INDEX

COVE FORT SULPHURDALE UNIT #31-33

PREFACE

Organization of Report

This report presents the technical details involved in the drilling of Union Oil Company's Cove Fort-Sulphurdale Unit Well #31-33. The report consists of the eleven chapters listed in the Index, as well as the well logs taken by Schlumberger, Geotex, and R. F. Smith. The contents of each chapter is summarized in the following. All depths in the report refer to rotating kelly bushing (R.K.B.) unless otherwise indicated. This is 20' above ground level (G.L.).

Chapter 1 presents a summary of the operations required to drill and complete CFSU #31-33. A listing of contractors used is also presented.

Chapter 2 summarizes what was learned about the hydrothermal system encountered by CFSU #31-33. This includes data on formation lithologies, fluid chemistries, and other geological information.

Chapter 3 contains a well history describing the day to day operations during the drilling of CFSU #31-33. Also included ... strings, and a listing of deviation surveys with the corresponding maximum reading thermometer results.

The two fishing operations engaged in while drilling this well are described in Chapter 4.

A time-depth progress graph is presented in Chapter 5. This graph also indicates the occurrence of events of major technical interest while drilling CFSU #31-33.

Chapter 6 lists the various kinds of logging data taken during the drilling of CFSU #31-33. Copies of each of the individual logs are supplied with the report. Maximum reading thermometer temperature surveys taken at various times when the hole had been static for two or more hours are also listed here.

Chapter 7 presents technical information about the drill bits used in CFSU #31-33.

Chapter 8 describes cementing operations carried out during casing jobs, while trying to control lost circulation, and while abandoning the lower section of the hole.

Chapter 9 is a technical summary of the drilling fluids used in drilling this well. This section was prepared by Baroid, the sales, service and engineering company responsible for the drilling fluids program.

Chapter 10 contains a summary of tubular goods corrosion which occurred while using aerated water as a drilling medium, as well as Union's attempts to maintain control.

Chapter 11 describes the equipment and procedures used on the wellsite to protect personnel from the potential danger of H_2S gas.

<u>COVE FORT SULPHURDALE UNIT #31-33</u>

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COVE FORT SULPHURDALE UNIT #31-33

I. GENERAL INFORMATION

UNION OIL CO. OF CALIFORNIA

GEOTHERMAL DIVISION

A. WELL RECORD

LEASE Cove Fort Sulphurdale Unit
WELL # 31-33
FIELD Cove Fort
LOCATION N89°28'W 1092.23 and South 479.21' from the South ¼ corner of Section 28, T25S, R6W, SLM. (The well is located in Section 33, T25S, R6W, SLM.)
B.H.L.
DEPTH: T.D. 5221' T.V.D. 5165' E.T.D. 2600'

COMPANY ENGINEER Harold Moss

SPUD DATE 5/24/78 COMP. DATE 7/27/78
CONTRACTOR Loffland Brothers Company
RIG # 5
ELEVATIONS: GROUND 6480'
K.B. TO GROUND 20'
K.B. TO LOWER CASING HEAD

TYPE WELL: EXPL. XX DEV.
STM HOT WTR XX INJ
DRY HOLE
APPROVED [signature]

CASING RECORD

SIZE	WEIGHT	GRADE	THREAD	TOP	BOTTOM	REMARKS
30"	.375" wall	H-40	Welded	G.L.	32'below G.L	cemented surface to 32'
20"	94#/ft	H-40	Buttress	20' K.B.	280' K.B.	cemented surface to 280'
13-3/8"	54.5#/ft	K-55	Buttress	20' K.B.	1733' K.B.	cemented surface to 1733'
2-7/8"	6.4#/ft	K-55	EUE 8RD	20' K.B.	2579.53'	hanging tubing with bottom joint perforated

WELL HEAD ASSEMBLY

	MAKE	TYPE	SIZE	PRESSURE RATING
CASING HEAD SPOOL	WKM	S.O.W.	13-3/8"x12"	3000#
SPOOL	Midway Fishing Tool	Tubing Hanger	12"x6"	3000#
ADAPTER	WKM	Double Studded	6"x3"	3000#/2000#
CASING HEAD VALVES	WKM	Gate	3"	2000#
HANGER SPOOL VALVES	Midway Fishing Tool	Blind Flange	2"	3000#
SWAB VALVE	WKM	Gate	3"	2000#

STEAM ENTRIES: DEPTH LBS. INCREASE

Not Applicable

SLOTTED LINER	SLOTS FROM	SLOTS TO	BLANK FROM	BLANK TO
2-7/8" EUE 8RD Tubing	2550.11	2579.53	G.L.	2550.11

TEST DATA ORIFICE SIZE

RIG TEST DATE	WHP	FLP	TEMP	POUNDS/HOUR

REMARKS: Total Cost of Well = $1,270,000

Cost Per Foot = $243.25

B. CONTRACTORS USED

Baroid

Basin Mud Service

B&W, Inc.

Christensen Company

Cove Fort Service

Del Mar Construction

Donham Oil Tool

Dresser Industries

Francis Engine Service

Geotex

Grant Oil Tool

Duane Hall Trucking

Halliburton

HOMCO

Howard Construction

Hughes Tool Company

Marion Kessler

La Sal Oil Company

Loffland Brothers

Mac's Welding

Bill Martin Rathole Service

Midway Fishing Tool

Mountain States Inspection

Oilwell Supply

B. <u>CONTRACTORS USED</u> (cont'd)

San Juan Casing Service.

Schlumberger

R. F. Smith Corporation

Smith Tool Company

Thatcher Chemical

West Coast Oil Tool

W-K-M Wellhead Systems

II. DRILLING OPERATIONS

A. RIG INFORMATION:

Loffland Brothers Rig #5 is an Ideco 1000 Portable Mast and 20' substructure with an Ideco H-1000 Drawworks. The rig is rated to drill to a depth of 12,000'. It is powered with two V12 GMC Diesel Engines rated at 434 INT. h.p. each at 1800 RPM. The telescoping Mast is 112' in height. The rotary table is an Ideco 27-1/2". The rig is limited to a 350,000# casing capacity.

B. PREPARATION OF LOCATION AND SETTING OF CONDUCTOR TO 52' (R.K.B.):

At the end of 1977, various operations were conducted to prepare the location for drilling. The location, sump and roads were built to specifications laid out in the "Approved Unit Plan of Operations:. A 36" conductor hole was drilled to 32' G.L. (52' R.K.B.) by Bill Martin Rathole Service. Thirty inch (30") conductor pipe was run and cemented from surface to 32' G.L. (52' R.K.B.) with Ready-Mix Cement.

C. 26" HOLE: 52' to 289': (20" Casing Set to 280')

Loffland Rig #5 moved in, rigged up, and was placed on day rate at 1200 hours, 5/24/78. Drilled mouse and rat holes.

C. Continued -

hole was drilled to 301' (recent alluvium to 180', andesite below). The hole was opened to 26" from 52' to 295'.

Two hundred-ninety four feet (294') of 20", 94#/ft K-55 buttress casing was set and cemented to surface. The 20" and 30" casing were cut off to ground level. A 20" Hydril GK and Double Shaffer blowout preventer was installed and tested to U.S.G.S. specifications.

D. <u>17-1/2" HOLE: 289' to 1735'</u>: (13-3/8" Casing Set to 1733')

1. General Description of Hole Drilled

   The 17-1/2" hole was drilled from 289' to 1733' (open hole and fill, 280' - 301'; andesite beginning at 301') with severe lost circulation problems. A parted shock sub while drilling at 711' necessitated a fishing job at this depth.

   Complete loss of circulation occurred numerous times over the interval 1236' to 1276' while drilling dolomitic limestone and dolomite. Nineteen lost circulation plugs (total volume of 4193 ft^3 cement) were set during the eight days required to drill this section. A total of 340 bbls mud were lost while drilling continued in dolomitic limestone and dolomite from 1276' to 1564',

D. Continued -

cement plug #20. A total of 410 bbls mud were lost while drilling occurred in the same formation from 1564' to 1735'. Complete loss of circulation occurred at this depth while circulating and conditioning mud to run 13-3/8" casing. Five more lost circulation plugs were set (558 ft^3 cement) before circulation was regained.

1,733' of 13-3/8", 54.5 #/ft, K-55 buttress casing was set and cemented to surface. The 13-3/8" casing was cut off to surface, and 12" - 3000# B.O.P. equipment was installed and tested to U.S.G.S. specifications.

2. Problems Encountered and Their Resolution

   a. Parted Shock Sub at 711'

      A shock sub parted while drilling at 711'. The lost tools were recovered on first run with an overshot fishing tool.

   b. Complete Loss of Circulation: 1236' to 1276'

      Complete loss of circulation occurred at 1236', but drilling continued to 1241'. The hole made H_2S while pulling the drill string, and H_2S alarms were set off at a level of 10 ppm.

      Seven cement plugs (total volume = 1925 ft^3) were

2. b. Continued -

the H_2S flow and an initial seep of methane were completely eliminated after the fifth plug.

A 17-1/2" drilling assembly was run to clean out a bridge from 1236' to 1241', and to drill from 1241' to 1252', with no drilling fluid returns. 500 bbls mud was lost while drilling at a rate of 20' - 30' per hour. There was no evidence of torquing, additional fractures, or running dolomite from 1241' to 1252'.

Five additional cement plugs (total volume 1090 ft^3) were set through open ended drill pipe at 1250'±.

The fluid level in wellbore was located at 600' using a wireline and wooden float, but there was no cement to be found in the hole.

Cement plug #13 (166 ft^3) was set through open ended drill pipe at 1250'±. The top of the cement was located at 1160'. The cement was drilled with a 17-1/2" drilling assembly from 1160' to 1252'. Complete loss of circulation occurred at 1236'. New 17-1/2" hole was drilled from 1252' to 1257' with no drilling fluid returns.

2. b. Continued -

zone. Cement was located at 1221' following plug #17.

Firm cement was drilled out from 1221' to 1247' at which depth complete loss of circulation occurred.

Cement plug #18 (235 ft^3) was then set. Preceding the injection of cement, three separate attempts were made to plug up the lost circulation zone by injecting 90 ft^3 amounts of a water/polymer lost circulation compound. We were unable to fill the hole following each attempt.

The top of the cement from plug #18 was located at 1183'. Firm cement was drilled out from 1183' to 1257', drilling continued in dolomitic limestone and dolomite from 1257' to 1276'. Complete loss of returns occurred at 1274'.

At this depth cement plug #19 (115 ft^3) was preceded by a 112 ft^3 mixture of water/polymer lost circulation compound. The top of the cement was located at 1230'.

c. Complete Loss of Circulation at 1564'

Fluid returns were lost completely at 1564' after

2. c. Continued -

1380' to 1564'. The drill pipe became stuck while pulling out of the hole, but was worked free in four hours.

Cement plug #20 was then set (115 ft^3), but was preceded by 95 ft^3 of water/polymer lost circulation compound.

The top of the cement was found at 1487'. Cement was cleaned out to 1500' with full drilling fluid returns. Circulation was lost completely at 1500', but was regained with 500 bbls of water.

The hole was then cleaned out to 1564'.

d. Complete Loss of Circulation at 1735'

A 17-1/2" hole was drilled in dolomite from 1564' to 1735', while losing a total of 410 bbls mud.

While circulating and conditioning mud in preparation for running 13-3/8" casing, drilling fluid returns were lost completely.

Five additional cement plugs were set (nos. 21-25, total volume = 594 ft^3), three of which were preceded by the water/polymer lost circulation compound (total volume = 316 ft^3). Following the last plug,

2. d. Continued -

mud, and the 13-3/8" casing was successfully run and cemented.

E. 12-1/4" HOLE: 1735' to T.D. at 5221' (Hole Plugged Back to 2600')

1. General Description of Hole Drilled

The 12-1/4" hole was drilled from 1735' to total depth at 5221' with continued lost circulation problems (1735' to 2770' in dolomitic limestone and limestone, 2770' to 4787' in siltstone and sandstone, and 4787' to 5221' in dolomite). After complete loss of circulation occurred at 2015', the remainder of the hole was drilled with chemically treated aerated water. There were intermittent returns to the surface from 2015' to 4832', and none from 4832' to total depth at 5221'. A parted shock sub required fishing at 2876'. Coring was attempted from 5015' to 5021' with only limited recovery. Various Schlumberger and Geotex well logs were run to 5200'±.

Efforts to abandon the lower portion of the hole were then begun. The 12-1/4" hole was plugged back to 2600' after setting 15 cement abandonment plugs.

E. 2. Problems Encountered and Their Resolution

a. Complete Loss of Returns at 2015': Rig Up for Aerated Water Drilling

After circulation was lost completely at 2015', drilling continued with chemically treated aerated water. While rigging up for drilling with air, a bottom hole temperature of 210°F was measured. The hole had been static for 12 hours.

b. Intermittent Returns to Surface: 2015' to 4832'

A 12-1/4" hole was drilled in dolomite from 2019' to 2672' using the chemically treated aerated water. Cuttings or liquid returns were not obtained while drilling this interval. Intermittent returns of water and cuttings were obtained from 2151' to 2550', while no returns were obtained from 2550' to 2672'.

Intermittent returns by heads were obtained every three to four hours while drilling from 2672' to 2920', at which depth a shock sub parted, requiring fishing.

Drilling continued, from 2920' to 3250'. Some intermittent cold water returns were experienced with temperatures from 50°F to 171°F. A 12-1/4" hole was drilled to 3765' and additional jet subs were added to the drill string to aid in lifting fluid and sodium nitrate was added to the injection water to

E. 2. b. Continued -

The 12-1/4" hole continued to be drilled to 4832' with intermittent fluid returns to surface. Temperature surveys at 4675' indicated 292°F after five hours static, and 292°F at 4735' after 18 hours static.

c. Parted Shock Sub at 2920'

At 2876', the shock sub failed, required fishing, and was recovered on the first attempt.

d. No Returns to Surface: 4832' to T.D. at 5221'

A 12-1/4" hole was drilled to 5009', without returns to surface.

Formation voids were noted at 4852' and 4858'. Drill cutting fill impaired drilling and caused drill string sticking.

Continual replenishment of the drill water supply was hampered due to lack of available tank trucks, although four in use.

An attempt to consolidate formation fill and regain partial returns was made by displacing a sodium silicate-calcium chloride solution, followed by cement-Perlite-silica flour-gel plugs and the hole filled to 4753'.

E. 2. d. Continued -

from 4753' to 4926', a void from 4926' to 4935' and fill was encountered from 4935' to 5009', with no fluid returns to surface. 12-1/4" hole was drilled to 5221'.

3. Coring Efforts - 5015' to 5021'

An attempt was made to obtain two cores of the formation, without success and only 8" of core, a highly fractured dolomite was recovered.

4. Logging Efforts

Two Schlumberger temperature logs, a DIL-8 and CNL-FDC, and a 4-arm Dipmeter with Caliper log were run. They indicated dolomite from 1735' to 2770', siltstone and sandstone from 2770' to 4782' and dolomite from 4782' to 5221'. Maximum reading thermometer temperatures were 282°F.

A Geotex Temperature Log, water aquifer locater and radioactive tracer were run, indicating cross flow of fluid, up and down the hole. The previous temperature were confirmed.

5. Plugging Back to 2600'

Lower hole section abandonment operations consisted of:

E. 5. Continued -

of two Halliburton EZSV 13-3/8" plugs. These operations resulted in the establishment of a plug from 5221' to 4728', and from 2750' to 2552'. The upper plug was drilled out to 2600'. The plugs were installed by U.S.G.S. direction in order to eliminate possible co-mingling of formation fluids.

F. WELL COMPLETION

A 2-7/8" EUE 8RD 6.4#/ft tubing temperature survey string was hung in a Shaffer tubing head at the surface. The bottom joint of tubing, 30', was perforated and orange peeled with a 3/4" hole in the bottom. The bottom tubing joint is located at 2558', ground level.

The purpose of this completion arrangement was to facilitate the execution of future temperature surveys in the upper portion of the hole.

The Loffland Brothers Company rig, #5, was released at 1800 hours, 7/27/78.

III. POST DRILLING OPERATIONS

Current plans are to continue monitoring temperatures in the upper portion of the hole. Union personnel carried out a temperature survey of the completed zone on August 9, 1978.

GEOLOGIC REPORT ON THE COVE FORT-SULPHURDALE UNIT #31-33 MILLARD COUNTY, UTAH

LITHOLOGY

The CFSU 31-33 well was drilled to a total depth of 5221 feet where a sequence of soft dolomitic shale and brecciated and fractured dolomite is present. The sequence of rock units encountered in the 31-33 well differs from that found in the CFSU 42-7 well, indicating that the local subsurface structure has considerably altered the normal stratigraphic sequence in the area. Those rock units that are present in both wells show significant variation in degree of alteration and metamorphism.

The following is a description and discussion of the rock types encountered in CFSU 31-33 from the surface to the total depth. The descriptions are based on examination of the well cuttings by binocular microscope and one x-ray diffractometer analysis.

Recent alluvium is present from the surface to approximately 180 feet. The alluvium consists of hydrothermally altered volcanic pebbles, gravel, and sand with abundant limonite staining.

Interval..............180-1005'

Formation...........Bullion Canyon Volcanics

Age.................Oligocene and Miocene(?)

Lithology............Andesite

The well penetrated 825 feet of Mid-Tertiary extrusive volcanics, the majority of which were characterized by extensive chloritic and argillic alteration. The volcanics can be divided into two major units based on the texture and composition of the samples. The upper unit (180-530 feet) consists of a greenish to reddish-gray porphyritic andesite and a minor greenish-gray aphanitic andesite. The fine to medium-grained phenocrysts are predominately feldspar, with trace pyroxene, and trace to rare biotite, calcite and quartz. In most cases, the pyroxene and biotite have been bleached or chloritized and some feldspar phenocrysts have been altered to kaolinite. The chloritization appears to increase with depth.

The lower unit (530-1005 feet) is characterized by the appearance of abundant pyrite and siliceous fracture-filling material. The volcanics of this unit consist of a gray, fine-grained porphyritic andesite and a chloritized and silicified greenish-gray, medium-grained porphyritic andesite. The phenocrysts consist mainly of white, subhedral feldspar, chloritized biotite and pyroxene, trace magnetite, and trace to rare calcite. Quartz phenocrysts are generally absent in the lower unit. Minor amounts of a pale reddish-orange welded tuff are present from 690-700 feet. The base of the volcanics is characterized by decreasing amounts of pyrite and siliceous fracture-filling material, and increasing amounts of calcite and greenish to reddish-gray porphyritic andesite. This andesite is similar to the andesite of the upper unit. Some of the volcanics from 730-1005 feet appear to be brecciated. Two fracture zones were encountered at 530-550 feet and 620-650 feet.

Interval............1005-1150'
Formation...........Claron(?)/North Horn(?) formation
Age.................Upper Cretaceous(?) to Paleocene(?)
Lithology...........Siltstone

An unconformity between the Bullion Canyon Volcanics and the Claron formation was penetrated at 1005 feet.

The Claron formation consists of a poorly-sorted red siltstone with fine to medium-grained subrounded quartz and quartzite clasts and medium to coarse-grained limestone clasts in a clayey red matrix cemented with calcite. The siltstone is moderately well-cemented and contains minor calcite-filled fractures. The quartz and limestone clasts become coarser-grained near the base of the formation as the siltstone becomes conglomeratic in part. This 145-foot section of red siltstone is generally hard and unfractured, with very low porosity.

Interval..............1150-2770'

Formation............Kaibab(?)/Pakoon(?)/Callville(?)(Oquirrh) formation

Age..................Permian(?) - Pennsylvanian(?)

Lithology............Dolomitic limestone, dolomite

An unconformity between the Claron formation and a carbonate unit of uncertain age and correlation was penetrated at 1150 feet.

The upper part of the unit consists of a light to dark gray, fine to medium-grained dolomitic limestone with rare crinoid fragments, trace white, slightly calcareous to non-calcareous fine sandstone, and minor chert. A light blue-gray, soft, slightly calcareous siltstone appears at 1170 feet and increases in amount with depth. Pyrite and quartz are trace to rare in this interval.

A major lost circulation zone was encountered at 1233-1255 feet. High concentrations of hydrogen sulphide gas and carbon dioxide gas were detected in the zone.

A sequence of light brown to light gray aphanitic and cherty dolomite and dark gray, fine to medium-grained calcareous dolomite with sugary texture occurs below the lost circulation zone. Trace to rare amounts of pyrite, sphalerite, galena, and calcite are present intermittently from 1210 to 1460 feet. White to light gray chert and aphanitic dolomite occur at 1520 to 1560 feet. This sequence of chert, aphanitic dolomite, and secondary sulphide minerals is similar to an interval described as Lower Permian Pakoon dolomite in the CFSU 42-7 well. However, a prominent sandstone marker bed in the Pakoon dolomite is absent in the CFSU 31-33 well.

The dolomite below the cherty interval is predominately dark grayish-brown, fine to medium-grained and slightly calcareous with minor brecciated calcite and siliceous veins. Rare crinoid stems are present from 1570 to 1590 feet. The dolomite becomes more calcareous with depth, accompanied by an increase in brecciation and calcite veining. This interval of dark gray crystalline calcareous dolomite could be tentatively correlated with the Pennsylvanian Callville (Oquirrh) formation.

A second major lost circulation zone was encountered at 2010 feet. Minor amounts of hydrogen sulphide gas were present at 2080 feet. Sample returns were minimal throughout the interval 2010-3030 feet, but generally consisted of brecciated crystalline dolomite.

The dipmeter log was run from 1733' to the total depth. The dips of the carbonate in this interval are extremely erratic, indicating the presence of many cavities and fractures.

The age and correlation of the carbonates in the interval 1150-2770 feet is uncertain. Dolomitization may have destroyed diagnostic fossils that might aid in the correlation of these units.

Interval............2770-4787'

Formation...........Chinle(?), Shinarump(?), Moenkopi formations

Age.................Triassic

Lithology...........Siltstone and sandstone

The presence of approximately 2000 feet of Triassic Red Beds below Permian(?) and Pennsylvanian(?) dolomite indicates that significant thrust or reverse faulting occurred in the area between Mid-Mesozoic and Late Cretaceous time.

The Triassic Red Beds consist of interbedded red, slightly calcareous, poorly-sorted micaceous siltstones, light gray to white calcareous sandstones, and pale green, slightly calcareous siltstones. Trace to rare gypsum occurs intermittently throughout the interval. A medium to dark gray, very calcareous sandy siltstone is present from 4180 to 4640 feet. Light gray mottled calcareous fragments containing trace to common gastropod fossils are also present in that interval. The base of the Red Beds is predominately reddish-brown non-calcareous to slightly calcareous siltstone grading into a fine sandstone, pale green siltstone, and minor dark gray, very calcareous siltstone.

The Red Beds are characterized by a generally low porosity.

Minor fractures are present in the red siltstones, but most fractures are filled with calcite. The white to pale red sandstones vary from being moderately well-cemented with silica and calcite to friable and poorly-cemented.

Formation dips obtained from the dipmeter log are fairly consistent throughout the Red Beds. The strike of the Red Beds ranges from E-W to N46W, averaging N75W. The dips range from 20° NE to 42° NE, averaging 22° NE. Variations in the strike and dip generally occur at the transitions between sandstone and siltstone beds and at minor fracture zones in the siltstones.

Interval.............4787-5221'
Formation...........Unknown
Age.................Pre Triassic
Lithology...........Dolomite

A major lost circulation zone was encountered at 4787 feet. The only sample return was obtained from the interval 4790-4800 feet. This sample consists of a medium gray to black very fine-grained, loosely-consolidated, slightly calcareous shale or siltstone. A powder x-ray diffractometer analysis was run at the University of Utah to determine the bulk composition of the sample. The three major constituents of the sample are quartz, K-mica, and dolomite.

Two cores were cut at 5015 to 5018 feet and at 5018 to 5021 feet. There was eight-inch recovery on the first core. Core #1 is a medium to dark gray fractured and brecciated dolomite. There was no recovery of Core #2.

The drill rates in this interval were very erratic, ranging from 150 feet/hour to 5 feet/hour. Several cavities and fracture zones one-to-two-feet thick were encountered.

The dips obtained from the dipmeter log in this unit are not quite as consistent as those in the Triassic Red Beds, and there were several intervals in which no dips were recorded. The average strike of the dolomite unit is N50W. The average dip is 22° NE. The contact with the Red Beds appears to be a fault or disconformity.

It is difficult to determine the formation and age of this unit because of the slight returns and brecciated nature of the dolomite. If the contact with the Red Beds is a thrust fault or disconformity, then the dolomite could belong to any of the pre-Triassic carbonates such as the Kaibab limestone, Pakoon dolomite, or Callville limestone. Detailed micro-paleo examination of the core might aid in the correlation of this unit.

GEOCHEMISTRY

While drilling with aerated water from 2021 to 5221 feet, formation water entered the borehole and circulated to the surface with the injected water. In order to determine the geochemistry of the system, flowline samples were collected during periods in which there were substantial fluid returns with relatively high temperatures and low pH compared to the injected water.

It was shown by a tracer survey run by GeoTex Corp. that fluid from the interval 4800-5000 feet was flowing upward to 2010 feet at a rate of greater than 500 bbls/hr. It was also found that fluid was flowing downward to 5175 feet at the rate of 10 to 20 bbls/hr. A sample of the fluid flowing up the wellbore was collected by entering the hole with drill pipe that had an inverted float sub on the bottom and a jet sub three stands above the float sub. The drill pipe was lowered to approximately 3000 feet. Fluid entered the drill pipe through the inverted float sub which allows fluid movement in only one direction. As the drill pipe was pulled up, the 90 feet of fluid between the float sub and jet sub was trapped and brought up to the surface.

The chemical analyses of the water samples were done by Ford Chemical Laboratory, Inc. in Salt Lake City. The results of these analyses are included in the appendix. Figures 1 and 2 are graphs of significant chemical constituents plotted against the depth when the samples were collected.

The maximum salinity attained in the flowline discharge was 10,000 ppm at 4170 feet. The marked decrease in salinity at 4800 feet to 1320 ppm is probably due to lower salinity water flowing into the borehole after the dolomitic shale and dolomite breccia were penetrated at 4787 feet.

Tables 1 and 2 contain data based on the silica and Na-K-Ca geothermometer calculations of the flowline discharge and fluid from the 4800-5000 foot interval. The equation used for the silica calculations was: $t°C = (1315/5.205 - \log SiO_2) - 273.15$. The equation used for the Na-K-Ca calculations was: $t°C = (1647/\log(Na/K) + \beta \log(\sqrt{Ca}/Na) + 2.24) - 273.15$.* Silica temperature estimates were calculated for both diluted and undiluted samples for each sample interval.

The most reliable silica temperature estimate, 379°F, is from the diluted sample collected at 4170 feet. This sample reached the laboratory within four days and was collected when the TDS were at a maximum.

The Na-K-Ca reservoir temperature estimates were very high and

*Proceedings of the Second UN Symposium on Development and Use of Geothermal Resources, Vol. I, p. lxxiii (1975).

less believable than the estimates from the silica calculations. The best Na-K-Ca temperature estimate, 495°F, is from the sample collected at 4170 feet. This sample probably has the least contamination and dilution of all the flowline samples because of its high salinity.

The flowline sample collected at 4170 feet probably best represents the geochemistry of the geothermal reservoir because of its high salinity and chemical similarity to water believed to represent the reservoir in the CFSU 42-7 well. The sample from 4170 feet is also the last flowline sample collected before lower salinity fluid entered the borehole around 4800 feet.

The borehole water sample from 4800 feet is more similar in chemistry to meteoric water than to the formation water samples collected at the flowline while drilling. This lower salinity fluid is probably local ground water. According to the free water level in the well measured after the zone at 4800 feet was plugged, the ground water table is approximately 1400 feet below the surface. The permeable dolomites in the interval 4800 to 5000 feet could intersect a part of the water table that had been faulted up to a level above 1400 feet, or the dolomite could be in fault communication with near-surface meteoric water several hundred feet above the deep ground water. The dolomite would act as a conduit through which the water would flow down dip. The Red Beds above the dolomite form an effective aquiclude. When the 4800 to 5000 feet zone was penetrated during drilling, the difference in head would cause the water to flow upward.

DISCUSSION

Figure 3 is a graph of the temperature profiles from surveys taken after reaching the total depth. The temperature profiles show the presence of a thermal conductive zone in the Bullion Canyon volcanics from the surface to approximately 1000 feet. Temperature gradients in this zone range from 6° to 20°F/100 feet. An isothermal zone is present from 1000 feet to about 1600 feet in red siltstone and dolomitic limestones. There is a small temperature increase around 1400 feet, which corresponds to the free water level in the well. A second conductive zone is present from 1600 feet to 2000 feet in brecciated dolomite. Temperature gradients in this zone range from 5° to 26°F/100 feet. A nearly isothermal zone occurs in the dolomite and Red Beds from 2000 feet to 4800 feet. Below 4800 feet, there is a temperature reversal to 5200 feet.

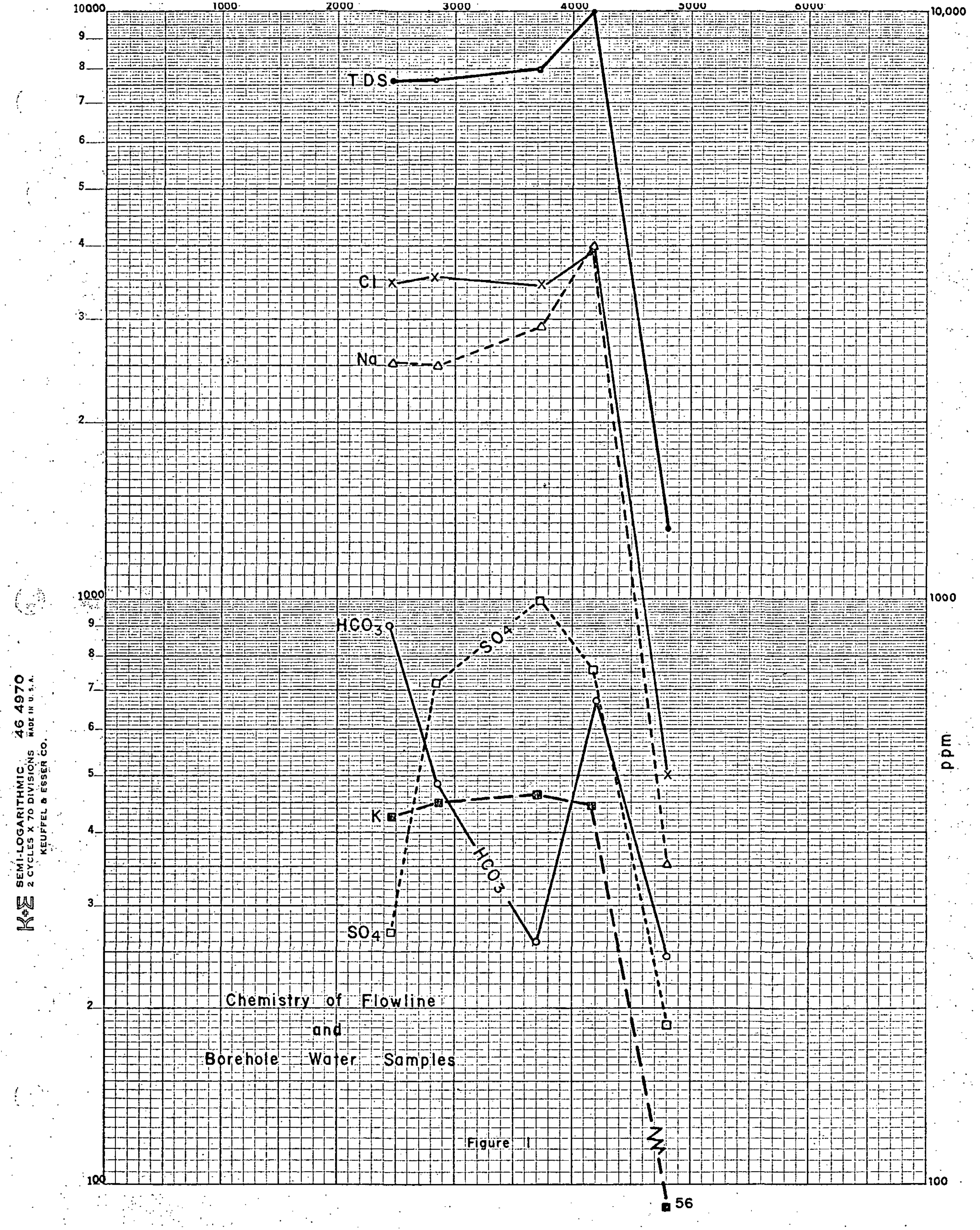
The isothermal zone in the interval 2000 to 4800 feet is probably the result of low salinity fluid from 4800 feet flowing up the wellbore and out into the formation to about 2010 feet. Temperatures recorded by maximum-reading thermometers during deviation surveys range from 210°F at 2000 feet to 294°F at 4700 feet (Table 3). After penetrating the zone at 4800 feet, the temperatures recorded by maximum-reading thermometers were consistently 291-294°F, above 5000 feet. The hole had been static (no circulation of injected water) for two hours when the reading was taken at 4700 feet. After a static time of 18 hours, the reading at 4735 feet was also 293°F. Normally, after 18 hours of static time, a temperature build-up at this depth would be expected. Therefore, the fluid flowing up the wellbore may have had a slight cooling effect on the zone above 4800 feet, or the maximum temperature at 4735 feet could be 293°F.

