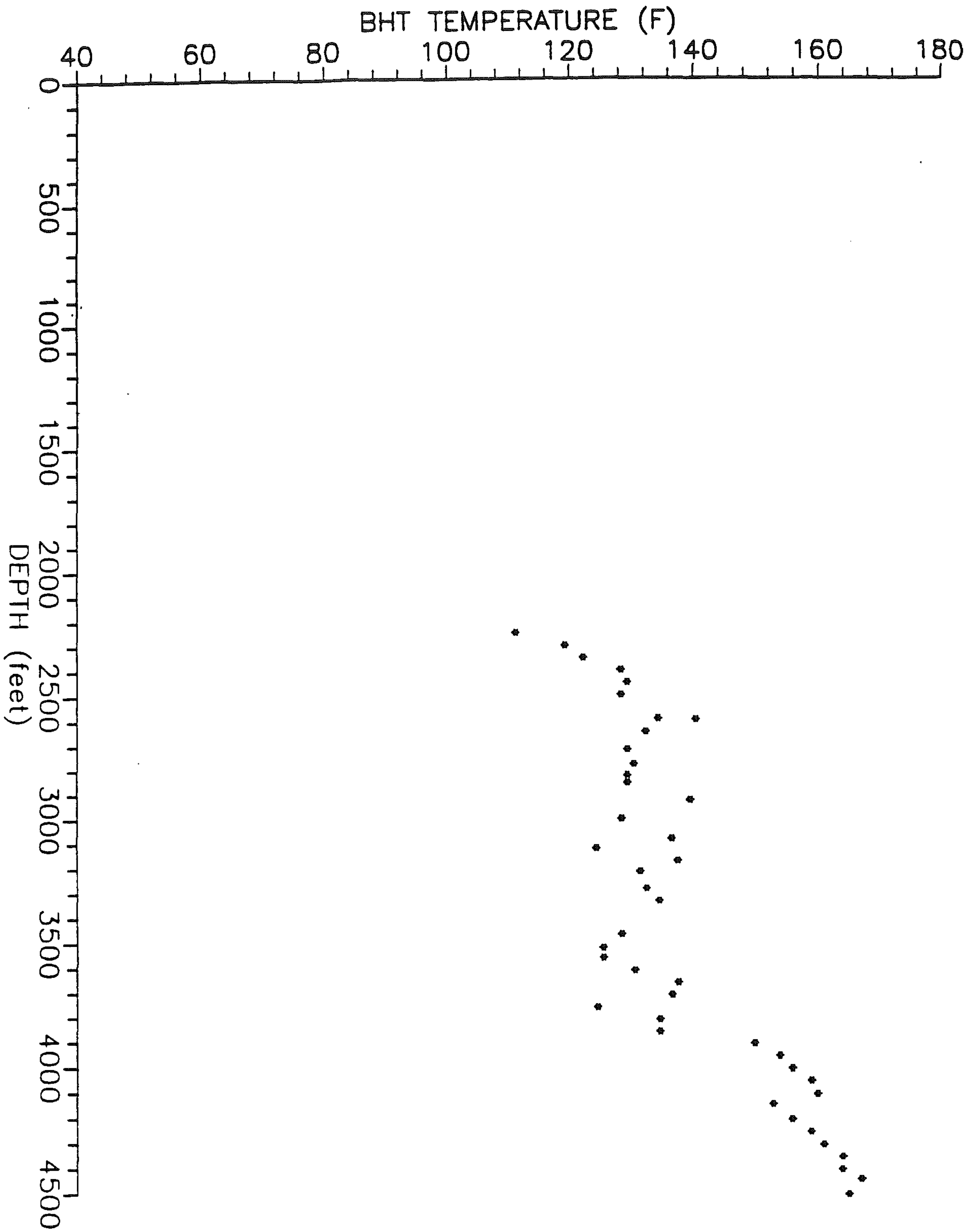


Figure 10. Subsurface bottom-hole mud temperature (BHT) versus drilling depth.

2.13 OBSERVATION WELL COMPLETION

A total depth of 4,505 feet was reached on 29 August within a basalt intrusion in the Yeso Formation. The drilling target, Precambrian basement was not reached because a thicker than anticipated section of Tertiary sediments was encountered. The rigid turn key contract of the State of Arizona precluded drilling deeper. Within this framework, the well completion was changed to provide a contigency for re-entering the hole at a later time inorder to drill to Precambrian basement and perform detailed scientific studies (Appendix 7).

Instead of a steel pipe liner, the hole was completed with the NQ drill rods after cutting the HQ rods and retrieving the HQ rods from 2,510 feet depth to the surface. The remaining 850 feet of HQ rods from 2,510 feet to 3,360 feet depth were left cemented in place to hold back the bad formation in that interval (Figure 11 and Table 9). The NQ rods were capped at the bottom and filled with water to allow formation temperature measurements. The completion will allow for later drilling to continue with a NQ drill string if the NQ rods in the hole can be retrieved or with a BQ drill string if the NQ rods cannot be retrieved. A BQ drill string may be inserted in the NQ rods and the bottom cap drilled-out for continued coring to Precambrian basement.

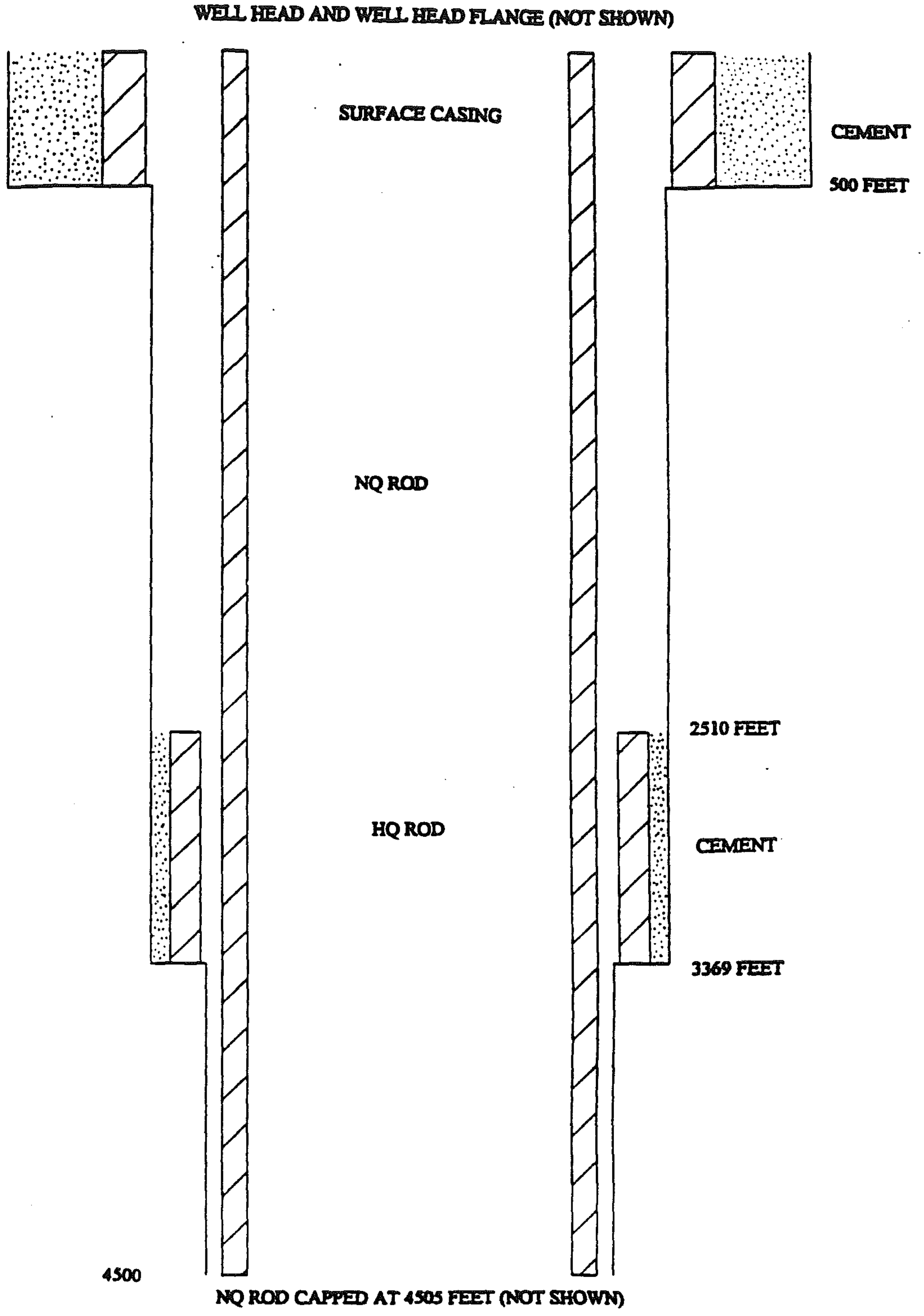


Figure 11. Temporary observation well completion diagram.

Table 9 Alpine1/Federal temporary observation completion specifications.

item	hole size inches	top ft	bottom ft	OD inches	ID inches	weight lbs/ft	cement sacks
well head flange	0	0		7.0625			
conductor casing	7.875	0	20	6.625	5.796	24	5
surface casing	5.875	20	502	4.5	3.875	11.6	44
HQ hole	3.850	500	3,369				
HQ casing	3.782	2,510	3,360	3.5	3.0625	7.7	22
NQ hole	3.040	3,369	4,505				
NQ casing	2.98	3,369	4,505	2.75	2.375	5.2	0

2.14 GEOPHYSICAL AND TEMPERATURE LOGGING

The Alpine1/Federal borehole was geophysically logged several times after the well was completed as a temporary observation well. A suite of temperature logs was performed by the USGS, Geothermal Studies Project, Flagstaff, Arizona (Table 10). SWTDI/NMSU contracted Southwest Geophysical Services, Farmington, New Mexico to perform an additional temperature log and neutron and gamma logs of the hole after the hole had mostly recovered from thermal disturbances of drilling.

The USGS and Southwest Geophysical Services temperature logs were performed with wireline tools that were outfitted with thermister probes. A continuous logging rate of about 20 feet per minute was used with a sampling interval of 0.3 seconds or about 3 measurements per foot. Digital acquistion equipment was used to sample the wireline signal. Data output in the form of digital ASCII files allows subsequent analysis and interpretation. Prior to logging the thermister probes were placed in a ice-water bath to check the ice-point calibration. Ice-point accracies were within 0.2 degrees Fahrenheit. Precision of the USGS system is in hundreths of a degree; while the Southwest Geophysical Services system is precise to a tenth of a degree.

Table 10 Geophysical and temperature logs of the Alpine1/Federal hole.

type log	date	interval ft	logged by
temperature	8/31/93	0-4505	USGS/Sass
temperature	9/7/93	0-4505	USGS/Sass
temperature	9/17/93	0-4505	USGS/Sass
temperature	9/30/93	0-4505	USGS/Sass
temperature	10/21/93	0-4505	USGS/Sass
temperature	10/22/93	0-4505	Southwest Geophysical
gamma/neutron	10/21/93	0-4505	Southwest Geophysical

The gamma and neutron logs were obtained on the same logging run by attaching both the gamma and neutron tools to the wireline. Normally, a caliper tool is also attached if logs are run in an open hole. Because the logs were run through the water-filled NQ rods, no caliper tool was used. Maximum sampling radius for the gamma and neutron logs is about 1 to 2 feet into the formation. A logging rate of 20 feet per minute is used. As with temperature logs, the wireline signal is digitally converted into ASCII files for analysis and interpretation.

The gamma log measures gamma radiation from naturally occurring uranium, thorium, and potassium. Because different rock types have different radioactivity levels, the gamma log is a very useful lithology correlation tool. For instance, shales and clay have higher natural radioactivity than sandstone and sand. The neutron tool contains an active radioactive source that emits neutrons and a detector that spaced on the tool about two feet from the neutron source. Neutrons emitted by the tool are principally slowed to low energies by hydrogen (i. e. water and hydrocarbons) in the formation, resulting in less signal for the detector if porosity is high. Where hydrogen content is low (low porosity) the neutrons diffuse much greater distances (closer to the detector) before slowing to low energies. Because of hydrogen sensitivity, the neutron log has use as an indicator of relative formation porosity.

2.15 SITE RESTORATION AND WELL ABANDONMENT

Site cleanup of the Alpine 1/Federal borehole at the end of the temporary well completion consisted of removing all trash and equipment from the site, except for the well head and locked well head housing. Mud in the mud pit was removed and properly disposed at a designated USFS site. The pits were then covered and the substructure pad recontoured to conform with natural terrain. A nearby USFS cement pad was also covered and the overlying surface was smoothed. Fences and gates were replaced in order to return the site or original condition.

When observation well studies are complete the well head will be removed and cement plugs will be placed at the surface and across the surface casing shoe. The well casing will be cut so that it may be covered below grade. Gravel that is providing a substrate for all-weather egress to the site from the logging road will be removed and all disturbed ground will be seeded.

3.0 REFERENCES

Minier, J. and Reiter, M., 1991, Heat flow on the southern Colorado Plateau: Tectonophysics, v. 200, p. 51-66.

Potter, R. M., Robinson, E. S., and Smith, M. C., 1974, Method of extracting heat from dry geothermal reservoirs: U. S. Patent #3,786,858.

Stone, 1980, Springerville-Alpine geothermal project, results of heat flow drilling: Arizona Bureau of Geology and Mineral Technology Open-File Report 79-17, 21 p.

Tester, J. W., Brown, D. W., and Potter, 1989, Hot Dry Rock geothermal energy - a new energy agenda for the 21st century: Los Alamos National Laboratory Report LA-11514-MS, 30 p.

APPENDIX 1

SUMMARY OF CANDIDATE DRILL SITES

ALPINE DIVIDE

Land Status

Apache-Sitgreaves National Forest

Attributes

This site had the highest measured temperature gradient in the area. The subsurface geology was known to depth over 1,000 feet. Regional geologic relationships suggested that the cavernous Kaibab limestones may be missing below an unconformity at this site. Access to the site was very good as the site was immediately adjacent a paved highway.

Drawbacks

The site had high visibility. The U. S. Forest service did not allow disposal of drilling fluids on site. The site was located about 7 miles from water sources.

Institutional Setting

Permitting and approvals was required from the U. S. Forest Service, U. S. Bureau of Land Management, and the Arizona Geological Survey, Oil and Gas Administrator.

Geothermal Potential Ranking

This site ranked the highest in terms of geothermal potential. The temperature of the Precambrian basement was highest at this location for two important reasons. First, the depth to Precambrian basement was greater and the sediments that act as thermal blankets had greater thickness. This translated into higher temperatures in the Precambrian. Second, the site was known to have the highest measured temperature gradients (71 C/km).

NUTRIOSO

Land Status

Private/Escudilla Management Corporation

Attributes

Access to the site was good and mud pits were be allowed along with drill mud disposal. The site was adjacent to sources of water for drilling. Permitting was only required by the Arizona Geological Survey, Oil and Gas Administrator. Drilling depth to Precambrian basement was probably about 500 feet less than at Alpine Divide.

Drawbacks

The subsurface geology in the upper 500 feet, the surface casing shoe depth, was not known. It was not known if the land owner would indemnify project participants. The San Andres/Kaibab Formation, a cavernous limestone with potential for serious drilling problems, was more likely to be present at the Nutrioso site than at the Alpine Divide site.

Institutional Setting

Permits were required from the Arizona Geological Survey, Oil and Gas Administrator.

Geothermal Potential Ranking

This site had less geothermal potential than the Alpine Divide site because of a thinner section of low thermal conductivity sediments than the site at Alpine Divide. Also, available information shows the site would have lower temperature gradients as well (see well DR-1 at Nutrioso in Stone (1980), temperature gradient is 51 °C/km).