The temperature reversal from 4800 to 5200 feet could have resulted from several factors. It could be a temporary reversal within the reservoir while drilling through the descending (cold) limb of a convection cell. If that is the case, then a positive gradient would be encountered by drilling deeper. The reversal could also indicate that the well had penetrated the edge of a geothermal system and then drilled out of it into the cooler rock below.

It is difficult to determine the reservoir characteristics of this geothermal system because of the cooling effect of the fluid flowing up the wellbore from 4800 feet and the lack of substantial fluid and rock sample returns while drilling. Samples of warm formation fluid were obtained from 2455 to 4170 feet. However, it is not known whether these fluids exist in isolated fractures or in an interconnecting fracture system forming a liquid-dominated convective reservoir.

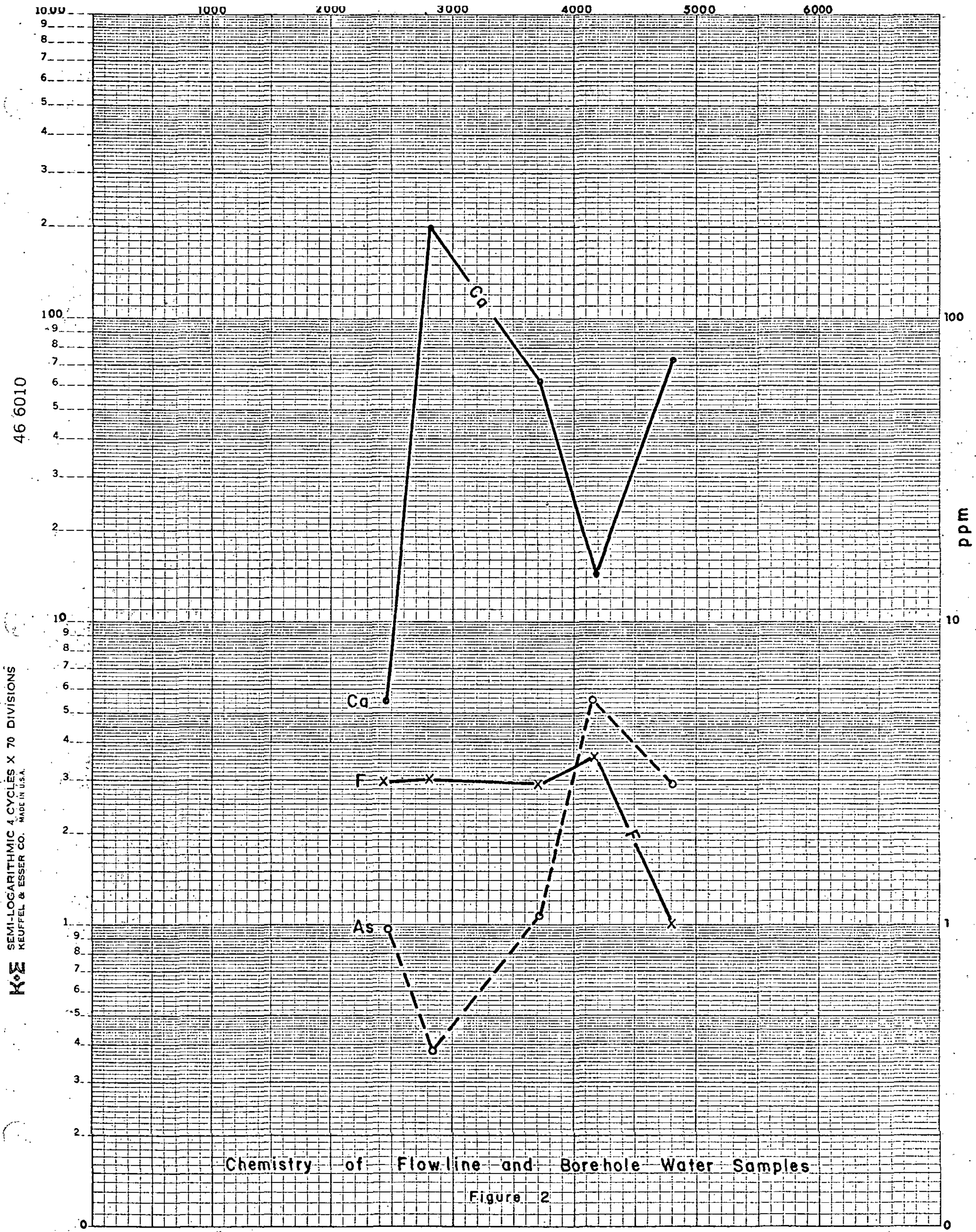
The Bullion Canyon volcanics and Claron formation were not as thick as expected in the CFSU 31-33 well, and as a result, dolomite and dolomitic limestones were encountered above the water table. However, unlike the unconsolidated ("sanded") dolomite that occurred above the water table in the Forminco #1 well, dolomite samples in the 31-33 well showed no signs of sanding. A minor dolomitic siltstone was present above the lost circulation zone at 1233-1270 feet where H_2S was encountered, but it did not resemble the unconsolidated crystalline dolomite from the Forminco #1 well. The samples below that first lost circulation zone in the 31-33 well are hard, crystalline to aphanitic dolomitic limestones and dolomites. These dolomites are above the water table and show no signs of sanding.

APPENDIX



Chemistry of Flowline and Borehole Water Samples

Figure 1



Chemistry of Flowline and Borehole Water Samples

Figure 2

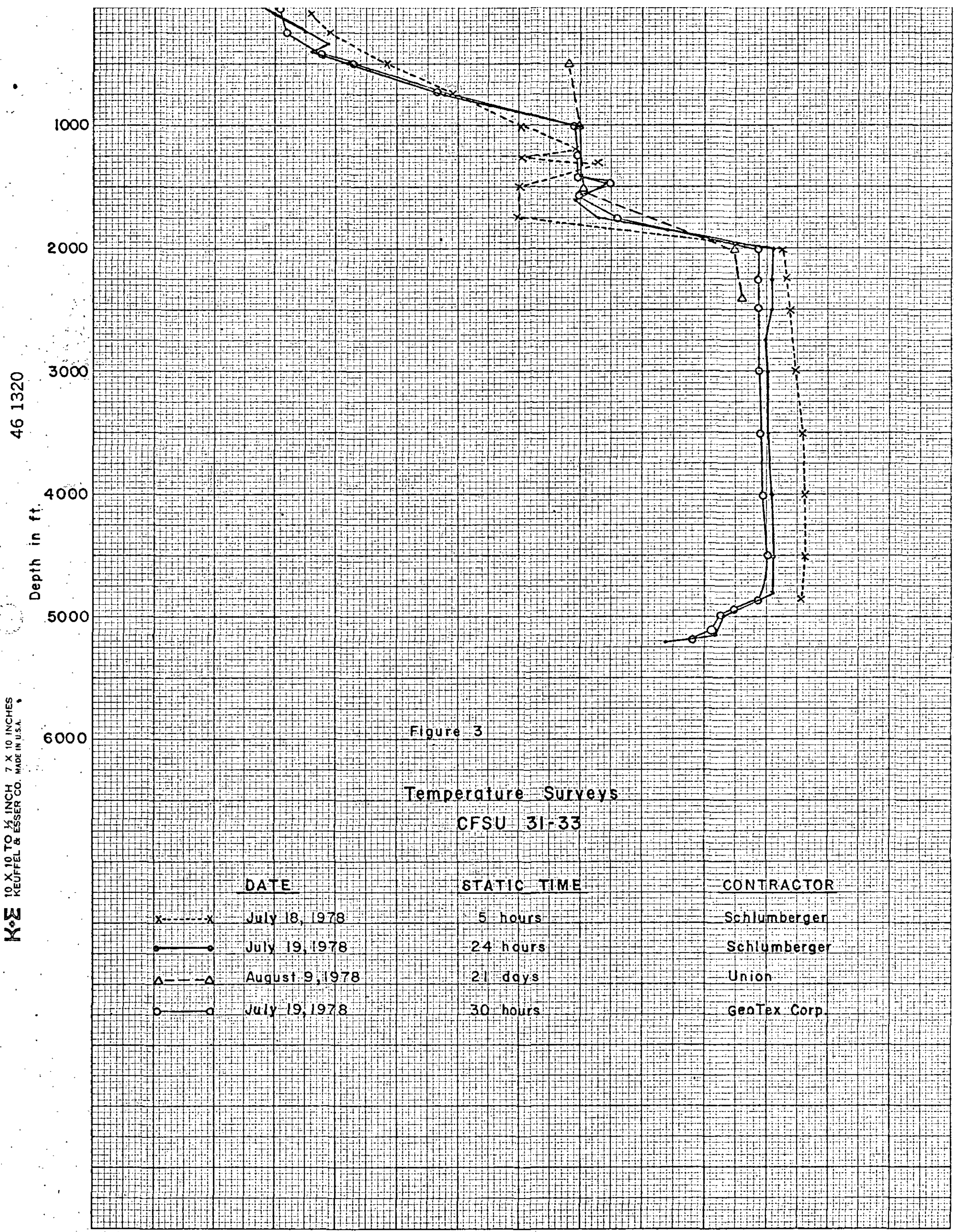


Figure 3
Temperature Surveys
CFSU 31-33
DATE
STATIC TIME
CONTRACTOR
July 18, 1978
5 hours
Schlumberger
July 19, 1978
24 hours
Schlumberger
August 9, 1978
21 days
Union
July 19, 1978
30 hours
GeoTex Corp.
1000
2000
3000
4000
5000
6000
Depth in ft.
46 1320
K+E 10 X 10 TO ½ INCH 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

Estimation of Subsurface Temperatures from the Silica Content of Water from the Flowline Discharge and Borehole Water Samples, CFSU 31-33 Millard Co., Utah

TABLE 1

Depth, ft	Temperature of Flowline, °F	pH	TDS	SiO_2 of diluting water	SiO_2 of diluted sample	Volumetric Ratio of Dilution: Fresh wtr/sample	Calculated SiO_2 of sample	SiO_2 of undiluted sample	Estimated temperature from SiO_2, °F (diluted sample)	Estimated temperature from SiO_2, °F (undiluted sample)
2455	138	8.77	7600	5.0	15.0	9:1	105	77.5	284	254
2825	79	7.38	7655	5.4	22.0	9:1	171.4	25.5	337	163
3720	155	7.94	8000	5.4	26.0	9:1	211.4	64	362	237
4170	102	9.79	10,000	5.4	29.0	9:1	241.4	79	379	256
4800	?	7.44	1320	22.5	34.5	9:1	142.5	64.5	316	237

Estimation of Subsurface Temperatures from the Empirical Na-K-Ca Geothermometer for Flowline Discharges and Borehole Water Samples, CFSU 31-33 Millard Co., Utah

TABLE 2

Depth, ft	Temperature of Flowline °F	TDS	Na	K	Ca	Estimated Temperature from Na-K-Ca β = 1/3 °F
2455	138	7600	2530	423	5.6	554
2825	79	7655	2475	452	200	482
3720	155	8000	2916	465	62.4	497
4170	102	10,000	4000	443	14.4	495
4800	?	1320	355	56.2	74.4	407

COVE FORT - SULPHURDALE #31-33
MAXIMUM READING THERMOMETER TEMPERATURE SURVEYS

TABLE 3

DATE	TIME SINCE CIRCULATION STOPPED	THERMOMETER READING	DEPTH
05-28-78	<30 min.	103°F	262'
06-02-78	<30 min.	108°F	445'
06-03-78	<30 min.	118°F	608'
06-04-78	<30 min.	120°F	733'
06-05-78	<30 min.	139°F	899'
06-05-78	<30 min.	138°F	987'
06-06-78	<30 min.	150°F	1080'
06-15-78	15 min.	122°F	1332'
06-16-78	15 min.	118°F	1400'
06-27-78	15 min.	133°F	1945'
06-28-78	12 hours	210°F	2000'
06-30-78	15 min.	138°F	2354'
07-04-78	1.3 hours	234°F	3250'
07-05-78	1.2 hours	260°F	3625'
07-08-78	2.2 hours	285-290°F	4090'
07-08-78	14.5 hours	283°F	4440'
07-10-78	5 hours	292-294°F	4675'
07-10-78	2 hours	292-294°F	4700'
07-10-78	10.5 hours	291-292°F	4727'
07-10-78	18 hours	293°F	4735'
07-17-78	19.5 hours	244-249°F	5035'

GEOCHEMICAL DATA

WELL: Union Oil Company of California
Cove Fort-Sulphurdale Unit #31-33
Millard County, Utah

Sample Information

Source.................................. Flowline
Collection Date and Time................ 6-30-78, 1200 Hrs.
Depth of Well at Time of Collection.... 2455
Temperature of Sample................... 138°F
Date Analysis Begun..................... Received by lab 7-11-78

Turbidity	150.0	NTU	Lithium as Li	12.05	mg/l
Conductivity	11,700	umhos/cm	Total Hardness as $CaCO_3$	24.0	mg/l
pH	8.77	Units	Iron as Fe (Total)	3,200	mg/l
TDS at 180°C	7,600	mg/l	Iron as Fe (Filtered)	0.347	mg/l
Alkalinity as $CaCO_3$	836.0	mg/l	Lead as Pb	0.345	mg/l
Arsenic as As	0.970	mg/l	Magnesium as Mg	2.40	mg/l
Bicarbonate as HCO_3	888.16	mg/l	Manganese as Mn	0.249	mg/l
Barium as Ba	0.07	mg/l	Mercury as Hg	<0.0002	mg/l
Boron as B	0.15	mg/l	Nickel as Ni	0.685	mg/l
Cadmium as Cd	0.004	mg/l	Nitrate as NO_3-N	0.04	mg/l
Calcium as Ca	5.60	mg/l	Nitrite as NO_2-N	<0.01	mg/l
Carbonate as CO_3	64.8	mg/l	Potassium as K	423.0	mg/l
Chloride as Cl	3,440	mg/l	Selenium as Se	<0.001	mg/l
Chromium as Cr (Total)	<0.001	mg/l	Silica as SiO_2	77.50	mg/l
Chromium as Cr (Hex)	<0.001	mg/l	Silver as Ag	0.026	mg/l
Copper as Cu	0.065	mg/l	Sulfate as SO_4	272.0	mg/l
Surfactants MBAS	<0.05	mg/l	Sodium as Na	2,530	mg/l
Fluoride as F	3.10	mg/l	Zinc as Zn	0.084	mg/l

GEOCHEMICAL DATA

WELL: Union Oil Company of California
Cove Fort-Sulphurdale Unit #31-33
Millard County, Utah

Sample Information

Source.................................... Flowline
Collection Date and Time............... 7-1-78, 1100 Hrs.
Depth of Well at Time of Collection.... 2825
Temperature of Sample.................. 79°F
Date Analysis Begun.................... Received by lab 7-11-78

Turbidity	260.0	NTU	Lithium as Li	12.46	mg/l
Conductivity	11,780	umhos/cm	Total Hardness as $CaCO_3$	560.0	mg/l
pH	7.38	Units	Iron as Fe (Total)	8.786	mg/l
TDS at 180°C	7,655	mg/l	Iron as Fe (Filtered)	1.920	mg/l
Alkalinity as $CaCO_3$	394.0	mg/l	Lead as Pb	0.350	mg/l
Arsenic as As	0.379	mg/l	Magnesium as Mg	14.40	mg/l
Bicarbonate as HCO_3	480.68	mg/l	Manganese as Mn	2.084	mg/l
Barium as Ba	0.29	mg/l	Mercury as Hg	<0.0002	mg/l
Boron as B	0.30	mg/l	Nickel as Ni	0.680	mg/l
Cadmium as Cd	0.006	mg/l	Nitrate as NO_3-N	0.03	mg/l
Calcium as Ca	200.0	mg/l	Nitrite as NO_2-N	<0.01	mg/l
Carbonate as CO_3	<0.01	mg/l	Potassium as K	452.0	mg/l
Chloride as Cl	3,550	mg/l	Selenium as Se	<0.001	mg/l
Chromium as Cr (Total)	<0.001	mg/l	Silica as SiO_2	25.50	mg/l
Chromium as Cr (Hex)	<0.001	mg/l	Silver as Ag	0.032	mg/l
Copper as Cu	0.049	mg/l	Sulfate as SO_4	720.0	mg/l
Surfactants MBAS	<0.05	mg/l	Sodium as Na	2,475	mg/l
Fluoride as F	3.20	mg/l	Zinc as Zn	0.231	mg/l

GEOCHEMICAL DATA

WELL: Union Oil Company of California
Cove Fort-Sulphurdale Unit #31-33
Millard County, Utah

Sample Information

Source.................................. Flowline
Collection Date and Time................ 7-5-78, 1200 Hrs.
Depth of Well at Time of Collection..... 3720
Temperature of Sample................... 155°F
Date Analysis Begun..................... Received by lab 7-11-78

Turbidity	200.0	NTU	Lithium as Li	11.62	mg/l
Conductivity	12,300	umhos/cm	Total Hardness as $CaCO_3$	188.0	mg/l
pH	7.94	Units	Iron as Fe (Total)	11.100	mg/l
TDS at 180°C	8,000	mg/l	Iron as Fe (Filtered)	8.660	mg/l
Alkalinity as $CaCO_3$	210.0	mg/l	Lead as Pb	0.345	mg/l
Arsenic as As	1.131	mg/l	Magnesium as Mg	7.68	mg/l
Bicarbonate as HCO_3	256.2	mg/l	Manganese as Mn	0.328	mg/l
Barium as Ba	0.16	mg/l	Mercury as Hg	<0.0002	mg/l
Boron as B	0.25	mg/l	Nickel as Ni	0.688	mg/l
Cadmium as Cd	0.007	mg/l	Nitrate as NO_3-N	0.02	mg/l
Calcium as Ca	62.4	mg/l	Nitrite as NO_2-N	<0.01	mg/l
Carbonate as CO_3	<0.01	mg/l	Potassium as K	465.0	mg/l
Chloride as Cl	3,410	mg/l	Selenium as Se	<0.001	mg/l
Chromium as Cr (Total)	0.048	mg/l	Silica as SiO_2	64.0	mg/l
Chromium as Cr (Hex)	<0.001	mg/l	Silver as Ag	0.030	mg/l
Copper as Cu	0.077	mg/l	Sulfate as SO_4	1,000	mg/l
Surfactants MBAS	<0.05	mg/l	Sodium as Na	2,916	mg/l
Fluoride as F	2.90	mg/l	Zinc as Zn	0.051	mg/l

GEOCHEMICAL DATA

WELL: Union Oil Company of California
Cove Fort-Sulphurdale Unit #31-33
Millard County, Utah

Sample Information

Source.................................Flowline
Collection Date and Time...............7-7-78, 0600 Hrs.
Depth of Well at Time of Collection....4170
Temperature of Sample..................102°F
Date Analysis Begun....................Received by lab 7-11-78

Turbidity	390.0	NTU	Lithium as Li	13.31	mg/l
Conductivity	15,380	umhos/cm	Total Hardness as $CaCO_3$	20.0	mg/l
pH	9.79	Units	Iron as Fe (Total)	10.600	mg/l
TDS at 180°C	10,000	mg/l	Iron as Fe (Filtered)	0.108	mg/l
Alkalinity as $CaCO_3$	1,440	mg/l	Lead as Pb	0.420	mg/l
Arsenic as As	5.707	mg/l	Magnesium as Mg	3.36	mg/l
Bicarbonate as HCO_3	658.8	mg/l	Manganese as Mn	0.016	mg/l
Barium as Ba	0.47	mg/l	Mercury as Hg	0.0007	mg/l
Boron as B	0.50	mg/l	Nickel as Ni	0.975	mg/l
Cadmium as Cd	0.045	mg/l	Nitrate as NO_3-N	<0.01	mg/l
Calcium as Ca	14.40	mg/l	Nitrite as NO_2-N	<0.01	mg/l
Carbonate as CO_3	540.0	mg/l	Potassium as K	443.0	mg/l
Chloride as Cl	3,900	mg/l	Selenium as Se	0.007	mg/l
Chromium as Cr (Total)	0.006	mg/l	Silica as SiO_2	79.0	mg/l
Chromium as Cr (Hex)	<0.001	mg/l	Silver as Ag	0.037	mg/l
Copper as Cu	0.166	mg/l	Sulfate as SO_4	760.0	mg/l
Surfactants MBAS	<0.05	mg/l	Sodium as Na	4,000	mg/l
Fluoride as F	3.60	mg/l	Zinc as Zn	0.041	mg/l

GEOCHEMICAL DATA

WELL: Union Oil Company of California
Cove Fort-Sulphurdale Unit #31-33
Millard County, Utah

Sample Information

Source.............................. Extract through inverted float sub into drill pipe
Collection Date and Time............ 7-20-78
Depth of Well at Time of Collection.. 5221
Temperature of Sample............... -
Date Analysis Begun................. 7-26-78

Turbidity	80.0	NTU	Lithium as Li	1.164	mg/l
Conductivity	2,035	umhos/cm	Total Hardness as $CaCO_3$	266.0	mg/l
pH	7.44	Units	Iron as Fe (Total)	2.154	mg/l
TDS at 180°C	1,320	mg/l	Iron as Fe (Filtered)	1.976	mg/l
Alkalinity as $CaCO_3$	200.0	mg/l	Lead as Pb	0.006	mg/l
Arsenic as As	2.991	mg/l	Magnesium as Mg	19.20	mg/l
Bicarbonate as HCO_3	244.0	mg/l	Manganese as Mn	0.043	mg/l
Barium as Ba	0.15	mg/l	Mercury as Hg	<0.0002	mg/l
Boron as B	0.20	mg/l	Nickel as Ni	<0.001	mg/l
Cadmium as Cd	0.040	mg/l	Nitrate as NO_3-N	0.45	mg/l
Calcium as Ca	74.40	mg/l	Nitrite as NO_2-N	<0.01	mg/l
Carbonate as CO_3	<0.01	mg/l	Potassium as K	56.20	mg/l
Chloride as Cl	502.0	mg/l	Selenium as Se	<0.001	mg/l
Chromium as Cr (Total)	<0.001	mg/l	Silica as SiO_2	64.5	mg/l
Chromium as Cr (Hex)	<0.001	mg/l	Silver as Ag	<0.001	mg/l
Copper as Cu	0.914	mg/l	Sulfate as SO_4	187.0	mg/l
Surfactants MBAS	<0.05	mg/l	Sodium as Na	355.0	mg/l
Fluoride as F	1.03	mg/l	Zinc as Zn	0.104	mg/l

Well History

Union Oil Company of California

UNION 76

TYPE WELL	
(Geothermal)	Hot Water

COMPANY	SEC	T	R	M
Union Oil Company of California	33	25S	6W	SLM

LEASE	WELL NO.	COUNTY
Cove Fort Sulphurdale Unit	31-33	Millard

LOCATION	AREA
N89°28'W 1092.23 and South 479.21' from the South ¼ corner of Section 28, T25S, R6W, SLM	Cove Fort - Sulphurdale

ELEVATION	SPUD	COMP.	ABAND.	TOTAL DEPTH	PLUG	RECOMP.
6480' GR	5/24/78	7/27/78	--	5221'	2600'	--

HOLE DEVIATION: 660' maximum possible

B.H.L.:

CASING RECORD

SIZE	CEM. LDD.	DEPTH	ft^3 cmt	W.S.O. - PERFS. - REMARKS
30"		52' K.B.	100	
20"		280' K.B.	767	
13-3/8"		1733' K.B.	2827	
2-7/8"		2579' K.B.	--	Hanging Tubing

WELL DATA

ELEC. LOG	1735' - 5207'
DIPMETER	1735' - 5207'
CORE RECORD	
HISTORY	
CORE ANALYSIS	
PALEO. LETTER	

MARKERS - HORIZONS

DATE	DEPTH	PROGRESS HISTORY
5-24-78 [54']		Moved in and rigged up Loffland Bros. Co. rig No. 5. Placed rig on day rate at 1200 hours, 5-24-78. Mixed mud. Drilled rat hole and mouse hole. Spudded 26" hole with a 26" pilot hole opener at 2000 hours. Center punched hole from 52' to 54'. Laid down hole opener. Ran 17-1/2" bit.
5-25-78 [123']		Drilled 17-1/2" hole from 54' to 79'. Repaired mud pump. Drilled 17-1/2" hole from 79' to 86'. Continued pump repairs. Unable to keep hole clean with one pump. Drilled 17-1/2" hole to 123'. Placed rig on repair rate. Repaired both mud pumps.
5-26-78 [144']		Continued mud pump repairs. Ran 17-1/2" bit at 2000 hours, following pump repairs. Cleaned out fill in hole from 103' to 123'. Drilled 17-1/2" hole from 123' to 144'.
5-27-78 [282']		Drilled 17-1/2" hole from 144' to 282'.
5-28-78 [301']		Drilled 17-1/2" hole from 282' to 301'. Opened 17-1/2" hole to 26" hole from 52' to 77'. Repaired mud pump. Opened 17-1/2" hole to 26" hole from 77' to 167'. Repaired and re-dressed 26" hole opener with new cutters.

5-29-78 [301'] — Opened 17-1/2" hole to 26" hole from 167' to 289'. Circulated hole until clean. Measured drill pipe and tools out of hole. Made 5' correction. Repaired no. 1 pump. Opened 17-1/2" hole to 26" hole from 289' to 295'. Laid down 26" hole opener.

5-30-78 [301'] — Rigged up and ran 7 joints, 20", 94 lb. per foot, H-40, buttress casing, total 294'. Casing stopped at 281'. Hung 20" casing with Halliburton Duplex Float shoe at 281'. Ran 9 joints, 4-1/2" drill pipe with Halliburton Duplex mandrel, stabbed into Duplex Float shoe. Circulated through float shoe to surface and conditioned mud. Halliburton mixed and pumped 767 ft^3 class "B" cement through drill pipe and shoe with 2% $CaCl_2$. Displaced cement slurry with 12 ft^3 mud. Had good cement returns to surface during cementing operation. Pulled drill pipe out of float shoe. Cement in place at 1330 hours. Waited on cement. Placed rig on repair time from 1600 hours to 2200 hours. Cut off 30" casing at 2200 hours.

5-31-78 [301'] — Cut off 30" casing, and 20" casing. Welded on 20" - 2000 psi rated flange. Installed 20" Double Shaffer blow-out preventor and 20" Hydril "GK" blow-out preventor.

6-01-78 [315'] — Completed installation of blow-out preventor actuating lines. Installed choke manifold. Tested blind rams to 500 psi with water for thirty minutes. Tested Hydril "GK" with water to 500 psi for thirty minutes. Tested kelley cock to 800 psi. All tests were witnessed and approved by John Reeves, U.S.G.S. representative. Ran 17-1/2" bit and drilling assembly. Drilled cement from 272' to casing shoe at 280' and cement to 282'. Cleaned out fill from 282' to 301'. Drilled 17-1/2" hole from 301' to 315'. Plugged bit. Pulled out of hole. Removed junk from drill collar float.

6-02-78 [507'] — Repaired no. 1 pump. Ran 17-1/2" bit and drilling assembly with two added stabilizers. Drilled 17-1/2" hole from 315' to 507'.

6-03-78 [711'] — Drilled 17-1/2" hole from 507' to 674'. Repositioned shock sub in drilling assembly for better stabilization. Drilled 17-1/2" hole from 674' to 711'. Shock sub failed, parted in spline. Pulled out of hole. Top of fish or drilling assembly at 662'. Left 17-1/2" bit, 17-1/2" stabilizer, bit sub, 8" drill collar, and broken shock sub in hole.

6-04-78 [844']	Ran 11-3/4" overshot with extension. Located and engaged fish. Recovered fish. Made up drilling assembly. Drilled 17-1/2" hole from 711' to 844'.
6-05-78 [1040']	Drilled 17-1/2" hole from 844' to 1040'.
6-06-78 [1241']	Drilled 17-1/2" hole from 1040' to 1236'. Lost circulation while drilling at 1236'. Drilled without returns from 1236' to 1241'. H_2S alarms sounded, indicating 10 PPM H_2S. Pulled out of hole.
6-07-78 [1241']	Ran open-end drill pipe to 1230'. Displaced lost circulation plug no. 1 through drill pipe as follows: 375 ft^3, class "B" cement with perlite in a 1:1 ratio, with 40% silica flour, 3% gel and 0.5% CFR-2. Cement in place at 1605 hours. Pulled out of hole. Waited on cement 5 hours. Ran drill pipe to 1241', no fill located. Pulled drill pipe to 1230'. Displaced lost circulation plug no. 2 through drill pipe as follows: 350 ft^3, class "B" cement with perlite in a 1:1 ratio, 40% silica flour, 3% gel and 0.5% CFR-2. Cement in place at 2050 hours. Pulled out of hole. Waited on cement. Gas flow stopped for twenty minutes and slowly returned at a low flow rate.
6-08-78 [1241']	Ran drill pipe to 1241', no fill located. Pulled drill pipe to 1230'. Displaced lost circulation plug no. 3 through drill pipe as follows: pumped 20 bbls thick gel mud mixed with lost circulation material ahead of 240 ft^3 class "B" cement with perlite in a 1:1 ratio with 40% silica flour, 3% gel and 0.5% CFR-2. Cement in place at 1010 hours. Pulled drill pipe to 280'. No H_2S emission from hole, but small amount of methane gas emission. Waited on cement 5 hours. Ran drill pipe to 1230', no fill located. Displaced lost circulation plug no. 4 as follows: 125 ft^3 class "B" cement with perlite in a 1:1 ratio with 40% silica flour, 3% gel, 0.5% CFR-2 with 15% lost circulation material. Cement in place at 1510 hours. Waited on cement 5 hours. Ran drill pipe to 1230', no fill located. Displaced lost circulation plug no. 5 through drill pipe at 1230' as follows: 225 ft^3 class "B" cement with perlite in a 1:1 ratio, 40% silica flour, 3% gel, 0.5% CFR-2 and 15% lost circulation material. Cement in place at 2145 hours. Waited on cement.
6-09-78 [1241']	Waited on cement 3 hours. Ran drill pipe to 1230', no fill located. Mixed 100 bbls thick gel mud with

6-09-78 Continued-----

25% lost circulation material, and displaced lost circulation plug no. 6 behind mud and LCM as follows: 305 ft^3 class "B" cement with perlite in a 2:1 ratio with 40% silica flour and 3% gel. Cement in place at 1400 hours. Pulled out of hole. Waited on cement 5 hours. Ran drill pipe to 1230', no fill located. Displaced lost circulation plug no. 7 through drill pipe at 1230' as follows: 305 ft^3 class "B" cement with perlite in a 2:1 ratio with 40% silica flour and 3% gel. Cement in place at 1915 hours. Pulled out of hole with drill pipe. Waited on cement.

6-10-78 [1252'] Ran drill pipe to 1230', no fill located. Pulled out of hole. Ran 17-1/2" drilling assembly to 1236', circulated with returns and cleaned out rocks and formation fill from 1236' to 1241'. Lost returns and drilled 17-1/2" hole from 1241' to 1252'. Lost 500 bbls drilling mud while drilling from 1241' to 1252' at a 20 to 30 ft per hour rate. No evidence of torque, indicating fractures or running dolomite in the 11' of newly drilled hole. Pulled drilling assembly. Ran drill pipe to 1230'. Displaced lost circulation plug no. 8 as follows: 230 ft^3 class "B" cement with perlite in a 1:1 ratio with 40% silica flour, 3% gel and 15% lost circulation material. Cement in place at 0830 hours. Waited on cement 5 hours. No fill located. Displaced lost circulation plug no. 9 through drill pipe at 1230' as follows: 230 ft^3 class "B" cement with perlite in a 1:1 ratio with 40% silica flour, 3% gel and 20 to 30% lost circulation material. Cement in place at 1345 hours. Waited on cement 4 hours. No fill from plug. Displaced lost circulation plug no. 10 through drill pipe at 1230' as follows: 210 ft^3 class "B" cement with perlite in a 1:1 ratio with 40% silica flour, 3% gel, 20% lost circulation material and 20% $CaCl_2$. Cement in place at 1915 hours. Waited on cement 4 hours. No fill from plug. Displaced plug no. 11 through drill pipe at 1230' as follows: 210 ft^3 class "B" cement with perlite in a 1:1 ratio, with 40% silica flour, 3% gel, 2% $CaCl_2$ and 20% lost circulation material. Cement in place at 2400 hours.

6-11-78 [1257'] Waited on cement 4 hours. Ran drill pipe to 1230'. No fill located. Displaced lost circulation plug no. 12 through drill pipe as follows: 210 ft^3 class "B" cement

6-11-78 Continued-----

with perlite in a 1:1 ratio with 40% silica flour, 3% gel, 2% $CaCl_2$ and 20% lost circulation material. Cement in place at 0530 hours. Pulled out of hole. Ran home-made lumber (2" x 4") float on wire line to locate fluid level in hole, indicated at 600'+. Waited on cement 5 hours. Ran drill pipe to 1241', no fill located. Displaced lost circulation plug no. 13 through drill pipe as follows: 166 ft^3 HOWCO, Thix-Set cement, with 25 lbs Gelsonite per sack of cement and .5 lbs Flo-Cele per sack of cement, .5 lbs nut plug per sack of cement and 2% $CaCl_2$. Cement in place at 1130 hours. Pulled out of hole. Waited on cement 4 hours. Ran drill pipe and located top of cement at 1160'. Filled hole with 175 bbls mud. Ran 17-1/2" drilling assembly. Drilled cement from 1160' to 1236'. Lost circulation. Drilled with no mud returns to surface from 1236' to 1257'.

6-12-78 [1257'] Pulled out of hole. Ran drill pipe to 1230'. Displaced lost circulation plug no. 14 through drill pipe as follows: 166 ft^3 class "B" cement with 2% $CaCl_2$, 25 lbs Gilsonite per sack of cement, .5 lbs Flo-Cele per sack of cement and .5 lbs nut plug per sack of cement. Cement in place at 0115 hours. Pulled out of hole. Waited on cement 4 hours. Ran drill pipe and located top of cement at 1236'. Pulled drill pipe to 1230'. Displaced lost circulation plug no. 15 through drill pipe as follows: 210 ft^3 class "B" cement with perlite in a 1:1 ratio with 40% silica flour, 3% gel and 0.5% CFR-2. Cement in place at 0715 hours. Waited on cement 5 hours. Ran drill pipe to 1236'. No fill up was gained from plug no. 15. Ran drill pipe to 1230'. Displaced lost circulation plug no. 16 through drill pipe as follows: 86 ft^3 class "B" cement with perlite in a 1:1 ratio, 40% silica flour, 3% gel and 3% $CaCl_2$. Cement in place at 1400 hours. Waited on cement. No fill up from plug no. 16. Displaced lost circulation plug no. 17 through drill pipe at 1230' as follows: 200 ft^3 class "B" cement with perlite in a 1:1 ratio, 40% silica flour, 3% gel and 3% $CaCl_2$. Cement in place at 2000 hours. Waited on cement. Pulled out of hole.

6-13-78 [1257'] Ran drill pipe to top of cement at 1221'. Filled hole with mud. Ran 17-1/2" drilling assembly. Drilled firm

6-13-78 Continued-----

cement from 1221' to 1247'. Lost mud returns at 1247'. Pulled out of hole. Ran drill pipe to 1230'. Displaced lost circulation Pal Mix plug no. 1 through drill pipe as follows: 90 ft^3 Pal Mix 110-R, displaced with 100 ft^3 H_2O. Waited 1 hours. No success in filling hole. Displaced additional Pal Mix plug no. 2 as follows: 90 ft^3 Pal Mix 110-R, through drill pipe at 1230', displaced with 100 ft^3 H_2O. Waited 1 hour. No success in filling hole. Displaced no. 3 Pal Mix plug as follows: 90 ft^3 Pal Mix 110-R, displaced with 100 ft^3 H_2O. Waited 1 hour. No success in attempting to fill hole. Displaced lost circulation plug no. 18 through drill pipe at 1230' as follows: 125 cubic feet Gel-Gilsonite 1:1 ratio high viscosity mixture, followed by 235 ft^3 class "B" cement, sand and perlite, mixed in equal amounts. Displaced with 67 ft^3 H_2O. Cement in place at 2000 hours. Waited on cement. Pulled drill pipe.

6-14-78 [1276'] Ran drill pipe and located top of cement at 1183'. Filled hole with water. Mixed mud. Pulled drill pipe. Ran 17-1/2" drilling assembly. Drilled firm cement from 1183' to 1257'. Drilled 17-1/2" hole from 1257' to 1276'. Lost returns to surface at 1274'. Pulled out of hole. Ran drill pipe to 1260'. Displaced lost circulation plug no. 19 through drill pipe as follows: 112 ft^3 H_2O with 700 lbs Pal Mix 110-R (Pal Mix plug no. 4). Waited 1 hour. Pumped 115 ft^3 class "B" cement with sand and perlite in equal amounts. Displaced with 67 ft^3 H_2O. Cement in place at 1700 hours. Pulled out of hole. Waited on cement 4 hours. Ran drill pipe. Located top of cement at 1230'. Filled hole with mud and mixed mud. Pulled out of hole.

6-15-78 [1400'] Ran 17-1/2" drilling assembly. Drilled firm cement from 1230' to 1261'. Drilled 17-1/2" hole from 1276' to 1400', with no fluid loss.

6-16-78 [1529'] Drilled 17-1/2" hole from 1400' to 1529'. Lost 60 bbls drilling mud at 1513'.

6-17-78 [1564'] Drilled 17-1/2" hole from 1529' to 1564'. Lost 250 bbls mud while drilling from 1530' to 1564'. Lost circulation completely at 1564'. Stuck drill pipe and tools. Worked pipe and tools until free. Required 4 hours. P.O.H. Ran drill pipe to 1535'. Displaced lost circulation plug #20 thru drill pipe as follows: 95 ft^3 Pal Mix 110-R

6-17-78 Continued-----

(Pal Mix plug no. 5) displaced with 120 ft^3 H_2O. Waited 30 minutes. Displaced 115 ft^3 class "B" cement with perlite and sand in equal amounts. Displaced with 92 ft^3 H_2O. Cement in place at 1945 hours. Pulled out of hole. Waited on cement.

6-18-78 [1623'] Ran drill pipe. Located top of cement at 1487'. Pulled out of hole. Ran 17-1/2" drilling assembly. Drilled cement with full returns from 1487' to 1500', lost returns. Regained returns after pumping 500 bbls H_2O into hole. Ran tools to 1564' with no restrictions. Drilled 17-1/2" hole from 1564' to 1623'. Lost 100 bbls mud while drilling from 1564' to 1623'.

6-19-78 [1730'] Drilled 17-1/2" hole from 1623' to 1730'. Lost 60 bbls mud from 1646' to 1656', 200 bbls mud from 1683' to 1691' and 50 bbls mud from 1696' to 1720'.

6-20-78 [1735'] Drilled 17-1/2" hole from 1730' to 1735'. Circulated and conditioned hole for casing. Lost complete returns. Pulled out of hole. Mixed mud. Ran drill pipe and found 2' fill at 1733'. Unable to fill hole with mud. Hung drill pipe at 1649'. Displaced lost circulation plug no. 21 through drill pipe as follows: 100 ft^3 Pal Mix 110-R (Pal Mix plug no. 6), displaced with 140 ft^3 H_2O, followed by 104 ft^3 class "B" cement with 2% $CaCl_2$, 25 lbs gilsonite per sack of cement, .5 lbs Flo-Cele per sack of cement and .5 lbs nut plug per sack of cement. Displaced with 112 ft^3 H_2O. Cement in place at 1415 hours. Pulled drill pipe to 1229'. Waited one hour. Displaced lost circulation no. 22, 104 ft^3 class "B" cement with 2% $CaCl_2$, 25 lbs gilsonite, .5 lbs Flo-Cele per sack of cement and .5 lbs nut plug per sack of cement. Cement in place at 1630 hours. Waited on cement to 2000 hours. Ran drill pipe to 1732'. No fill located. Displaced lost circulation plug no. 23 through drill pipe as follows: 112 ft^3 Pal Mix 110-R (Pal Mix plug no. 7), displaced with 134 ft^3 H_2O.

6-21-78 [1735'] Waited 1 hour. Displaced remainder of lost circulation plug no. 23 through drill pipe at 1610' as follows: 104 ft^3 class "B" cement with perlite in a 1:1 ratio with 40% silica flour, 3% gel and 0.5% CFR-2. Displaced slurry with 112 ft^3 H_2O. Cement in place at 0100 hours. Waited on cement. Pulled out of hole.

6-21-78 Continued-----

Ran drill pipe to top of cement at 1638'. Filled hole with 230 bbls mud. Fluid level dropped out of sight after 10 minutes. Displaced lost circulation plug no. 24 through drill pipe at 1550' as follows: 104 ft^3 Pal Mix 110-R displaced with 128 ft^3 H_2O (Pal Mix plug no. 8), followed after 1 hour by 101 ft^3 class "B" cement, with perlite in a 1:1 ratio with 40% silica flour, 3% gel and 0.5% CFR-2. Displaced slurry with 112 ft^3 H_2O. Cement in place at 1030 hours. Waited on cement 4 hours. Ran drill pipe to 1638'. No fill located. Displaced lost circulation plug no. 25 through drill pipe at 1580' as follows: 145 ft^3 class "B" cement, with perlite in a 1:1 ratio, with 40% silica flour, 3% gel and 2% $CaCl_2$. Displaced with 112 ft^3 H_2O. Had mud returns to surface while pumping last 20 ft^3 of displacement H_2O.

6-22-78 [1735'] Pulled drill pipe. Ran 17-1/2" drilling assembly. Cleaned out (suspected cement stringers) from 1197' to 1515'. Drilled firm cement from 1515' to 1580'. Passed through void from 1580' to 1638'. Cleaned out soft cement from 1638' to 1675'. Passed through void from 1675' to 1735'. No fluid loss experienced. Circulated and conditioned mud and hole. Pulled drilling assembly. Ran 45 joints 13-3/8" 54.5 lb/ft, K-55, buttress casing, total length less threads, 1734'. Landed casing with Halliburton 13-3/8" float shoe at 1733', B&W insert float at 1697' and Halliburton "DV" collar at 1115'. Mixed and pumped 100 ft^3 H_2O, followed by 100 ft^3 H_2O mixed with 70 lbs FR-20 flushing agent and silica flour, followed by 53 ft^3 H_2O mixed with 30 ft^3 sodium silicate, followed by 200 ft^3 H_2O through casing shoe at 1733'. Followed pre-flush with cement slurry as follows: 795 ft^3 class "B" cement with perlite in a 1:1 ratio, 3% gel, 40% silica flour and 0.5% CFR-2, followed by 326 ft^3 class "B" cement with 40% silica flour and 0.5% CFR-2. Displaced slurries with 1520 ft^3 mud. Did not bump top cement plug on insert float. Cement in place, first stage cement job at 2230 hours. Dropped "DV" cementer opening bomb. Opened "DV" at 1115' at 2240 hours. Circulated mud through "DV", received 392 ft^3 cement slurry to surface from above "DV".

6-23-78 [1735'] — Circulated mud through "DV" with no fluid loss for four hours. Performed second stage cement job as follows: mixed and pumped through "DV" cementer at 1115', 168 ft^3 H_2O, followed by 1611 ft^3 class "B" cement, with Perlite in a 1:1 ratio, with 40% Silica Flour, 3% Gel and 0.5% CFR-2, followed with "DV" closing and wiper plug, and then 174 bbls mud. Closed "DV" cementer with 1000 psi. Released pressure. No indication of bleed back from "DV". C.I.P. at 0445 hours. Had complete and full returns to surface during stage #1 and partial returns to surface during stage #2. 50 ft^3 cement slurry estimated to surface during second stage. W.O.C. 4 hours. Removed B.O.P.'s. Cut off 20" casing and 13-3/8" casing. Located top of second stage cement at 180' in annulus between 13-3/8" and 20" casing. Filled annulus to surface with 95 ft^3 class "B" cement with Perlite in a 1:1 ratio, 40% Silica Flour, 3% Gel and 0.5% CFR-2, all pumped through 1" pipe. Installed 12" - 900 series S.O.W. casing head.

6-24-78 [1735'] — Installed 12" - 900 series Double Shaffer and Hydril "GK" B.O.P.'s and banjo box. Installed choke manifold and kill and choke lines. Tested B.O.P.'s, pipe rams, blind rams and Hydril to 1500 psi for 30 minutes. Tested banjo box to 500 psi for thirty minutes. Tested Kelly cock to 2000 psi for 15 minutes. All tests witnessed and approved by John Reeves of the U.S.G.S..

6-25-78 [1770'] — Ran 12-1/4" drilling assembly. Drilled through Halliburton "DV" cementer at 1115' and insert float at 1697'. Drilled cement from 1697' to 1733'. Drilled Halliburton 13-3/8" float shoe at 1733' and cement from 1733' to 1735'. P.O.H. Ran bit #7 on 12-1/4" drilling assembly. Drilled 12-1/4" hole from 1735' to 1770'.

6-26-78 [1902'] — Drilled 12-1/4" hole from 1770' to 1800'. P.O.H. Stabilized drilling assembly. Drilled 12-1/4" hole from 1800' to 1902'. 60 bbl increase in mud volume at 1830'.

6-27-78 [2019'] — Drilled 12-1/4" hole from 1902' to 2015'. Lost all fluid returns. Drilled 12-1/4" hole without returns to surface from 2015' to 2019'. Pumped 400 bbls mud into hole. Unable to fill hole. Pulled drilling assembly out of hole. Rigged up to air drill.

6-28-78 [2019'] — Installed Grant rotating drilling stripper. Ran 12-1/4" drilling assembly to 2000'. Ran temperature survey (#1) after hole static for 12 hours, indicating 210°F. Pulled and magnafluxed drilling assembly. Continued to install air drilling equipment.

6-29-78 [2322']	Ran 12-1/4" drilling assembly to 2019', no obstructions. Circulated with 195 psi air pressure through drill pipe. No fluid indicated to be in hole. Injected 200 gpm H_2O co-mingled with 1200 cfm air. Partial air returns to surface without fluid or cuttings experienced while drilling 12-1/4" hole from 2019' to 2151'. Had intermittent returns of water and drill cuttings to surface from 2151' to 2322'.
6-30-78 [2672']	Drilled 12-1/4" hole from 2322' to 2672'. Had intermittent fluid returns to surface with drill cuttings while drilling from 2322' to 2350'. No returns to surface while drilling below 2550'. No fill on bottom.
7-01-78 [2920']	Drilled 12-1/4" hole from 2672' to 2920' with aerated water. Had intermittent returns by heads every three to four hours. Shock sub parted. P.O.H. Shock sub mandrel parted, leaving 12-1/4" bit, stabilizer, bit sub, drill collar stabilizer and shock sub mandrel in hole. Top of fish at 2876'. Made up 11-3/4" Bowen overshot fishing tool and ran in hole.
7-02-78 [2920']	Worked overshot over top of fish and engaged mandrel. Circulated with intermittent returns through the fish with aerated water. Unable to pull fish. Released from fish and pulled out of hole with fishing tool. Installed jars and bumper sub above overshot. Re-engaged fish and jarred tools free. Recovered entire fish. (Jars and bumper sub not on location for first run.)
7-03-78 [3161']	Laid down all tools. Ran in hole with 12-1/4" drilling assembly. Reamed 12-1/4" hole from 2876' to 2920'. Drilled 12-1/4" hole from 2920' to 2940'. P.O.H. and installed corrosion ring in drill collars. Drilled 12-1/4" hole from 2940' to 3161'. Received some intermittent heads of cold water, 50°F, while drilling from 2920' to 3161'.
7-04-78 [3550']	Drilled 12-1/4" hole from 3161' to 3348'. Surveyed at 3250', 234°F temperature after 80 minutes. Drilled 12-1/4" hole from 3348' to 3550'. Had intermittent returns to surface at temperatures ranging from 50°F to 171°F.
7-05-78 [3765']	Drilled 12-1/4" hole from 3550' to 3728'. Changed bit. Mixed sodium nitrate for corrosion control. Drilled 12-1/4" hole from 3728' to 3765'. Corrosion rates indicated to be severe as indicated by rings contained within the drill collars. Indicated rates = 42.8 #/ft/yr, while drilling from 3550' to 3728'.

7-06-78 [4070'] Drilled 12-1/4" hole from 3765' to 3865'. Pulled drill pipe and assembly. Added a jet sub, changed jet sub placements to 379' and 946' above the bit. R.I.H. Drilled 12-1/4" hole from 3865' to 4070'. Received air/fluid returns during first 80 minutes following the addition and placement change of jet subs, but no additional returns. Continuous returns were experienced prior to adding jet sub, while drilling from 3950' to 4070'. Water volume injected with air stream approximates slightly more than that returning to surface.

7-07-78 [4500'] Drilled 12-1/4" hole from 4070' to 4500'. Water rate to sump approximates 40 bbls/hr.

7-08-78 [4578'] Drilled 12-1/4" hole from 4500' to 4540'. Attempted to run directional and temperature survey without success. Pulled drill string. Replaced 12-1/4" bit and two stabilizers. Changed position of jet subs, now placed at 750' and 1140' above the bit. R.I.H. to 4460'. Ran survey at 4460'. Indicated 14° angle and 282°F temperature after 15 hours without injection of aerated water. Washed and reamed with 12-1/4" drilling assembly from 4465' to 4540'. Stuck drill string at 4530'. Worked tools free after two hours. Drilled 12-1/4" hole from 4540' to 4578'.

7-09-78 [4794'] Drilled 12-1/4" hole from 4578' to 4636'. Pulled drill string to reposition jet subs to improve fluid returns. Placed jet subs at 385' and 950' above the bit. Ran drilling assembly to 4494'. Cleaned out fill while pumping aerated water from 4494' to 4636'. Drilled 12-1/4" hole from 4636' to 4794'. Had very fast drilling from 4782' to 4794'. Hole cleaning impossible with recurring fill from 4782' to 4794'. One air compressor failed.

7-10-78 [4826'] Removed drill pipe string float. Ran #2 temp. survey at 4700' indicated to be 292°F after 2 hours without injection. Ran #3 temp. survey at 4675' after 5 hours static, indicating 292°F. Ran #4 temp. survey at 4675', 10-1/2 hours static, indicated 292°F. Ran temp. survey #5 after 18 hours static at 4735', indicated 292°F. Repaired air compressor. P.O.H. Levelled derrick. Removed jet subs from drilling assembly.

7-11-78 [4882'] Ran 12-1/4" drilling assembly. Washed out fill from 4800' to 4826'. Drilled 12-1/4" hole from 4826' to 4882', while pumping only water through bit. No fluid returns to surface. A possible formation change was indicated at 4853' and one foot voids at 4852' and 4858'. P.O.H. Placed jet subs in drilling assembly, 385' and 950' above bit. R.I.H. Cleaned out fill from 4785' to 4847' with aerated water. Unable to keep hole clean

7-11-78 Continued -

from 4832' to 4847'. No fluid returns to surface. Pulled assembly up 315' and attempted to circulate with air only. Fluid flowed back through drill pipe, 100% water, for 25 minutes, indicating a fluid level. P.O.H. Removed jet subs.

7-12-78 [5009'] Ran 12-1/4" drilling assembly to top of fill at 4785'. Cleaned out fill from 4785' to 4882' while pumping only water through bit, with no returns to surface. Drilled 12-1/4" hole from 4882' to 4958'. Pulled bit to 4785'. Replenished water supply. R.I.H. to 4890'. Cleaned out fill, pumping water, from 4890' to 4950'. Stuck pipe and tools. Worked pipe and tools free after 90 minutes. Cleaned out to 4958'. Drilled 12-1/4" hole from 4958' to 5009' while pumping only water through bit, with no returns to surface. Pulled drill string to 4270'. Waited on water trucks to replenish supply.

7-13-78 [5009'] R.I.H. to 4910', with drilling assembly. Pumped water down drill pipe and washed to 4950'. Mixed and pumped a modified formation consolidation treatment through the 12-1/4" bit at 4930' as follows: 76 bbls sodium silicate - calcium chloride solution. Pulled bit to 4785'. Pumped an additional, 76 bbls, modified formation consolidation treatment through the 12-1/4" bit, consisting of sodium silicate and calcium chloride solution. P.O.H. Ran drill pipe to 4926' and displaced lost circulation plug #26 through the drill pipe as follows: 112 ft^3, class "B" cement with Perlite mixed in a 1:1 ratio, with 40% Silica Flour, 3% Gel and 0.5% CFR-2. Displaced slurry with 381 ft^3 H_2O. Pulled drill pipe to 4170'.

7-14-78 [5009'] Waited two hours. Located top of cement plug at 4840', with drill pipe. Displaced lost circulation plug #27 through drill pipe hung at 4833', as follows: 125 ft^3 class "B" cement with Perlite in a 1:1 ratio with 40% Silica Flour, 3% Gel and 0.5% CFR-2. Displaced slurry with 369 ft^3 H_2O. C.I.P. at 0300 hours. Pulled drill pipe to 4475'. Waited five hours. Ran drill pipe to obstruction at 4753'. P.O.H. R.I.H. with 12-1/4" drilling assembly. Drilled firm cement at 2100 hours, with aerated water from 4770' to 4790'. Encountered a void with no cement from 4790' to 4805', firm cement from 4805' to 4830' and cement stringers from 4830' to 4900'. Firm cement was drilled from 4900' to 4926' and a void to fill from 4926' to 4935'. Cleaned out

7-14-78	Continued -
	fill from 4935' to 5009'. No fluid returns to surface while drilling and/or cleaning out.
7-15-78 [5018']	Drilled 12-1/4" hole while injecting water with both mud pumps, from 5009' to 5015', with no fluid returns to the surface. Had fill on bottom 4979' to 5009'. P.O.H. with drilling assembly. R.I.H. with Christensen 8-3/4" x 6-3/4" diamond core barrel to 4985'. Washed through fill from 4985' to 5015'. Cored from 5015' to 5018'. Core barrel jammed. Pulled core barrel.
7-16-78 [5068']	Recovered 8" of highly fractured dolomite from core barrel, Core #1. Re-ran core barrel. Washed through fill from 5003' to 5018'. Cut Core #2 from 5018' to 5021'. P.O.H. No recovery. Ran 12-1/4" drilling assembly. Reamed core run from 4985' to 5021'. Drilled 12-1/4" hole from 5021' to 5068' while pumping water through drill pipe with no returns to surface.
7-17-78 [5121']	Drilled 12-1/4" hole from 5068' to 5121' while pumping water through drill pipe with no returns to surface until water supply temporarily exhausted. Pulled bit to 1720'. Four trucks continued to haul water. Ran bit to obstruction at 5040'. Ran #6 temperature and deviation survey at 5035', indicating a 13°15' angle and a 249°F temperature after 19-1/2 hours with no fluid injection.
7-18-78 [5221' TD]	Pumped water down drill pipe. Washed with 12-1/4" drilling assembly through fill from 5040' to 5121'. Drilled 12-1/4" hole from 5121' to 5221' with no returns. P.O.H. Ran Schlumberger Temperature Log from surface to 4858', tool stopped. Maximum temperature indicated was 342°F suspected to be malfunctioning as maximum reading thermometers only indicated 279°F and 281°F. Ran Schlumberger Dipmeter and four arm Caliper from 5207' to 1735'. Maximum recording thermometers indicated 276°F, 279°F and 282°F. Formations were indicated from logs as follows: Pennsylvanian Dolomite; surface to 2770'; Triassic Redbeds, 2770' to 4782'; Permian Dolomite, 4782' to 5221'.
7-19-78 [5221' TD]	Ran Schlumberger DIL-8 Log from 5207' to 1735', with maximum reading thermometers indicating 282°F, 281°F and 276°F. Ran Schlumberger CNL-FDC Log from 5206' to 1735' and a repeat log section from 2000' to 1735'. Three Maximum reading thermometers indicated 278°F. Reran Schlumberger Temperature Log with replacement readout panel, that indicated a malfunction of the #1 or first

7-19-78 Continued -

temperature log run and corresponded to the maximum reading thermometers. Rigged down Schlumberger equipment. Rigged up Geotex equipment. Ran temperature log, corresponded to other temperature logs, plus spinner, water aquifer and radioactive tracer surveys. Rigged down Geotex. Logs indicated crossflow of fluid up and down, leaving the wellbore. Ran drill pipe to 5009'. Displaced a cement abandonment plug #28 through drill pipe as follows: 312 ft^3 class "B" cement with Perlite in a 1:1 ratio with 40% Silica Flour, 3% Gel and 0.5% CFR-2. Displaced slurry with 364 cu. ft. H_2O. C.I.P. at 2000 hours. No fill from plug #28.

7-20-78 [5221' TD]

Pulled drill pipe to 5009'. Displaced cement abandonment plug #29 through drill pipe as follows: 139 ft^3 class "B" cement with Perlite in a 1:1 ratio, with 40% Silica Flour, 3% Gel, 0.5% CFR-2 and 50# cedar pulp. Displaced slurry with 364 ft^3 H_2O. C.I.P. at 0100 hours. W.O.C. No fill from plug #29. Displaced cement abandonment plug #30 through drill pipe at 5009' as follows: 162 ft^3 class "B" cement with Perlite in a 1:1 ratio, 40% Silica Flour, 3% Gel, 0.5% CFR-2 and 50# cedar pulp. Displaced slurry with 350 ft^3 H_2O. C.I.P. at 0700 hours. Pulled drill pipe to 4350'. W.O.C. Pumped modified formation consolidation treatment through drill pipe at 5009' consisting of sodium silicate and calcium chloride, followed by cement abandonment plug #31 as follows: 162 ft^3 class "B" cement with Perlite, 40% Silica Flour, 3% Gel, and 0.5% CFR-2. Displaced slurry with 300 ft^3 H_2O. C.I.P. at 1445 hours. Plugged bottom joint of drill pipe to make sample catcher with jet sub 90' above bottom. Ran drill pipe to 3000'. P.O.H. Recovered 90' of produced fluid. Removed jet sub and plug. Ran drill pipe to 5009'. No cement plug fill up. Displaced 200 bbls lost circulation material ahead of plug #32 and displaced cement slurry through drill pipe at 5009' as follows: 187 ft^3 class "B" cement with Perlite in a 1:1 ratio with 40% Silica Flour, 3% Gel and 0.5% CFR-2. Displaced slurry with 300 ft^3 H_2O. C.I.P. at 2400 hours.

7-21-78 [5221' TD]

Pulled drill pipe to 1700'. W.O.C. Ran drill pipe to 5009'. No fill from plug #32. Displaced 100 bbls gel and lost circulation material through drill pipe, followed by cement abandonment plug #33 , as follows:

7-21-78 Continued -

162 ft^3 class "B" cement with Perlite in a 1:1 ratio, 40% Silica Flour, 3% Gel and 0.5% CFR-2. Displaced slurry with 310 ft^3 H_2O. C.I.P. at 0945 hours. P.O.H. Ran 12-1/4" drilling assembly to 5011'. No cement fill up from plug #32. P.O.H. Ran Halliburton 13-3/8" EZSV plug to 1608' on drill pipe. Plug stuck. Released from plug. P.O.H.

7-22-78
[5221' TD]

Ran 12-1/4" drilling assembly. Drilled and pushed plug down the hole from 1608' to 4947'. P.O.H. Ran drill pipe to 4935'. Displaced cement lost circulation plug #34, through drill pipe as follows: 84 ft^3 class "B" cement with 15# Gilsonite per sack of cement and .25# Flo-Cele per sack of cement. Displaced slurry with 397 ft^3 H_2O. C.I.P. at 1445 hours. P.O.H. Waited four hours. Ran drill pipe to 4937', located top of cement plug#34. Displaced cement abandonment plug #35 through drill pipe at 4935' as follows: 82 ft^3 class "B" cement with 15# Gilsonite per sack cement and .25# Flo-Cele per sack of cement. Displaced slurry with 385 ft^3 H_2O. C.I.P. at 1930 hours. P.O.H. R.I.H. with Halliburton 13-3/8" EZSV plug #2 on drill pipe.

7-23-78
[5221' TD]

Set 13-3/8" EZSV at 4750'. Displaced cement abandonment plug #36 through drill pipe at 4735' as follows: 86 ft^3 class "B" cement with 15# Gilsonite per sack and .25# Flo-Cele per sack. Displaced slurry with 352 ft^3 H_2O. C.I.P. at 0145 hours. P.O.H. W.O.C. Ran drill pipe to bridge plug, no cement fill. Displaced cement abandonment plug #37 through drill pipe at 4742' as follows: 150 ft^3 class "B" cement, with Perlite in a 1:1 ratio, 40% Silica Flour, 3% Gel and 0.5% CFR-2. Displaced slurry with 355 ft^3 H_2O. C.I.P. at 0900 hours. P.O.H. Waited four hours. Ran drill pipe to top of plug at 4750', no cement fill, plug #37. Repaired Halliburton equipment.