APPENDIX 2

PARTICIPANTS AND SUPPLIERS IN THE ALPINE1/FEDERAL DRILLING PROJECT

U. S. DEPARTMENT OF ENERGY

DOE REGIONAL OPERATIONS OFFICE/ALBUQUERQUE

Niles Lackey-project manager

Daniel Sanchez-progect manager

STATE OF ARIZONA

ARIZONA DEPARTMENT OF PROCUREMENT

Robert E. Stephenson-administrator

ARIZONA DEPARTMENT OF COMMERCE

Jim Marsh-director

ENERGY OFFICE

Jack Haenichen-director

Dr. Frank Mancini-program manager

GEOTHERMAL EVALUATION COMMITTE

Dr. Frank Mancini-chairman/AZ Commerce Dept Energy Office

Dr. Larry Fellows-state geologist/AZ Geological Survey

Steven L. Rauzi-oil and gas administrator/AZ Geological Survey

John Crawford-consultant

John Hauskins-AZ Dept of Transportation

PRIME CONTRACTOR/DRILLING CONTRACTOR

TONTO DRILLING SERVICES

George Mclaren-president

Larry Pisto-manager Core Division

Ron Fierbach-supervisor Core Division

Mike LaOrange-drill forman

George Behunin-driller

Dan Antonioli-driller

Carl McCracken-driller

Jim Thagard-helper

James Powell-helper

C. W. Roseberry-helper

Tim Lambert-helper

GEOTECHNICAL SUBCONTRACTOR

SOUTHWEST TECHNOLOGY DEVELOPMENT INSTITUTE (SWTDI)

NEW MEXICO STATE UNIVERSITY (NMSU)

Dr. James Halligan-president

NMSU Engineering College

Dr. Darryl Morgan-dean

NMSU/SWTDI

Dr. Rudi Schoenmackers-director

James C. Witcher-geologist/project manager

H. Richard Hahman-consultant/registered geologist

Dr. Chandler A. Swanberg-geothermal consultant

INVITED PARTICIPANT

U. S. GEOLOGICAL SURVEY/GEOTHERMAL STUDIES PROJECT

Dr. John Sass-geophysicist/director

Fred Grubb-geophysicist

Dr. Thomas Moses-geophysicist

PERMITS AND REGULATORS
- FEDERAL
  - U. S. FOREST SERVICE/APACHE-SITGREAVES NATIONAL FOREST
    - ALPINE DISTRICT
      - Dean Berkey-district ranger
      - Bob Dyson-district minerals manager
      - Sandra Boone-archeologist
      - Don Hoffman-assistant
  - U. S. BUREAU OF LAND MANAGER/STATE OFFICE
    - John Haas-engineer
- STATE
  - ARIZONA GEOLOGICAL SURVEY
    - Steven L. Rauzi-oil and gas administrator
  - ARIZONA DEPARTMENT OF TRANSPORTATION
  - ARIZONA DEPARTMENT OF WATER RESOURCES

SUPPLIERS AND SERVICES
- WATER
  - LUNA IRRIGATION DISTRICT/LUNA, NM
    - Phil Swapp-rancher
    - Max Reynolds-rancher
- SITE SURVEY
  - Larry K. Whitmer-registered surveyer/Alpine, AZ
- LODGING/CABINS
  - M. J. SCOTT COMPANY/ALPINE, AZ
    - Millard Scott-owner
- WIRELINE GEOPHYSICAL SURVEYS
  - SOUTHWEST GEOPHYSICAL SURVEYS/FARMINGTON, NM
    - Don Pierson-president/geophysicist
    - Mick Peterson-geophysicist
- DRILLING MUD
  - SUMMIT DRILLING FLUIDS/DENVER, CO
    - Keven Buchanan-engineer/Tucson, AZ
- DRILL SITE PREPARATION/DIRT WORK
- H2S MONITORING AND SAFETY EQUIPMENT
  - TECTON GEOLOGIC/HEALDSBURG, CA
- BLOWOUT PREVENTION EQUIPMENT
  - H & H OIL TOOL COMPANY
- PORTABLE TOILETS
  - BURKS SANITATION/ALPINE-SPRINGERVILLE, AZ
- DRILL SITE TRASH PICKUP
  - HUGHES REFUSE/ALPINE-SPRINGERVILLE, AZ
- CASING, SHOES, CENTRALIZERS, AND OTHER DRILLING SUPPLIES
  - REPUBLIC STEEL
  - HALIBURTON
  - LONGYEAR

APPENDIX 3

CORE MARKING PROCEDURES FOR THE ALPINE1/FEDERAL DRILLING PROJECT

REMOVAL OF CORE FROM CORE BARREL

Measurement of core

When the core barrel was removed from the well, the amount of core in the core barrel was measured with a tape measure after the core was removed from the core barrel.

Placement of core in core tray

Core was removed from the barrel and placed in the core tray. Care was taken to insure that:

- All core pieces were in the proper sequence.
- All core pieces were oriented in the same direction.
- The top of the core sequence (core run) was indicated using a wooden block with the label "TOP".

Washing core

If the core needed to be washed, the core was washed in the core tray. A bucket of water and a stiff paint brush was used for core washing.

Marking core

Any peices of core longer than one core width (about 3 inches) were marked with a grease pencil while the core was in the core tray. Individual pieces were marked as follows:

- A downhole arrow pointing away from the "TOP" block.
- The core run number.
- The piece number (beginning with 1 for the top piece nearest the "TOP" block and numbered sequentially to the last or bottom piece).
- Core was labeled so that if the core needed to be broken for boxing or sampling, the break would not occur where the piece of core is labeled.

In other words, labeling the run number and piece number at the ends of the core piece or over geologically important features such as mineralized veins or fossils was avoided.

BOXING AND LABELING THE CORE

Labeling core boxes

Cardboard boxes were used to store core. One end of the core boxes was labeled. Minimum labeling included:

- Well name (TONTO/ALPINE #1)
- Core run number.
- Beginning footage and ending footage.

Placing core in the core boxes

The core was boxed so that the top of the run was in the upper left corner.

Figure A4 shows an example core placement in a core box.

A run block (a wooden block wrapped with yellow or orange flagging) was placed in the core box in the upper left corner. The first piece of core from an individual run was placed behind the run block. The run block was labelled with a permanent marker (indelible ink) as follows:

front

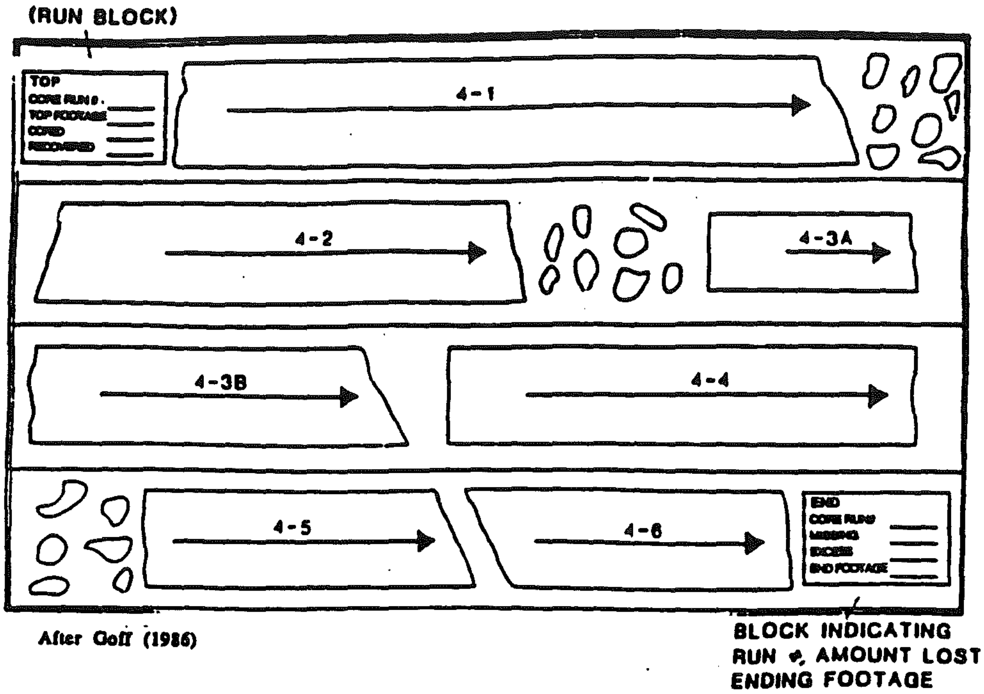
- Well name (TONTO/ALPINE #1).

back

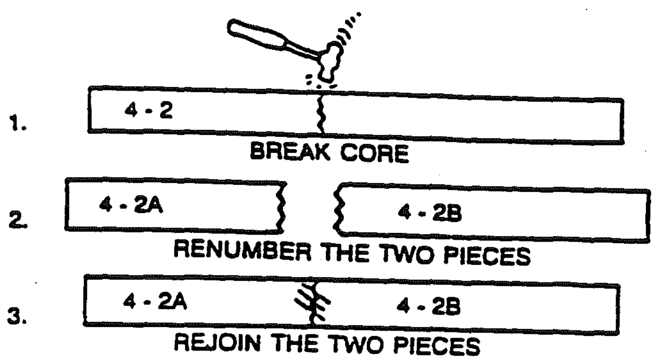
- Core run number, followed by "TOP".
- Interval cored.
- Amount cored.
- Amount recovered.

When it was necessary to break core for boxing or sampling, the break was marked and the pieces renumbered with alphabetically (Figure A4).

- Core pieces were relabeled with alphabetical designations ("A" for the top piece).
- The two pieces of broken core were fitted back together.
- Two or three (3) diagonal parallel lines were placed across the break with a grease pencil or felt tip permanent marker.



After Goff (1986)



After Goff (1986)

An end block followed the last piece of core in the box. The end block was labeled with a permanent marker as follows.

front

- Core run number, followed by "END".
- Missing core (Label with "M").
- Excess core (Label with "E").
- Ending footage.

side

- Ending footage.

REFERENCE

Goff, S., 1986, Curational policy guidelines and procedures for the Scientific Drilling Program: Los Alamos National Laboratory Report LA-10542-OBES, 23 p.

APPENDIX 4

CORING OPERATIONS LOG FOR THE ALPINE 1/FEDERAL BOREHOLE

RUN #	BEGIN date/time	END date/time	DRILL TIME hrs:min	TOP ft	BOTTOM ft	CORED ft	RATE min/ft	RECOV'D ft	BOX #
1	7/13/89 11:20	7/13/89 11:50	0:30	497.0	504.0	7.0	0:04	1.9	1
2	7/13/89 12:10	7/13/89 13:30	1:20	504.0	514.0	10.3	0:08	10.5	1/2
3	7/13/89 13:40	7/13/89 15:00	1:20	514.0	524.0	10.0	0:08	9.9	2/3
4	7/13/89 15:10	7/13/89 16:50	1:40	524.0	534.0	10.0	0:10	9.8	3/4
5	7/13/89 17:00	7/13/89 18:30	1:30	534.0	544.0	10.0	0:09	10.0	4/5
6	7/13/89 19:50	7/13/89 21:50	2:00	544.0	554.0	10.0	0:12	9.0	5/6
7	7/13/89 22:00	7/13/89 23:08	1:08	554.0	564.0	10.0	0:06	9.5	6/7
8	7/13/89 23:33	7/14/89 0:23	0:50	564.0	574.0	10.0	0:05	10.0	7/8
9	7/14/89 0:40	7/14/89 1:42	1:02	574.0	584.0	10.0	0:06	10.0	9
10	7/14/89 1:45	7/14/89 2:42	0:57	584.0	594.0	10.0	0:05	10.0	10
11	7/14/89 2:45	7/14/89 3:41	0:56	594.0	604.0	10.0	0:05	10.4	11
12	7/14/89 3:45	7/14/89 4:45	1:00	604.0	614.0	10.2	0:06	10.2	12
13	7/14/89 5:25	7/14/89 6:30	1:05	614.0	624.0	10.0	0:06	10.0	13
14	7/14/89 8:35	7/14/89 9:28	0:53	624.0	633.0	10.0	0:05	10.0	14
15	7/14/89 9:35	7/14/89 10:40	1:05	633.0	642.0	10.0	0:07	10.0	15
16	7/14/89 10:51	7/14/89 11:46	0:55	642.0	652.0	10.0	0:05	10.0	16
17	7/14/89 12:04	7/14/89 13:05	1:01	652.0	664.0	12.0	0:05	12.0	17/18
18	7/14/89 13:26	7/14/89 14:15	0:49	664.0	674.0	10.0	0:04	10.0	18/19
19	7/14/89 14:30	7/14/89 15:30	1:00	674.0	684.0	10.0	0:06	9.9	19/20
20	7/14/89 15:45	7/14/89 16:45	1:00	684.0	694.0	10.0	0:06	9.6	20/21
21	7/14/89 16:58	7/14/89 17:51	0:53	694.0	704.0	10.0	0:05	10.4	21/22
22	7/14/89 18:10	7/14/89 19:10	1:00	704.0	714.0	10.0	0:06	10.0	22/23
23	7/14/89 19:25	7/14/89 20:35	1:10	714.0	724.0	10.0	0:07	9.7	23/24
24	7/14/89 20:48	7/14/89 22:00	1:12	724.0	734.0	10.0	0:07	9.7	24/25
25	7/14/89 22:15	7/14/89 23:15	1:00	734.0	744.0	10.0	0:06	10.1	25/26
26	7/14/89 23:30	7/15/89 0:53	1:23	744.0	754.0	10.0	0:08	10.0	27
27	7/15/89 1:10	7/15/89 2:20	1:10	754.0	764.0	10.0	0:07	10.0	28
28	7/15/89 2:30	7/15/89 3:31	1:01	764.0	774.0	10.0	0:06	10.0	29
29	7/15/89 3:48	7/15/89 4:44	0:56	774.0	784.0	10.0	0:05	9.8	30
30	7/15/89 4:56	7/15/89 5:46	0:50	784.0	794.0	10.0	0:05	11.0	31
31	7/15/89 7:28	7/15/89 8:22	0:54	794.0	804.0	10.0	0:05	10.0	32
32	7/15/89 8:36	7/15/89 9:15	0:39	804.0	814.0	10.0	0:03	9.5	33
33	7/15/89 9:35	7/15/89 10:23	0:48	814.0	824.0	10.0	0:04	9.0	34

RUN #	BEGIN date/time	END date/time	DRILL TIME hrs:min	TOP ft	BOTTOM ft	CORED ft	RATE min/ft	RECOV'D ft	BOX #
34	7/15/89 10:30	7/15/89 11:35	1:05	824.0	834.0	10.0	0:06	10.4	35/36
35	7/15/89 11:45	7/15/89 12:35	0:50	834.0	844.0	10.0	0:05	10.0	36/37
36	7/15/89 12:37	7/15/89 13:35	0:58	844.0	854.0	10.0	0:05	9.7	37/38
37	7/15/89 13:53	7/15/89 14:49	0:56	854.0	864.0	10.0	0:05	10.0	38/39
38	7/15/89 15:10	7/15/89 16:00	0:50	864.0	874.0	10.0	0:05	10.0	39/40
39	7/15/89 16:15	7/15/89 17:45	1:30	874.0	884.0	10.0	0:09	10.2	40/41
40	7/15/89 17:55	7/15/89 19:31	1:36	884.0	894.0	10.0	0:09	10.0	41/42
41	7/15/89 19:40	7/15/89 21:22	1:42	894.0	904.0	10.0	0:10	9.9	43/44
42	7/15/89 21:50	7/16/89 0:00	2:10	904.0	914.0	10.0	0:13	10.2	44/45
43	7/16/89 0:08	7/16/89 1:42	1:34	914.0	924.0	10.0	0:09	10.1	45/46
44	7/16/89 1:56	7/16/89 3:07	1:11	924.0	934.0	10.0	0:07	10.0	46/47
45	7/16/89 4:44	7/16/89 5:20	0:36	934.0	939.0	5.0	0:07	2.3	47/48
46	7/16/89 5:35	7/16/89 6:08	0:33	939.0	944.0	5.0	0:06	8.1	48
47	7/16/89 6:24	7/16/89 7:10	0:46	944.0	954.0	10.0	0:04	9.5	49/50
48	7/16/89 7:36	7/16/89 8:08	0:32	954.0	964.0	10.0	0:03	8.0	50/51
49	7/16/89 8:45	7/16/89 9:25	0:40	964.0	972.0	8.0	0:05	9.8	51/52
50	7/16/89 9:55	7/16/89 10:32	0:37	972.0	982.0	10.0	0:03	10.5	52/53
51	7/16/89 10:50	7/16/89 11:50	1:00	982.0	992.0	10.0	0:06	9.9	53/54
52	7/16/89 12:05	7/16/89 12:45	0:40	992.0	1002.0	10.0	0:04	10.6	54/55
53	7/16/89 13:15	7/16/89 13:50	0:35	1002.0	1012.5	10.0	0:03	10.4	55/56
54	7/16/89 14:05	7/16/89 15:12	1:07	1012.5	1023.0	10.0	0:06	10.5	56/57
55	7/16/89 15:30	7/16/89 16:25	0:55	1023.0	1033.0	10.0	0:05	10.3	57/58
56	7/16/89 16:35	7/16/89 17:47	1:12	1033.0	1043.0	10.0	0:07	10.4	58/59
57	7/16/89 18:03	7/16/89 18:40	0:37	1043.0	1053.0	10.0	0:03	10.4	59/60
58	7/16/89 19:05	7/16/89 19:45	0:40	1053.0	1064.0	10.0	0:03	10.4	60/61
59	7/16/89 20:00	7/16/89 20:30	0:30	1064.0	1069.6	10.0	0:05	5.6	62
60	7/16/89 21:35	7/16/89 21:55	0:20	1069.6	1075.6	10.0	0:03	6.0	63
61	7/16/89 22:00	7/16/89 22:25	0:25	1075.6	1084.0	5.5	0:02	8.4	64
62	7/16/89 22:30	7/16/89 23:02	0:32	1084.0	1094.0	8.4	0:03	10.1	65/66
63	7/16/89 23:25	7/17/89 0:10	0:45	1094.0	1104.0	10.0	0:04	10.2	66/67
64	7/17/89 0:25	7/17/89 1:22	0:57	1104.0	1114.0	10.0	0:05	10.1	67/68
65	7/17/89 1:35	7/17/89 2:30	0:55	1114.0	1124.0	10.0	0:05	10.0	68/69
66	7/17/89 2:40	7/17/89 3:45	1:05	1124.0	1134.0	10.0	0:06	10.3	69/70