7-24-78
[5221' TD]

Displaced cement abandonment plug #38 through drill pipe at 4745' as follows: 221 ft^3 class "B" cement with Perlite in a 2:1 ratio, 40% Silica Flour, and 3% Gel. Displaced slurry with 347 ft^3 H_2O. C.I.P. at 0100 hours. P.O.H. No cement fill from plug #38. Displaced cement abandonment plug #39 through drill pipe at 4745' as follows: 71 ft^3 class "B" cement with 15# Gilsonite per sack of cement and .25# Flo-Cele per sack of cement. Displaced slurry with 340 ft^3 H_2O. C.I.P. at 0845 hours. Waited four hours. Ran drill pipe to 4728' top of cement. P.O.H. Ran Halliburton 13-3/8" EZSV plug #3

7-24-78	Continued -
	and set at 2750'. Pumped cement plug #40, for abandonment of lower zone, through drill pipe as follows: 157 ft^3 class "B" cement with Perlite in a 2:1 ratio, 40% Silica Flour and 3% Gel, followed by 218 ft^3 class "B" cement with Perlite in a 1:1 ratio, 40% Silica Flour, 3% Gel and 0.5% CFR-2 pumped through and below EZSV plug. Displaced slurry with 230 ft^3 H_2O. Pulled setting tool out of 13-3/8" EZSV to 2740'. Displaced cement abandonment plug #41 through drill pipe as follows: 62 ft^3 class "B" cement with 40% Silica Flour, 3% Gel and 0.5% CFR-2. Displaced slurry with 202 ft^3 H_2O. C.I.P. at 1800 hours. Laid down 62 joints of drill pipe.
7-25-78 [5221' TD]	Ran drill pipe to 2750', top of EZSV, no cement fill. Displaced cement lower zone abandonment plug #42 through drill pipe at 2740' as follows: 75 ft^3 class "B" cement with 40% Silica Flour, 3% Gel and 0.5% CFR-2. Displaced slurry with 200 ft^3 H_2O. C.I.P. at 0100 hours. P.O.H. Ran drill pipe and located obstruction at 2574'. P.O.H. Ran 12-1/4" bit and drilling assembly. Drilled cement from 2574' to 2745'. P.O.H. Pushed Halliburton 13-3/8" rubber casing wiper plug to 1775' with drill pipe. P.O.H. Ran 12-1/4" drilling assembly and pushed wiper plug to 2745'. P.O.H. Ran drill pipe to 2745'. Displaced cement plug #43 through drill pipe at 2745' as follows: 164 ft^3 class "B" cement with Perlite in a 1:1 ratio, 40% Silica Flour, 3% Gel and 0.5% CFR-2. Displaced slurry with 112 ft^3 H_2O. C.I.P. at 2130 hours. P.O.H.
7-26-78 [2600' Plug back depth]	Ran drill pipe and located top of cement at 2552'. P.O.H. Ran 12-1/4" drilling assembly to firm cement at 2552'. Drilled firm cement to 2600'. Laid down 88 joints drill pipe and drill collars. Disassembled B.O.P.'s and allied equipment.
7-27-78 [2600' PBD]	Continued to disassemble B.O.P.'s. Installed 12" 900 series x 6" 900 series tubing landing head. Ran 85 joints 2-7/8" EUE 8RD thread tubing. Bottom joint of tubing orange peeled to a point with a .75" hole. Slotted tubing for fluid entry at 3' intervals. Slot size approximates 4" in length by .75" in width. Landed tubing on donut-pack off hanger in 6"-900 series tubing head 21' below RKB at 2579.53'. Released Loffland Bros. Company rig #5 at 1800 hours, 7/27/78.

CFSU 31-33

RKB to Cellar Floor = 24.00'
RKB to Ground Level = 20.00'
RKB to 12" Casing Head = 22.50'

CASING DETAIL

NO. JTS.	DESCRIPTION	LENGTH FEET	BOTTOM FEET	TOP FEET
	30" CASING			
1	30", 3/8" Wall H-40 Casing	27.50	52.00	Cellar Floor
1				
	20" CASING			
	20" HOWCO Duplex Float Shoe	2.10	280.00	277.90
7	20", 94#/ft H-40 Buttress Casing	289.90	277.90	-0-
7	Total:	292.00		
	Landed Above Zero or KB	12.00		
		280.00		
	13-3/8" CASING			
	13-3/8" HOWCO Float Shoe	2.05	1733.00	1730.95
16	13-3/8", 54.50#/ft K-55 Buttress Casing	614.85	1730.95	1116.10
	13-3/8" HOWCO "DV" Cementer	3.35	1116.10	1112.75
29	13-3/8", 54.50#/ft K-55 Buttress Casing	1112.95	1112.75	-0-
45	Total:	1733.20		
	Landed Above Zero or KB	.20		
		1733.00		
	Cut Off RKB to Casing Head	23.00		
	12" - 900 Casing Head to Shoe	1710.00		
	2-7/8" TUBING			
1	2-7/8" EUE 8RD Tubing with Slots and Bullnose with 3/4" Hole	29.42	2579.53	2550.11
84	2-7/8" EUE 8RD K-55 Tubing	2529.11	2550.11	-0-
85	Total:	2558.53		
	Landed in Tubing Hanger Below Zero or KB	21.00		
	Tubing Head to Bottom of Slotted Joint	2579.53		

Cove Fort Sulphurdale Unit Well #31-33

DEVIATION SURVEYS

MEASURED DEPTH	DRIFT ANGLE	TRUE VERTICAL DEPTH	MAXIMUM POSSIBLE COURSE DEVIATION	TEMPERATURE MAXIMUM-READING THERMOMETER
140'	0°30'	139.99'	1.22'	---
262'	0°45'	161.99'	2.82'	103°F
445'	1°15'	444.94'	6.81'	108°F
608'	1°45'	607.86'	11.79'	118°F
733'	1°00'	732.85'	13.97'	120°F
899'	1°45'	898.77'	19.04'	139°F
987'	1°00'	986.75'	20.58'	138°F
1080'	1°30'	1079.72'	23.01'	150°F
1332'	5°00'	1330.76'	44.97'	122°F
1400'	4°30'	1398.55'	50.31'	118°F
1587'	4°30'	1584.98'	64.98'	---
1800'	5°45'	1796.91'	86.32'	---
1945'	4°45'	1941.41'	98.33'	133°F
2354'	6°00'	2348.17'	141.08'	138°F
2731'	6°00'	2723.10'	180.49'	---
3250'	8°00'	3237.05'	252.72'	234°F
3625'	9°45'	3606.64'	316.22'	260°F
4090'	10°15'	4064.21'	398.97'	280,290,325°F
4440'	13°30'	4404.54'	480.67'	283°F
5035'	13°15'	4983.70'	617.05'	249°F
**5221'T.D.	13°15'	5164.75'	659.68'	---

**No survey was taken at total depth of 5221' so the previous drift angle of 13°15' was used to extrapolate to total depth.

COVE FORT SULPHURDALE UNIT #31-33

FISHING OPERATIONS

Overview

It was necessary to carry out fishing operations twice during the drilling of CFSU #31-33. Both instances were caused by a parted shock sub. In both cases the fish was retrieved without difficulty.

Fishing Job #1

Well Depth: 711'

Date: 6/03/78

Cause: Parted Shock Sub

Results: Fish Recovered with an Overshot

While drilling 17-1/2" hole through andesite at 711', the shock sub failed, parting in the spline. The top of the fish was located at 662'. The fish consisted of a 17-1/2" bit, 17-1/2" stabilizer, bit sub, 8" drill collar and the lower portion of the shock sub. An 11-3/4" overshot fishing tool with an extension was run and engaged and recovered the fish on the first try.

Fishing Job #2

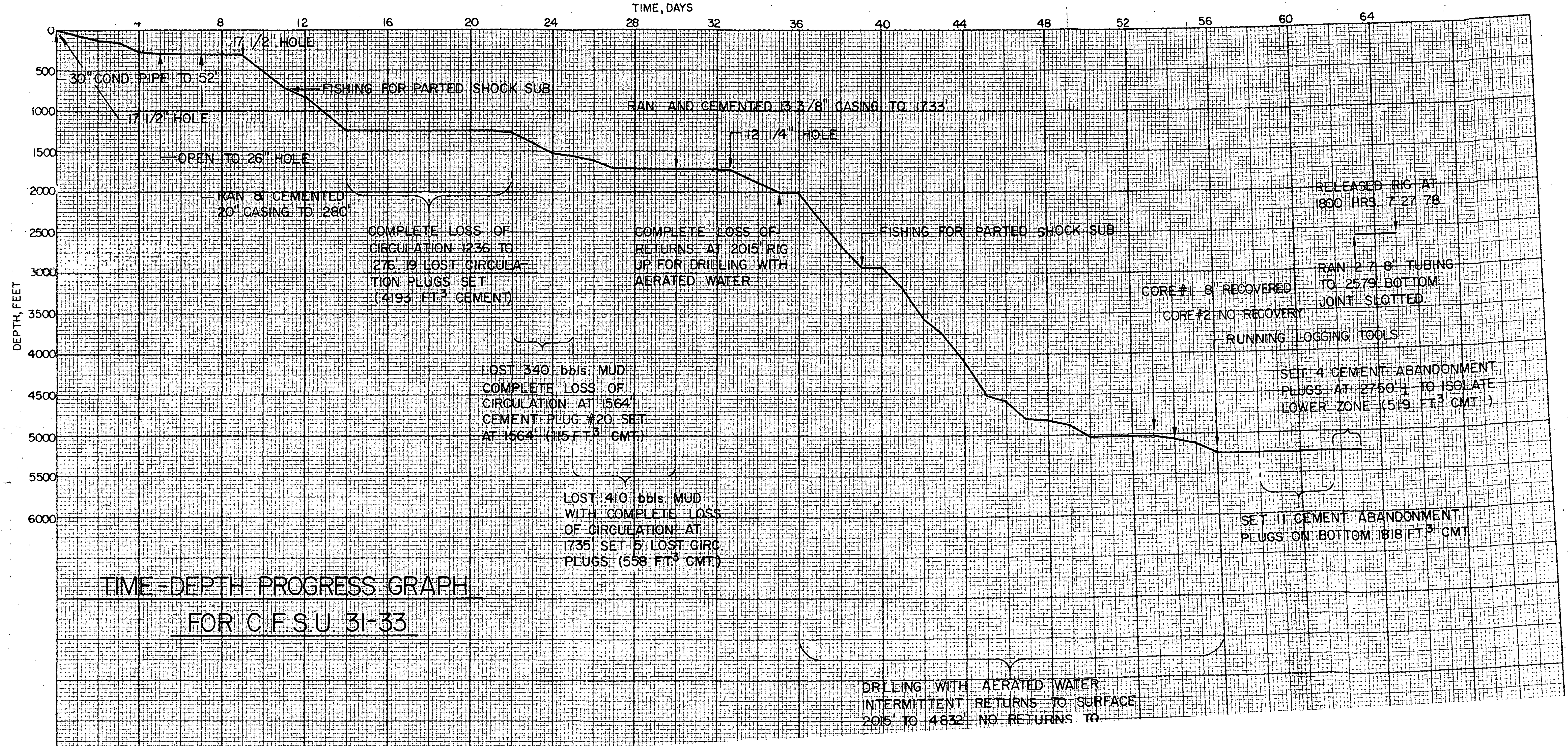
Well Depth: 2920'

Date: 7/01/78

Cause: Parted Shock Sub

Results: Fish Recovered with an Overshot

While drilling 12-1/4" hole through siltstone and sandstone at 2920', the shock sub failed, parting at the mandrel. The top of the fish was located at 2876', and it consisted of a 12-1/4" bit, 12-1/4" stabilizer, bit sub, drill collar stabilizer, and the shock sub mandrel. An 11-3/4" Bowen overshot fishing tool was run in the hole, and engaged with the mandrel. It was not possible to pull out the fish after circulating through it with aerated water and intermittent returns to the surface. The tool was disengaged from the fish, and pulled out of the hole. Jars and a bumper sub had reached the location since going into the hole with the fishing tool the first time. These tools were installed above the overshot, and then the assembly was run back into the hole. The fish was re-engaged and jarred free, recovering the entire fish.



TIME-DEPTH PROGRESS GRAPH FOR C.F.S.U. 31-33

COVE FORT - SULPHURDALE #31-33

LOGGING DATA (*)

DATE	TYPE OF LOG RUN	LOGGED INTERVAL	TOTAL DEPTH
	Schlumberger		
7/18/78	Temperature Log (malfunction suspected) [two maximum reading thermometers run simultaneously]	0' - 4858'	4858'
	Dipmeter and Four Arm Caliper [three maximum reading thermometers run simultaneously]	5207' - 1735'	5207'
7/19/78	Dual Induction - Laterolog [three maximum reading thermometers run simultaneously]	5207' - 1735'	5207'
	Compensated Neutron - Formation Density [three maximum reading thermometers run simultaneously]	5206' - 1735'	5206'
	Temperature Log	0' - 4858'	4858'
	Geotex		
7/19/78	Temperature, Spinner and Water Aquifer Log	0' - 4858'	4858'
	Radioactive Tracer and Spinner Log	0' - 4858'	4858'
	R. F. Smith Corporation		
5/24/78 to 7/24/78	Geothermal Data Log (includes engineering data related to drilling, geological, and other data)	52' - 5221'	5221'

(*) Copies of all these logs will be supplied with the Technical Report.

COVE FORT - SULPHURDALE #31-33

MAXIMUM READING THERMOMETER TEMPERATURE SURVEYS

DATE	TIME SINCE FLUID INJECTION	THERMOMETER READING	DEPTH
6/28/78	12 hours	210°F	2000'
7/10/78	2 hours	294°F±	4700'±
	5 hours	294°F±	4700'±
	10½ hours	293°F±	4700'±
	18 hours	293°F±	4700'±
7/17/78	19½ hours	249°F	5035'

NOTE: Maximum reading thermometer temperature measurements run in conjection with deviation surveys are listed with the deviation surveys in the Well History section of this report.

BIT RECORD

FORM NO. PM-663B

Security | DRESSER

SECURITY DIVISION
Dresser Industries, Inc.
OILFIELD PRODUCTS GROUP
P. O. BOX 6504 HOUSTON, TEXAS 77005 (713) 784-6011

WD BROS.
OIL CO. OF CAL.
RT

RIG NO. 5
FIELD COVE FORT
WELL NO. CFSU 31-33
COUNTY MILLARD

RIG MAKE IDECO
RIG SIZE 1000
PUMP NO. 1 D500
PUMP NO. 2 D500
MUD COMPANY MAGCOBAR

DC. OD X ID X LENGTH (HOLE SIZE)
8" x 30 x ___ (___)
7" x 30 x ___ (___)
___ x ___ x ___ (___)
D.P. SIZE/T.J.: 4½" ("X" HOLE)

	MO./	DAY/	YEAR
SPUD:	5	24	78
U.S.:			
INTER:			

TD: 65
TOTAL DAYS: TOTAL ROT. HRS:

PAGE 1 OF 1
SALESMAN
BUYER
RIG PERSONNEL
FUEL SOURCE DIESEL
WATER SOURCE SPRING

TYPE	SERIAL NO.	JETS - 32NDS REG. R OR RO 1.	2.	3.	DEPTH OUT	FEET	HOURS	FEET PER HOUR	CUM. HRS.	WT. 1000 LBS.	R.P.M.	PUMP PRESS.	PUMP NO. 1 LINER	PUMP NO. 1 SPM	PUMP NO. 2 LINER	PUMP NO. 2 SPM	MUD PROPERTIES WT.	W.L.	F.V.	PV/YP	% SOL	VER. DEV.	DULL COND 1/4-1/8 T	B	G	RG*	GRADED BY**	REMARKS	DATE	DEPTH
TC GS	567 PP	18	18	18	—	—		—	—	—	—	—	—	—	—		—	—	—	—	—							DRLD RAT HOLE DRLD MOUSE HOLE		
EED 3J	831265	16	16	16	301	249	33½	7.4	33½	12	55	500	6	56			64	/	35	/	/		3	2	I			CONE LOCKED		
EC OT	68674	18	18	18	167	167	9½	17.5	43	15	55	500	6	56	5½	58	68	10	63	26/23	6		—	—	—			CONE LOCKED		
C OT	68674	18	18	18	295	128	16½	7.8	59½	15	55/65	600	6	56	5½	58	68	10	63	26/23	TR		2	2	I					
TC J	186JN	16	16	16	502	201	17	11.8	76½	30	60	1100	6	52	5½	44	67	36	45	10/16	5	1¼	3	4	I					
EC TJ	679196	15	16	20	711	209	14½	14.4	91	35	60	1000	6	54	5½	48	66	37	37	6/9	5	1¾	4	5	1/8					
EED 2J	417430	16	16	16	1276	545	58¾	9.3	149¾	30	45/60	600	6	58			65	41	32	5/4	1	1	3	6	1/4					
TC JS	973NJ	20	20	20	1735	459	83½	5.5	233¼	15/30	35/50	800	6½	52	5½	46	64	36	39	5/8	2	4½	4	4	1/8			LOST CIRCULATION		
TC GJ	186JN	20	20	20	—	—		—	—	—		—	—		—	—		—	—				3	4	I			CLEAN OUT CEMENT		
EED 2J	828782	14	14	14	2920	1185	101	11.7	334¼	30	60	200/500	6½	26			/	/	/	/	/	6	6	6	1/8			AIR/WATER		
TC JS	719 LR	0	0	0	3728	808	46¼	17.4	380½	30	60/80	200	6½	27			/	/	/	/	/	9¾	2	8	1/8			AIR/WATER		
TC JS	234 PP	0	0	0	4540	812	47½	17.0	428	30	65	400	6½	26			/	/	/	/	/	14	3	6	1/4			AIR/WATER		
TC GJ	626827	0	0	0	5009	469	24	19.5	452	10/30	60	700	6½	44	5½	40	/	/	/	/	/		3	6	1/4			AIR/WATER		
TC NV	122449	0	0	0	5015	6	1	6.0	453	15/20	40	650	6½	47	5½	41	/	/	/	/	/		5	4	I			AIR/WATER		
TC JS	397 HR	0	0	0	5221	206	15½	13.3	467½	30	60	450	6½	53	5½	34	/	/	/	/	/	13¼	3	3	I			AIR/WATER		
TC 1HJ	279 PD	0	0	0	—	—	—				—	—	—					—	—	—			6	4	I			AIR/WATER	DRLD CMT. AND PLUG	
HRISTENSEN DIAMOND		—	—		5015/5018	3	8	/		10/20	30	650	6½	47			AIR/WATER											CORE No. 1		JAMMED CORE
HRISTENSEN DIAMOND		—	—		5018/5021	3	10	/		10/20	30	650	6½	47			AIR/WATER											CORE NO 2		JAMMED CORE

(N) - NO. (L) - LIGHT (M) - MEDIUM OR (H) - HEAVY ROUNDING OF GAGE

AN 2. ENGINEER 3. RIG PERSONNEL

SUBJECT TO PROVISIONS ON REVERSE SIDE

COVE FORT SULPHURDALE UNIT #31-33

CEMENTING OPERATIONS

Introduction

Two major kinds of cementing operations were carried out during the drilling of CFSU #31-33. The first type of operation involved attempts to seal off lost circulation zones to enable casing to be set and competently cemented, and the abandonment of the well. The second type of operation was the cementing of the 20" and 13-3/8" casing strings.

A total of 7440 ft^3 of cement was mixed, pumped and set in 43 separate plugs while attempting to plug lost circulation zones. These efforts occupied approximately 21 days of rig time, and accounted for a total cost of approximately $320,000. These efforts are discussed below.

The cementing of the 20" and 13-3/8" casing strings required an additional 3594 ft^3 cement. These efforts are described in a separate section below.

Lost Circulation Control Efforts

A significant amount of effort was required in attempting to plug lost circulation zones prior to running the 13-3/8" casing. These efforts were necessary in order to ensure that the 17-1/2" x 13-3/8" annulus would contain a column of cem[illegible] to the formation. In the lower part of the hole efforts were aimed at plugging it back to 2600' (abandonment of the lower section). Table 1 presents a comprehensive description of all cement operations carried out while attempting to control lost circulation in CFSU #31-33. Table 2 presents a summary and description of cement additives used on CFSU #31-33.

Cement of API classification, "Class B", was employed in all but one instance. This Portland cement is intended for use from surface to a depth of 6000' when conditions require moderate to high sulfate resistance. One cement plug (#13) used Halliburton Thix-Set Cement. This cement forms a thixotropic slurry which is designed to rapidly develop high viscosity and gel strength when in a static state. These properties make the cement particularly suited for plugging the highly fractured or vugular zones encountered in CFSU #31-33. However, great care is required in order to prevent cementing the drill pipe into the hole.

Eight plugs of a patented water/polymer lost circulation compound were also used with limited success while attempting to control the lost circulation condition. This compound, Pal Mix 110-R, is a specially processed material which remains a nonviscous slurry for about 45 minutes after mixing, and then sets into a tough plastic plug.

Table 3 summarizes cementing operations associated with running casing. The 30" casing cement poured between the 30" casing and the hole wall prior to the start of drilling operations.

The 20" casing was successfully cemented through drill pipe engaged with the 20" duplex casing float shoe to reduce the volume of cement required, allowing additional cement to be added. The 13-3/8" casing was successfully cemented in two stages to reduce the hydrostatic head or pressure on the formation allowing the first stage to partially set and support the weight of the second stage thereby reducing the chance of fluid loss to the formation. While waiting on cement after the second stage cementation, the cement level in the 13-3/8" x 20" annulus fell 180'. This annulus was filled with cement using 1" pipe inserted into the void.

DATE	SITUATION	NO.	FT.	FT.														
7/21/78		33	5221	5009	562	LCM plug				√			√		0			
					163	cement	class "B"	1:1	40%	3%	0.5%				0			
					310	water									-			
7/22/78		34		4935	84	cement	class "B"					0.25		15	0	-		No cement fill at 5011'. Attempted to set Halliburton EZSV plug #1. Plu pushed to 4947'.
					397	water									4 hrs			
		35	4937	4935	82	cement	class "B"					0.25		15	0	4937	-	Theoretical bottom of cement = 5039'.
					385	water									-			
7/23/78		36		4735	86	cement	class "B"					0.25		15	0	-	-	Set Halliburton EZSV plug #2 at 4750' following cement plug #35.
					352	water									-			
		37		4742	150	cement	class "B"	1:1	40%	3%	0.5%				0	-	-	No fill at bridge plug.
					355	water									4 hrs			
7/24/78		38		4745	221	cement	class "B"	2:1	40%	3%					0	-	>55%	No fill at bridge plug.
					347	water									0			
		39		4745	71	cement	class "B"					0.25		15	0	-	-	No fill at bridge plug.
					340	water									4 hrs			
		40	4728	{through}	157	cement	class "B"	2:1	40%	3%					0	4728	75%	Set Halliburton EZSV plug #3 at 2750'.
				{EZSV plug}	218	cement	class "B"	1:1	40%	3%	0.5%				0			
				{at 2750}														
					230	water									0			
		41		2740	62	cement	class "B"		40%	3%	0.5%				0			Pulled setting tool out of EZSV plug #3 to 2740'.
					202	water									6 hrs			
7/25/78		42		2740	75	cement	class "B"		40%	3%	0.5%				0		-	No fill at top of EZSV plug #3 at 2750'.
					200	water									-			
		43	2745	2745	164	cement	class "B"	1:1	40%	3%	0.5%				0	2574	-	Capacity of drill pipe = 219 ft^3. Drilled out cement from 2574' to 2745'. of cement drilled - 140 ft^3.
					112	water									3 hrs	2552	4%	Drilled out firm cement from 2552' to 2600'.

DATE	SITUATION	PLUG NO.	OPEN HOLE FT.	OEDP @, FT.	VOLUME FT^3	MATERIAL	CEMENT TYPE													
																	0			
															25		0			
												0.5	0.5	2%			0			
6/20/78	Lost circulation		1735	1649	100	Pal Mix 110R											1 hr	-	-	Did not attempt to locate cement.
	Polymer Plug #6				140	water	class "B"					0.5	0.5	2%	25		4 hrs	not located	100%	
					104	cement											0			
		21			112	water	class "B"										1 hr			
				1229	104	cement														
		22		1732	112	Pal Mix 110R											0			
					134	water				3%	0.5%						-	1638	-	{Theoretical top of cement only, with no loss = 1672'. Implies 57 ft^3 water
	Polymer Plug #7						class "B"	1:1	40%								0			{ Filled hole with 1291 ft^3 mud. Theoretical volume to fill hole from 1638'
				1610	104	cement											1 hr			{ Theoretical volume to fill 4½" drill pipe from surface to 1638' = 131 ft^3.
		23			112	water											0			out of sight after 10 minutes.
6/21/78				1550	104	Pal Mix 110R				3%	0.5%						4 hrs	not located at 1638		
					128	water	class "B"	1:1	40%								0			
	Polymer Plug #8				101	cement		1:1	40%	3%	0.5%			2%			-	1515	0%	{Mud returns to surface during last 20 ft^3 of displacement water. Capacity c
		24			112	water	class "B"													{ surface to 1580' = 126 ft^3. Firm cement from 1515' to 1580'. Theoretical
				1580	145	cement														{ = 108 ft^3. Soft cement from 1638' to 1675'. No fluid loss experienced. T
		25			112	water								✓		sodium	0			soft cement = 62 ft^3.
				4930	427	{ modified										silicate		4840	0%	Should occupy 137' of 12¼" hole.
			5009			{ formation								✓		sodium	2 hrs			Theoretical bottom of cement plug = 4977'.
7/13/78	Lost circulation in 12¼" hole			4785	427	{ consolidation				3%	0.5%					silicate				
						{ treatment	class "B"	1:1	40%								0			
				4926	112	cement											2 hrs			
		26			381	water				3%	0.5%									
							class "B"	1:1	40%								0			
					125	cement											5 hrs	4770	<55%	{Firm cement from 4770' to 4790', 4805' to 4830', 4900' to 4926'. Cement stri
		27		4833	369	water														Fill 4935' to 5009'. No fluid returns to surface.
7/14/78																				
	Begin Cement Abandonment Plugs to Abandon Lower Zone									3%	0.5%						0	not located	100%	No fill.
7/19/78							class "B"	1:1	40%								-			
					312	cement				3%	0.5%									
		28	5221	5009	364	water		1:1	40%								0			
							class "B"			3%	0.5%						-	not located	100%	No fill.
					139	cement		1:1	40%								0			
		29			364	water	class "B"										-			
7/20/78					162	cement										50# cedar pulp	0			
		30			350	water														
					--	modified								✓		sodium				
						formation										silicate				
						consolidation			40%	3%	0.5%						0			
						treatment	class "B"	1:1									3 hrs	not located	100%	No fill.
					162	cement											0			
		31			300	water			40%	3%	0.5%						0			
					1123	LCM	class "B"	1:1									-	not located	100%	No fill.
					187	cement														
		32			300	water														

PLUG NO.	DEPTH OF OPEN HOLE FT.	OEDP @, FT.	PLUG VOLUME FT^3	MATERIAL	CEMENT TYPE	PERLITE BY WT.CMT.	SILICA FLOUR BY WT.CMT.	GEL BY WT.CMT.	CFR-2 BY WT.CMT.	FLO-CELE LB/SK CMT.	NUT PLUG LB/SK CMT.	$CaCl_2$ BY WT.CMT.	LCM BY WT.CMT.	GILSONITE LB/SK CMT.	OTHER	TIME BEFORE NEXT OPERATION	LOCATION OF TOP OF CEMENT	THEORETICAL % PLUG LOST	REMARKS
1	1241	1230	375	cement	Class "B"	1:1	40%	3%	0.5%							5 hrs	Not located	100%	
I_2S 2		1230	350	cement	Class "B"	1:1	40%	3%	0.5%							5 hrs	Not Located	100%	Gas flow stopped for 20 min and slowly returned at a low rate.
3		1230	112	thick gel mud												0			
			240	cement	Class "B"	1:1	40%	3%	0.5%							5 hrs	No fill @ 1230'	>95%	H_2S emissions stopped, but small amount of CH_4 emission continued.
4		1230	125	cement	Class "B"	1:1	40%	3%	0.5%				15%			5 hrs	No fill @ 1230'	>95%	
5		1230	225	cement	Class "B"	1:1	40%	3%	0.5%				15%			3 hrs	No fill @ 1230'	>95%	
6		1230	561	thick gel mud									25%			0			
			305	cement	Class "B"	2:1	40%	3%								5 hrs	No fill @ 1230'	>95%	
7		1230	305	cement	Class "B"	2:1	40%	3%								5 hrs	No fill @ 1230'	>95%	
8	1252	1230	230	cement	Class "B"	1:1	40%	3%					15%			5 hrs	No fill	>95%	
9		1230	230	cement	Class "B"	1:1	40%	3%					25%			4 hrs	No fill	>95%	
10		1230	210	cement	Class "B"	1:1	40%	3%				20%	20%			4 hrs	No fill	>95%	
11		1230	210	cement	Class "B"	1:1	40%	3%				2%	20%			4 hrs	No fill @ 1230'	>82%	
12		1230	210	cement	Class "B"	1:1	40%	3%				2%	20%			5 hrs	No fill @ 1241'	>91%	Fluid level located at 600' ±.
13		1241	166	cement	HOWCO, Thix-Set					0.5	0.5	2%		25%		4 hrs	1160	7%	Lost circulation again at 1236' while drilling out cement. Continued drilling to 1257'.
14	1257	1230	166	cement	Class "B"					0.5	0.5			25%		4 hrs	1236	79%	
15		1230	210	cement	Class "B"	1:1	40%	3%	0.5%							5 hrs	1236	100%	
16		1230	86	cement	Class "B"	1:1	40%	3%								0	1236	100%	
17		1230	200	cement	Class "B"	1:1	40%	3%								4 hrs	1221	87%	Lost circulation @ 1247' while drilling firm cement.
	1247	1230	90	Pal Mix 110R												0			
			100	water												1 hr			No success in filling hole.
	1247	1230	90	Pal Mix 110R												0			
			100	water												1 hr			No success in filling hole.
	1247	1230	90	Pal Mix 110R												0			
			100	water												1 hr			No success in filling hole.
18	1247	1230	125	high visc. plug				50%						50%		0			
			235	cement	Class "B", 1/3	1:1									Sand 1:1	0			
			67	water												4 hrs	1183	54%	Drilled out firm cement with full returns.
19	1276	1260	112	water											700# Pal Mix 110R	1 hr			
		1260	115	cement	Class "B"	1:1									Sand 1:1	4 hrs	1230	33%	Drilled out firm cement with full returns.
	1564	1535	95	Pal Mix 110R												0			
20			120	water												½ hr			
		1535	115	cement	Class "B"	1:1									Sand 1:1	0			
		1535	92	water												4 hrs	1487	33%	Lost returns at 1500' while drilling firm cement. Regained circulation after pumping 500 BBLS H_2O in hole. Open hole to 1564'.

TABLE 2

SUMMARY AND DESCRIPTION OF CEMENT ADDITIVES USED ON CFSU 31-33

ADDITIVE	DESCRIPTION	FUNCTION OF ADDITIVE			REMARKS
		LIGHTEN SLURRY WEIGHT	ACCELERATE SETTING TIME	CONTROL LOST CIRCULATION	
Perlite (expanded)	treated volcanic material	X			absorbs water under high pressure
Silica Flour	finely powdered silicon dioxide				prevents loss of strength at high temperatures
Gel	Wyoming-type bentonite	X		X	increases suspension of particulate additives; maintains even distribution of other additives; reduces slurry weight
$CaCl_2$	in powder or flake form		X		accelerates early strength
CFR-2 (*)	a napthalene polymer		X		a cement dispersant to reduce viscosity and a friction loss reducer
Gilsonite	particulated naturally occurring asphaltite	X		X	inert - does not absorb water; high cement strength; resists corrosion; granular lost circulation additive
Flo-Cele (*)	cellulose flakes			X	lost circulation additive
Nut-Plug (**)	walnut shells			X	granular lost circulation additive
LCM	any mixture of lost circulation materials			X	mixture of gilsonite, cellulose flakes, and walnut shells

(*) Halliburton trademark (**) Magcobar trademark

TABLE 3

SUMMARY OF CASING CEMENTING OPERATIONS

CFSU #31-33

CASING SIZE	HOLE SIZE	DEPTH OF OPEN HOLE	CASING FLOAT SHOE AT	OTHER CASING ACCESSORIES	MATERIAL INJECTED	COMPOSITION	VOLUME	REMARKS
30"	36"	32' G.L.	32' G.L.		cement slurry	•ready mix cement	3½ yd^3	Bill Martin Rathole Service
20"	26"	289' K.B.	280' K.B.		cement slurry	•class "B" cement 2% $CaCl_2$ by weight	767ft^3	80% excess volume
					displacement fluid	•drilling mud	12ft^3	injected through 4½ drill pipe stabbed into shoe. Good cement returns to surface. Located cement at 272'. Theoretical cement location = 274.3'.
13-3/8"	17-1/2"	1735' K.B.	1733' K.B.	Insert float collar at 1697'. Multiple-stage "DV" cementing collar at 1115'	Flush #1	•water	100ft^3	Begin First Cementi Stage
					Flush #2	•water FR-20 flushing agent and Silica Flour	100ft^3 70#	
					Flush #3	•water sodium silicate	53ft^3 30ft^3	
					Flush #4	•water	200ft^3	

CASING SIZE	HOLE SIZE	DEPTH OF OPEN HOLE	CASING FLOAT SHOE AT	OTHER CASING ACCESSORIES	MATERIAL INJECTED	COMPOSITION	VOLUME	REMARKS
					cement slurry followed by wiper plug	•class "B" cement, 1:1 Perlite, 40% Silica Flour, 0.5% CFR-2	795ft^3	70% excess volume
					displacement fluid	•drilling mud	1520ft^3	Did not bump top cement plug on insert float collar. Theoretical displacement volume t bump = 1473ft^3. Opened "DV" collar circulated cement through it. Recei 392ft^3 cement slur from above "DV" co Theoretical excess volume = 331ft^3. Circulated mud thro "DV" collar four h without fluid loss
					Flush #1	•water	168ft^3	Begin Second Cementi Stage
					cement slurry	•same as first stage	1611ft^3	90% excess, followe "DV" closing and wi plug.
					displacement fluid	•drilling mud	977ft^3	"DV" collar closed. Theoretical displac ment volume = 968ft Partial cement retur to surface ~50ft^3. Theoretical return 746ft^3. 93% of exc lost to formation. Cement level in annu fell 180' while wai ing on cement. Fil with cement using l Located top of cemen in casing at 1697'.

MAGCOBAR DIVISION, DRESSER INDUSTRIES, INC. 475 17TH STREET SUITE 1600 DENVER, COLORADO 80202

MAGCOBAR MUD COST SUMMARY

for

UNION OIL OF CALIFORNIA
CFSU 31-33
Section 31, 25 South - 6 West
Millard County, Utah

NUMBER OF UNITS	PRODUCT DESCRIPTION	AMOUNT
60.00	Magcobar	$ 363.60
1,714.00	Magcogel	8,467.16
5.00	Kwik Thik	28.25
140.00	Magco Dustless	691.60
3.00	Spersene	85.17
64.00	Tannathin	649.09
141.00	Chip Seal	1,680.12
12.00	Cottonseed Hulls	149.52
76.00	Mud Fiber	1,067.04
9.00	Nut Plug Fine	120.87
8.00-	Nut Plug Medium	107.44-
5.00	Aluminum Stearate	300.50
10.00	Magconol	607.90
15.00	Calcium Chloride	264.15
546.00	Caustic Soda	12,110.28
15.00	Lime	90.90
449.00	Miscellaneous Products	26,827.75
55.00	Zinc Carbonate	5,247.00
15.00	Sodium Bicarbonate	763.41
51.00	OS 1	1,512.15
2.00	SI-1000	1,158.46
	State Sales Tax	2,483.10
	Sundry Rebill	7,405.98
	Utah County Tax	470.18
	TOTAL MUD COST	$ 72,436.74

(Above retyped from Magcobar Mud Cost Summary issued 8/21/78)/

DATE: 8/1/78

COMPANY:	Union Oil of California	CONTRACTOR/RIG #:	Loffland 5
WELL NAME:	CFSU 31-33	SPUD DATE:	5-24-78
LEGAL DSCRP:	Sec. 31, 25S-6W	COMPLETION DATE:	7-23-78
COUNTY/STATE:	Millard, Utah	MUD ENGINEER(S):	Ralph W. Bowie
TOTAL DEPTH:	5221' ETD 2600'	MAG STOCK POINT(S):	Milford, Utah
TOTAL DAYS:	60	TOTAL COST:	

CASING/BIT INFORMATION

INTERVAL...			HOLE SIZE	BIT SIZE	CASING SIZE	# BITS USED
0'	to	280'	28"	17 1/2/26"	20"	2
280'	to	1735'	17 1/2"	17 1/2"	13 3/8"	4
1735'	to	5221'	12 1/4"	12 1/4"	OPEN HOLE	7
'	to	'				

DRILLING FLUID INFORMATION

MUD UP AT: SURFACE '

INTERVAL...			MUD TYPE	MUD WEIGHT (low-high)	DAYS	COST	COST/FT
0'	to	280'	SPUD MUD	8.7 - 9.1	6	$ 2,050.13	$ 7.32
280'	to	2100'	FLOCCULATED	8.4 - 9.0	29	18,472.14	10.15
2100'	to	5221'	AERATED WATER		27	51,914.47	16.63
'	to	'					

SUMMARY OF COMMENTS/PROBLEMS

(indicate depth interval on left)

See Interval Breakdown and Daily Drilling Log for more information.

GEOLOGIC INFORMATION

FORMATION	DEPTH
Andesite Surface Debris	205'
Competent Andesite	300'
Altered Andesite	520'
Andesite with quartz veins and sulfides	920'
Red Silt Stone and intermittent Grey Dolomite	1740'
No returns	5221'
No actual formation tops logged.	'

OPERATOR: Union Oil of California WELL NAME: CFSU 31-33

LEGAL DSCRP: Sec. 31, 25S-6W COUNTY, STATE: Millard, Utah

Interval: 0 ' to 280 '

Footage: 280

Days: 6

Ft/Day: 46.5

Mud Cost: $ 2,050.00

Cost/Day: $ 7.32

Mud Properties....

Weight: 8.7 - 9.1 Cl⁻: 600

Vis: 45 Solids: 2-6%

F/L: 15 Oil: 0

pH: 11.0 LCM: 0

MATERIALS....

Product	Units	Cost	Units/Day	Cost/Day
Magcogel	207	$ 4.94	34 1/2	$ 170.43
Caustic Soda	8	22.18	1 1/3	29.57
Lime	3	6.06	1	6.06

REMARKS....

This interval was drilled with a flocculated mud having sufficient viscosity (45-55 sec/qt) to clean the hole. No problems were encountered during the drilling of this interval. A 17 1/2" hole was drilled to 282' and opened to 26". 20" surface casing was run to 280' and cemented without any trouble.

OPERATOR: Union Oil of California WELL NAME: CFSU 31-33

LEGAL DSCRP: Sec. 31, 25S-6W COUNTY, STATE: Millard, Utah

Interval: 280 ' to 1735 ' Mud Properties....

Footage: 1455	Weight: 8.4 - 9.0	Cl^-:	900
Days: 29	Vis: 32 - 40	Solids:	4%
Ft/Day: 50.2	F/L: 40	Oil:	0
Mud Cost: $ 18, 724.84	pH: 10.5 - 11.5	LCM:	0
Cost/Day: $ 645.68			

MATERIALS....

Product	Units	Cost	Units/Day	Cost/Day
Magcogel	1425	$ 4.94	49.14	$ 242.74
Caustic Soda	85	22.18	2.93	65.01
Tannathin	59	10.49	2.03	21.34
Lime	13	6.06	.45	2.72
Sodium Bicarbonate	26	23.77	.9	21.31
Zinc Carbonate	38	95.00	1.07	101.55
Mud Fiber	31	14.04	1.07	15.02
Chip Seal	20	11.32	.69	7.81
SI-1000	2	579.23	.03	19.97
Aluminum Stearate	4	60.10	.14	8.29
Magconol	5	60.79	.17	10.48

OPERATOR: Union Oil of California　　WELL NAME: CFSU 31-33

LEGAL DSCRP: Sec. 31, 25S-6W　　COUNTY, STATE: Millard, Utah

Interval:	1735 ' to 5221 '	Mud Properties....			
Footage:	3486	Weight:	8.5 - 9.0	Cl⁻:	700
Days:	27	Vis:	30 - 36	Solids:	1 1/2 to 4%
Ft/Day:	129	F/L:	N/C - 40	Oil:	0
Mud Cost:	$51,914.47	pH:	10.5 - 11.5	LCM:	0
Cost/Day:	$ 1,922.75				

MATERIALS....

Product	Units	Cost	Units/Day	Cost/Day
Sodium Nitrite	531	$ 59.75	19.67	$ 1,175.08
Caustic Soda	424	22.18	15.70	348.31
OS-1	46	29.65	1.7	50.51
Calcium Chloride	15	17.17	.56	9.54
Magcogel	45	4.94	1.67	8.23
Mud Fiber	65	14.04	2.41	33.80
Chip Seal	20	11.32	.74	8.39
Nut Plug	5	13.43	.19	2.55

Operator Union Oil of California	**Location** Sec. 31, 25S-6W	**MAGCOBAR DIVISION**		
Well CFSU 31-33	**County** Millard	**DRILLING MUD LOG**		
Contractor Loffland 5	**State** Utah	**Page** 1 **of** 3		
Engineer R.W. Bowie	**Elevation**			

Hole Size	Casing Size	Interval Length
inch	inch	ft.
26 inch	20 inch	280 ft.
17 1/2 inch	13 3/8 inch	1455 ft.
12 1/4 inch	OPEN inch	3486 ft.
inch	inch	ft.

Spud Date
Under Surf
Finish D
Total Dep
Mud Cost $ 7

K = 1000

DATE	DEPTH	WT. LBS./GAL.	SAMPLE TEMP.	VISC. SEC./QT.	PLASTIC VIS.	YIELD POINT	GELS INITIAL	GELS 10 MIN.	pH	FILTRATE API	HT-HP API	Alkalinity Pm	Alkalinity Pf	Alkalinity Mf	Chloride ppm	Calcium ppm	Sand % Vol.	Solids % Vol.	Oil % Vol.	#/bbl. Bentonite	#/bbl. Drill Solids	L.C.M. #/bbl.	'n' Value	'K' Value		MAGCOBAR	MAGCOGEL	SPERSENE	CAUSTIC SODA	TANNATHIN	Lime	Sodium Bicarbonate	Zinc Carbonate	FER
-25		SURFACE																								63		2		2				881
-26	123	8.7	60	36	16	8	8	12	9.0	12		1.0	.2	.4	500	0	Tr	2 3/4		14	10					56		1						566
-27	182	9.0	65	40	17	13	13	21	11.5	12		1.2	.7	.7	400		1/2	5		10	35					56		1						314
-28	301	8.8	65	39	14	11	5	10	11.0	15		.6	.2	.3	750	100	Tr	4		17	20					15		2						124
-28	112	9.1	69	43	17	17	11	18	10.5								Tr	5 3/4								Mid Day Check								0
-29	218	9.1	88	63	23	26	12	26	10.5	10		.9	.4	.6	900	100	1/2	6		24	30							2		1				53
-30	294	RUNNING CASING (20") TO 294'																								17		1						111
-31	280	CASING SET AT 280' - NIPPLED UP B.O.P. - W.O.C. TO SET																																253
-01	300	8.5	63	30	4	2	2	2	11.0	47		.2	.3	.4	400	200	1	1-1/2					.74											0
-02	320	8.7	83	37	11	8	7	13	12.0	46		1.8	.9	1.2	700	150	3/4	3		135	135		.66	159				1		3				98
-03	588	9.0	118	46	16	10	6	3	10.5	36		.7	.3	.7	1.3K	100	1/2	5 1/2		19	280		.69	178		50								259
-04	711	9.0	83	43	6	3	2	5	11.0	19		.7	.35	.7	1.7K	100	Tr	5 1/2		16	31		.74	455		39		3	3					305
-05	899	8.9	125	35	9	6	5	9	10.5	21		.7	.3	.7	2.1K	100	1/2	4 1/2		17	23		.68	112		4		2	1					78
-06	1089	8.9	100	35	7	4	2	6	11.0	20			.3	.6	1.5K	100	0	4 1/2		17	23		.71	67		22		3	3					217
-07	1233	W.O.C.; LOST CIRCULATION AND ENCOUNTERED H_2S (AVG 500 ppm) AT 1233', 9:50 p.m.																								50		2	2					525
-08	1233	W.O.C. - NO DRILLING ACTIVITY																																0
-09	1240	8.6	85	34	8	1	2	3	11.0	16		1.1	.6	.9	400	<40	Tr	2.4		159	579		.9	151										0
-10	1253	LOST ALL MUD, 6 CEMENT PLUGS SET (UNABLE TO TAG)																										4						309
-11	1253	12TH CEMENT PLUG (UNABLE TO TAG)																								25		6						269
-12	1253	DRILLED 83' CEMENT, LOST ALL RETURNS AT 1253', W.O.C.																								50		3			3			404
-13	1230	CEMENT PLUG #16 IN PLACE																								50		5						558
-14	1230	CEMENT PLUG #16 TAGGED AT 1230', DRILLED OUT WITH 33 VISCOSITY MUD																								55		2			1	2		775
-15	1230	8.5	78	35	7	4	2	6	12.5	40		1.2	1.1	.4	700	50		1.2		129			.71	67		125		6	3	1		5		1326
-16	1400	8.5	105	36	6	12	4	6	11.5	41		2.5	.85	1.0	1K	40	Tr	1-1/4		11	2.7		.41	713		74		2	6	1	3	2		777

Operator Union Oil of California
Well CFSU 31-33
Contractor Loffland 5
Engineer R.W. Bowie

Location Sec. 31, 25S-6W
County Millard
State Utah
Elevation

MAGCOBAR DIVISION

DRILLING MUD LOG

Hole Size	Casing Size	Interval Length
inch	inch	ft.
26 inch	20 inch	280 ft.
17 1/2 inch	13 3/8 inch	1455 ft.
12 1/4 inch	OPEN inch	3486 ft.
inch	inch	ft.

Spud Date 5-
Under Surfac
Finish Date
Total Depth
Mud Cost $ 72,

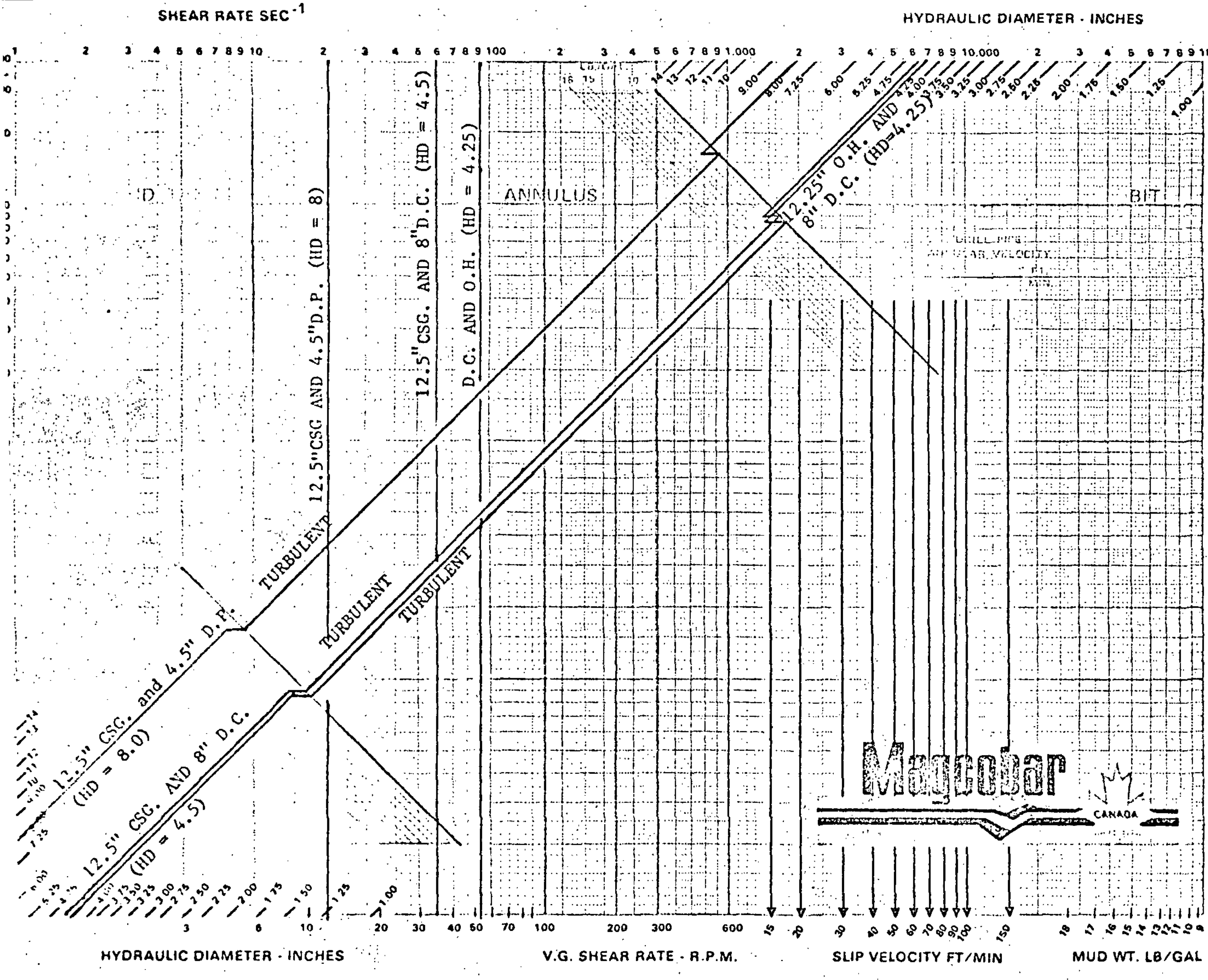
TE	DEPTH	MUD PROPERTIES: WT. LBS./GAL.	SAMPLE TEMP.	VISC. SEC./QT.	PLASTIC VIS.	YIELD POINT	GELS: INITIAL	GELS: 10 MIN.	pH	FILTRATE API	HT-HP API	Alkalinity Pm	Alkalinity Pf	Alkalinity Mf	Chloride ppm	Calcium ppm	Sand % Vol.	Solids % Vol.	Oil % Vol.	#/bbl. Bentonite	#/bbl. Drill Solids	Zinc Carbonate	'n' Value	'K' Value	MATERIALS: Sodium Nitrite	MAGCOGEL	SPERSENE	CAUSTIC SODA	TANNATHIN	Lime	Sodium Bicarbonate	Zinc Carbonate	Mud Fiber	Chip Seal	SI-1000	Aluminum Stearate	Magconol	PER DAY
'	1553	8.5	80	31	3	3	2	4	115	36		2.3	.57	1.0	700	<40		165		935	546	.2	.58	80		72		3	3	1		3						972
3	1460	8.5	75	36	8	6	4	6	120	97		235	1.2	1.75	900	<40		128		193		1.4	.65	122		245		10	2	2		3	20/20					2370
)	1646	8.5	110	32	5	7	4	11	115	34		2.3	1	1.3	850	<40		Tr		939	546	1.1	.5	267		55		6	8	1		2		1				1390
)	1730	LOST CIRCULATION : NO MUD IN PITS																								226		11	4	2		8						2488
1	1730	CEMENT PLUG #21 and #22																								104		8	3	3		4		11				1555
1	1650	8.5	110	32	4	6	3	2	115	37		2.3	1.1	1.4	600	<40		1-1/4																				0
2	1600	8.4	101	39	6	7	4	6	120	34		1.1	1.3	1.6	700	<40		1-1/4								47		2			3							365
3	1735	8.5	85	39	8	5	5	6	110	37		1.1	1.0	1.3	700	150	1/2	1-3/4					.68	96		6		5	6		4							313
4	1735	NIPPLED UP B.O.P. (13 3/8")																																				0
5	1735	DRILLED OUT DV TOOL AT 1115'																																				0
6	1770	8.5	115	30	5	10	4	6	125	42		5.5	2.1	2.5	650	100	1	1-1/4								35		1	5	1	8	5			1	2		1241
7	1935	8.4	110	30	5	4	4	12	115	41		5.5	1.4	2.1	700	<40	1/2	1								54			10	1	1	4			3	3		1203
8	2100	LOST ALL FLUID AT 1530 HOURS; RIGGED UP FOR AERATED WATER																								37												418
9	2100	AERATED WATER																										1										23
0	2462	AERATED WATER																										12										279
1	2755	AERATED WATER																										23										736
1	2920	AERATED WATER																										36										838
3	2920	AERATED WATER																										52										270
4	3276	AERATED WATER																										10										233
5	3634	AERATED WATER																										17										396
6	3725	AERATED WATER																							14			8										1064
7	4085	AERATED WATER																							123			22										8229
8	4540	AERATED WATER																							126			60										9302
9	4606	AERATED WATER																							76			30										5466

Operator Union Oil of California	Location Sec. 31, 25S-6W	MAGCOBAR DIVISION	
Well CFSU 31-33	County Millard	DRILLING MUD LOG	
Contractor Loffland 5	State Utah	Page 3 of 3	
Engineer R.W. Bowie	Elevation		

Hole Size	Casing Size	Interval Length
inch	inch	ft.
26 inch	20 inch	280 ft.
17 1/2 inch	13 3/8 inch	1455 ft.
12 1/4 inch	OPEN inch	3486 ft.
inch	inch	ft.

Spud Date
Under Surfac
Finish Date
Total Depth
Mud Cost $ 72,

TE	DEPTH	MUD PROPERTIES	MATERIALS: Sodium Nitrite	MAGCOGEL	OS1	CAUSTIC SODA	TANNATHIN	Sodium Bicarbonate	Zinc Carbonate	Mud Fiber	Chip Seal	Cotton Seed Hulls	Nut Plug			PER DAY	
0	4796	AERATED WATER	112			64										8517	5
0	4826	BIT PLUGGED IN SILICA CLAY AT 2015'			2											748	5
1	4800	WORKED BIT THROUGH CLAY	36		4	10										2615	5
2	5004	TRIPPED OUT OF HOLE; W.O.C.; ATTEMPT TO SEAL OFF RUNNING CLAY			10	11										567	5
3	4900	W.O.C. TO SET												15		220	6
4	4900	DRILLED OUT CEMENT PLUGS WITH NO RETURNS	34		18	18										2552	6
5	5017	NO RETURNS, FRESH WATER, CAUSTIC SODA, AND OS1	10		6	18										1775	6
6	5040	CORING, WATER, AND CAUSTIC SODA, OS1			16	16										1227	6
7	5135	NO RETURNS, WATER AND CAUSTIC SODA			8	16										886	6
1	5221	LOGGED WELL; SET CEMENT PLUG AT 5221'		25						10	10	10				657	6
2	5221	SET EZ-SV PLUG WITH CEMENT AND LCM AT 4700'								55	10		5			1240	6
3	5221	SET EZ-SV PLUG UP HOLE AT APPROXIMATELY 1000' + 12 BBL CEMENT	20													784	6
4	5221	STARTED RIG DOWN PROCEDURE														305	6
5	5221	TOTAL $1309.34 FOR RETURN TRUCKING															7



Magcobar

ANNULAR FLOW DYN

WELL NAME CFSU 31-33

LOCATION Sec. 31, 25S-6W

CONTRACTOR Loffland 5

DATE 6-27-78 DEPTH

HYDRAULICS AND RHEOLOGY DATA

PUMP No. 1 D-500 SIZE 6½" x 16" @ 56

PUMP No. 2 D-500 SIZE 5½" x 16" @

Hole Size	D.P. or D.C.	Hyd. Dia.	Ann. Vel.		Ann. Shear Rate
12.5"	4.5"	8.0"	77	ft./min.	23 SEC-1
12.5"	8"	4.5"	114	ft./min.	61 SEC-1
12¼"	8"	4.25"	164	ft./min.	92 SEC-1
"	"	"		ft./min.	SEC-1

V.G. R.P.M.	DIAL	EFF. VIS.		
600	13	6.5 CPS	FUNNEL VIS.	31
300	8	8 CPS	*A.V.	
200		CPS	P.V.	5
100		CPS	Y.P.	3
6		CPS	In. Gel	2
3		CPS	10 Min. Gel	9
			Sample Temp.	105

MUD WT. 8.55 FLOWLINE TEMP.

TOTAL ANNULAR ΔP 2.87 psi E.C.D.

REMARKS 'n' = .70 'K' = 52

APL = .03 #/gal

MUD ENGINEER Ralph W. Bowie, J

Hydraulics Work Sheet

Security — DRESSER

Security Division • Dresser Industries, Inc. • P.O. Box 6504 • Houston, Texas 77005 • (713) 784-6011

OPERATOR Union Oil of California CONTRACTOR Loffland RIG NO. 5 DATE 6-27-78

WELL NAME CFSU NO. 31-33 COUNTY Millard STATE Utah

WELL DATA:

Hole size 12.5 from Surface to 1735 Drill pipe size 4 1/2 wt. 16.60 t.j. type XH length 1435

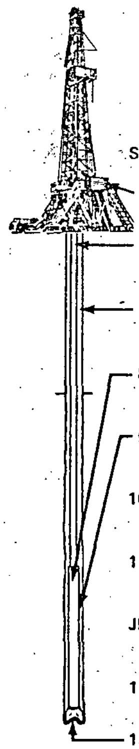
Drill collar length 300' OD x ID 8 X 2.5 Mud wt. 8.55 Min. annular velocity (drill pipe) 77

PUMP DATA:

Make EMSCO Liner size 6 1/2 X 16 / / /

Model D-500 Press. Rating 1317 / / /

SPM 56 Oper. Press. limit 1200 / / /



1. Maximum Operating Pressure (Table 1) .... 1200 psi

   Volumetric Discharge (Table 1) .... 7.64 gal/stk

2. Circulation Rate (Table 2A or 2B) .... 428 gpm

3. Annular Velocity: (a) Drill pipe (Table 3A) .... 77 ft/min

   (b) Drill collars (Table 3B) .... 164 ft/min

4. Surface Equipment Type (Table 4) 2

SYSTEM PRESSURE LOSSES:

5. Surface Equipment (Table 5) .... 54.0 psi

6. Drill Pipe Bore (Table 6): loss per 1000 ft. X length .... 75/1000 X 1735 = 130.0 psi

7. Drill Pipe Annulus (Table 7): loss per 1000 ft. X length .... 1/1000 X 1735 = 1.7 psi

8. Drill Collar Bore (Table 8): loss per 100 ft. X length .... 53/100 X 237 = 125.6 psi

9. Drill Collar Annulus (Table 9): loss per 100 ft. X length .... 1/100 X 237 = 2.4 psi

10. System pressure loss (excluding nozzles): add lines 5 thru 9 X Mud Wt./10 .... 313.7 X 8.55/10 = 268.2 psi

11. Pressure available for nozzle selection: line 1 minus line 10 X 10/Mud Wt. .... 931.8 X 10/8.55 = 1090 psi

JET NOZZLE SELECTION:

12. Jet Nozzle Size (Table 10) 14 32nd

13. Pressure loss through jet nozzles (Table 10): pressure loss X Mud Wt./10 .... 8.37 X 8.55/10 = 715 psi

14. Jet Velocity (Table 11) .... 305 ft/sec

15. Total pressure expenditure for system: (add line 10 and line 13) .... 983 psi

16. % HHp at bit: line 13/line 15 X 100: .... 715/983 X 100 = 73 %

$$\text{Actual H Power} = \frac{715 \times 428}{1714} = 178.5$$

DRESSER

4-979-2

CORROSION REPORT

DATE	6-21-78
CORROSION REPORT NO	F-14510

TO	FROM
Union Oil of California	MAGCOBAR DIVISION
	FIELD CORROSION LAB:
	~~XXXXXXXX~~ 1020 Atherton Dr., Suite C-201
(Loffland Rig 5)	CITY, STATE AND ZIP CODE: Salt Lake City, Utah 84107
SUBJECT WELL: C.F.S.U. 31-33	NUMBER: / AREA: Salt Lake
COPY TO: Harold Moss, Steve Pye	COPY TO: Dee Thomas, Jim Fox ✓, Tom Cox
COPY TO: Bernie Sansing, Ralph Bowie	COPY TO: Art Vincent, Dee Slaugh, Bob Perkins

THIS WILL CONFIRM THE CONVERSATION CONCERNING THE CORROSION RING(S) FROM THE SUBJECT WELL.

COUPON NUMBER 19341 PULLED AT A DEPTH OF 1241 (pulled 6-7-78) FT. SHOWED A CORROSION RATE OF Approx 1.4 * LB/FT²/YR. trace CARBONATE positive SULFIDE.

COUPON NUMBER ______ PULLED AT A DEPTH OF ______ FT. SHOWED A CORROSION RATE OF ______ LB/FT²/YR. ______ CARBONATE ______ SULFIDE.

COUPON NUMBER ______ PULLED AT A DEPTH OF ______ FT. SHOWED A CORROSION RATE OF ______ LB/FT²/YR. ______ CARBONATE ______ SULFIDE.

*

The measured corrosion rate on this ring was 1.7; however, at least 20% of the weight loss was due to mechanical erosion by mud solids, giving a true corrosion rate of about 1.4 $lb/ft^2/yr$. H_2S was encountered two days before this ring was pulled. Zinc carbonate has been used to treat for H_2S during drilling since that time.

Following are the conversion rates between the various units for steel coupons (specific gravity 7.86):

- mpy = 24.62 × $lb/ft^2/yr$
- mpy = 5.03 × $kg/m^2/yr$
- $lb/ft^2/yr$ = 0.04 × mpy
- $lb/ft^2/yr$ = 0.20 × $kg/m^2/yr$
- $kg/m^2/yr$ = 0.20 × mpy
- $kg/m^2/yr$ = 4.90 × $lb/ft^2/yr$

PLEASE CONTACT THE OPERATOR AND CONTRACTOR CONCERNING THIS REPORT.