RUN #	BEGIN date/time	END date/time	DRILL TIME hrs:min	TOP ft	BOTTOM ft	CORED ft	RATE min/ft	RECOV'D ft	BOX #
67	7/17/89 3:59	7/17/89 5:05	1:06	1134.0	1144.0	10.0	0:06	9.8	70/71
68	7/17/89 5:23	7/17/89 6:42	1:19	1144.0	1154.0	10.0	0:07	10.2	71/72
69	7/17/89 7:15	7/17/89 8:08	0:53	1154.0	1164.0	10.0	0:05	9.9	72/73
70	7/17/89 8:25	7/17/89 9:23	0:58	1164.0	1174.0	10.0	0:05	10.1	73/74
71	7/17/89 12:07	7/17/89 13:07	1:00	1174.0	1184.0	10.0	0:06	9.4	74/75
72	7/17/89 13:26	7/17/89 14:10	0:44	1184.0	1194.0	10.0	0:04	10.2	75/76
73	7/17/89 14:30	7/17/89 15:17	0:47	1194.0	1204.0	10.0	0:04	10.0	76/77
74	7/17/89 15:38	7/17/89 16:32	0:54	1204.0	1214.0	10.0	0:05	9.9	77/78
75	7/17/89 16:58	7/17/89 17:43	0:45	1214.0	1224.0	10.0	0:04	10.0	79/80
76	7/17/89 18:09	7/17/89 18:59	0:50	1224.0	1234.0	10.0	0:05	10.1	80/81
77	7/17/89 19:16	7/17/89 20:06	0:50	1234.0	1244.0	10.0	0:05	10.3	81/82
78	7/17/89 20:20	7/17/89 21:23	1:03	1244.0	1254.0	10.0	0:06	10.0	82/83
79	7/17/89 21:38	7/17/89 22:20	0:42	1254.0	1264.0	10.0	0:04	10.1	83/84
80	7/17/89 22:38	7/17/89 23:44	1:06	1264.0	1274.0	10.0	0:06	9.6	84/85
81	7/18/89 0:10	7/18/89 1:00	0:50	1274.0	1284.0	10.0	0:05	10.3	85/86
82	7/18/89 1:13	7/18/89 2:02	0:49	1284.0	1294.0	10.0	0:04	10.3	86/87
83	7/18/89 2:15	7/18/89 3:10	0:55	1294.0	1304.0	10.0	0:05	9.7	87/88
84	7/18/89 3:40	7/18/89 4:20	0:40	1304.0	1314.0	10.0	0:04	8.9	88/89
85	7/18/89 4:35	7/18/89 5:14	0:39	1314.0	1324.0	10.0	0:03	10.8	89/90
86	7/18/89 7:27	7/18/89 8:06	0:39	1324.0	1334.0	10.0	0:03	10.0	91/92
87	7/18/89 8:27	7/18/89 9:14	0:47	1334.0	1344.0	10.0	0:04	10.2	92/93
88	7/18/89 9:37	7/18/89 10:24	0:47	1344.0	1354.0	10.0	0:04	10.2	93/94
89	7/18/89 10:50	7/18/89 12:08	1:18	1354.0	1364.0	10.0	0:07	10.0	94/95
90	7/18/89 12:31	7/18/89 13:45	1:14	1364.0	1374.0	10.0	0:07	10.4	95/96
91	7/18/89 14:08	7/18/89 14:50	0:42	1374.0	1384.0	10.0	0:04	9.3	96/97
92	7/18/89 15:08	7/18/89 16:16	1:08	1384.0	1393.5	9.5	0:07	10.1	97/98
93	7/18/89 16:30	7/18/89 17:07	0:37	1393.5	1404.0	10.0	0:03	10.5	99/100
94	7/18/89 17:35	7/18/89 18:19	0:44	1404.0	1414.0	10.0	0:04	10.0	100/101
95	7/18/89 19:10	7/18/89 19:45	0:35	1414.0	1424.0	10.0	0:03	10.5	101/102
96	7/18/89 20:00	7/18/89 21:13	1:13	1424.0	1434.0	10.0	0:07	9.4	102/103
97	7/18/89 21:28	7/18/89 22:30	1:02	1434.0	1444.0	10.0	0:06	10.4	103/104
98	7/18/89 22:55	7/18/89 23:41	0:46	1444.0	1454.0	10.0	0:04	10.3	104/105
99	7/19/89 0:03	7/19/89 0:35	0:32	1454.0	1464.0	10.0	0:03	10.1	105/106

RUN #	BEGIN date/time	END date/time	DRILL TIME hrs:min	TOP ft	BOTTOM ft	CORED ft	RATE min/ft	RECOV'D ft	BOX #
100	7/19/89 0:55	7/19/89 1:37	0:42	1464.0	1474.0	10.0	0:04	10.0	106/107
101	7/19/89 1:56	7/19/89 2:45	0:49	1474.0	1481.6	10.0	0:06	7.4	107/108
102	7/19/89 3:07	7/19/89 4:12	1:05	1481.6	1491.6	7.5	0:06	10.0	108/109
103	7/19/89 4:50	7/19/89 6:08	1:18	1491.6	1502.0	10.0	0:07	10.4	109/110
104	7/19/89 6:30	7/19/89 7:17	0:47	1502.0	1512.0	10.0	0:04	10.4	110/111
105	7/19/89 7:38	7/19/89 8:38	1:00	1512.0	1522.5	10.5	0:05	10.5	111/112
106	7/19/89 9:00	7/19/89 9:40	0:40	1522.5	1532.5	10.0	0:04	10.5	112/113
107	7/19/89 10:02	7/19/89 10:48	0:46	1532.5	1543.0	10.5	0:04	10.2	114/115
108	7/19/89 11:09	7/19/89 12:22	1:13	1543.0	1553.0	10.0	0:07	10.2	115/116
109	7/19/89 12:45	7/19/89 14:00	1:15	1553.0	1563.0	10.0	0:07	10.3	116/117
110	7/19/89 14:26	7/19/89 15:12	0:46	1563.0	1573.5	10.5	0:04	10.3	117/118
111	7/19/89 15:40	7/19/89 16:55	1:15	1573.5	1583.5	10.0	0:07	10.3	118/119
112	7/19/89 17:13	7/19/89 18:35	1:22	1583.5	1594.0	10.0	0:07	10.0	119/119
113	7/19/89 19:36	7/19/89 20:24	0:48	1594.0	1604.0	10.0	0:04	9.4	119/120
114	7/19/89 20:39	7/19/89 21:41	1:02	1604.0	1614.0	10.0	0:06	10.0	121/122
115	7/19/89 22:03	7/19/89 22:48	0:45	1614.0	1624.0	10.0	0:04	9.6	122/123
116	7/19/89 23:10	7/19/89 23:57	0:47	1624.0	1634.0	10.0	0:04	10.3	123/124
117	7/20/89 0:09	7/20/89 1:37	1:28	1634.0	1641.0	10.0	0:12	7.0	124/125
118	7/20/89 2:00	7/20/89 2:30	0:30	1641.0	1651.5	7.0	0:02	10.5	125/126
119	7/20/89 3:28	7/20/89 4:17	0:49	1651.5	1661.5	10.0	0:04	9.7	126/127
120	7/20/89 4:41	7/20/89 5:27	0:46	1661.5	1669.0	7.5	0:06	8.7	127/128
121	7/20/89 9:00	7/20/89 9:50	0:50	1669.0	1679.0	10.0	0:05	7.5	128/129
122	7/20/89 10:28	7/20/89 10:55	0:27	1679.0	1684.0	5.0	0:05	7.5	129
123	7/20/89 11:21	7/20/89 12:21	1:00	1684.0	1694.0	10.0	0:06	9.8	129/130
124	7/20/89 23:18	7/21/89 0:45	1:27	1694.0	1704.0	10.0	0:08	10.1	131/132
125	7/21/89 1:09	7/21/89 1:46	0:37	1704.0	1713.0	10.0	0:04	9.0	132/133
126	7/21/89 2:10	7/21/89 2:47	0:37	1713.0	1723.4	9.0	0:03	10.1	133/134
127	7/21/89 3:10	7/21/89 4:16	1:06	1723.4	1731.2	10.0	0:08	7.5	134/135
128	7/21/89 5:18	7/21/89 5:47	0:29	1731.2	1738.0	5.0	0:04	7.3	135/136
129	7/21/89 6:15	7/21/89 7:01	0:46	1738.0	1748.0	10.0	0:04	10.0	136/137
130	7/21/89 8:25	7/21/89 9:53	1:28	1748.0	1758.0	10.0	0:08	10.0	137/138
131	7/21/89 10:22	7/21/89 10:58	0:36	1758.0	1768.0	10.0	0:03	10.0	138/139
132	7/21/89 11:25	7/21/89 13:10	1:45	1768.0	1778.0	10.0	0:10	9.5	139/140

RUN #	BEGIN date/time	END date/time	DRILL TIME hrs:min	TOP ft	BOTTOM ft	CORED ft	RATE min/ft	RECOV'D ft	BOX #
133	7/21/89 13:26	7/21/89 14:06	0:40	1778.0	1784.0	6.0	0:06	6.5	140/141
134	7/21/89 14:25	7/21/89 15:45	1:20	1784.0	1794.0	10.0	0:08	10.5	141/142
135	7/21/89 16:07	7/21/89 17:52	1:45	1794.0	1804.0	10.0	0:10	9.5	142/143
136	7/21/89 18:19	7/21/89 19:10	0:51	1804.0	1814.0	10.0	0:05	10.4	143/144
137	7/21/89 19:32	7/21/89 20:52	1:20	1814.0	1824.0	10.0	0:08	10.0	144/145
138	7/21/89 21:16	7/21/89 22:49	1:33	1824.0	1834.0	10.0	0:09	10.3	145/146
139	7/21/89 23:15	7/22/89 0:12	0:57	1834.0	1844.0	10.0	0:05	10.0	146/147
140	7/22/89 0:35	7/22/89 0:55	0:20	1844.0	1849.0	10.0	0:04	4.9	147/148
141	7/22/89 1:25	7/22/89 1:44	0:19	1849.0	1859.0	5.0	0:01	10.2	148/149
142	7/22/89 2:35	7/22/89 3:05	0:30	1859.0	1869.0	10.0	0:03	10.3	149/150
143	7/22/89 3:29	7/22/89 4:50	1:21	1869.0	1879.0	10.0	0:08	8.1	150/151
144	7/22/89 5:17	7/22/89 5:45	0:28	1879.0	1884.0	5.0	0:05	3.6	151
145	7/22/89 6:14	7/22/89 6:58	0:44	1884.0	1892.0	8.0	0:05	9.8	151/152
146	7/22/89 7:30	7/22/89 8:35	1:05	1892.0	1902.0	10.0	0:06	10.4	152/153
147	7/22/89 9:03	7/22/89 10:30	1:27	1902.0	1912.0	10.0	0:08	10.4	154/155
148	7/22/89 10:55	7/22/89 12:34	1:39	1912.0	1922.5	10.5	0:09	10.3	155/156
149	7/22/89 13:00	7/22/89 14:12	1:12	1922.5	1933.0	10.5	0:06	10.5	156/157
150	7/22/89 14:50	7/22/89 15:55	1:05	1933.0	1943.0	10.0	0:06	10.1	157/158
151	7/22/89 16:29	7/22/89 17:30	1:01	1943.0	1953.0	10.0	0:06	10.1	158/159
152	7/22/89 17:50	7/22/89 19:18	1:28	1953.0	1963.0	10.0	0:08	10.0	159/160
153	7/22/89 19:40	7/22/89 20:55	1:15	1963.0	1973.0	10.0	0:07	8.5	160/161
154	7/22/89 21:41	7/22/89 22:11	0:30	1973.0	1982.0	9.0	0:03	10.2	161/162
155	7/22/89 22:36	7/22/89 23:25	0:49	1982.0	1992.5	10.0	0:04	10.0	162/163
156	7/22/89 23:50	7/23/89 1:00	1:10	1992.5	2002.5	10.0	0:07	10.1	163/164
157	7/23/89 1:25	7/23/89 3:24	1:59	2002.5	2012.5	10.0	0:11	10.3	164/165
158	7/23/89 3:57	7/23/89 5:30	1:33	2012.5	2022.5	10.0	0:09	9.8	166/167
159	7/23/89 5:58	7/23/89 7:40	1:42	2022.5	2033.0	10.5	0:09	10.5	167/168
160	7/23/89 8:00	7/23/89 9:11	1:11	2033.0	2043.5	10.5	0:06	10.5	168/169
161	7/23/89 9:20	7/23/89 10:50	1:30	2043.5	2053.5	10.0	0:09	10.3	169/170
162	7/23/89 11:18	7/23/89 13:00	1:42	2053.5	2064.0	10.5	0:09	10.5	170/171
163	7/23/89 13:35	7/23/89 15:00	1:25	2064.0	2074.0	10.0	0:08	10.3	171/172
164	7/23/89 15:35	7/23/89 16:15	0:40	2074.0	2084.0	10.0	0:04	9.9	172/173
165	7/23/89 16:39	7/23/89 17:34	0:55	2084.0	2094.0	10.0	0:05	10.0	173/174

RUN #	BEGIN date/time	END date/time	DRILL TIME hrs:min	TOP ft	BOTTOM ft	CORED ft	RATE min/ft	RECOV'D ft	BOX #
166	7/23/89 17:52	7/23/89 19:19	1:27	2094.0	2104.0	10.0	0:08	10.1	174/175
167	7/23/89 19:45	7/23/89 20:47	1:02	2104.0	2114.0	10.0	0:06	10.0	175/176
168	7/23/89 21:15	7/23/89 22:46	1:31	2114.0	2124.0	10.0	0:09	10.0	176/177
169	7/23/89 23:11	7/24/89 0:12	1:01	2124.0	2134.0	10.0	0:06	9.9	177/178
170	7/24/89 0:40	7/24/89 1:48	1:08	2134.0	2144.0	10.0	0:06	9.8	179/180
171	7/24/89 2:16	7/24/89 4:05	1:49	2144.0	2154.0	10.0	0:10	9.0	180/181
172	7/24/89 4:33	7/24/89 5:43	1:10	2154.0	2164.0	10.0	0:07	9.9	181/182
173	7/24/89 6:10	7/24/89 7:37	1:27	2164.0	2174.0	10.0	0:08	10.3	182/183
174	7/24/89 8:10	7/24/89 10:10	2:00	2174.0	2184.0	10.0	0:12	10.0	183/184
175	7/24/89 10:41	7/24/89 12:00	1:19	2184.0	2194.0	10.0	0:07	10.0	184/185
176	7/24/89 12:33	7/24/89 14:33	2:00	2194.0	2204.0	10.0	0:12	10.3	185/186
177	7/24/89 16:20	7/24/89 17:54	1:34	2204.0	2214.0	10.0	0:09	10.0	186/187
178	7/24/89 18:20	7/24/89 19:50	1:30	2214.0	2224.0	10.0	0:09	10.0	187/188
179	7/24/89 20:18	7/24/89 21:52	1:34	2224.0	2234.0	10.0	0:09	10.1	188/189
180	7/24/89 22:20	7/24/89 23:12	0:52	2234.0	2244.0	10.0	0:05	10.2	189/190
181	7/24/89 23:40	7/25/89 1:23	1:43	2244.0	2254.0	10.0	0:10	10.4	191/192
182	7/25/89 2:41	7/25/89 3:23	0:42	2254.0	2264.0	10.0	0:04	10.1	192/193
183	7/25/89 3:51	7/25/89 5:00	1:09	2264.0	2274.0	10.0	0:06	10.4	193/194
184	7/25/89 5:26	7/25/89 5:58	0:32	2274.0	2284.0	10.0	0:03	10.0	194/195
185	7/25/89 6:32	7/25/89 7:18	0:46	2284.0	2294.0	10.0	0:04	10.1	195/196
186	7/25/89 9:15	7/25/89 10:20	1:05	2294.0	2304.0	10.0	0:06	10.2	196/197
187	7/25/89 10:52	7/25/89 11:30	0:38	2304.0	2314.0	10.0	0:03	10.1	197/198
188	7/25/89 12:03	7/25/89 14:06	2:03	2314.0	2324.0	10.0	0:12	10.1	198/199
189	7/25/89 14:40	7/25/89 16:05	1:25	2324.0	2334.0	10.0	0:08	10.1	199/200
190	7/25/89 16:38	7/25/89 17:15	0:37	2334.0	2344.0	10.0	0:03	10.2	200/201
191	7/25/89 18:45	7/25/89 20:26	1:41	2344.0	2354.0	10.0	0:10	10.0	201/202
192	7/25/89 21:00	7/25/89 22:10	1:10	2354.0	2364.0	10.0	0:07	9.9	202/203
193	7/25/89 22:39	7/26/89 0:29	1:50	2364.0	2374.0	10.0	0:11	10.2	204
194	7/26/89 1:00	7/26/89 1:37	0:37	2374.0	2384.0	10.0	0:03	10.1	205/206
195	7/26/89 2:11	7/26/89 3:12	1:01	2384.0	2394.0	10.0	0:06	10.0	206/207
196	7/26/89 3:51	7/26/89 4:47	0:56	2394.0	2404.0	10.0	0:05	10.1	207/208
197	7/26/89 5:15	7/26/89 6:02	0:47	2404.0	2414.0	10.0	0:04	9.9	208/209
198	7/26/89 6:30	7/26/89 7:30	1:00	2414.0	2424.0	10.0	0:06	10.2	209/210