SIGNED	TITLE	AREA CODE	PHONE NUMBER
Bob Perkins	Sales Engineer	801	262-9954

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Houston, Texas 77001
Bldg. 1-A, Rm. 352

OILFIELD PRODUCTS DIVISION—DRESSER INDUSTRIES INC.

F--766-A

CORROSION RING REPORT

TITE HOLE ☐ YES ☐ NO

DATE ______

OPERATOR: UNION OIL OF CALIF.	CONTRACTOR: LOFFLAND	RIG NO.: 5
ADDRESS: RIG	ADDRESS: RIG	SPUD DATE: 5-24-78
REPORT FOR MR.: HAROLD MOSS	REPORT FOR MR.: BERNIE SANSING	SECTION, TOWNSHIP, RANGE: 33-25S-6W.

WELL NAME AND NO.: C.F.S.U. 31-33	FIELD OR BLOCK NO.: W/C	COUNTRY, PARISH, OR OFFSHORE AREA: MILLARD	STATE OR PROVINCE: UTAH

OPERATION		CASING	MUD VOLUME (BBL)	CIRCULATION DATA	
PRESENT ACTIVITY		SURFACE 20 IN. AT 280 FT.	HOLE / PITS	PUMP SIZE 5½ X 16 IN.	ANNULAR VEL. (FT./MIN.) OPPOSITE DP 50
SIZE (IN.) ½	NO.	INTERMEDIATE IN. AT FT.	TOTAL CIRCULATING VOLUME 870	PUMP MAKE EMSCO MODEL D-500	OPPOSITE COLLAR 59
DRILL PIPE SIZE 4½	TYPE XH	PRODUCTION OR LINER IN. AT FT.	IN STORAGE	BBL/STROKE / STROKE/MIN.	CIRCULATING PRESSURE PSI 1000
DRILL COLLAR SIZE 7"	LENGTH	MUD TYPE GEL & WATER		BBL/MIN.	BOTTOMS UP (MIN.) / SYSTEM TOTAL (MIN.)

SAMPLE FROM ☐ FLOWLINE ☐ PIT

FLOWLINE TEMPERATURE ______ °F

MUD PROPERTIES	INSERT COUPON	REMOVE COUPON
Time Sample Taken		1100
Depth (ft.)		
Weight ☒ (ppg) ☐ (lb./cu. ft.)		8.6
Mud Gradient (psi/ft.		
Funnel Viscosity (sec./qt.) API at ______ °F		34
Plastic Viscosity cps at ______ °F		8
Yield Point (lb./100 sq. ft.)		1
Gel Strength (lb./100 sq. ft.) 10 sec./10 min.	/	2/3
pH ☒ Strip ☐ Meter		11.5
Filtrate API (ml./30 min.)		16
HP-HT Filtrate (ml/30 min.) ______ °F		—
Cake Thickness 32nd in. API ☒ HP-HT ☐		2
Alkalinity, Mud (Pm)		1.1
Alkalinity, Filtrate (Pf/Mf)	/	.6/.9
Salt ☐ ppm ☐ gpg Chloride ☒ ppm ☐ gpg		400
Calcium ☒ ppm ☐ Gyp (ppb)		40
Sand Content (% by Vol.)		TR
Solids Content (% by Vol.)		2.4
Oil Content (% by Vol.)		—
Water Content (% by Vol.)		97.6
Methylene Blue Capacity ☐ (ml/ml mud) ☐ (equiv. #/bbl. bent.)		
Sulfides ☐ ppm Phosphate ☐ ppm		
Sulfite Residual ☐ ppm		

CORROSION RING DATA

COUPON NUMBER: 19341 4½ FH K=207

INSTALL DATE 6-1-78 TIME 6:00 P.M.

REMOVE DATE 6-7-78 TIME 10:00 A.M.

HOURS 136 NO. DAYS 5½

INSTALL DEPTH (ft.) 280

REMOVE DEPTH (ft.) 1241

LOCATION IN DRILL STRING-DEPTH

KELLY SUB: CHANGE OVER: ✓

INHIBITOR ADDED: NONE

TUBING STRING	DRILL STRING	PITTED	SCALE	RUSTED
☐	☐	☐	☐	☐

COUPON SIZE (circle one) 3 3½ (4½) 5 5½ INCHES I.F. E.H. (F.H.)

PIN OR BOX FAILURE

OTHER 138.9280

GRADE DRILL PIPE

PLASTIC COATED ☐ YES ☐ NO

CORROSION TEST REPORT

COUPON CORROSION RATE APPROX 1.4 * lb./ft.²/yr.

Fe S	CO_3		TYPE	DEGREE
+ −	+ −	MECHANICAL DAMAGE ☐	GENERAL ☐	LOW ☒
+	TR	SCALE TR ☒	LIGHT ☐	MODERATE ☐
		☐	PITTING ☐	RATHER HIGH ☐
		☐	LOCALIZED ☒	SEVERE ☐

BY BOB PERKINS

REMARKS—Give operation depth and nature of any problems encountered

☐ Drilling @ 138.9280 g
☐ Salt Water flow @ 137.7841 g
☐ Gas kick @ 1.1439 × 207
☐ Stuck pipe @ 136 hrs. = 1.7*
☐ Tight hole @
☐ Sloughing Shale @
☐ Lost Returns @

MUD TREATMENT: GEL, CAUSTIC, TANNATHIN

* AT LEAST 20% OF THE WEIGHT LOSS WAS DUE TO EROSION BY MUD SOLIDS. THE ACTUAL CORROSION RATE WAS APPROX. 1.4 lb/ft²/yr. or LESS.

ENGINEER RALPH BOWIE

PHONE

ADDRESS

CITY

PRINTED IN U.S.A.

THIS REPORT IS SUBJECT TO THE TERMS AND CONDITIONS AS SET FORTH ON THE REVERSE SIDE

☐ C[illegible]SIO[illegible] [illegible]OUP[illegible] BOX [illegible] HO[illegible]N, T[illegible] 770[illegible]
☐ FIELD CORROSION LAB. ______ CITY ______

Magcobar
DRILLING FLUID SERVICES
OILFIELD PRODUCTS GROUP–DRESSER INDUSTRIES INC.

COMPOSITE
CORROSION RING REPORT

TITE HOLE ☐ YES ☐ NO

NUMBER

Page

PM-1017

OPERATOR: UNION OIL CO. OF CALIFORNIA	SURVEY SEC. 33 T 25 S. R 6 W	SURFACE CASING SIZE 20"	DEPTH 280'	BIT SIZE	
WELL: C.F.S.U. 31-33	FIELD: WILDCAT	INTERMEDIATE CASING SIZE 13 3/8"	1735'		
CONTRACTOR: LOFFLAND BROS. – RIG #5	COUNTY: MILLARD				
ENGINEER: RALPH BOWIE	STATE: UTAH				

PLASTIC COATED ☐ YES ☐ NO

MUD TYPE ______

COUPON NUMBER	DEPTH INSTALL / REMOVE	1978 DATE	WEIGHT	FUNNEL VISCOSITY	PV	YP	GELS		pH	A.P.I. F.L. (CC)	Pf/Mf	Cl PPM.	Ca. PPM.	SO_3 ppm	ppm	NO. DAYS	LB./FT.²/YR.	MUD TREATMENT
19341	280	6-1														5½	1.4	TR. CO_3 (X-O SUB) GEL,
	1241	6-7	8.6	34	8	1	2	3	11.5	16.0	.6/.9	400	40					CAUSTIC, TANNATHIN
479	1734	6-25	8.5	30	3	3	3	5	12.5	55.0	1.9/2.3	650	<40			2	0.2	TR. CO_3 (X-O SUB)
	2019	6-27	8.6	31	5	3	2	9	11.3	33.0	.8/1.3	700	<40					
708	2941	7-3	AERIATED WATER						11.7	MECH. DAMAGE – ACTUAL						2	42.78	(X-O) SCALES: $CaCO_3$, IRON
	3728	7-5							10.7	RATE > 30 lb/FT²/YR.								CARBONATE, MAGNETITE
1768	3728	7-5	AERIATED WATER						10.7							2½	8.01	(X-O) SCALE – SAME AS #708
	4570	7-8							11.7		1.5/1.9	5250	<40					
19326	3728	7-5	AERIATED WATER						10.7							2½	8.42	(TOP X-O SUB) SAME SCALES
	4540	7-8							11.7		1.5/1.9	5250	<40					
470	4540	7-8	AERIATED WATER						11.7		1.5/1.9	5250	<40			2½	8.01	(X-O) IRON CARBONATE,
	4828	7-11							11.0									MAGNETITE, FeS.
1767	4828	7-11							11.0							2½	7.48	(X-O)
	5009	7-13							11.0									

DATE SPUD: 5-24-78 DATE T.D.: 7-18-78 B.H.T.

M-979-2

DRESSER

CORROSION REPORT

DATE: 6-21-78

CORROSION REPORT NO: F-14510

TO: Union Oil of California

(Loffland Rig 5)

FROM: MAGCOBAR DIVISION

FIELD CORROSION LAB:

XXXXXXX 1020 Atherton Dr., Suite C-201

CITY, STATE AND ZIP CODE: Salt Lake City, Utah 84107

SUBJECT WELL: C.F.S.U. 31-33

NUMBER:

AREA: Salt Lake

COPY TO: Harold Moss Steve Pye

COPY TO: Bernie Sansing Ralph Bowie

COPY TO: Dee Thomas Jim Fox Tom Cox

COPY TO: Art Vincent Dee Slaugh Bob Perkins

THIS WILL CONFIRM THE CONVERSATION CONCERNING THE CORROSION RING(S) FROM THE SUBJECT WELL.

COUPON NUMBER 19341 PULLED AT A DEPTH OF 1241 (pulled 6-7-78) FT. SHOWED A CORROSION RATE OF Approx 1.4 * $LB/FT^2/YR.$ trace CARBONATE positive SULFIDE.

COUPON NUMBER ______ PULLED AT A DEPTH OF ______ FT. SHOWED A CORROSION RATE OF ______ $LB/FT^2/YR.$ ______ CARBONATE ______ SULFIDE.

COUPON NUMBER ______ PULLED AT A DEPTH OF ______ FT. SHOWED A CORROSION RATE OF ______ $LB/FT^2/YR.$ ______ CARBONATE ______ SULFIDE.

*

The measured corrosion rate on this ring was 1.7; however, at least 20% of the weight loss was due to mechanical erosion by mud solids, giving a true corrosion rate of about 1.4 $lb/ft^2/yr$. H_2S was encountered two days before this ring was pulled. Zinc carbonate has been used to treat for H_2S during drilling since that time.

Following are the conversion rates between the various units for steel coupons (specific gravity 7.86):

mpy =	$24.62 \times lb/ft^2/yr$
mpy =	$5.03 \times kg/m^2/yr$
$lb/ft^2/yr$ =	$0.04 \times$ mpy
$lb/ft^2/yr$ =	$0.20 \times kg/m^2/yr$
$kg/m^2/yr$ =	$0.20 \times$ mpy
$kg/m^2/yr$ =	$4.90 \times lb/ft^2/yr$

PLEASE CONTACT THE OPERATOR AND CONTRACTOR CONCERNING THIS REPORT.

SIGNED: Bob Perkins

TITLE: Sales Engineer

AREA CODE: 801

PHONE NUMBER: 262-9954

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DRESSER

CORROSION REPORT

DATE	CORROSION REPORT NO.
	F-14516

4-979-2

TO	FROM
Union Oil Co.	MAGCOBAR DIVISION
	FIELD CORROSION LAB:
	XXXXXX 1020 Atherton Dr., Suite C-201
(Loffland Rig 5)	CITY, STATE AND ZIP CODE: Salt Lake City, Utah 84107
SUBJECT WELL: C.F.S.U. 31-33	NUMBER: / AREA: Salt Lake
COPY TO: Harold Moss, Steve Pye	COPY TO: Dee Thomas, Jim Fox, Tom Cox
COPY TO: Bennet Smith, Ralph Bowie	COPY TO: Art Vincnet, Dee Slaugh, Bob Perkins

THIS WILL CONFIRM THE CONVERSATION CONCERNING THE CORROSION RING(S) FROM THE SUBJECT WELL.

COUPON NUMBER 479 PULLED AT A DEPTH OF 2019 pulled 6-27-78 FT. SHOWED A CORROSION RATE OF 0.2 LB/FT²/YR. trace CARBONATE negative SULFIDE.

COUPON NUMBER 708 PULLED AT A DEPTH OF 3728 pulled 7-5-78 FT. SHOWED A CORROSION RATE OF 42.78 LB/FT²/YR. positive CARBONATE negative SULFIDE.

COUPON NUMBER 1768 PULLED AT A DEPTH OF 4570 FT. SHOWED A CORROSION RATE OF 8.01 LB/FT²/YR. positive CARBONATE negative SULFIDE.

Ring #708 was run after switching to air drilling with water injection. Ammonia, caustic, and Unisteam were used for corrosion control during this interval. Some of the weight loss on ring #708 was due to mechanical damage. The actual corrosion rate was estimated to be something over 30 $lb/ft^2/yr$. During the run of ring #1768, sodium nitrite and caustic were used for corrosion control. Both #708 and #1768 were scaled with calcium carbonate, iron carbonate, and Magnetite.

Following are the conversion rates between the various units for steel coupons (specific gravity 7.86):

mpy = 24.62 × lb/ft²/yr
mpy = 5.03 × kg/m²/yr
lb/ft²/yr = 0.04 × mpy
lb/ft²/yr = 0.20 × kg/m²/yr
kg/m²/yr = 0.20 × mpy
kg/m²/yr = 4.90 × lb/ft²/yr

PLEASE CONTACT THE OPERATOR AND CONTRACTOR CONCERNING THIS REPORT.

SIGNED	TITLE	AREA CODE	PHONE NUMBER
Bob Perkins	Sales Engineer	801	262-9954

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DRESSER

M-979-2

CORROSION REPORT

DATE:

CORROSION REPORT NO. F-14536

TO: Union Oil Co.

(Loffland Rig 5)

FROM: MAGCOBAR DIVISION

FIELD CORROSION LAB:

XXXXXX 1020 Atherton Dr., Suite C-201

CITY, STATE AND ZIP CODE: Salt Lake City, Utah 84107

SUBJECT WELL: C.F.S.U. 31-33

NUMBER:

AREA: Salt Lake

COPY TO: Harold Moss Steve Pye

COPY TO: Bennet Smith Ralph Bowie

COPY TO: Dee Thomas Jim Fox Tom Cox

COPY TO: Art Vincent Dee Slaugh Bob Perkins

THIS WILL CONFIRM THE CONVERSATION CONCERNING THE CORROSION RING(S) FROM THE SUBJECT WELL.

COUPON NUMBER 19326 PULLED AT A DEPTH OF 4540 FT. (pulled 7-8-78) SHOWED A CORROSION RATE OF 8.42 LB/FT²/YR. positive CARBONATE negative SULFIDE.

COUPON NUMBER 470 PULLED AT A DEPTH OF 4828 FT. (pulled 7-11-78) SHOWED A CORROSION RATE OF 8.01 LB/FT²/YR. positive CARBONATE positive SULFIDE.

COUPON NUMBER 1767 PULLED AT A DEPTH OF 5009 FT. (pulled 7-13-78) SHOWED A CORROSION RATE OF 7.48 LB/FT²/YR. positive CARBONATE negative SULFIDE.

Rings #19326 and #1767 were scaled with Iron Carbonate, Calcium carbonate, and Magnetite. #470 had small amounts of FeS on its surface - an indication of H_2S in the system. #470 was also scaled with Iron Carbonate and Magnetite.

Following are the conversion rates between the various units for steel coupons (specific gravity 7.86):

- mpy = 24.62 × lb/ft²/yr
- mpy = 5.03 × kg/m²/yr
- lb/ft²/yr = 0.04 × mpy
- lb/ft²/yr = 0.20 × kg/m²/yr
- kg/m²/yr = 0.20 × mpy
- kg/m²/yr = 4.90 × lb/ft²/yr

PLEASE CONTACT THE OPERATOR AND CONTRACTOR CONCERNING THIS REPORT.

SIGNED: Bob Perkins

TITLE: Sales Engineer

AREA CODE: 801

PHONE NUMBER: 262-9954

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UNION 76

To:	Mr. G. W. Hendricks Mr. D. L. Ash	Memo:	E&PP 78-110M
From:	D. S. Pye W. C. Allen	Date:	August 29, 1978
Division:	Exploration & Production Research	Project:	638-18810 638-67226
Subject:	CORROSION CONTROL ON CFSU #31-33, LABORATORY TESTS AND FIELD RESULTS	Supervisor:	R. F. Krueger

cc: Library (2)
Patent

Carl Cron
M. M. Ellis
R. O. Engebretsen
P. W. Fischer
D. E. Pyle

During the drilling of CFSU #42-7, corrosion was recognized as a severe problem during aerated water drilling, and various chemical methods of inhibition were attempted. Unfortunately, the problem did not respond to any of the treatments, and the drill pipe was severely damaged. During the time lapse between the completion of CFSU #42-7 and the drilling of CFSU #31-33, various methods of corrosion control were studied in the laboratory, and the most practical method was selected for use during the drilling of CFSU #31-33. This report summarizes the laboratory studies and the field test in CFSU #31-33.

<u>CORROSION WAS REDUCED, BUT NOT CONTROLLED WITH SODIUM NITRITE ($NaNO_2$) AND CAUSTIC - DEVELOPMENT OF AN INERT GAS SYSTEM IS RECOMMENDED</u>

Our laboratory studies showed that using sodium nitrite ($NaNO_2$) and maintaining a high pH with caustic was the most cost effective of the corrosion control methods that would be available by the time well CFSU #31-33 was drilled. This method effectively reduced the corrosion rate while drilling this well from 43 lbs/ ft^2/yr (obtained with a standard inhibitor system) to 8 lbs/ft^2/yr. However, this corrosion rate is still unacceptably high (allowable rates are 2#/ft^2/yr), especially since this oxygen corrosion problem forms pits which accelerate drill pipe damage far beyond what would occur if the corrosion occurred uniformly. Consequently, 33 joints of drill pipe were downgraded at the end of this well due to corrosion pits, even though we spent over $68,000 on chemicals to control this corrosion. However, we have estimated that 120 joints would have been downgraded, and fishing jobs would have resulted* had we allowed the corrosion to continue at the 43 lb/ft^2/yr rate.

There are a number of possible explanations for the higher corrosion rates and the drill pipe loss. They are listed below from the most probable cause to the least probable cause:

1) Loss of pH in the return fluid due to CO_2 stripping, formation water dilution, and reaction with drill cuttings.

2) Reduced inhibitor effectiveness caused by both the concentration and type of dissolved solids in the drilling fluid.

3) Inability to maintain the desired pH and $NaNO_2$ concentrations 100% of the time due to occasional system upsets.

Since 1 and 2 are not usually controllable in a drilling operation, we will be unable to economically control corrosion with chemical inhibitors in many cases, and we will not be able to predict ahead of time when or if corrosion can be controlled.

Consequently, we believe that a more universally usable system should be developed. The one that appears most economically feasible at this time is the use of combustion gas, and we recommend that a commercial system be developed and tested as soon as possible.

CHEMICAL TREATMENT FOR OXYGEN CORROSION DURING THE AERATED DRILLING OF CFSU WELL #31-33

Well CFSU #31-33 was drilled without using air assist down to 2019 feet, and air assist was initiated at this point. The initial corrosion control program consisted of maintaining a pH at the suction in excess of 11, and injecting approximately 2000 ppm of Unisteam (a proprietary corrosion inhibitor) and 2000 ppm of concentrated NH_4OH. This was a program which had been used successfully in another area, and we wanted to utilize this method until the corrosion rates justified converting to the sodium nitrite ($NaNO_2$) method which would be much more costly.

The corrosion ring data for the aerated portion of this well is summarized in TABLE 1. The portion of the hole from 2019 to 3728 used the Unisteam, NH_4OH, caustic system. Corrosion was fairly well controlled by this system from 2019 to 2920, but went completely out of control in the interval from 2941 to 3728. The sodium nitrite program was instituted at 3728, and markedly reduced the corrosion rates (from 43 to 8#/ft^2/yr). However, the corrosion rates (8#/ft^2/yr) were still well above the acceptable limit of 2#/ft^2/yr.

POSSIBLE REASONS WHY THE CORROSION RATE DID NOT REACH ACCEPTABLE LEVELS

There are two possible reasons why the corrosion rates were not reduced to acceptable levels:

1. Upset conditions which allowed the concentrations of $NaNO_2$ and/or pH to drop below the critical level part of the time.

2. Differences between the chemical composition of the drill water in CFSU #31-33 and the test solutions used in the laboratory. The differences made the corrosion problem more severe in CFSU #31-33.

TABLES 2 and 3 list data from monitoring and chemical analyses of the drilling fluid during drilling.

Although we did not have a continuous monitor of $NaNO_2$ concentration, estimates made from TABLE 2 would indicate that the $NaNO_2$ concentration at the suction line was below 1.5 lbs/bbl, 7% of the time during bit run 1 (7/5-7/8) and 0% of the time during bit run 2 (7/8-7/11). We did have a continuous monitor on pH, which indicated the pH at the suction was below 10.0, 2% of the time during bit run one and 6% of the time during bit run 2. The return pH was below 10, 100% of the time, and the return $NaNO_2$ concentrations were below 1.5, 50% of the time during bit run 1 and 0% of the time during bit run 2. Although having the concentrations below the desired amounts part of the time may be partly responsible for the higher corrosion rates, the large quantities of totally dissolved solids (TDS) and chloride ion (Cl^-) content were more likely candidates . As shown in TABLE 3, the TDS was as high as 10,000 ppm. A total analysis was not made as frequently as Cl^- analysis, and TABLE 2 shows a maximum Cl^- concentration of 5500 ppm. This was considerably higher than the concentrations in CFSU #42-7 which reached a maximum TDS of 9,400 ppm and Cl^- concentration of 2450 ppm.

Since the literature indicates[2,3] that an increase in Cl^- is one of the primary problems in controlling oxygen corrosion, we increased the $NaNO_2$ concentration, but without knowing how high we should go to achieve control. From the corrosion rates observed, one might conclude that we did not go high enough, or that $NaNO_2$ will not be able to control the corrosion in the presence of the dissolved salts encountered in the drill water in CFSU #31-33.

One of the major problems in controlling the corrosion was the inability to control or maintain a high pH in the returning fluid as shown in TABLE 2. Although we were able to obtain reasonable concentrations of $NaNO_2$ in the return fluid, the pH was always below that required for adequate inhibition. There are a number of probable causes for this pH reduction.

1) dilution with formation water

2) reaction with drill cuttings

3) reaction with gas (primarily CO_2) produced from the well.

Based on the observed reductions in $NaNO_2$ concentrations, dilution with formation waters would not be adequate to explain the pH reductions encountered, but it is undoubtedly responsible for part of it. Reaction with the drill cuttings is an unknown. Reaction with CO_2 is a definite possibility since the produced CO_2 concentrations were high, but both the CO_2 effect and the reactions with the cuttings are difficult to quantify.

From these data (TABLE 2), we know the pH in the return fluid was always below that required for inhibition at the surface, and was almost always high enough to achieve inhibition at the bit (since no loss in pH should occur going down the drill pipe). What we don't know is the pH profile in the annulus, and where the pH dropped below the critical point. Consequently, we don't know how severe the corrosion problem was on the outside of the drill pipe, because our coupon measurements were all made on the inside of the drill pipe where the pH is controlled. As will be seen in the next section, the damage to the drill pipe exceeded that which would be expected from the average metal loss determined from the coupons, and an increase in exterior corrosion due to low pH would be one of two plausible explanations for this difference. The other explanation involves the difference between an average metal loss (uniform over the surface area as calculated from the coupons) compared to the metal loss being concentrated over a smaller pitted area. Pitting is characteristic of oxygen corrosion.

DRILL PIPE LOSS AND ECONOMICS

At the end of this well, 33 joints of pipe were downgraded due to pitting caused by corrosion (TABLE 4). We estimated that 120 joints would probably have been lost if the $NaNO_2$ inhibitor procedure had not been used. Since approximately $68,000 in chemicals were used in this corrosion control attempt, the cost is about at the break-even point compared to purchasing drill pipe. However, the damage would have been so severe on some of the drill pipe (2 joints went to junk as it is) that failures of the drill string (fishing jobs) probably would have occurred, along with damage to the casing. Because of the possibility of fishing jobs and casing damage, the corrosion control costs were economic, but large increases in chemical costs beyond what was spent on this well would probably not be justified.

ESTIMATING DRILL PIPE LOSS FROM COUPON RESULTS, AND A COMPARISON TO ACTUAL DRILL PIPE DAMAGE ENCOUNTERED

TABLE 5 shows the number of joints that would experience a given thickness reduction, both for the present well CFSU #31-33 and the last well CFSU #42-7.

TABLE 4 shows the amounts of drill pipe that were downgraded for each well.

Comparing TABLE 4 and TABLE 5, drill pipe was downgraded when the average metal loss exceeded about 9 mils in CFSU #42-7, and 12 mils in CFSU #31-33. When drill pipe is downgraded on the basis of pitting, the transition between premium and grade II is specified as approximately a 70 mil loss from nominal thickness, the transition between grade II and grade III occurs with approximately a 120 mil loss from nominal thickness and the transition from grade III to junk occurs with approximately a 155 mil loss from nominal thickness. Since the drill pipe was downgraded at an average loss between 10 and 12 mils, either the pitting was very severe, or the coupons do not accurately reflect the corrosion rate on the exterior of the pipe. What has actually occurred is probably a combination of both explanations, but oxygen corrosion is a pitting type corrosion, and it would not be unreasonable to expect that the majority of the average metal loss was actually occurring over only 15% of the surface area, which would explain the amount of drill pipe lost when only a 10 to 15 mils average metal loss occurred.

One final uncertainty should be noted from TABLE 1. The corrosion rates based on air time decreased significantly when $NaNO_2$ was introduced, but climbed when the air time/total time was reduced. This indicates there are other factors contributing to corrosion besides oxygen, and that some corrosion rate exists (2-4#/ft^2/yr) even with no oxygen present. This assumes that no oxygen was present when air was not injected, because an oxygen scavenger was used during these times. However, these rates may also be due to an inefficiency in the oxygen scavenger, as we didn't measure residual oxygen contents, and there may still have been residual oxygen present.

THE CORROSION PROBLEM INCREASES IN SEVERITY WHEN AERATED WATER IS USED AS THE DRILLING FLUID

Oxygen corrosion is a problem in almost all drilling operations. Normally the oxygen is present in only small quantities due to oxygen in the air dissolving in the drilling fluid at ambient conditions, and corrosion is normally curtailed by removing the oxygen from the drilling fluid by either chemical or mechanical means.

When well conditions dictate that air be injected with the drilling fluid, then oxygen is present in solution in large quantities due to the increased solubilities of oxygen at the elevated pressures that exist downhole. Neither chemical nor mechanical removal systems are operable under these circumstances, and inhibitors must be used. An inhibitor in this case is defined as a chemical which prevents the oxygen from reaching or reacting with the surface of the pipe, but does not remove the oxygen from the drilling fluid.

CORROSION CONTROL OPTIONS THAT WERE CONSIDERED, AND THE LABORATORY TESTING OF PROMISING SOLUTIONS

Numerous methods of controlling corrosion were considered. Candidates were rejected based on:

2) Availability - the method had to be operational for the drilling of CFSU #31-33.

3) Ease of Use - The method had to be safe as far as personnel hazards and the environment.

4) Wide Range Tolerance - Since the conditions (temperature, pressure, chemical composition of the water, etc.) were expected to vary widely, the method should not be overly sensitive to these changes.

Non-Oxygen Containing Gases

One certain way of preventing oxygen corrosion is to use a non-oxygen containing gas to replace air as the gas phase in the drilling system. Three candidates were considered: natural gas, nitrogen, and combustion gas.

Natural gas was discarded because:

1. It is not readily available.

2. It represents a potential personnel hazard.

3. It is costly.

Nitrogen was discarded because:

1. Its cost would exceed the value of the drill pipe.

2. It was marginal whether an adequate continuous supply of the required volume could be maintained.

This left combustion gas. Combustion gas is readily available from the diesel engines on the rig (no cost), and it is not hazardous to handle. However, it does contain oxides of carbon, sulfur and nitrogen, residual hydrocarbons and unreacted oxygen. Therefore, it requires treatment to make it a truly non-oxygen containing gas. It also requires treatment before it can become a tolerable charging gas for compressors. (The gas used in these drilling systems must be compressed up to 800 psi in order to be injected into the drilling fluid.) The effect of the acid gas components must be negated, or they will cause mechanical problems with the compressors. Although the technology for this system is theoretically available, no such system now exists, and there was no way to build an operating system within the allowable time frame.

Consequently, we were again forced to rely on chemical inhibition for corrosion control.

Chemical Corrosion Inhibitors

TABLE 6 summarizes the results of our laboratory inhibitor studies. Since we are not reproducing the field system in the laboratory, these corrosion rates should be compared relatively and not assumed to be the exact rates we would expect to find in the field. There are a number of interesting observations which can be made from these data.

First, the concentrations required to achieve inhibition are many orders of magnitude above the concentrations the literature indicates is applicable[2]. However, the drilling fluid used in these tests was simulated from an analysis of the waters present in CFSU #42-7, and these waters contain dissolved solids, including chloride salts. The literature[2] does show that inhibitor effectiveness is reduced, and concentrations must be raised when chlorides are present, but the concentrations found in the literature are still well below those we found required in our test work.

Consequently, we can conclude that none of the chemical inhibitors will pass our fourth criteria, wide range tolerance, because they are sensitive to drilling water composition which we know will fluctuate from past experience. However, since use of chemical inhibitors is the only viable method at this time, we designed the concentrations to provide inhibition under the worst conditions encountered in CFSU #42-7. Unfortunately, this turned out to cause problems, because the conditions in CFSU #31-33 were more severe than the worst conditions in CFSU #42-7.

Sodium nitrite was selected as the inhibitor for the field test, based on the data in TABLE 6. This conclusion is also supported by data that Dresser Industries obtained for us in their test system which is entirely different[4].

Of the other candidates:

1) Amines were eliminated because they were not effective at practical concentration levels.

2) Chromates were eliminated because they create environmental problems, and they are not cost effective compared to nitrites.

3) Caustic (high pH) was eliminated because it causes personnel hazards. At pH levels exceeding 13, chemical burns will result from even short duration skin contact.

4) Silicates were eliminated because:

   a) they resulted in an increase in the corrosion when an under-treated condition existed

   b) very high concentrations were required

   c) they are difficult to handle

   d) they may cause unknown precipitation problems.

LABORATORY TESTS ON SODIUM NITRITE ($NaNO_2$)

Once $NaNO_2$ was selected as candidate inhibitor, more extensive tests were conducted to define the important parameters which control its effectiveness. Unfortunately, there was insufficient time to do all the desired test work prior to drilling CFSU #31-33. The important parameters are:

1) The composition of the drilling fluid, which was set at the worst conditions encountered in CFSU #42-7 for these tests.

2) The concentration of the NO_2^- ion.

3) The pH of the drilling fluid (the OH^- ion concentration).

TABLE 6 and FIGURE 1 show the results of the data we accumulated on NO_2^- concentration and pH. These indicate that a minimum specification would be a concentration of 1.5 #/bbl $NaNO_2$ and a pH of 10.0.

However, due to the shape of the corrosion rate versus concentration curves, an adequate margin of safety must be incorporated. The data show that the corrosion is either controlled, or proceeding at an extremely rapid rate. Since there will be concentration fluctuations due to system variations and upsets, the target concentration must be high enough to allow the fluctuations to occur without the minimum concentrations falling below the crucial level. Consequently, the initial target concentrations were set at 2.6 lbs/bbl $NaNO_2$ and 11.5 pH.

More testing is needed and should be done before nitrite is used as an inhibitor again. The concentrations of the dissolved solids, NO_2^-, and OH^- are all interrelated. We should develop a ternary diagram defining the concentrations of OH^- and NO_2^- which result in effective inhibition in drilling fluids with various dissolved solids contents. We currently only have sufficient data to define one point on this curve.

REFERENCES

1. Letter from H. E. Mallory of Loffland Brothers Company, Tulsa, Oklahoma to Stephen Pye, Union Oil Company, Brea, California, dated August 21, 1978.

2. M. J. Pryor and M. Cohen, "The Inhibition of the Corrosion of Iron by Some Anodic Inhibitors", Jo. of the Electrochemical Society, Vol. 100, No. 5, 205 (1953).

3. O. L. Riggs, Jr., J. D. Sudbury and Merle Hutchison, "Effect of pH on Oxygen Corrosion at Elevated Pressures", Corrosion-National Association of Corrosion Engineers, Vol. 16, 94 (June 1960).

4. Letter from Tom Cox of Dresser Industries, Houston, Texas to Stephen Pye, Union Oil Company, Brea, California, dated June 21, 1978.

Stephen Pye

TABLE 1

CORROSION COUPON TEST RESULTS

In Date	In Time	Out Date	Out Time	Depth in	Depth out	Original Weight grams	Final Weight, grams	Total Hours	Corrosion Rate, lb/sq.ft./yr	Remarks	Time Spent Drilling (including connections) with air	Time Spent Drilling (including connections) without air	Trip	Other	Corr Rate B on Ai Injec Tin
6/28	2200	7/1	2000	2019	2920	138.3556	136.8368	70	4.49	$CaCO_3$, $FeCO_3$ magnitite light pitting	62.0	–	6	2	4.8
7/3	1030	7/5	1620	2941	3728	135.8783	123.9178	54.8	42.78	Mechanical damage Same scale	45.5	0	9.3	0	51.5
7/5	1630	7/8	0800	3728	4540	133.2101	130.6132	63.5	8.02	Same scale	48	0	16	0	10.6
7/5	1930	7/8	0800	3728	4540	137.6394	135.1797	60.5	8.42	Same scale	48	0	12.5	0	10.6
7/8	1300	7/11	0200	4540	4828	135.6897	133.1959	61	8.01	FeS, other scale the same	25 3/4	0	27	8 1/4	19.0
7/11	0200	7/13	1600	4828	5009	133.6703	131.3051	62	7.48	Same scale	5	9	22	26	92.7
7/14	1400	7/18	1000	5009	5221	134.2887	133.7432	92	1.16	$CaCO_3$--no air injection during this time, drill pipe pulled in casing during "other".	0	30	30.5	31.5	∞

CHEMICAL MONITORING OF THE DRILLING FLUID

			$NaNO_2$ Concentration, pounds/barrel		pH		Cl^- Concentration, ppm		
Date	Time	Depth	Suction	Returns	Suction	Returns	Suction	Returns	Remarks
7/5	2100		3.6		12				
	2220		3.8						
	2230				11.8				
	2300		2.04		11.1				
	2330		2.82	1.08	11.2	7.8			
	2400		1.74	1.26	10.7	7.9			
7/6	0030		1.80	1.68	11.4	7.8			
	0100		2.28		11.4				
	0130		2.58	1.02	11.5	8.3			
	0200		2.82		11.4				
	0230		1.92	1.02	11.1	7.9			
	0300		2.52		11.3				
	0400		3.00		11.6				
	0430			2.04		7.8			
	0500		3.54		11.7				No returns.
	0600		2.10		11.8				
	0700		1.74		10.5				Tripping jet sub.
	1200		1.38	1.56	11.4	7.4			Intermittent returns.
	1300		3.24		11.0				
	1400		3.78		12.1				
	1500		1.98		11.8		1000		
	1550			1.92		8.1		2500	
	1600		3.6		11.7		600		
	1700		0.6		11.7				
	1800		2.91		11.5				
	1815								Started injecting ammonia
	1900		1.5		11.4				
	1915			1.38		8.1		1750	
	1940			0.96		7.6		2600	
	1950			1.20		7.7		3000	
	2005			1.05		7.8		3300	
	2015		2.16	1.05	11.0	7.9	2000	3500	
	2100		1.80	0.75	10.0	7.4	2700	3800	
	2130		2.4	1.26	11.2	8.0	3100	4600	
	2200		2.4	1.65	11.0	8.5	3400	4300	
	2300		2.1	1.20	11.1	8.1	3700	4800	
	2400	4073	2.25	1.35	10.9	7.4	3800	4600	
7/7	0100	4096	2.43	1.86	11.2	8.3	3300	3800	Two compressors on
	0200	4107	3.00	2.40	11.5	10.4	3400	3500	at 0145.
	0300	4125	2.85	1.65	10.6	8.6	3500	4000	
	0400	4136	2.70		11.0		3900		One compr. at 0400.
	0430	4148		1.35		8.2		4400	
	0500	4158	2.85	1.05	11.4	8.5	3800	4600	Two compressors
	0600	4172	2.46	2.25	11.6	9.6	3600	4100	at 0530.
	0700	4196	2.58	1.65	11.5	8.8	3900	4200	
	0800	4215	3.00	1.59	10.5	8.8	3900	4400	
	0900	4237	3.45	2.01	11.0	8.8	4150	4450	
	1000	4255	3.78	1.80	10.8	8.6	4200	4800	
	1100	4269	2.10	1.26	10.8	8.3	4500	5250	
	1200	4293	2.61	1.56	10.7	8.9	4500	5000	
	1300	4309	3.00	1.80	10.3	8.6	5000	4350	
	1400	4325	3.30	1.35	11.0	8.6	4500	5500	
	1500	4340	3.51	1.95	11.3	8.7	4340	4750	
	1600	4350	3.33	1.44	11.6	9.0	4450	4750	
	1700	4382	3.45	1.50	10.8	9.0	5200	5300	
	1800	4397	2.88	1.80	10.4	8.5	5000	5200	
	1900	4422	2.94	1.56	11.1	8.9	4900	5100	
	2000	4436	3.00	1.68	11.2	9.0	5000	5100	
	2100	4460	2.58	1.50	11.8	8.5	5400	5300	
	2200	4481	2.64	1.56	11.5	8.7	5300	5200	
	2300	4491	2.25	1.20	12.4	8.6	5300	5100	

TABLE 2
(Continued)

Date	Time	Depth	$NaNO_2$ Concentration, pounds/barrel Suction	Returns	pH Suction	Returns	Cl^- Concentration ppm Suction	Returns	Remarks
7/8	0100	4531	3.30	1.26	11.7	8.5	5100	5300	
	0200	4544	3.24	1.35	11.5	8.6	5150	5200	Trip--33 stands looked all right, no magnitite. 32 stands and the drill collars looked bad with magnitite growth.
	1730		3.63		11.4		4700		
	1800		3.69		11.6		4600		
	1900		3.9	1.05	11.2	8.3	5000	5100	
	2000		3.69	1.20	11.4	8.4	4900	5300	Pipe stuck about 30 minutes.
	2100	4544	3.45	1.59	11.2	8.3	4800	5150	
	2200		2.94		11.4		4950		
	2300		3.69		10.8		5050		
	2400	4580	3.57	1.74	11.2	8.9	5200	5300	
7/9	0100	4600	3.69	1.92	11.5	9.1	5100	5300	
	0200	4610	3.60	2.10	11.6	9.4	5000	5200	
	0300	4635	3.63	1.65	12.8	9.1	5200	5350	Trip
	1200	4635	3.6		11.6		4900		
	1300	4670	4.41	2.46	11.6	9.5	4750	4750	
	1400	4692	3.90	2.25	11.6	8.4	5000	5000	
	1500	4701	3.84	2.64	11.7	8.6	4750	5000	
	1600	4720	4.08	3.3	11.5	11.2	4750	5000	
	1700	4731	4.17	2.4	11.5	8.6	4700	5500	
	1800	4753	3.72	2.1	11.4	8.9	4900	5100	
	1900	4765	3.90	2.25	11.7	8.7	5000	4900	
	2000	4782	3.69	2.52	11.6	8.6	4800	5200	
	2100	4796	4.05	2.70	11.5	8.8	4700	5300	Unable to clean out and make connection.
	2200	4796	4.20	2.10	11.8	8.5	4400	4500	
	2300	4796	4.08	2.25	11.8	8.0	4500	4600	
	2400	4796	4.08	2.10	11.8	8.1	4700	4600	

TABLE 3

CHEMICAL ANALYSIS* OF RETURN FLUIDS FROM
CFSU WELL #31-33

Data are in milligrams/liter unless otherwise noted

Date	June 30	July 1	July 5	July 7	July 20
Depth, feet	2455	2825	3720	4170	3000
Turbidity, NTU	150	260	200	390	80
Conductivity, umhos/cm	11,700	11,780	12,300	15,380	2035
pH	8.77	7.38	7.94	9.79	7.44
TDS	7600	7655	8000	10,000	130
Alkalinity as $CaCO_3$	836	394	210	1440	200
As	0.970	0.379	1.131	5.707	2.991
HCO_3	888.1	480.6	256.2	658.8	244
Ba	0.07	0.29	0.16	0.47	0.15
B	0.15	0.30	0.25	0.50	0.20
Cd	0.004	0.006	0.007	0.045	0.040
Ca	5.60	200	62.4	14.4	74.4
CO_3	64.8	<0.01	<0.01	540	<0.01
Cl	3440	3550	3410	3900	502
Cr	<0.001	<0.001	0.048	0.006	<0.001
Cu	0.065	0.049	0.077	0.166	0.914
Surfactants	<0.05	<0.05	<0.05	<0.05	<0.05
F	3.10	3.20	2.90	3.60	1.03
Li	12.05	12.46	11.62	13.31	1.164
Hardness as $CaCO_3$	24.0	560	188	20.0	266
Fe	3.20	8.78	11.1	10.6	2.154
Pb	0.345	0.350	0.345	0.420	0.006
Mg	2.40	14.40	7.68	3.36	19.2
Mn	0.249	2.084	0.328	0.016	0.043
Hg	<0.0002	0.0002	<0.0002	0.0007	<0.0062
Ni	0.685	0.680	0.688	0.975	<0.001
NO_2	0.04	0.03	0.02	<0.01	0.45
NO_3	<0.01	<0.01	<0.01	<0.01	<0.01
K	423	452	465	443	56.2
Se	<0.001	<0.001	<0.001	0.007	<0.001
Si	77.5	25.5	64	79	
Ag	0.026	0.032	0.030	0.037	<0.001
SO_4	272	720	1000	760	187
Na	2530	2475	2916	4000	355
Zn	0.084	0.231	0.051	0.41	0.104

* Analysis was made by Ford Laboratories,
Salt Lake City, Utah.

TABLE 4

DRILL PIPE LOSS

CFSU Well 31-33

238 joints were inspected

Joints downgraded	Starting Grade	Ending Grade
17	Premium	2
3	Premium	3
1	Premium	5
11	2	3
1	2	5
33 Total		

CFSU Well 42-7

218 joints of premium pipe were inspected

Joints downgraded	Starting Grade	Ending Grade
82	Premium	2
28	Premium	3
7	Premium	5
117 Total		

TABLE 5

NUMBER OF JOINTS EXPERIENCING A PARTICULAR LOSS IN AVERAGE WALL THICKNESS AS CALCULATED FROM THE CORROSION COUPON RESULTS

CFSU Well 31-33		CFSU Well 42-7	
Number of Joints	Thickness Lost, mils	Number of Joints	Thickness Lost, mils
33[a]	0	33[a]	0
7	0.3	4	
8	1.6	4	2.9
18	3.0	11	3.9
27	4.5	19	5.3
29	11.2	21	7.4
15[b]	12.1	15	8.4
		14[b]	9.4
		21	10.2
		22	12.1
		12	13.6
		11	14.8
		13	15.7
		21	16.8

a Calculation assumes the top 1000 feet of pipe suffered no metal loss, and that the remaining pipe suffered a loss equivalent to the loss measured by the corrosion coupons which were positioned at the top of the drill collar during the time that those joints of pipe were in the hole. The total number of joints of pipe in the hole at any time was assumed to be (average depth less 500 feet of drill collars and tools) ÷ 30. It was also assumed that no corrosion occurred on the pipe before air drilling was initiated, and that corrosion only occurred on the exterior of the pipe (the interior was plastic coated). If the internal coatings failed and there was corrosion on both surfaces, the average thickness lost would be twice that in the table.

b This is the approximate point where the number of joints that were downgraded (TABLE 4) would fall, between 11 and 12 mils on CFSU Well 31-33 and 8 and 9 mils on CFSU Well 42-7.

TABLE 6

CHEMICAL CORROSION INHIBITOR TESTS IN THE LABORATORY

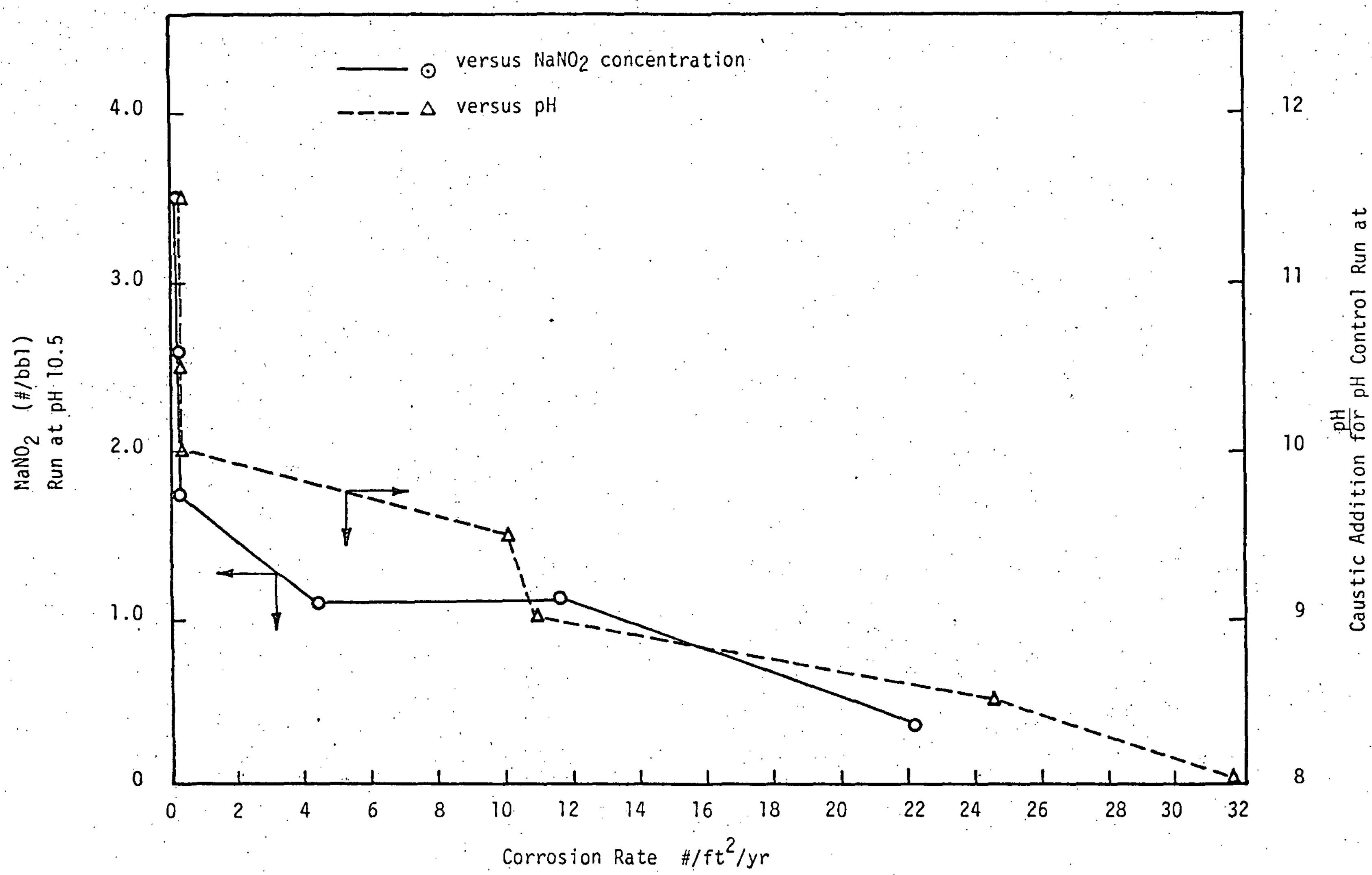
Compounds Used	Concentrations Used pounds/barrel	Corrosion Rate lb/sq.ft/yr	pH Initial	pH Final
Blank	--	19.2	9.8	9.8
		20.8		
Unisteam[R], Ammonium hydroxide, organic phosphonate	0.39, 0.39, 0.12,	22.3		
	3.9, 3.9, 1.2	5.5	11.5	8.8
$NaCrO_4$	0.7	7.4	9.7	8.7
	1.24	1.1	9.7	9.6
	1.75	0.8	9.6	9.2
Caustic	Quantity of caustic required was not measured. Sufficient quantity was added to obtain the desired initial pH.	50.0	11.0	12.4
		0.8	13.0	12.9
		1.0	13.5	13.2
		0.2	14.0	11.0
Na_2SO_3	3.2	49.0	10.5	12.2
Na_2SiO_3 37.6% active	4.8	36.8	10.4	10.1
	9.7	0.2		
$NaNO_2$	0.35	22.1	10.5	10.9
	1.1	4.6	10.5	9.9
	1.1	11.5	10.5	10.6
$NaNO_2$ at different pH	1.75	31.9	8.0	12.4
	1.75	24.6	8.5	11.0
	1.75	10.9	9.0	10.1
	1.75	10.0	9.5	10.3
	1.75	0.4	10.0	9.7
	1.75	0.4	10.5	9.8
	1.75	0.6	11.5	10.8
$NaNO_2$, NH_4OH	1.75, 3.5	0.3	10.5	10.1
$NaNO_2$, Na_2SO_3	1.75, 0.35	0.3	10.5	9.2
$NaNO_2$, Na_2SO_3, organic phosphonate	1.75, 0.35, 1.2	0.3	10.5	9.1
$NaNO_2$, Na_2SO_3, organic phosphonate, NH_4OH	1.75, 0.35, 1.2, 3.5	0.5	10.5	10.1
$NaNO_2$	2.6	0.4	10.5	9.8
	3.5	0.2	10.5	9.5*
	3.5	0.1	10.5	11.0

* This test was run for 64 hours.

Tests were conducted at 600-700 psig oxygen pressure at 450°F for 24 hours. The test solutions consisted of a synthetic produced water from CFSU 42-7 plus the added compounds. Coupons of J-55 were placed in the solutions inside Teflon[R] bottles, and the coupons were used to determine the corrosion rates.

FIGURE 1

CORROSION RATE VERSUS $NaNO_2$ CONCENTRATION AND pH



Ford Chemical
LABORATORY, INC.
Bacteriological and Chemical Analysis
40 WEST LOUISE AVENUE
SALT LAKE CITY, UTAH 84115
PHONE 485-5761

Don Ash

Name Union Oil Co. of California

Address P.O. Box 6854
Santa Rosa, Ca. 95401

Date: August 10, 1978

CERTIFICATE OF ANALYSIS
78-1803-1

CFSU 31-33, 6-30-78, 2455 ft., received 7-11-78

Analysis started on:

Turbidity	150.0	NTU	Total Hardness as $CaCO_3$	24.0	mg/1
Conductivity	11,700	umhos/cm	Iron as Fe (Total)	3.200	mg/1
pH	8.77	Units	Iron as Fe (Filtered)	0.347	mg/1
Total Dissolved Solids at 180°C.	7,600	mg/1	Lead as Pb	0.345	mg/1
Alkalinity as $CaCO_3$	836.0	mg/1	Magnesium as Mg	2.40	mg/1
Arsenic as As	0.970	mg/1	Manganese as Mn	0.249	mg/1
Bicarbonate as HCO_3	888.16	mg/1	Mercury as Hg	<0.0002	mg/1
Barium as Ba	0.07	mg/1	Nickel as Ni	0.685	mg/1
Boron as B	0.15	mg/1	Nitrate as NO_3-N	0.04	mg/1
Cadmium as Cd	0.004	mg/1	Nitrite as NO_2-N	<0.01	mg/1
Calcium as Ca	5.60	mg/1	Potassium as K	423.0	mg/1
Carbonate as CO_3	64.8	mg/1	Selenium as Se	<0.001	mg/1
Chloride as Cl	3,440	mg/1	Silica as SiO_2	77.50	mg/1
Chromium as Cr (Total)	<0.001	mg/1	Silver as Ag	0.026	mg/1
Chromium as Cr (Hex)	<0.001	mg/1	Sulfate as SO_4	272.0	mg/1
Copper as Cu	0.065	mg/1	Sodium as Na	2,530	mg/1
Surfactants MBAS	<0.05	mg/1	Zinc as Zn	0.084	mg/1
Fluoride as F	3.10	mg/1			
Lithium as Li	12.05	mg/1			

[signature]
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Don Ash

Name Union Oil Co. of California

Address P.O. Box 6854

Santa Rosa, Ca. 95401

Date: August 10, 1978

CERTIFICATE OF ANALYSIS
78-1803-2

CFSU 31-33, 7-1-78, 2825 ft., received 7-11-78

Analysis started on:

Turbidity	260.0	NTU	Total Hardness as $CaCO_3$	560.0	mg/1
Conductivity	11,780	umhos/cm	Iron as Fe (Total)	8.786	mg/1
pH	7.38	Units	Iron as Fe (Filtered)	1.920	mg/1
Total Dissolved Solids at 180°C.	7,655	mg/1	Lead as Pb	0.350	mg/1
Alkalinity as $CaCO_3$	394.0	mg/1	Magnesium as Mg	14.40	mg/1
Arsenic as As	0.379	mg/1	Manganese as Mn	2.084	mg/1
Bicarbonate as HCO_3	480.68	mg/1	Mercury as Hg	<0.0002	mg/1
Barium as Ba	0.29	mg/1	Nickel as Ni	0.680	mg/1
Boron as B	0.30	mg/1	Nitrate as NO_3-N	0.03	mg/1
Cadmium as Cd	0.006	mg/1	Nitrite as NO_2-N	<0.01	mg/1
Calcium as Ca	200.0	mg/1	Potassium as K	452.0	mg/1
Carbonate as CO_3	<0.01	mg/1	Selenium as Se	<0.001	mg/1
Chloride as Cl	3,550	mg/1	Silica as SiO_2	25.50	mg/1
Chromium as Cr (Total)	<0.001	mg/1	Silver as Ag	0.032	mg/1
Chromium as Cr (Hex)	<0.001	mg/1	Sulfate as SO_4	720.0	mg/1
Copper as Cu	0.049	mg/1	Sodium as Na	2,475	mg/1
Surfactants MBAS	<0.05	mg/1	Zinc as Zn	0.231	mg/1
Fluoride as F	3.20	mg/1			
Lithium as Li	12.46	mg/1			

Ford Chemical Laboratory, Inc.

Ford Chemical LABORATORY, INC.

Bacteriological and Chemical Analysis

40 WEST LOUISE AVENUE
SALT LAKE CITY, UTAH 84115
PHONE 485-5761

Don Ash

Name Union Oil Co. of California

Date: August 10, 1978

Address P.O. Box 6854

Santa Rosa, Ca. 95401

CERTIFICATE OF ANALYSIS
78-1803-3

CFSU 31-33- 7-5-78, 3720 ft., received 7-11-78

Analysis started on:

Turbidity	200.0	NTU	Total Hardness as $CaCO_3$	188.0	mg/1
Conductivity	12,300	umhos/cm	Iron as Fe (Total)	11.100	mg/1
pH	7.94	Units	Iron as Fe (Filtered)	8.660	mg/1
Total Dissolved Solids at 180°C.	8,000	mg/1	Lead as Pb	0.345	mg/1
Alkalinity as $CaCO_3$	210.0	mg/1	Magnesium as Mg	7.68	mg/1
Arsenic as As	1.131	mg/1	Manganese as Mn	0.328	mg/1
Bicarbonate as HCO_3	256.2	mg/1	Mercury as Hg	<0.0002	mg/1
Barium as Ba	0.16	mg/1	Nickel as Ni	0.688	mg/1
Boron as B	0.25	mg/1	Nitrate as NO_3-N	0.02	mg/1
Cadmium as Cd	0.007	mg/1	Nitrite as NO_2-N	<0.01	mg/1
Calcium as Ca	62.4	mg/1	Potassium as K	465.0	mg/1
Carbonate as CO_3	<0.01	mg/1	Selenium as Se	<0.001	mg/1
Chloride as Cl	3,410	mg/1	Silica as SiO_2	64.0	mg/1
Chromium as Cr (Total)	0.048	mg/1	Silver as Ag	0.030	mg/1
Chromium as Cr (Hex)	<0.001	mg/1	Sulfate as SO_4	1,000	mg/1
Copper as Cu	0.077	mg/1	Sodium as Na	2,916	mg/1
Surfactants MBAS	<0.05	mg/1	Zinc as Zn	0.051	mg/1
Fluoride as F	2.90	mg/1			
Lithium as Li	11.62	mg/1			

[signature]

Ford Chemical Laboratory, Inc.

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Bacteriological and Chemical Analysis
40 WEST LOUISE AVENUE
SALT LAKE CITY, UTAH 84115
PHONE 485-5761

Don Ash

Name Union Oil Co. of California

Date: August 10, 1978

Address P.O. Box 6854

Santa Rosa, Ca. 96501

CERTIFICATE OF ANALYSIS
78-1803-4

CFSU 31033, 7-7-78, 4170 ft., received 7-11-78

Analysis started on:

Turbidity	390.0	NTU	Total Hardness as $CaCO_3$	20.0	mg/1
Conductivity	15,380	umhos/cm	Iron as Fe (Total)	10.600	mg/1
pH	9.79	Units	Iron as Fe (Filtered)	0.108	mg/1
Total Dissolved Solids at 180°C.	10,000	mg/1	Lead as Pb	0.420	mg/1
Alkalinity as $CaCO_3$	1,440	mg/1	Magnesium as Mg	3.36	mg/1
Arsenic as As	5.707	mg/1	Manganese as Mn	0.016	mg/1
Bicarbonate as HCO_3	658.8	mg/1	Mercury as Hg	0.0007	mg/1
Barium as Ba	0.47	mg/1	Nickel as Ni	0.975	mg/1
Boron as B	0.50	mg/1	Nitrate as NO_3-N	<0.01	mg/1
Cadmium as Cd	0.045	mg/1	Nitrite as NO_2-N	<0.01	mg/1
Calcium as Ca	14.40	mg/1	Potassium as K	443.0	mg/1
Carbonate as CO_3	540.0	mg/1	Selenium as Se	0.007	mg/1
Chloride as Cl	3,900	mg/1	Silica as SiO_2	79.0	mg/1
Chromium as Cr (Total)	0.006	mg/1	Silver as Ag	0.037	mg/1
Chromium as Cr (Hex)	<0.001	mg/1	Sulfate as SO_4	760.0	mg/1
Copper as Cu	0.166	mg/1	Sodium as Na	4,000	mg/1
Surfactants MBAS	<0.05	mg/1	Zinc as Zn	0.041	mg/1
Fluoride as F	3.60	mg/1			
Lithium as Li	13.31	mg/1			

Ford Chemical Laboratory, Inc.

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SALT LAKE CITY, UTAH 84115
PHONE 485-5761

August 10, 1978

CERTIFICATE OF ANALYSIS
78-1803-5

Union Oil Co. of California
Union Geothermal Division
P.O. Box 7600
Los Angeles, Ca. 90051

Attn: Mr. Neil Stefanides

Gentlemen:

The following analysis is on samples of water received on July 11, 1978.

Sample: water

	Silica as SiO_2 mg/l
Blank #1	5.0
CFSU 31-33 Depth 2455' 6-30-78 9:1 Dil	15.0
Blank #2	5.4
CFSU 31-33 Depth 2825' 7-1-78 9:1 Dil	22.0
CFSU 31-33 Depth 3720' 7-5-78 9:1 Dil	26.0
CFSU 31-33 Depth 4170' 7-7-78 9:1 Dil	29.0

Sincerely,

FORD CHEMICAL LABORATORY, INC.

Lyle S. Ford

LSF:ka

Ford Chemical
LABORATORY, INC.
Bacteriological and Chemical Analysis
40 WEST LOUISE AVENUE
SALT LAKE CITY, UTAH 84115
PHONE 485-5761

DON L. ASH
AUG 22 1978

Date: August 18, 1978

Name Union Oil Company-Geothermal Division

Address 2099 Range Avenue, Box 6854
Santa Rosa, CA 95401

CERTIFICATE OF ANALYSIS

Well water labeled "Depth 3000 feet, 7-20-78" received on July 26, 1978:

Analysis started on: July 26, 1978

Turbidity	80.0	NTU	Total Hardness as $CaCO_3$	266.0	mg/1
Conductivity	2,035	umhos/cm	Iron as Fe (Total)	2.154	mg/1
pH	7.44	Units	Iron as Fe (Filtered)	1.976	mg/1
Total Dissolved Solids at 180°C.	1,320	mg/1	Lead as Pb	0.006	mg/1
Alkalinity as $CaCO_3$	200.0	mg/1	Magnesium as Mg	19.20	mg/1
Arsenic as As	2.991	mg/1	Manganese as Mn	0.043	mg/1
Bicarbonate as HCO_3	244.0	mg/1	Mercury as Hg	< 0.0002	mg/1
Barium as Ba	0.15	mg/1	Nickel as Ni	< 0.001	mg/1
Boron as B	0.20	mg/1	Nitrate as NO_3-N	0.45	mg/1
Cadmium as Cd	0.040	mg/1	Nitrite as NO_2-N	< 0.01	mg/1
Calcium as Ca	74.40	mg/1	Potassium as K	56.20	mg/1
Carbonate as CO_3	< 0.01	mg/1	Selenium as Se	< 0.001	mg/1
Chloride as Cl	502.0	mg/1	Silica as SiO_2	64.5	mg/1
Chromium as Cr (Total)	< 0.001	mg/1	Silver as Ag	< 0.001	mg/1
Chromium as Cr (Hex)	< 0.001	mg/1	Sulfate as SO_4	187.0	mg/1
Copper as Cu	0.914	mg/1	Sodium as Na	355.0	mg/1
Surfactants MBAS	< 0.05	mg/1	Zinc as Zn	0.104	mg/1
Fluoride as F	1.03	mg/1			
Lithium as Li	1.164	mg/1			

Lyle Ford (VW)
Ford Chemical Laboratory, Inc.