RUN #	BEGIN date/time	END date/time	DRILL TIME hrs:min	TOP ft	BOTTOM ft	CORED ft	RATE min/ft	RECOV'D ft	BOX #
199	7/26/89 8:23	7/26/89 9:16	0:53	2424.0	2434.0	10.0	0:05	10.1	210/211
200	7/26/89 9:45	7/26/89 10:55	1:10	2434.0	2444.0	10.0	0:07	10.0	211/212
201	7/26/89 11:34	7/26/89 12:37	1:03	2444.0	2454.0	10.0	0:06	9.8	212/213
202	7/26/89 13:07	7/26/89 13:52	0:45	2454.0	2464.0	10.0	0:04	10.0	214/215
203	7/26/89 14:22	7/26/89 15:55	1:33	2464.0	2474.0	10.0	0:09	10.3	215/216
204	7/26/89 17:08	7/26/89 17:46	0:38	2474.0	2484.0	10.0	0:03	10.3	216/217
205	7/26/89 18:25	7/26/89 19:25	1:00	2484.0	2494.0	10.0	0:06	7.1	217/218
206	7/26/89 20:07	7/26/89 21:54	1:47	2494.0	2501.0	10.0	0:15	8.3	218
207	7/26/89 22:50	7/27/89 0:15	1:25	2501.0	2509.5	10.0	0:10	10.3	218/219
208	7/27/89 0:46	7/27/89 2:31	1:45	2509.5	2520.0	10.5	0:10	10.3	219/220
209	7/27/89 3:00	7/27/89 3:33	0:33	2520.0	2530.0	10.0	0:03	10.0	221/222
210	7/27/89 4:08	7/27/89 5:00	0:52	2530.0	2540.0	10.0	0:05	10.4	222/223
211	7/27/89 5:28	7/27/89 5:55	0:27	2540.0	2544.0	4.0	0:06	4.0	223
212	7/27/89 10:22	7/27/89 11:08	0:46	2544.0	2549.5	5.5	0:08	5.5	223/224
213	7/27/89 11:42	7/27/89 13:06	1:24	2549.5	2560.0	10.5	0:08	10.5	224/225
214	7/27/89 13:40	7/27/89 14:37	0:57	2560.0	2570.0	10.0	0:05	10.2	225/226
215	7/27/89 15:10	7/27/89 16:20	1:10	2570.0	2580.0	10.0	0:07	10.3	226/227
216	7/27/89 16:52	7/27/89 17:58	1:06	2580.0	2590.5	10.5	0:06	10.4	227/228
217	7/27/89 18:39	7/27/89 20:34	1:55	2590.5	2601.0	10.5	0:10	4.5	228
218	7/27/89 21:15	7/27/89 21:38	0:23	2601.0	2604.0	3.0	0:07	8.3	228/229
219	7/27/89 22:07	7/27/89 23:28	1:21	2604.0	2614.0	10.0	0:08	8.5	230/232
220	7/28/89 0:04	7/28/89 0:57	0:53	2614.0	2622.0	8.0	0:06	9.6	232
221	7/28/89 1:28	7/28/89 2:52	1:24	2622.0	2632.0	10.0	0:08	10.4	233/234
222	7/28/89 3:23	7/28/89 4:33	1:10	2632.0	2642.0	10.0	0:07	10.4	234/235
223	7/28/89 5:17	7/28/89 6:35	1:18	2642.0	2652.5	10.0	0:07	10.2	235/236
224	7/28/89 7:32	7/28/89 8:56	1:24	2652.5	2663.0	10.5	0:08	10.5	236/237
225	7/28/89 9:36	7/28/89 10:43	1:07	2663.0	2673.0	10.0	0:06	10.3	237/238
226	7/28/89 11:20	7/28/89 12:14	0:54	2673.0	2683.5	10.5	0:05	10.5	238/239
227	7/28/89 12:50	7/28/89 14:08	1:18	2683.5	2694.0	10.5	0:07	10.5	240/241
228	7/28/89 14:43	7/28/89 15:45	1:02	2694.0	2704.0	10.0	0:06	10.2	241/242
229	7/28/89 16:35	7/28/89 17:32	0:57	2704.0	2714.0	10.0	0:05	9.4	242/243
230	7/28/89 18:12	7/28/89 19:48	1:36	2714.0	2724.0	10.0	0:09	10.4	243/244
231	7/28/89 20:18	7/28/89 22:14	1:56	2724.0	2734.0	10.0	0:11	10.3	244/245

RUN #	BEGIN date/time	END date/time	DRILL TIME hrs:min	TOP ft	BOTTOM ft	CORED ft	RATE min/ft	RECOV'D ft	BOX #
232	7/28/89 22:54	7/29/89 0:07	1:13	2734.0	2744.0	10.0	0:07	10.2	245/246
233	7/29/89 0:38	7/29/89 1:56	1:18	2744.0	2754.0	10.0	0:07	9.8	246/247
234	7/29/89 2:28	7/29/89 3:34	1:06	2754.0	2764.0	10.0	0:06	10.6	247/248
235	7/29/89 3:54	7/29/89 6:13	2:19	2764.0	2774.0	10.0	0:13	4.9	248/249
236	7/29/89 7:08	7/29/89 8:21	1:13	2774.0	2779.0	5.0	0:14	4.0	249/250
237	7/29/89 10:37	7/29/89 11:47	1:10	2779.0	2784.0	5.0	0:14	9.5	250
238	7/29/89 12:23	7/29/89 14:33	2:10	2784.0	2795.5	11.5	0:11	7.5	250/251
239	7/29/89 19:45	7/29/89 20:26	0:41	2795.5	2802.0	6.5	0:06	6.4	251/252
240	7/29/89 21:05	7/29/89 22:27	1:22	2802.0	2810.5	8.5	0:09	9.0	252/253
241	7/29/89 23:01	7/30/89 0:40	1:39	2810.5	2820.5	10.0	0:09	10.4	253/254
242	7/30/89 1:45	7/30/89 3:28	1:43	2820.5	2831.0	10.0	0:09	10.2	254/255
243	7/30/89 4:03	7/30/89 5:40	1:37	2831.0	2841.0	10.0	0:09	10.3	255/256
244	7/30/89 6:25	7/30/89 8:50	2:25	2841.0	2851.0	10.5	0:14	10.5	256/257
245	7/30/89 9:39	7/30/89 11:52	2:13	2851.0	2862.0	10.5	0:23	10.5	257/258
246	7/30/89 12:30	7/30/89 14:25	1:55	2862.0	2872.0	10.0	0:11	10.5	259/260
247	7/30/89 15:08	7/30/89 17:01	1:53	2872.0	2882.5	10.5	0:10	10.4	260/261
248	7/30/89 17:35	7/30/89 19:37	2:02	2882.5	2892.5	10.0	0:12	9.3	261/262
249	7/30/89 20:15	7/30/89 22:02	1:47	2892.5	2902.0	9.5	0:11	10.0	262/263
250	7/30/89 22:40	7/31/89 0:12	1:32	2902.0	2912.0	10.0	0:09	10.2	263/264
251	7/31/89 0:48	7/31/89 2:28	1:40	2912.0	2922.0	10.0	0:10	10.6	264/265
252	7/31/89 11:15	7/31/89 13:15	2:00	2922.0	2934.0	12.0	0:10	10.0	265/266
253	7/31/89 14:15	7/31/89 18:20	4:05	2934.0	2946.0	12.0	0:20	0.0	266
254	7/31/89 19:20	7/31/89 20:10	0:50	2946.0	2949.0	3.0	0:16	13.0	266/267
255	7/31/89 21:05	7/31/89 22:31	1:26	2949.0	2956.0	7.0	0:12	2.3	267/268
256	7/31/89 23:48	8/1/89 3:26	3:38	2956.0	2966.0	10.0	0:21	11.5	268/269
257	8/1/89 4:13	8/1/89 7:35	3:22	2966.0	2976.0	10.0	0:20	14.0	269/270/271
258	8/1/89 8:30	8/1/89 13:30	5:00	2976.0	2996.0	20.0	0:15	17.0	271/272
259	8/1/89 14:52	8/1/89 16:28	1:36	2996.0	3006.0	10.0	0:09	13.0	272/273/274
260	8/1/89 19:10	8/1/89 23:18	4:08	3006.0	3016.0	10.0	0:24	8.5	274/275
261	8/2/89 0:06	8/2/89 4:30	4:24	3016.0	3026.0	10.0	0:26	11.7	275/276
262	8/2/89 5:25	8/2/89 0:00	6:35	3026.0	3046.0	20.0	0:55	17.0	276/277/278
263	8/2/89 15:10	8/2/89 20:58	5:48	3046.0	3054.0	8.0	0:43	8.2	278/279
264	8/3/89 3:58	8/3/89 6:30	2:32	3054.0	3062.0	8.0	0:19	8.2	279/280

RUN #	BEGIN date/time	END date/time	DRILL TIME hrs:min	TOP ft	BOTTOM ft	CORED ft	RATE min/ft	RECOV'D ft	BOX #
265	8/3/89 7:20	8/3/89 14:00	6:40	3062.0	3077.0	15.0	0:26	15.0	280/281/282
266	8/3/89 15:33	8/4/89 1:44	10:11	3077.0	3096.0	19.0	0:32	13.8	282/283
267	8/4/89 2:47	8/4/89 5:37	2:50	3096.0	3102.0	6.0	0:28	0.0	283
268	8/4/89 6:25	8/4/89 10:50	4:25	3102.0	3114.0	12.0	0:22	11.0	283/284
269	8/4/89 12:05	8/4/89 13:10	1:05	3114.0	3116.0	2.0	0:32	11.0	284/285
270	8/4/89 13:52	8/4/89 18:23	4:31	3116.0	3134.0	18.0	0:15	20.2	285/286/287
271	8/4/89 19:21	8/5/89 2:03	6:42	3134.0	3155.0	21.0	0:19	15.8	287/288/289
272	8/5/89 3:05	8/5/89 5:24	2:19	3155.0	3166.0	11.0	0:12	16.1	289/290/291
273	8/5/89 6:09	8/5/89 11:10	5:01	3166.0	3187.0	21.0	0:14	20.0	291/292/293
274	8/5/89 12:00	8/5/89 17:35	5:35	3187.0	3207.0	20.0	0:16	19.6	293/294/295
275	8/6/89 13:20	8/6/89 17:46	4:26	3207.0	3216.5	10.0	0:28	10.2	295/296
276	8/6/89 18:38	8/7/89 0:41	6:03	3216.5	3236.0	20.0	0:18	20.0	296/297/298/
277	8/7/89 1:27	8/7/89 8:00	6:33	3236.0	3256.0	20.0	0:19	20.0	299/300/301
278	8/7/89 9:15	8/7/89 14:23	5:08	3256.0	3276.0	20.0	0:15	20.0	301/302/303
279	8/7/89 15:35	8/7/89 18:30	2:55	3276.0	3296.0	20.0	0:08	20.0	303/304/305
280	8/7/89 19:22	8/7/89 23:30	4:08	3296.0	3308.0	12.0	0:20	11.9	305/306
281	8/8/89 0:33	8/8/89 7:15	6:42	3308.0	3326.0	18.0	0:22	18.0	306/307/308
282	8/8/89 8:53	8/8/89 13:50	4:57	3326.0	3337.0	11.0	0:27	11.0	308/309
283	8/9/89 19:15	8/9/89 21:45	2:30	3337.0	3338.0	1.0	2:30	1.0	309
284	8/10/89 8:03	8/10/89 14:15	6:12	3338.0	3345.0	7.0	0:53	7.0	309/310
285	8/10/89 14:30	8/10/89 19:24	4:54	3345.0	3352.0	7.0	0:42	7.0	310/311
286	8/10/89 23:08	8/11/89 6:27	7:19	3352.0	3369.0	17.0	0:25	14.3	311/312
287	8/15/89 12:30	8/15/89 13:30	1:00	3369.0	3372.0	3.0	0:20	2.0	312
288	8/15/89 16:35	8/15/89 19:19	2:44	3372.0	3382.0	10.0	0:16	10.0	312/313/314
289	8/15/89 20:15	8/15/89 22:10	1:55	3382.0	3392.0	10.0	0:11	10.0	314/315
290	8/15/89 22:45	8/16/89 0:15	1:30	3392.0	3399.0	7.0	0:12	7.0	315/316
291	8/16/89 0:51	8/16/89 2:50	1:59	3399.0	3409.0	10.0	0:11	10.0	316
292	8/16/89 3:27	8/16/89 5:38	2:11	3409.0	3419.0	10.0	0:13	10.0	316/317
293	8/16/89 6:13	8/16/89 7:42	1:29	3419.0	3429.0	10.0	0:08	10.0	317/318
294	8/16/89 8:00	8/16/89 10:22	2:22	3429.0	3439.0	10.0	0:14	10.0	318/319
295	8/16/89 11:51	8/16/89 15:20	3:29	3439.0	3449.0	10.0	0:20	10.0	319/320
296	8/16/89 17:10	8/16/89 18:40	1:30	3449.0	3459.0	10.0	0:09	10.2	320/321
297	8/16/89 20:40	8/16/89 21:40	1:00	3459.0	3465.0	6.0	0:10	6.8	321/322

RUN #	BEGIN date/time	END date/time	DRILL TIME hrs:min	TOP ft	BOTTOM ft	CORED ft	RATE min/ft	RECOV'D ft	BOX #
298	8/16/89 23:10	8/17/89 0:22	1:12	3465.0	3475.0	10.0	0:07	10.0	322/323
299	8/17/89 10:26	8/17/89 12:27	2:01	3475.0	3485.0	10.0	0:12	10.0	323/324
300	8/17/89 13:15	8/17/89 14:47	1:32	3485.0	3495.0	10.0	0:09	10.0	324/325
301	8/17/89 16:12	8/17/89 17:54	1:42	3495.0	3505.0	10.0	0:10	10.2	325/326
302	8/17/89 18:40	8/17/89 20:15	1:35	3505.0	3515.0	10.0	0:09	10.0	326/327
303	8/17/89 23:45	8/18/89 0:40	0:55	3515.0	3525.0	10.0	0:05	9.9	327/328
304	8/18/89 2:53	8/18/89 4:00	1:07	3525.0	3535.0	10.0	0:06	9.8	329
305	8/18/89 10:08	8/18/89 11:40	1:32	3535.0	3545.0	10.0	0:09	10.1	330/331
306	8/18/89 12:40	8/18/89 14:20	1:40	3545.0	3555.0	10.0	0:10	9.8	331/332
307	8/18/89 15:17	8/18/89 17:14	1:57	3555.0	3565.0	10.0	0:11	10.0	332/333
308	8/18/89 18:00	8/18/89 20:24	2:24	3565.0	3575.0	10.0	0:14	10.0	333/334
309	8/18/89 21:11	8/18/89 22:58	1:47	3575.0	3585.0	10.0	0:10	10.0	334/335
310	8/18/89 23:40	8/19/89 1:38	1:58	3585.0	3595.0	10.0	0:11	10.1	335/336
311	8/19/89 2:29	8/19/89 4:42	2:13	3595.0	3605.0	10.0	0:13	10.2	336/337
312	8/19/89 5:25	8/19/89 7:15	1:50	3605.0	3615.0	10.0	0:11	10.2	337/338
313	8/19/89 8:05	8/19/89 10:20	2:15	3615.0	3625.0	10.0	0:13	9.9	338/339
314	8/19/89 11:15	8/19/89 13:23	2:08	3625.0	3635.0	10.0	0:12	10.2	339/340
315	8/19/89 14:12	8/19/89 16:52	2:40	3635.0	3645.0	10.0	0:16	9.5	340/341
316	8/19/89 17:45	8/19/89 21:21	3:36	3645.0	3655.0	10.0	0:21	10.0	341/342
317	8/19/89 22:24	8/20/89 1:12	2:48	3655.0	3665.0	10.0	0:16	10.2	342/343
318	8/20/89 2:06	8/20/89 4:04	1:58	3665.0	3675.0	10.0	0:11	10.1	344/345
319	8/20/89 4:51	8/20/89 6:43	1:52	3675.0	3685.0	10.0	0:11	10.2	345/346
320	8/20/89 7:45	8/20/89 10:10	2:25	3685.0	3695.0	10.0	0:14	10.0	346/347
321	8/20/89 11:15	8/20/89 14:10	2:55	3695.0	3705.0	10.0	0:17	10.0	347/348
322	8/20/89 15:07	8/20/89 17:39	2:32	3705.0	3715.0	10.0	0:15	10.1	348/349
323	8/20/89 18:26	8/20/89 21:02	2:36	3715.0	3725.0	10.0	0:15	10.0	349/350
324	8/21/89 1:24	8/21/89 3:25	2:01	3725.0	3735.0	10.0	0:12	10.0	350/351
325	8/21/89 4:09	8/21/89 6:20	2:11	3735.0	3745.0	10.0	0:13	10.1	351/352
326	8/21/89 7:04	8/21/89 10:00	2:56	3745.0	3755.0	10.0	0:17	10.2	352/353
327	8/21/89 10:55	8/21/89 13:24	2:29	3755.0	3765.0	10.2	0:14	10.2	353/354
328	8/21/89 15:10	8/21/89 17:40	2:30	3765.0	3775.0	10.0	0:15	0.0	355
329	8/22/89 0:33	8/22/89 1:05	0:32	3775.0	3777.0	2.0	0:16	3.7	355
330	8/22/89 3:29	8/22/89 5:35	2:06	3777.0	3785.0	8.0	0:15	7.2	355/356

RUN #	BEGIN date/time	END date/time	DRILL TIME hrs:min	TOP ft	BOTTOM ft	CORED ft	RATE min/ft	RECOV'D ft	BOX #
331	8/22/89 6:25	8/22/89 8:15	1:50	3785.0	3795.0	10.0	0:11	9.0	356/357
332	8/22/89 9:15	8/22/89 10:57	1:42	3795.0	3805.0	10.0	0:10	10.0	357/358
333	8/22/89 11:54	8/22/89 14:23	2:29	3805.0	3815.0	10.0	0:14	10.0	358/359
334	8/22/89 15:50	8/22/89 17:26	1:36	3815.0	3825.0	10.0	0:09	10.1	359/360
335	8/22/89 18:10	8/22/89 19:35	1:25	3825.0	3835.0	10.0	0:08	10.0	360/361
336	8/22/89 21:12	8/22/89 22:22	1:10	3835.0	3845.0	10.0	0:07	10.0	361/362
337	8/22/89 23:02	8/23/89 0:00	0:58	3845.0	3855.0	10.0	0:05	10.3	362/363
338	8/23/89 0:49	8/23/89 1:46	0:57	3855.0	3865.0	10.0	0:05	10.0	363/364
339	8/23/89 2:28	8/23/89 3:34	1:06	3865.0	3875.0	10.0	0:06	10.0	364/365
340	8/23/89 4:14	8/23/89 5:28	1:14	3875.0	3885.0	10.0	0:07	10.2	365/366
341	8/23/89 6:15	8/23/89 7:10	0:55	3885.0	3895.0	10.0	0:05	10.0	367/368
342	8/23/89 7:45	8/23/89 8:58	1:13	3895.0	3905.0	10.0	0:07	10.0	368/369
343	8/23/89 9:54	8/23/89 11:20	1:26	3905.0	3915.0	10.0	0:08	10.0	369/370
344	8/23/89 12:17	8/23/89 13:48	1:31	3915.0	3925.0	10.0	0:09	10.1	370/371
345	8/23/89 14:37	8/23/89 15:42	1:05	3925.0	3935.0	10.0	0:06	10.1	371/372
346	8/23/89 16:35	8/23/89 17:46	1:11	3935.0	3945.0	10.0	0:07	10.0	372/373
347	8/23/89 18:34	8/23/89 19:37	1:03	3945.0	3955.0	10.0	0:06	10.0	373/374
348	8/23/89 20:32	8/23/89 21:50	1:18	3955.0	3965.0	10.0	0:07	10.0	374/375
349	8/23/89 22:35	8/23/89 23:57	1:22	3965.0	3975.0	10.0	0:08	10.1	375/376
350	8/24/89 0:45	8/24/89 2:00	1:15	3975.0	3985.0	10.0	0:07	10.2	376/377
351	8/24/89 2:43	8/24/89 4:09	1:26	3985.0	3995.0	10.0	0:08	9.9	377/378
352	8/24/89 4:47	8/24/89 5:47	1:00	3995.0	4005.0	10.0	0:06	10.0	378/379
353	8/24/89 6:46	8/24/89 7:59	1:13	4005.0	4015.0	10.0	0:07	10.0	379/380
354	8/24/89 8:53	8/24/89 10:00	1:07	4015.0	4025.0	10.0	0:06	10.0	380/381
355	8/24/89 10:53	8/24/89 12:13	1:20	4025.0	4035.0	10.0	0:08	10.0	381/382
356	8/24/89 13:05	8/24/89 14:17	1:12	4035.0	4045.0	10.0	0:07	10.0	383/384
357	8/24/89 15:08	8/24/89 16:35	1:27	4045.0	4055.0	10.0	0:08	10.0	384/385
358	8/24/89 17:45	8/24/89 19:45	2:00	4055.0	4065.0	10.0	0:12	10.0	385/386
359	8/24/89 20:25	8/24/89 21:43	1:18	4065.0	4075.0	10.0	0:07	10.0	386/387
360	8/24/89 22:35	8/25/89 0:02	1:27	4075.0	4085.0	10.0	0:08	9.9	387/388
361	8/25/89 0:45	8/25/89 2:07	1:22	4085.0	4095.0	10.0	0:08	10.1	388/389
362	8/25/89 2:46	8/25/89 3:54	1:08	4095.0	4105.0	10.0	0:06	9.9	389/390
363	8/25/89 4:49	8/25/89 5:59	1:10	4105.0	4115.0	10.0	0:07	10.1	390/391

RUN #	BEGIN date/time	END date/time	DRILL TIME hrs:min	TOP ft	BOTTOM ft	CORED ft	RATE min/ft	RECOV'D ft	BOX #
364	8/25/89 6:50	8/25/89 8:05	1:15	4115.0	4125.0	10.0	0:07	10.1	391/392
365	8/25/89 9:00	8/25/89 10:18	1:18	4125.0	4135.0	10.0	0:07	10.1	392/393
366	8/25/89 12:08	8/25/89 13:37	1:29	4135.0	4145.0	10.0	0:08	9.8	393/394
367	8/25/89 15:29	8/25/89 17:00	1:31	4145.0	4155.0	10.0	0:09	10.2	394/395
368	8/25/89 18:02	8/25/89 19:10	1:08	4155.0	4165.0	10.0	0:06	10.0	395/396
369	8/25/89 19:50	8/25/89 21:02	1:12	4165.0	4175.0	10.0	0:07	10.0	396/397
370	8/25/89 21:45	8/25/89 22:51	1:06	4175.0	4185.0	10.0	0:06	10.0	397
371	8/25/89 23:35	8/26/89 0:57	1:22	4185.0	4195.0	10.0	0:08	9.9	399/400
372	8/26/89 1:40	8/26/89 3:03	1:23	4195.0	4205.0	10.0	0:08	10.2	400/401
373	8/26/89 3:59	8/26/89 5:12	1:13	4205.0	4215.0	10.0	0:07	10.1	401/402
374	8/26/89 5:59	8/26/89 7:09	1:10	4215.0	4225.0	10.0	0:07	10.0	402/403
375	8/26/89 8:05	8/26/89 9:33	1:28	4225.0	4235.0	10.0	0:08	10.2	403/404
376	8/26/89 10:30	8/26/89 11:45	1:15	4235.0	4245.0	10.0	0:07	10.0	404/405
377	8/26/89 12:35	8/26/89 14:00	1:25	4245.0	4255.0	10.0	0:08	10.1	405/406
378	8/26/89 15:03	8/26/89 16:48	1:45	4255.0	4264.0	9.0	0:11	9.0	406/407
379	8/26/89 17:58	8/26/89 20:33	2:35	4264.0	4274.0	10.0	0:15	10.3	407/408
380	8/26/89 21:23	8/26/89 23:45	2:22	4274.0	4284.0	10.0	0:14	9.9	408/409
381	8/27/89 0:27	8/27/89 2:15	1:48	4284.0	4294.0	10.0	0:10	10.0	409/410
382	8/27/89 3:06	8/27/89 4:29	1:23	4294.0	4304.0	10.0	0:08	10.0	410/411
383	8/27/89 5:20	8/27/89 6:44	1:24	4304.0	4314.0	10.0	0:08	10.1	411/412
384	8/27/89 7:30	8/27/89 9:30	2:00	4314.0	4324.5	10.5	0:11	10.5	412/413
385	8/27/89 10:23	8/27/89 12:22	1:59	4324.5	4335.0	10.5	0:11	10.5	413/414
386	8/27/89 13:17	8/27/89 15:12	1:55	4335.0	4345.0	10.0	0:11	10.0	414/415
387	8/27/89 15:58	8/27/89 17:22	1:24	4345.0	4355.0	10.0	0:08	10.0	415/416
388	8/27/89 18:37	8/27/89 20:10	1:33	4355.0	4365.0	10.0	0:09	10.0	416/417
389	8/27/89 20:57	8/27/89 22:40	1:43	4365.0	4375.0	10.0	0:10	10.0	418/419
390	8/27/89 23:20	8/28/89 1:07	1:47	4375.0	4385.0	10.0	0:10	10.0	419/420
391	8/28/89 1:44	8/28/89 3:19	1:35	4385.0	4395.0	10.0	0:09	10.0	420/421
392	8/28/89 4:05	8/28/89 5:32	1:27	4395.0	4405.0	10.0	0:08	10.0	421/422
393	8/28/89 6:28	8/28/89 8:00	1:32	4405.0	4415.0	10.0	0:09	10.0	422/423
394	8/28/89 8:50	8/28/89 10:18	1:28	4415.0	4425.0	10.0	0:08	10.0	423/424
395	8/28/89 11:14	8/28/89 12:44	1:30	4425.0	4435.0	10.0	0:09	10.0	424/425
396	8/28/89 13:36	8/28/89 15:07	1:31	4435.0	4445.0	10.0	0:09	10.0	425/426

RUN #	BEGIN date/time	END date/time	DRILL TIME hrs:min	TOP ft	BOTTOM ft	CORED ft	RATE min/ft	RECOV'D ft	BOX #
397	8/28/89 15:53	8/28/89 17:45	1:52	4445.0	4455.0	10.0	0:11	10.0	427/428
398	8/28/89 18:51	8/28/89 20:55	2:04	4455.0	4465.0	10.0	0:12	10.0	428/429
399	8/28/89 21:40	8/28/89 23:30	1:50	4465.0	4475.0	10.0	0:11	10.0	429/430
400	8/29/89 0:15	8/29/89 2:02	1:47	4475.0	4485.0	10.0	0:10	10.1	430/431
401	8/29/89 2:40	8/29/89 4:13	1:33	4485.0	4495.0	10.0	0:09	10.0	431/432
402	8/29/89 4:58	8/29/89 6:34	1:36	4495.0	4505.0	10.0	0:09	10.3	432/433

APPENDIX 5

SUMMARY WELL HISTORY OF THE ALPINE 1/FEDERAL BOREHOLE

7/1/93

Drilling equipment, rig, and supplies mobilizing from Tonto Drilling yard in Salt Lake City. Drill rig moved on to the Alpine Divide site (1500 hrs), begin rigging-up (1500-1900 hrs). USFS, USBLM, and AZGS officials alerted.

7/2/93

Supply trucks arrive at site entrance (0900 hrs). Truck with mud tanks and substructure refuse to make sharp turn off highway on to the logging road access to drill site. Mud tanks and substructure unloaded at sawmill in Nutrioso. Backhoe, parts trailor, and crane arrive on site (1130 hrs). Drill pad constructed and mud tanks dug. Water tank from Farmington arrives (1645 hrs).

7/3/93

Rigging-up continues (0700-1900 hrs). Tonto crane breaks down, unable to move substructure onto site. Unable to find mechanic for crane or a replacement crane due to 4th of July holiday weekend. John Hass (USBLM) and Bob Dyson (USFS) visit site (1649 hrs).

7/4/93

No activity.

7/5/93

Rigging-up continues (0700-1330 hrs). Rental crane acquired.

7/6/93

Rigging-up continues (0700-1900 hrs). Substructure and last of equipment arrive on site (1100 hrs).

7/7/93

Continue rigging-up (0700-1200 hrs). Nipple-up mud tanks, mix mud, transfer mud from mixing tank to mud tank, rack casing and drill pipe, make-up drill string. Spud hole with 7 7/8 inch tricone (1200 hrs). Complete drilling 20 feet (1240 hrs). Rig hydraulics malfunction (1245 hrs). WOP (1245-2400 hrs).

7/8/93

WOP (0000-0600 hrs). Repair hydraulics and perform rig maintenance (0600-0708 hrs). Run surface casing and begin mixing cement (0738 hrs). Cementing conductor casing with good returns (0752-0802 hrs), WOC (0802-1600 hrs). Tag cement (1613 hrs), drill-out cement (1650 hrs). Rotary with 5 7/8 inch tricone bit from 20 to 193 feet (1650-2400 hrs). Samples collected at 10 feet intervals.

7/9/93

Rotary 5 7/8 inch tricone from 193 to 465 feet (0000-2400 hours. Samples collected at 10 feet intervals. Trip-out, change bit, trip-in (0154-0345 hrs). John Sass (USGS), Tom Moses (USGS), and Frank Grubb (USGS) on location (0800-0925 hrs). Frank Mancini (AZDC) and Jack Haenichen (AZDC) on location (0823-0920 hrs). Maintenance on rig hydraulics(1500-1600 hrs).

7/10/93

Rotary 5 7/8 inch tricone from 465 to 502 (0000-0730 hrs). Condition hole and trip-out (0730-0830 hrs). Run 500 feet of surface casing with centralizers (0830-1230 hrs). Circulate and flush mud from hole (1230-1330 hrs). Begin mixing cement, nipple-up cement head (1330-1500 hrs). Pump cement (1525 hrs) and drop plug and displace cement (1530 hrs). Plug fails to drop and cement job fails (1540 hrs). Adjust cement head and plug, begin to mix second batch of cement (1625 hrs), pump cement (1651 hrs). Drop plug and displace cement (1700 hrs), good cement returns (1710 hrs). Cement job witnessed by John Hass (USBLM) and Steve Rauzi (AZGS). WOC (1710-0000 hrs).

7/11/93

WOC (0000-2300 hrs). Nipple-up and test BOP (0700-2300 hrs). Rig maintenance and repair hydraulics (2330-2400 hrs) Complete nipple-up of double gate (1330 hrs). Successful test of manifold valves on blooie line to 1000 psi (1626 hrs). Successful test of choke valve to 1000 psi (1639 hrs). Pipe ram and blind ram successfully tested to 1000 psi (1645 hrs). H & H hotshot arrives from Farmington with BOP bolts for the annular BOP flange. Nipple-up annular (1845 hrs). Test annular to 1000 psi, leaking at flange (1858 hrs). Tighten BOP bolts, retest 1000 psi, still leaking (1918 hrs). Replace flange, retest to 1000 psi, still leaking (1216 hrs). Tighten BOP bolts and retest. Sucessful annular BOP test to 1000 psi (2216 hrs). All BOP tests witnessed by John Haas (USBLM) and Steve Rauzi (AZGS). Make-up and run drill string with 3 7/8 inch tricone bit. Charge pump for hydraulics fails (2330 hrs).

7/12/93

Install and test hydrogen sulfide sniffer, alarms, and wind sock (0700 2300 hrs). WOP (0000-2300 hrs). Cleaned location and performed rig maintenance. Drill helper sprains foot (2300 hrs), taken to hospital.

7/13/93

Tagged cement 478 feet. Drill-out float shoe and plug (0800-0830 hrs). Sucessfully test surface- casing cement to 1000 psi at 495 feet (0830-0850 hrs). Make-up core barrell and circulate plug rubber from the hole (0850-0940 hrs). Trip-in core barrell and diamond core bit (0940-1045 hrs). Coring from 497 to 564 feet (0940-2400 hrs).

7/14/93

Coring from 564 to 734 feet (0000-2400 hrs).

7/15/93

Coring from 754 to 914 feet (0000-2400 hrs). Harris Crosby of Nutrioso visits site (1625-1705 hrs)

7/16/93

Coring from 914 to 1104 feet (0000-2400 hrs). Trip-out, change bit, trip-in (0300-0435 hrs).

7/17/93

Coring from 1104 to 1274 feet (0000-2400 hrs). Mix new mud at 1174 feet, anchor blooie line manifold and choke valves and perform rig maintenance (0923-1207 hrs).

7/18/93

Coring from 1274-1454 feet (0000-2400 hrs). Diaphram pump down, replace with centrifigal mud pump at 1380 feet (1528-1545 hrs).

7/19/93

Coring 1454 to 1634 feet (0000-2400 hrs). Nipple-up and test new accumulator at 1553 feet (1245-1345 hrs).

7/20/93

Coring 1634 to 1694 feet (0000-2400 hrs). Trip-out, change bit, trip-in (0535-0850 hrs). Shut down at 1694 feet, haul old mud, haul water, mix new mud (1244-2318 hrs).

7/21/93

Coring 1694 to 1849 feet (0000-2400 hrs). Bob Dyson (USFS) visits site (0900-0920 hrs). Jim Witcher (SWTDI/NMSU) gives geothermal talk to Alpine Chamber of Commerce (1900-2130 hrs).

7/22/93

Coring 1849 to 2002.5 feet (0000-2400 hrs). Daniel Sanchez and Niles Lackey (USDOE-Albuquerque), John Sass (USGS-Flagstaff), John Crawford (AZDC, consultant), Frank Mancini (AZDC), and John Hoskins (AZDOT) visit the site (1300-1530 hrs).

7/23/93

Coring 2002.5 to 2134 feet (0000-2400 hrs). Daniel Sanchez and Niles Lackey (USDOE-Albuquerque), John Sass (USGS-Flagstaff), John Crawford (AZDC, consultant), Frank Mancini (AZDC), and John Hoskins (AZDOT) visit the site (0830-0930 hrs).

7/24/93

Coring 2134 to 2244 feet (0000-2400 hrs). Repair diaphram mud pump at 2204 feet (1513-1613 hrs).

7/25/93

Coring 2244 to 2374 feet (0000-2400 hrs).

7/26/93

Coring 2374 to 2509.5 feet (0000-2400 hrs). Rig maintenance (0730-0830 hrs).

7/27/93

Coring 2509.5 to 2614 feet (0000-2400 hrs). Trip-out, change bit, trip-in at 2544 feet (0550-0940 hrs).

7/28/93

Coring 2614-2744 feet (0000-2400 hrs).

7/29/93

Coring 2744-2820.5 feet (0000-2400 hrs). Stuck core barrell 2784 feet (0900-1022 hrs).

7/30/93

Coring 2820.5 to 2912 feet (0000-2400 hrs).

7/31/93

Coring 2912 to 2966 feet (0000-2400 hrs). Trip-out, add 20 foot core barrel, change bit, trip-in (0330-0950 hrs). Conditional hole 2922 feet (1021-1115 hrs).

8/1/93

Coring from 2966 to 3016 feet (0000-2400 hrs).

8/2/93

Coring from 3016 to 3054 feet (0000-2130 hrs). Change-out old mud, mix new mud (1100-1255 hrs). Trip-out, change bit (2130-2400 hrs).

8/3/93

Bit change continues, trip-in, chase cave at 3046 to 3054 feet, 1.5 feet cave recovered (0000-0030 hrs). Coring from 3054 to 3096 feet (0358-2400 hrs).

8/4/93

Coring from 3096 to 3155 feet (0000-2400 hrs). Clean drill cuttings from mud pits with backhoe (1030-1130 hrs).

8/5/93

Coring from 3155 to 3207 feet (0000-1839 hrs). No core retrieval on run 275, replace overshot (1740-1810 hrs), condition hole (1815-1828 hrs), retry to retrieve core tube (1828-1839 hrs), stuck tube (bent drill rod obstruction). Trip-out to retrieve tube and core, change bit and reamer shell (1921-2400 hrs), dented and bent rod replaced at 2980 to 2990 feet, probable cave (rods sticking while pulling out of hole (2800 to 3010 feet).

8/6/93

Trip-in, chase cave to bottom (0000-1235 hrs). Replace core catcher (1235-1320 hrs). Coring from 3207 to 3236 feet (1320-2400 hrs). Rods torque-up three times while coring run 276 from 3216 to 3236 feet (1838-2400 hrs).

8/7/93

Coring from 3236 to 3308 feet (0000-2400 hrs).

8/8/93

Coring from 3308 to 3337 feet (0000-1350 hrs). Pull-back rods 480 feet, condition hole, ream hole and chase cave back to bottom (1350-2400 hrs). Encountered cave bridges at 3020 feet and from 3036 to 3039 feet.

8/9/93

Continue conditioning hole, reaming and chasing cave, 3 feet of cave recovered (0000-0320 hrs). Mix new mud, change-out old mud (1100-1430 hrs). Reaming back to bottom (1430-1820 hrs). Coring from 3337 to 3338 feet (1915-2145 hrs).

8/10/93

Coring from 3338 to 3352 feet (0000-2400 hrs).

8/11/93

Coring from 3352 to 3369 feet (0000-7333 hrs).Differential stuck at 3369 feet (0733 hrs). Circulate detergent, try to work rods free (0800-2400 hrs).

8/12/93

Continue differential stuck at 3369 feet, circulate detergent, try to work rods free (0000-1900 hrs). Nipple-down BOP, prepare to cement for reduction from HQ to NQ (0700-1900 hrs). Run cement, HQ bit 10 feet from bottom at 3360 feet (1930-2210 hrs).WOC (2210-2400 hrs).

8/13/93

WOC, prepare NQ string, nipple-up and test BOP (0000-1200 hrs). Trip-in NQ rods (0700-1200 hrs), tag cement at 3294 feet, drill-out cement (1335-2400 hrs).

8/14/93

Continue to drill-out cement to 3345 feet, no cement below HQ core-barrel landing ring, stuck NQ tube (0000-0122 hrs). Perform rig maintenance, change out mud, and haul water (0122-0350 hrs). Trip-out, and haul water (0350-0720 hrs). Free-up stuck tube and makeup wash rod (0720-0930 hrs). Trip-in wash rod 0930-1200 hrs). Wash and clean hole and prepare to cement (1200-1900 hrs). Run cement (1900-2130 hrs). WOC, trip-out (2130-2400 hrs).

8/15/93

WOC, trip-in and wash-down hole (0000-0400 hrs). Tag cement at 3200 feet, core cement (0400-1230 hrs). Mix new mud, change-out old mud (1415-1600 hrs). Coring from 3369 to 3399 feet (1230-2400 hrs).

8/16/93

Coring from 3399 to 3475 feet (0000-2400 hrs). Lost circulation from 3415 to 3475 feet, major open fractures in core at 3459 and 3462 feet. Lost circulation material (LCM) slugs at 3415 feet (0400-0430 hrs), at 3439 feet (1030-1135 hrs), and at 3349 feet (1540-1710 hrs).

8/17/93

Coring from 3475 to 3515 feet (0800-2400 hrs).Condition hole and send LCM slug at 3475 feet (0000-0800 hrs). Condition hole and send LCM slug at 3515 feet (2100-2345 hrs).

8/18/93

Coring from 3515 to 3585 feet (0000-2400 hrs).Condition hole and send LCM slug at 3535 feet (0400-0930 hrs).

8/19/93

Coring from 3585 to 3655 feet (0000-2400 hrs). Partial returns from 3635 to 3655 feet.

8/20/93

Coring from 3655 to 3725 feet (0000-2400 hrs). Partial returns from 3655 to 3685 feet. Pull-back rods 440 feet at 3725 feet to condition hole and flush LCM and mud rings from drill string (2200-2400 hrs).

8/21/93

Continue to condition hole and ream to bottom (0000-0121 hrs). Coring from 3725 to 3775 feet (0121-1425 hrs). Differential stuck, circulate detergent and work rods free at 3765 feet (1425-1510 hrs). Core barrel mislatch on run 328 from 3765 to 3775 feet, lost core (1510-1740 hrs). Trip-out from 3775 feet (1820-2400 hrs).

8/22/93

Coring from 3775 to 3855 feet (0000-2400 hrs). Lost circulation from 3815 to 3835 feet (1600-2112 hrs). Condition hole, send LCM slugs at 3185 feet (1445-1537 hrs), and at 3835 feet (1940-2112 hrs). Perform maintenance on rig hydraulics at 3805 feet (1225-1307 hrs).

8/23/93

Coring from 3855 to 3975 feet (0000-2400 hrs).

8/24/93

Coring from 3975 to 4085 feet (0000-2400 hrs).

8/25/93

Coring from 4085 to 4195 feet (0000-2400 hrs).Condition hole, circulate LCM slug at 4135 feet (1045-1145 hrs) and at 4145 feet (1400-1525 hrs).

8/26/93

Coring from 4195 to 4284 feet (0000-2400 hrs).

8/27/93

Coring from 4284 to 4375 feet (0000-2400 hrs). Rig maintenance at 4355 feet (1740-1800 hrs).

8/28/93

Coring from 4375 to 4475 feet (0000-2400 hrs).

8/29/93

Coring from 4475 to 4505 feet, total depth (TD) at 4505 feet (0000-0634 hrs). Rig maintenance (0652-0800 hrs). Wiper-run then trip-out from 4505 feet (0830-1300 hrs). Nipple-down BOP (1300-1330 hrs). Test and trip-in cutter, make first cut at 2700 feet on HQ rods (1345-1900 hrs). Pull-out of hole, rebuild cutter, trip-back, try two more cuts, pull-out, trip-back with new cutter (1900-2400 hrs).

8/30/93

Sucessful cut at 2510 feet, pull 251 HQ rods, 85 HQ rods left in hole (0000-2400 hrs). Jim Witcher leaves Alpine with load of core for the AZGS depository in Tucson.

8/31/93

Trip-in 4505 feet of greased-up NQ rods, capped at bottom and filled with clean water (0000-0700 hrs). Nipple-up well head, begin rigging-down and demobilization, temperature log bore hole through the NQ rods (0700-1900 hrs). Witcher delivers core to AZGS in Tucson.

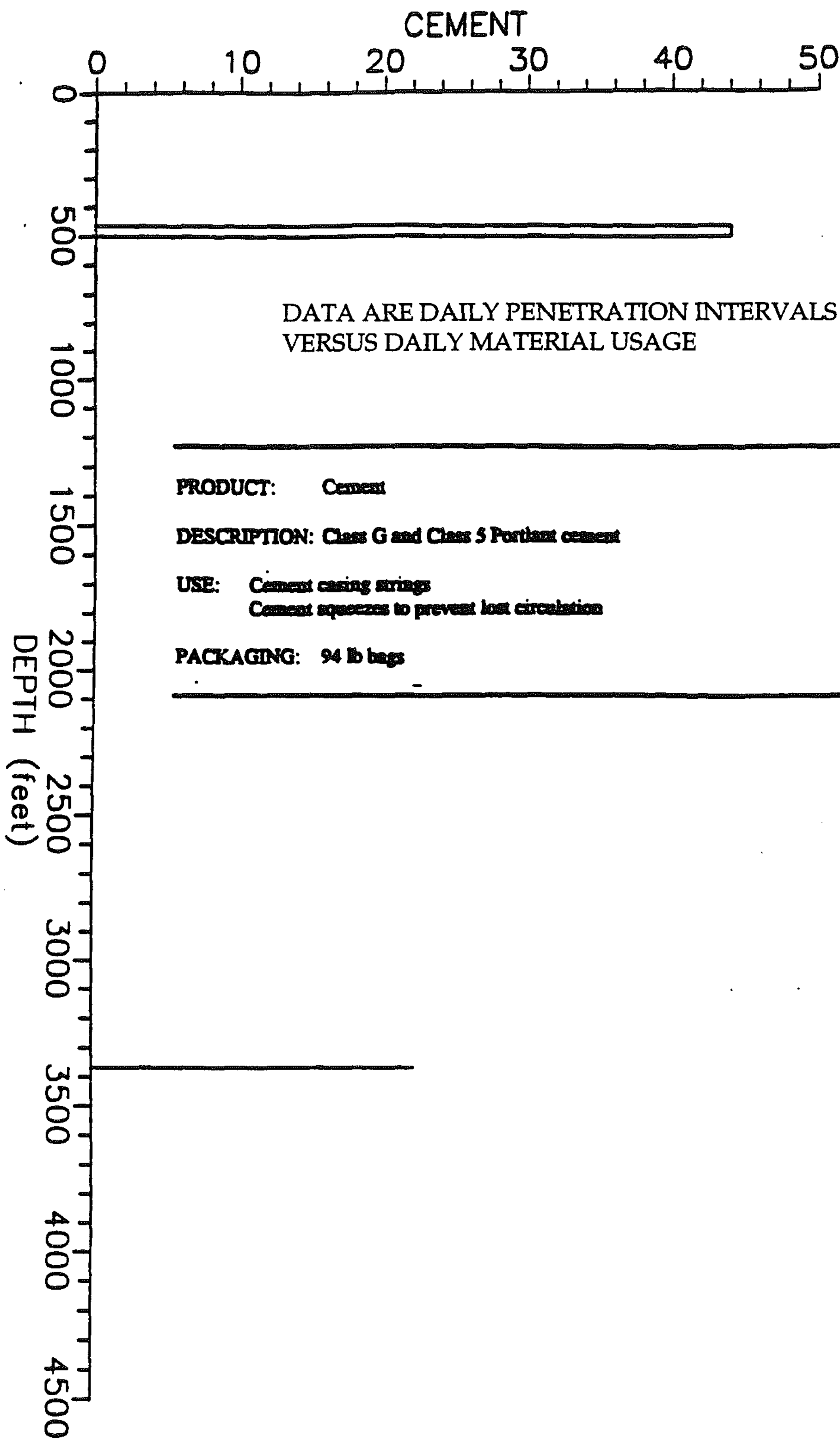
APPENDIX 6

CEMENT AND DRILLING MUD ADDITIVES USED IN THE ALPINE 1/FEDERAL BOREHOLE

DATA ARE DAILY PENETRATION INTERVALS
VERSUS DAILY MATERIAL USAGE

List of drilling products with registered names and trademarks.

product	company
DRISPAC	Drilling Specialities Company, Inc.
SDF K-LA LUBE PLUS	Summit Drilling Fluids, Inc.
SDF RING FREE L PLUS	Summit Drilling Fluids, Inc.
SDF 2000	Summit Drilling Fluids, Inc.
SDF SUPER GEL	Summit Drilling Fluids, Inc.
TORKEASE	Drilling Specialities Company, Inc.

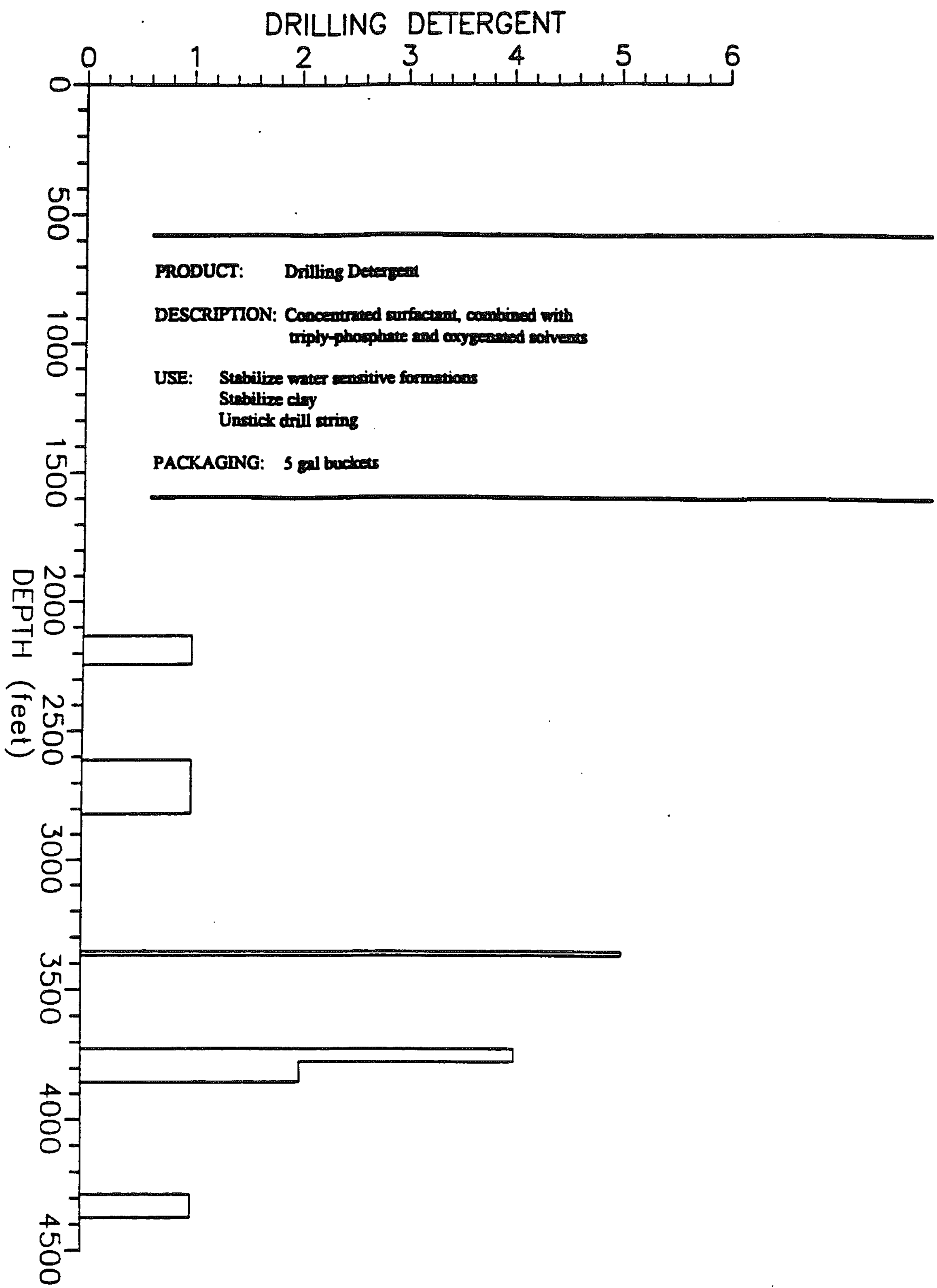


PRODUCT: Cement

DESCRIPTION: Class G and Class 5 Portland cement

USE: Cement casing strings
Cement squeezes to prevent lost circulation

PACKAGING: 94 lb bags

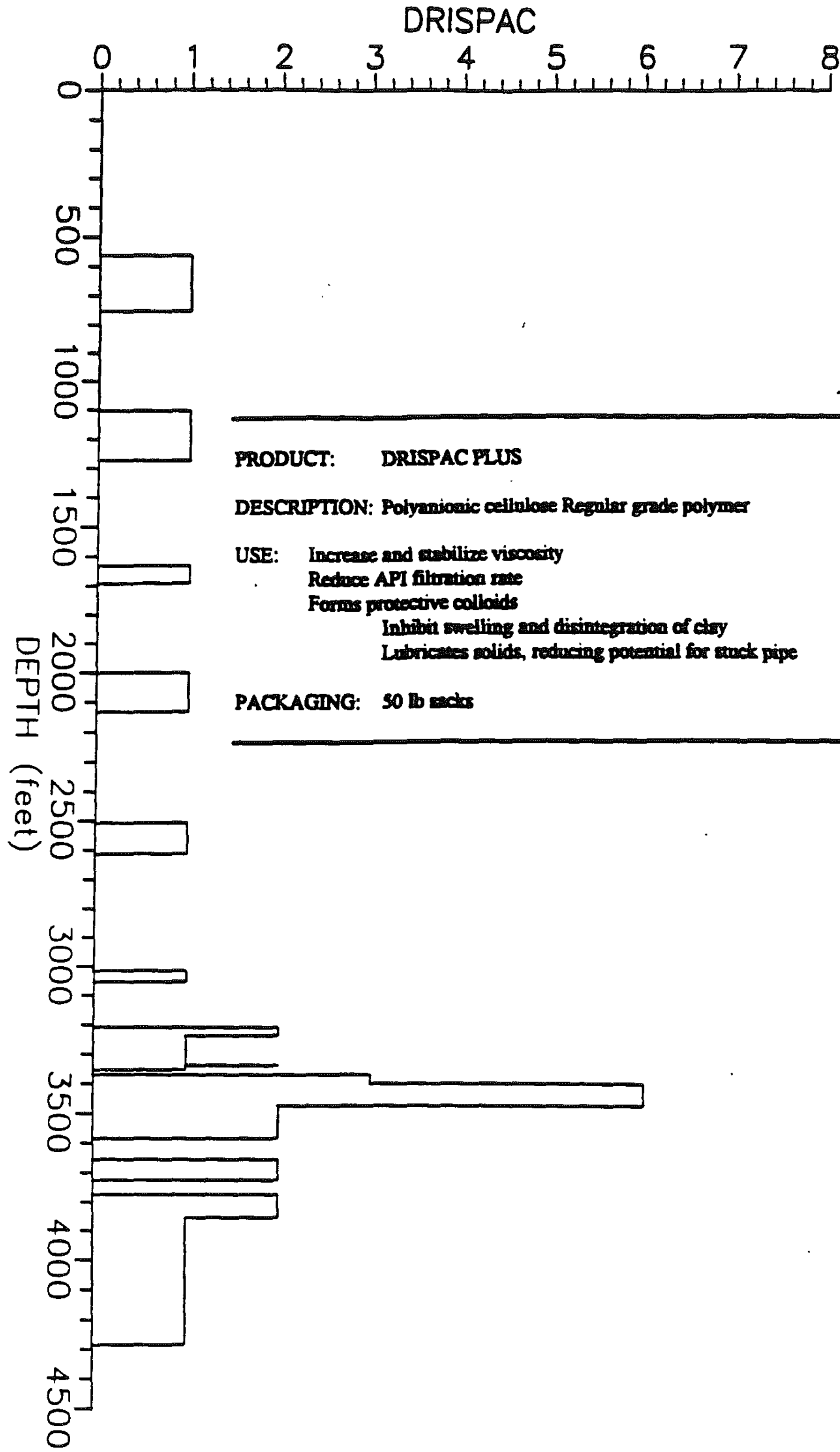


PRODUCT: Drilling Detergent

DESCRIPTION: Concentrated surfactant, combined with triply-phosphate and oxygenated solvents

USE: Stabilize water sensitive formations
Stabilize clay
Unstick drill string

PACKAGING: 5 gal buckets

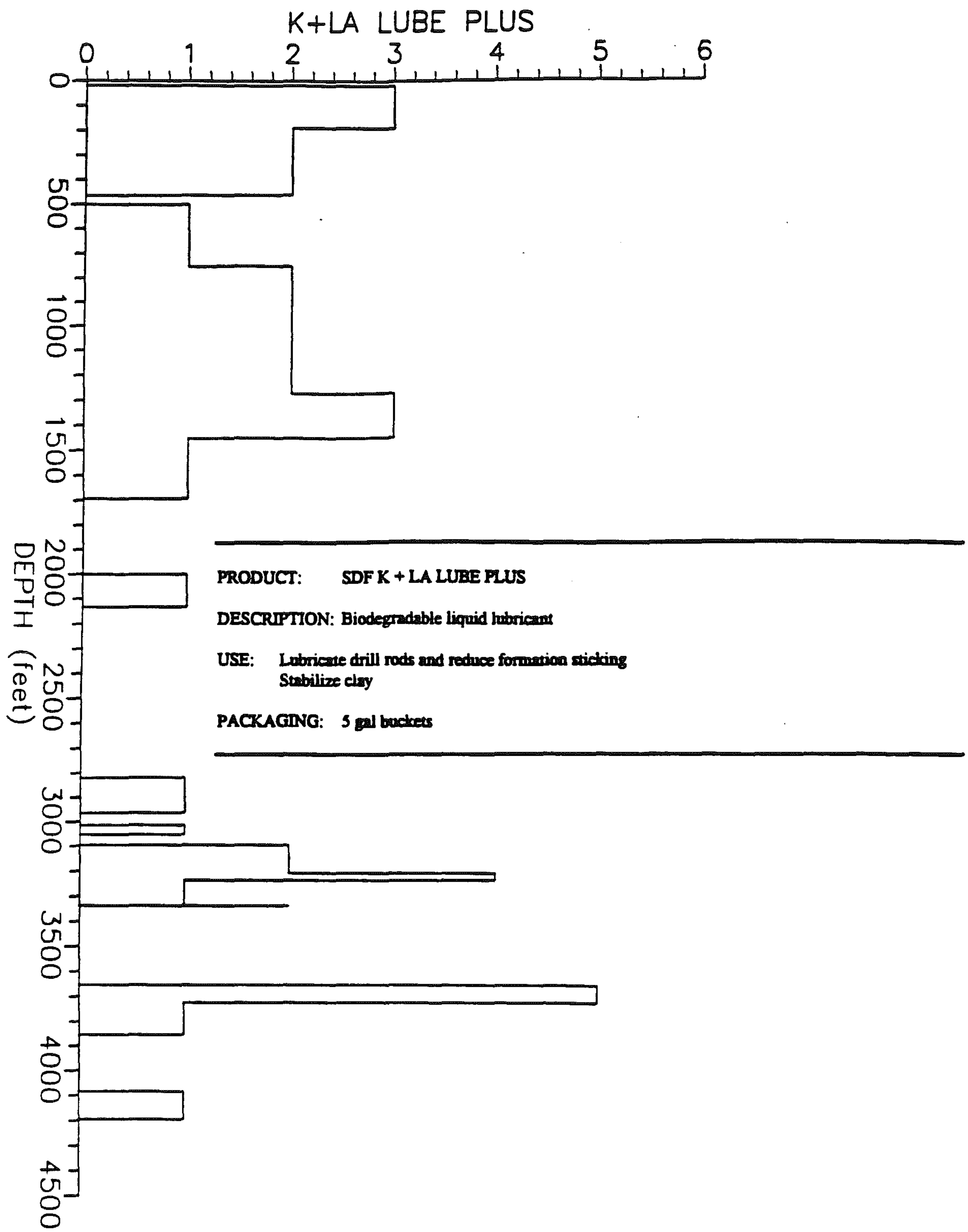


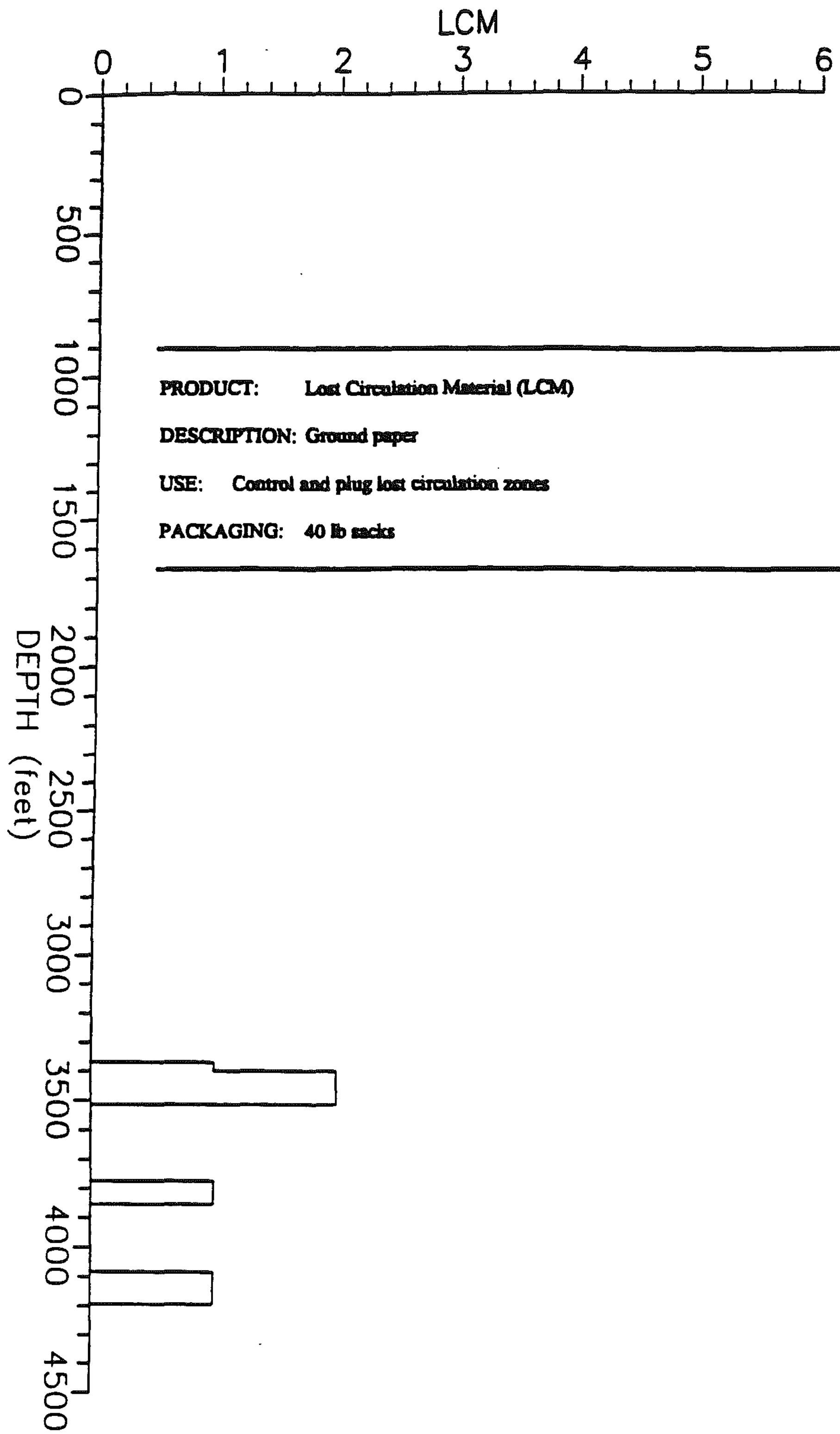
PRODUCT: DRISPAC PLUS

DESCRIPTION: Polyanionic cellulose Regular grade polymer

USE: Increase and stabilize viscosity
Reduce API filtration rate
Forms protective colloids
Inhibit swelling and disintegration of clay
Lubricates solids, reducing potential for stuck pipe

PACKAGING: 50 lb sacks


K+LA LUBE PLUS
0
1
2
3
4
5
6
0
500
1000
1500
2000
2500
3000
3500
4000
4500
DEPTH (feet)
PRODUCT: SDF K + LA LUBE PLUS
DESCRIPTION: Biodegradable liquid lubricant
USE: Lubricate drill rods and reduce formation sticking
Stabilize clay
PACKAGING: 5 gal buckets

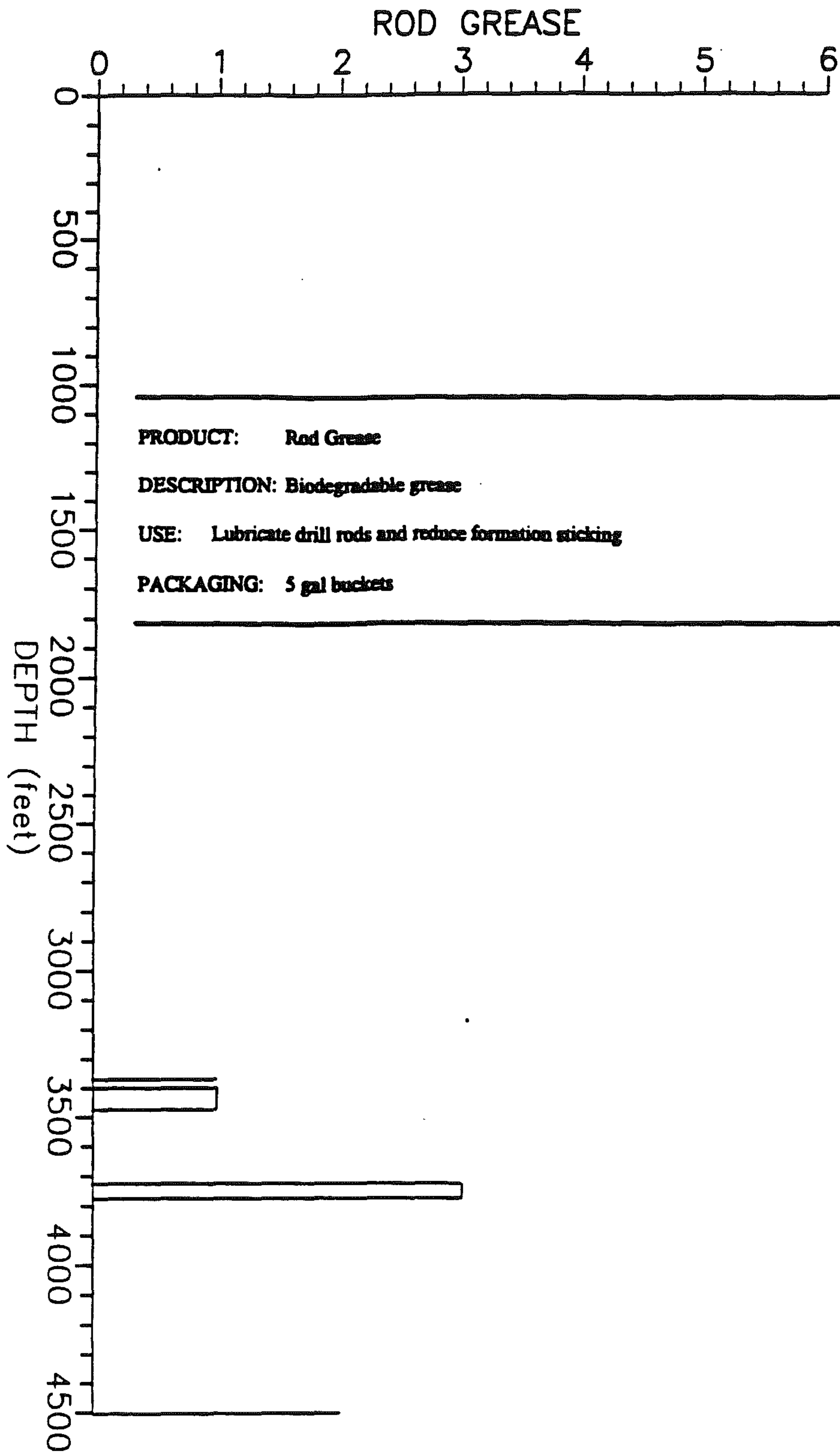


PRODUCT: Lost Circulation Material (LCM)

DESCRIPTION: Ground paper

USE: Control and plug lost circulation zones

PACKAGING: 40 lb sacks

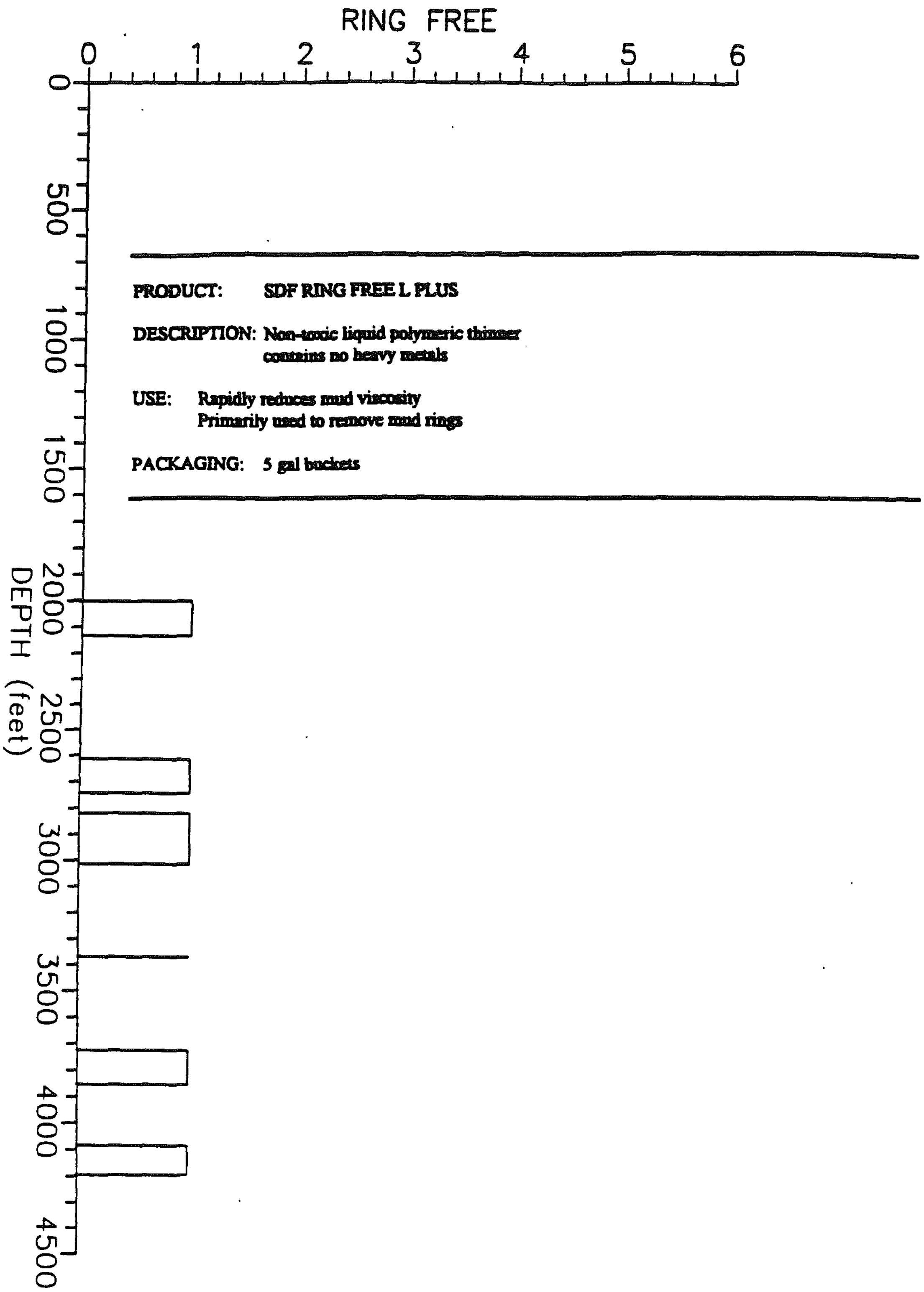


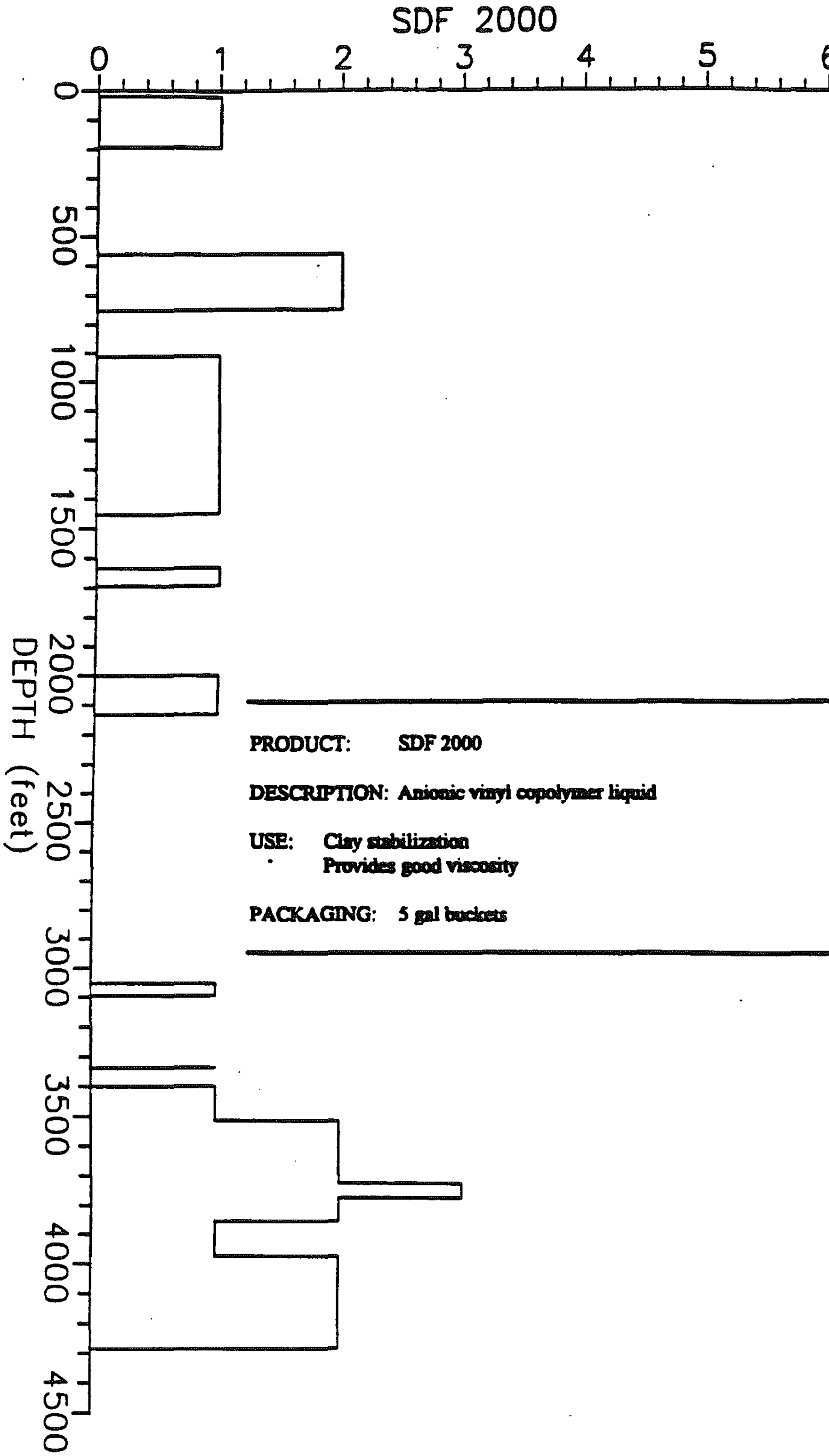
PRODUCT: Rod Grease

DESCRIPTION: Biodegradable grease

USE: Lubricate drill rods and reduce formation sticking

PACKAGING: 5 gal buckets


RING FREE
0 1 2 3 4 5 6
0 500 1000 1500 2000 2500 3000 3500 4000 4500
DEPTH (feet)
PRODUCT: SDF RING FREE L PLUS
DESCRIPTION: Non-toxic liquid polymeric thinner
contains no heavy metals
USE: Rapidly reduces mud viscosity
Primarily used to remove mud rings
PACKAGING: 5 gal buckets

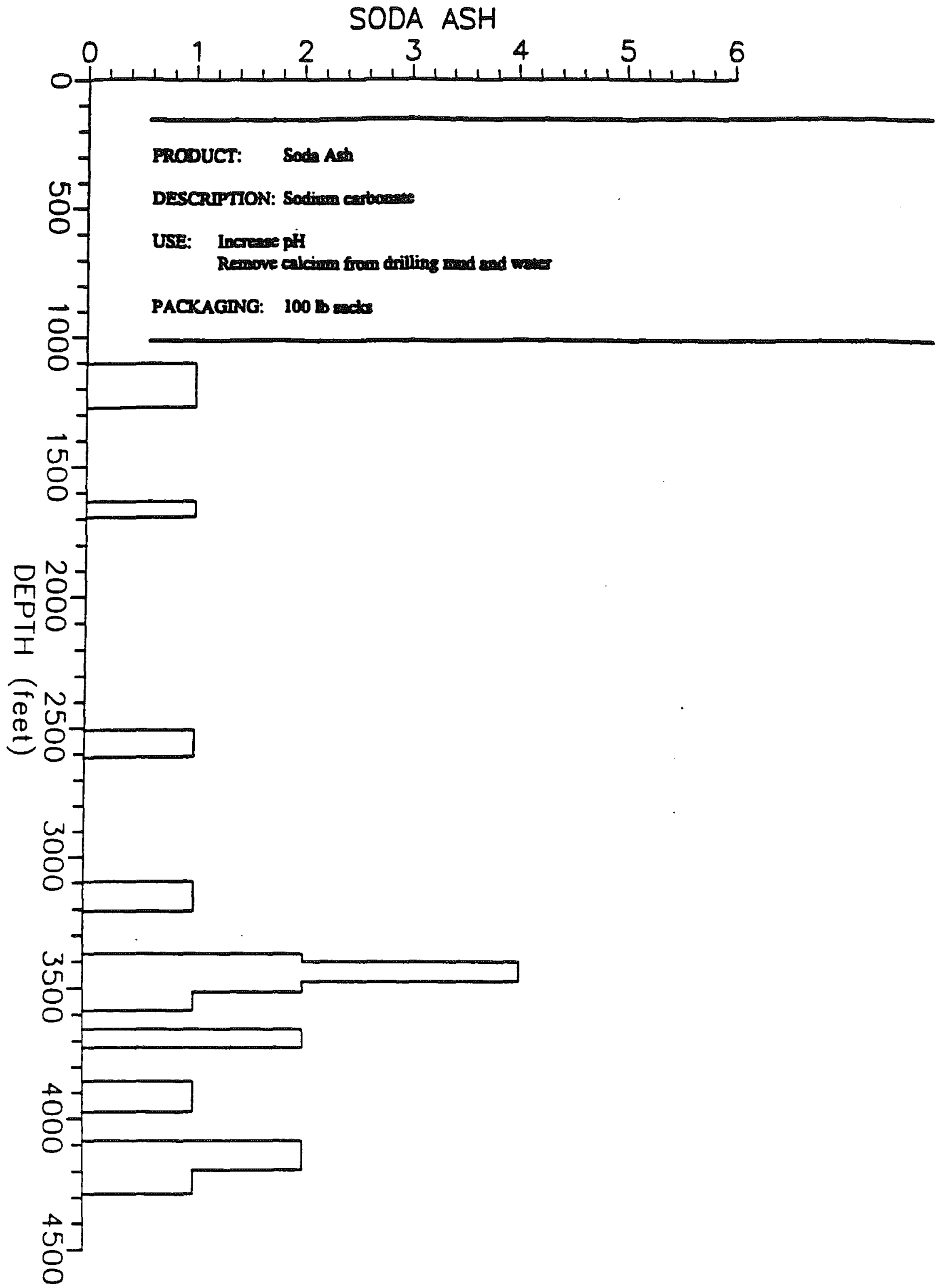


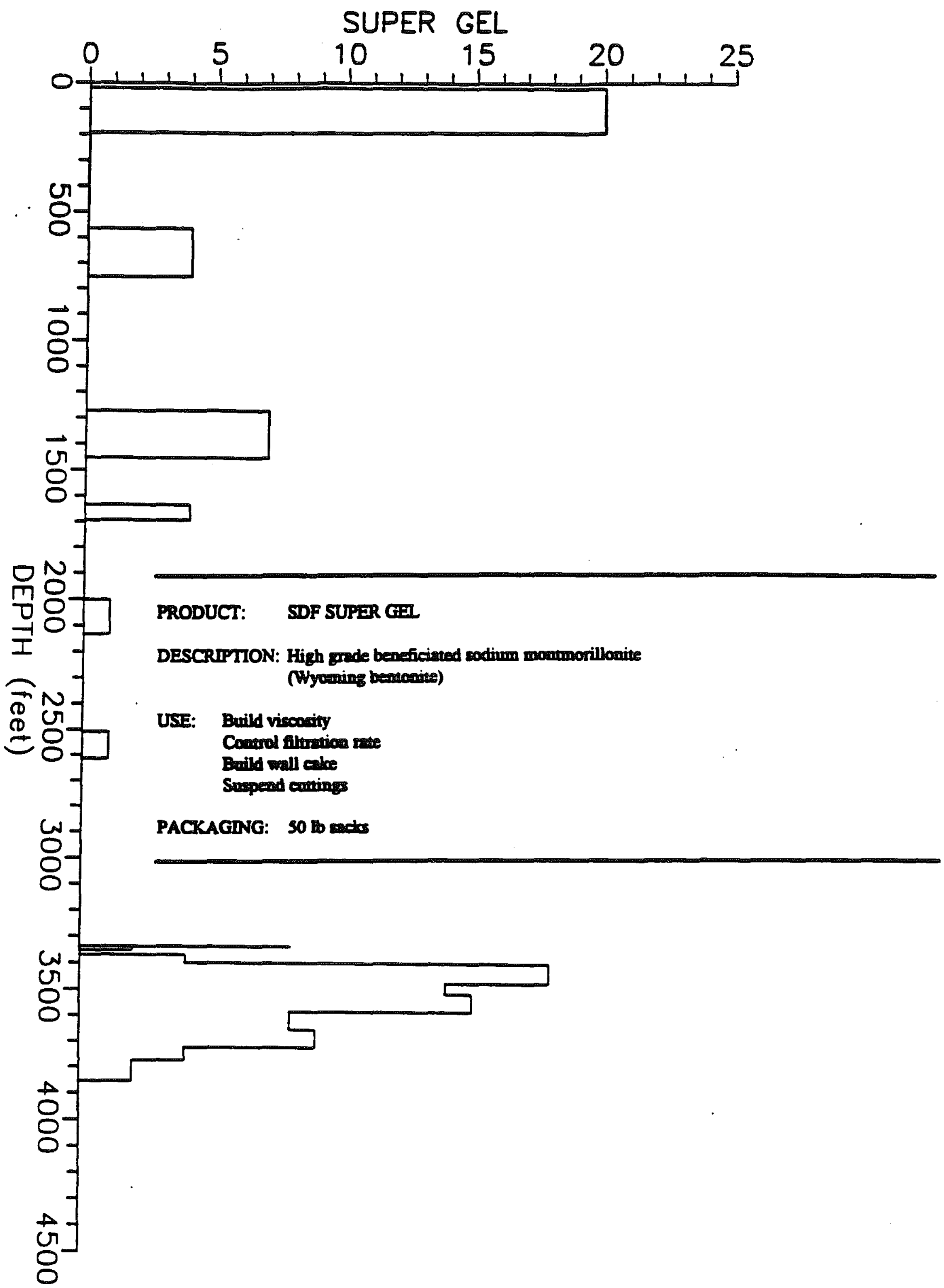
PRODUCT: SDF 2000

DESCRIPTION: Anionic vinyl copolymer liquid

USE: Clay stabilization
Provides good viscosity

PACKAGING: 5 gal buckets


SODA ASH
0 1 2 3 4 5 6
PRODUCT: Soda Ash
DESCRIPTION: Sodium carbonate
USE: Increase pH
Remove calcium from drilling mud and water
PACKAGING: 100 lb sacks
0 500 1000 1500 2000 2500 3000 3500 4000 4500
DEPTH (feet)

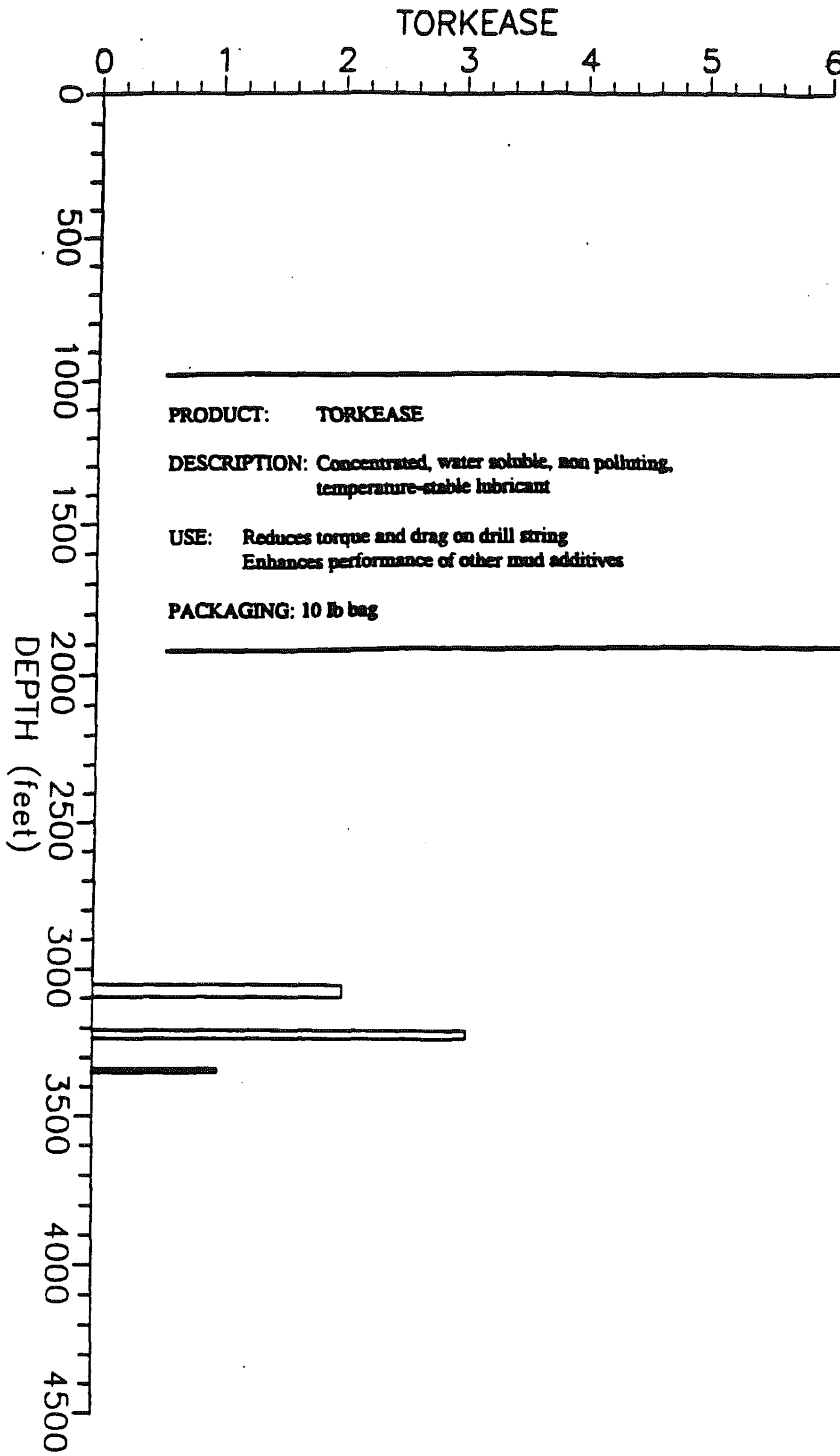


PRODUCT: SDF SUPER GEL

DESCRIPTION: High grade beneficiated sodium montmorillonite (Wyoming bentonite)

USE:
- Build viscosity
- Control filtration rate
- Build wall cake
- Suspend cuttings

PACKAGING: 50 lb sacks



PRODUCT: TORKEASE

DESCRIPTION: Concentrated, water soluble, non polluting, temperature-stable lubricant

USE: Reduces torque and drag on drill string
Enhances performance of other mud additives

PACKAGING: 10 lb bag

APPENDIX 7

LETTER OUTLINING A CONTINGENCY PLAN TO COMPLETE THE ALPINE 1/FEDERAL BOREHOLE IN PRECAMBRIAN BASEMENT

SOUTHWEST TECHNOLOGY DEVELOPMENT INSTITUTE

Box 30001/Dept. 3SOL/Las Cruces, New Mexico 88003-0001
Telephone: (505) 646-1846
Telefax: (505) 646-2960

NEW MEXICO STATE UNIVERSITY

8/16/93

Steven L. Rauzi
Oil and Gas Program Administrator
Arizona Geological Survey
845 North Park Ave.
Tucson, Arizona 85719

Dear Steve:

An unusually thick section of Tertiary sediments, unconformable with underlying Cretaceous sandstones, probably indicates that a primary drilling objective, Precambrian crystalline basement, will not be achieved by the Tonto/Alpine #1/Federal bore hole (State permit #878) under the current contract unless a thin sequence of Paleozoic strata overlies the Precambrian. A "rigid" contract between Tonto Drilling Services of Salt Lake City and the Arizona Procurement Office in Phoenix precludes drilling past 4,500 feet depth, jeopardizing a satisfactory hot dry rock (HDR) evaluation of the White Mountains region in Arizona.

Great uncertainty exists as to the type of Precambrian rocks beneath the White Mountains area. It is of paramount importance to an HDR evaluation to determine the character of the Precambrian basement. A contingency solution to the problem of reaching Precambrian basement may include: (1) designation of the Alpine #1/Federal test as an observation hole for up to 2 years until the hole can be reoccupied and completed into basement and much desired scientific studies are complete. (2) transferring the responsibility and liability of the bore hole from Tonto Drilling Services to the U. S. Geological Survey (USGS) when the conditions of the Tonto/State of Arizona contract are fulfilled in January 1994. Under this scenario the USGS would plug and abandon the hole and restore the site under the terms and conditions of the Arizona Oil and Gas Commission, U. S. Forest Service, and U. S. Bureau of Land Management.

This contingency may provide the best alternative within the current drilling contract framework, provide a quality HDR assessment, and protect the bore hole from third party interference until an adequate evaluation is complete. Because a thorough HDR evaluation will insure the maximum geologic and geophysical information, a temporary observation hole status could lead to economic benefits to include the discovery of new oil and gas in Arizona. In any case, much scientific value will accrue to regional geologists who study Paleozoic stratigraphy and Precambrian terranes.

As geotechnical subcontractor to Tonto Drilling Services, I am working with Thomas H. Moses of the USGS in Menlo Park and John Sass of the USGS in Flagstaff to find a suitable contingency to complete the Alpine #1/Federal bore hole in Precambrian basement. Tom Moses may be reached at (415) 329-4870. Any assistance or feedback on how to proceed with regard to well designation and transfer of operators would be of tremendous importance to the Alpine #1/Federal HDR evaluation.

Sincerely,

J C Witcher

James C. Witcher
Geologist

cc
Larry Pisto
Frank Mancini
Tom Moses
John Sass