Ford Chemical
LABORATORY, INC.
Bacteriological and Chemical Analysis
40 WEST LOUISE AVENUE
SALT LAKE CITY, UTAH 84115
PHONE 485-5761

August 18, 1978

CERTIFICATE OF ANALYSIS
78-1956-2

Union Oil Company
Geothermal Division
2099 Range Avenue
Bos 6854
Santa Rosa, CA 95401

Gentlemen:

The following analysis is on samples of water received on July 26, 1978:

Sample: Water

	Silica as SiO_2
3000 feet, 9:1 Dilution	34.5 mg/l
Blank	22.5 mg/l

Sincerely,

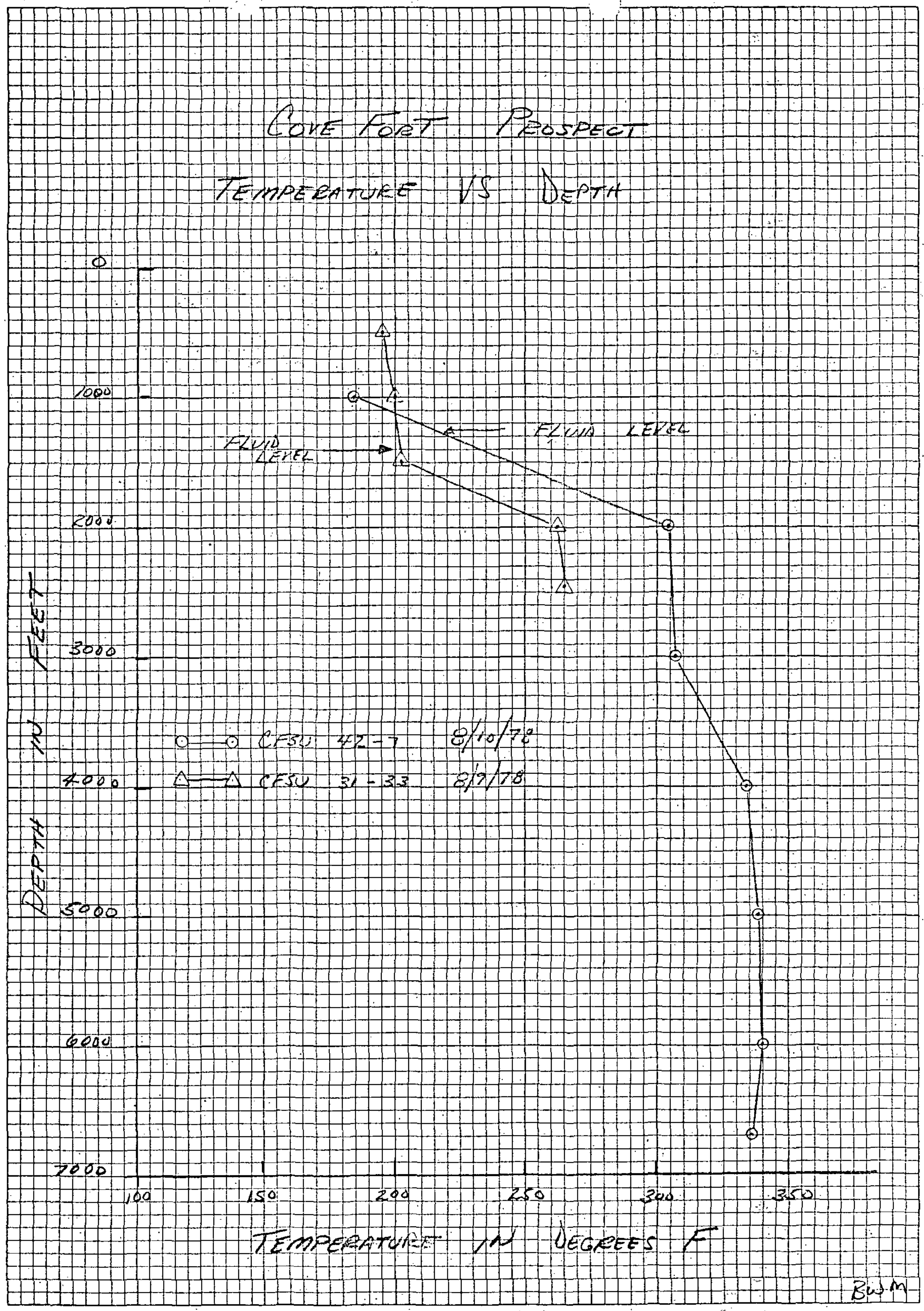
FORD CHEMICAL LABORATORY, INC.

Lyle S. Ford

LSF:vh

CFSU #31-33 8/9/78

	TEMPERATURE	PRESSURE	
0	min	0	Fluid level = 1400'
500'	195°	0	Pickup = 2464'
1000'	200°	0	WHP = 0
1500'	202°	30	WHT = min
2000'	263°	210	
2460'	265°	394	



K+E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

46 0700

UNION 76

GEOTHERMAL DIVISION

SUBSURFACE SURVEY

Field Work Sheet CFSU 31-33 - SI - PT

OWNER Union Oil Company FIELD Cove Fort WELL NAME CFSU 31-33

CASING 30" @ 52' 20" @ 280' ELEV. DATE: 8/9/78

LINER DESCRIPTION: 13 3/8" @ 1733. ZERO POINT SWAB GATE (GL)

2 7/8" @ 2559 DEPTH 2559 (KB)

REMARKS: FLUID LEVEL ± 1400'

PURPOSE GRADIENT SURVEY

ELEMENT Temp SERIAL NO. 10172 CLOCK 17498 TURN

PRESS 12833 17499

STABILIZATION PERIOD

MAX. °F

ENGAGE STYLUS 1138 DISENGAGE STYLUS 1348

COR. CSG. PRESS. ⊖

PICKUP @ 2464

TIME ON BOTTOM

TIME OFF BOTTOM

WELL STATUS

SHUT IN: ✓ ON PRODUCTION:

Open Swab Gate

Close Swab Gate

	Temp								Press								
TIME	DEPTH	DEFL.	F—T	GRAD.	/D	TIME	DEPTH	DEFL.	F—T	GRAD.	/D	TIME	DEPTH	DEFL.	F—T	GRAD.	/D
	0		min						min								
	500		195						min								
	1000		200						min								
	1500		202						30								
	2000		263						210								
	2460		265						394								

COMMENTS: 17500 FT of wire on drum

GEOTHERMAL DIVISION

SUBSURFACE TEMPERATURE SURVEY

OWNER: Union Oil Company
FIELD: Cove Fort
WELL NAME: CFSU 31-33
CASING:
ELEV:
DATE: 8/9/78
LINER DESCRIPTION:
ZERO POINT: Swab Gate
DEPTH: 2559

HOLE DESCRIPTION:

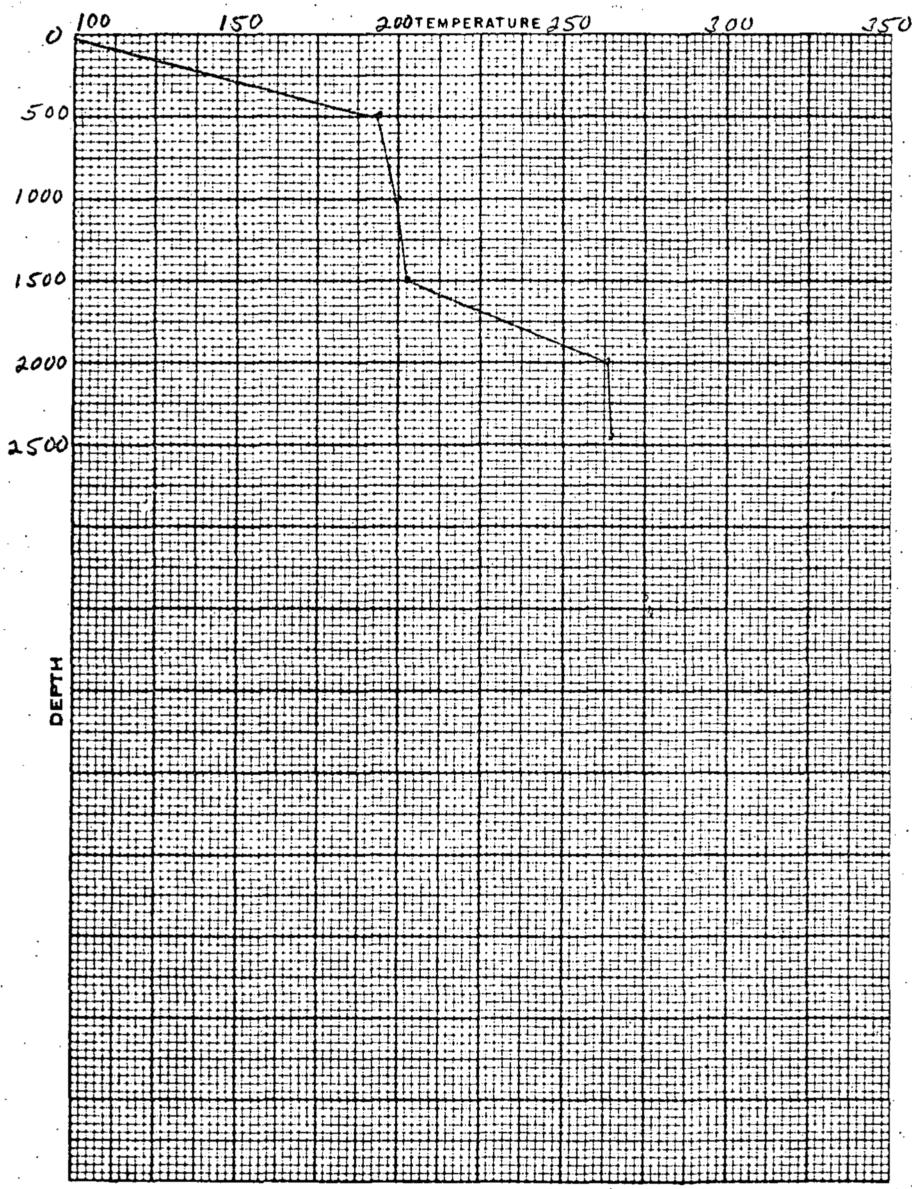
INSTRUMENT: 104-768 FAHR.
SERIAL NO: 10172

PURPOSE: Gradient Survey
MAX TEMP: 265 °F @ 2460
REMARKS:

STABLIZATION PERIOD

PRESSURES	GAUGE	BOMB
CASING, PSI	-0-	-0-

DEPTH	TEMP.	DEPTH	TEMP.
0	MIN		
500	195		
1000	200		
1500	202		
2000	263		
2460	265		



BY: Sam Timmons

UNION 76

GEOTHERMAL DIVISION

SUBSURFACE PRESSURE SURVEY

OWNER: Union Oil Company FIELD: Cove Fort WELL NAME: CFSU 31-33

CASING: ELEV: DATE: 8/9/78

LINER DESCRIPTION: 2 7/8" Tbg To 2559 ZERO POINT: SWAB GATE

DEPTH: 2559

HOLE DESCRIPTION:

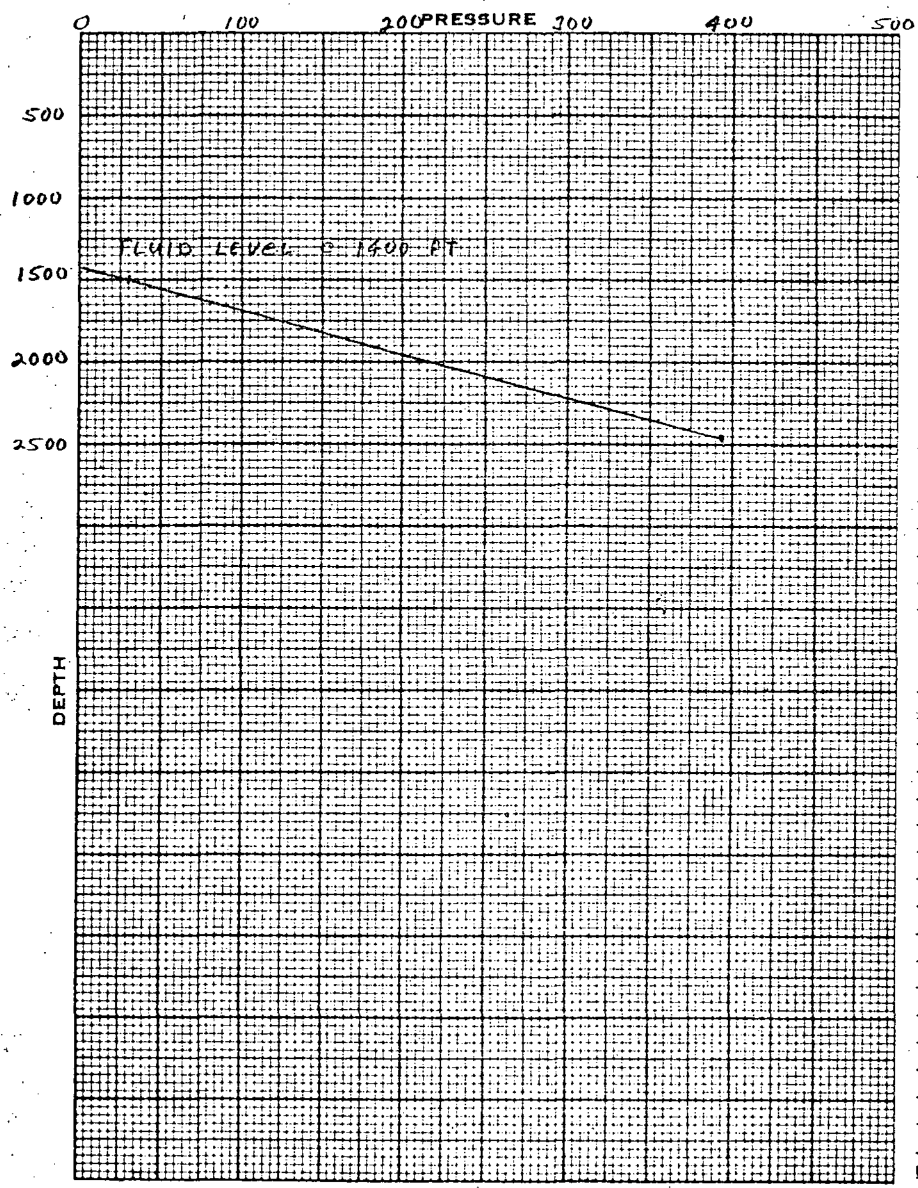
INSTRUMENT: 4100 PSIG

SERIAL NO: 12833

PURPOSE: GRADIENT SURVEY MAX TEMP: 265 °F @ 2460

REMARKS:

STABLIZATION PERIOD:



PRESSURES	GAUGE	BOMB
CASING. PSI	0	0

DEPTH	PRESSURE	GRADIENT
0	MIN	
500	MIN	
1000	MIN	
1500	30	
2000	210	
2460	394	

BY: Sam Timmons

COVE FORT SULPHURDALE UNIT #31-33

H_2S SAFETY PROCEDURES

Protection of all people on and around the Cove Fort Sulphurdale #31-33 location from possible H_2S gas poisoning was of the utmost importance to Union Oil Company of California.

With the help of R. F. Smith Company, Union Oil implemented a state of the art safety program to ensure the safety of everyone. The safety equipment and personnel consisted of:

1) Safety trailer with 15 - 300 C.F. cylinder cascade air supply system.
2) Two thousand feet of low pressure air line hose with quick connects.
3) High pressure air compressor.
4) Five low pressure manifolds.
5) Fourteen air line masks with escape cylinders.
6) Thirteen 30 minute self contained oxygen units.
7) Two head-fixed H_2S monitor systems.
8) Warning sirens and revolving amber light.
9) Three wind socks.
10) First aid kit.
11) Two resuscitators with cylinders (oxygen powered).
12) Flare gun with shells.
13) Gas detector (pump type).
14) Safety supervisor.

There were three H_2S gas monitors on the location: one was located on the rig floor, one under the rig floor at the flow nipple, and one at the mud shakers. The monitors were set to detect H_2S concentrations in excess of 10 ppm and automatically activate a warning siren and revolving amber light. In addition, a sampling system collected vapors at the flow nipple and transported them to the R. F. Smith trailer where they were analyzed continuously by a gas chromatograph.

In the event of a warning, the men on the rig floor were instructed to immediately put on air breathing apparatus with escape cylinders and alternate reserve air line. Air was supplied to the masks through manifolds from the cascade air supply system. If for some reason there was a malfunction in the air supply system, the masks were equipped with escape cylinders which would supply air for sufficient time to allow a person to leave the area.

After it was determined that everyone was wearing a mask, either a safety supervisor or drilling foreman would check the area for H_2S using a hand operated gas detector. One of the 30 minute self-contained units was worn by the foreman and/or supervisor so that he could move safely around the location while making the check. If an H_2S concentration of over 10 ppm was found in or around the work area, the men were required to work wearing masks. If less than 10 ppm H_2S was found, the men could continue work normally. Constant monitoring was continued until

Three wind socks were located strategically around the location. If the warning siren sounded when an employee was away from either a self-contained air unit or air line mask, he could observe the wind sock and move quickly up wind escaping the gas.

In addition to the above, two oxygen resuscitators and a flare gun were on location at all times. The resuscitators were to be employed to revive any individual overcome by H_2S. If it was determined that any H_2S leak was adequate to endanger human or animal life in an area adjacent to the location, use of the flare gun would be a last resort measure to ignite and eliminate the gas.

All personnel required to be present or perform any type of service on or in the proximity of the CFSU #31-33 location were given instruction relating to safe operating procedures in the presence of H_2S gas. Safety instruction was conducted in all cases by a qualified representative of R. F. Smith Corporation. In addition to instruction, an inspection for broken eardrums was made by an M.D. and all personnel were required to be cleanly shaven to ensure an airtight fit of the available breathing apparatus.

Many scheduled and unscheduled H_2S drills were conducted, exposing each person associated with the drilling operation to at least one drill. The drills were triggered by manual activation of the H_2S alarm system.

The H_2S alarms were activated once when steam and vapors were seen to be coming out of the rotating head rubber, while drilling the interval 1236' to 1241'. All personnel on the location followed prescribed H_2S safety procedures at this point. Immediately following the activation of the alarms, manual measurements of H_2S were made on the rig floor, indicating concentration on the order of 10 ppm H_2S. A brisk wind was blowing at the time, and the gas was quickly dispersed. The gas chromatograph sampling vapors from the flow nipple did not detect any H_2S during this event.

Beaver
CF/S
Union Fin

GEOTHERMAL RESERVOIR ASSESSMENT

COVE FORT SULPHURDALE UNIT

FINAL REPORT
FOR THE PERIOD
SEPTEMBER 1977 - JULY 1979

D. L. ASH, R. F. DONDANVILLE, AND M. S. GULATI

DECEMBER 1979

WORK PERFORMED UNDER CONTRACT

DE-AC08-77ET-28405

UNION OIL COMPANY OF CALIFORNIA
GEOTHERMAL DIVISION
UNION OIL CENTER
461 S. BOYLSTON STREET
LOS ANGELES, CALIFORNIA 90017

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ABSTRACT

During 1978 and 1979 Union Oil Company of California drilled three exploratory geothermal wells in the Cove Fort-Sulphurdale geothermal resource area in southwestern Utah to obtain new subsurface data for inclusion in the U.S. Department of Energy's geothermal reservoir assessment program. Existing data from prior investigations which included the drilling of an earlier exploratory well at the Cove Fort-Sulphurdale area was also provided.

Two of the wells were abandoned before reaching target depth because of severe lost circulation and hole sloughing problems. The two completed holes reached depths of 5,221 ft. and 7,735 ft., respectively, and a maximum reservoir temperature of 353°F at 7,320 ft. was measured. The deepest well flow tested at the rate of 47,000 lbs./hr with a wellhead temperature of 200°F and pressure of 3 psig. Based upon current economics, the Cove Fort-Sulphurdale geothermal resource is considered to be sub-commercial for the generation of electrical power.

This report is a synopsis of the exploratory drilling activities and results, and it contains summary drilling, testing, geologic and geochemical information from four exploratory geothermal wells. Detailed information for each of the wells is contained in four separate technical reports available through the University of Utah Research Institute, Earth Science Laboratory (UURI/ESL), Salt Lake City, Utah.

GEOTHERMAL RESERVOIR ASSESSMENT

COVE FORT SULPHURDALE UNIT

FINAL REPORT
FOR THE PERIOD
SEPTEMBER 1977 - JULY 1979

D. L. ASH, R. F. DONDANVILLE, AND M. S. GULATI

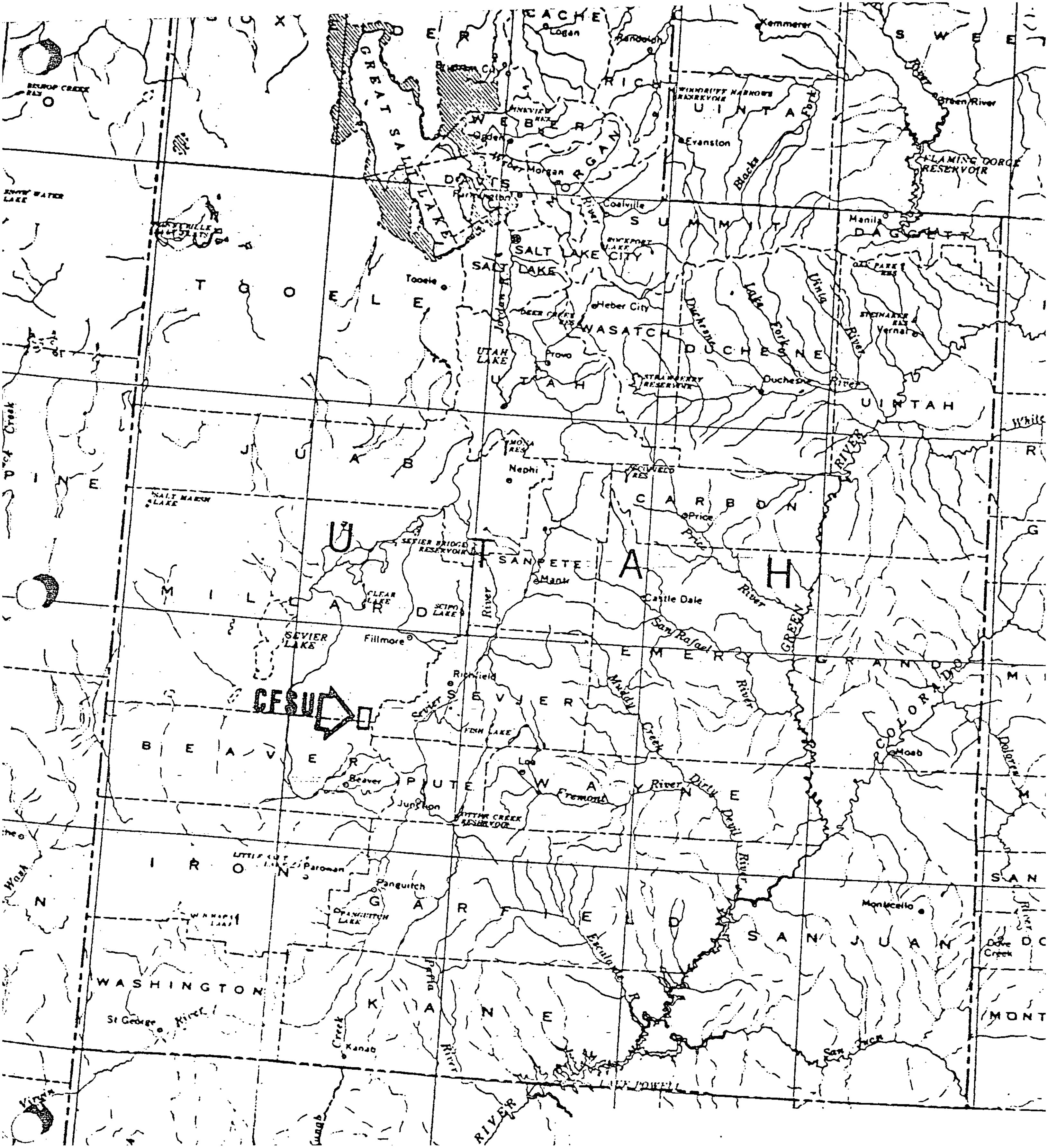
UNION OIL COMPANY OF CALIFORNIA
GEOTHERMAL DIVISION
UNION OIL CENTER
461 S. BOYLSTON STREET
LOS ANGELES, CALIFORNIA 90017

U. S. DEPARTMENT OF ENERGY
DIVISION OF ENERGY TECHNOLOGY
NEVADA OPERATIONS OFFICE
UNDER CONTRACT DE-AC08-77ET-28405

TABLE OF CONTENTS

INTRODUCTION

The Cove Fort Sulphurdale Unit (CFSU) Final Report has been prepared to compare and summarize results from the four exploratory geothermal wells drilled on the unit. The general location of CFSU is shown in Figure 1. Specific well locations are shown in Figure 2.



UTAH
CFSU
GREAT SALT LAKE
Logan
Randolph
Kemmerer
Brigham City
Ogden
Morgan
Farmington
Coalville
Evanston
Green River
FLAMING GORGE RESERVOIR
Manila
SALT LAKE CITY
Tooele
Heber City
Provo
UTAH LAKE
Vernal
Duchesne
Nephi
Price
Manti
Castle Dale
Fillmore
SEVIER LAKE
Richfield
FISH LAKE
Loa
Moab
Beaver
Junction
Parowan
Panguitch
Monticello
St George
Kanab
LAKE POWELL
TOOELE
DAVIS
WEBER
MORGAN
SUMMIT
DAGGETT
UINTA
WASATCH
DUCHESNE
UINTAH
JUAB
CARBON
SANPETE
MILLARD
EMERY
GRAND
SEVIER
BEAVER
PIUTE
WAYNE
IRON
GARFIELD
SAN JUAN
WASHINGTON
KANE
CACHE
RICH
GREEN RIVER
COLORADO
Fremont River
Dirty Devil River
San Rafael
Price River
Muddy Creek
Escalante R
Sevier River
Jordan R

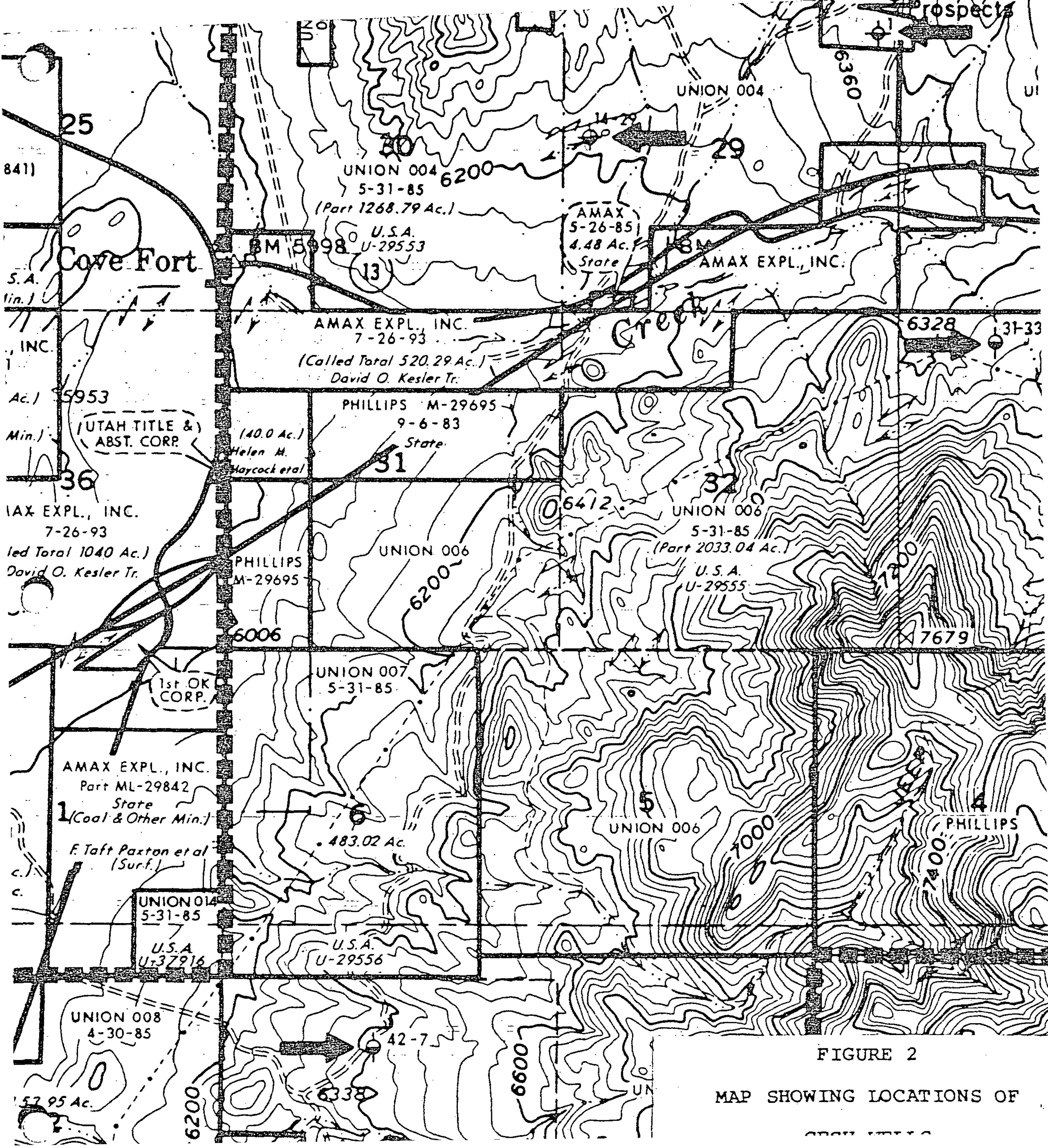


FIGURE 2

MAP SHOWING LOCATIONS OF

COVE FORT SULPHURDALE UNIT

DRILLING SUMMARY

The four exploration wells in the Cove Fort Sulphurdale Unit were drilled at the following total depths, days and costs per foot:

1. Forminco #1: 1051'; 34 days; $594/foot;
2. CFSU #42-7: 7735'; 105 days; $266/foot;
3. CFSU #31-33: 5221'; 64 days; $243/foot;
4. CFSU #14-29: 2620'; 45 days; $407/foot.

The two wells with the highest costs per foot, Forminco #1 and CFSU #14-29 were abandoned before reaching target depth because of severe hole cleaning problems. In the case of Forminco #1 a "sanded dolomite" caused the hole cleaning problems, while in CFSU #14-29 a formation of conventional dolomite/dolomitic limestone caused sloughing problems. CFSU #31-33 was plugged back to 2600' to eliminate cross flow below that point, and a 2-7/8" tubing string was hung to facilitate future temperature surveys. CFSU #42-7 was completed with a 7" liner at total depth and a 7" tie-back to surface.

The major problems contributing to the high costs per foot in the CFSU wells were lost circulation and corrosion. Each of the wells encountered severe lost circulation zones. The major corrosion problems were experienced while drilling with aerated water in wells CFSU #42-7 and #31-33. Details of lost circulation and corrosion are discussed in separate sections devoted to these topics.

Fishing jobs were confined to losses of one to two days per well with one exception. While spotting a lost circulation cement plug in Forminco #1, the cement flash set sticking the drill string. A ten day fishing/washing-over operation was required before the well was sidetracked and drilled ahead.

H_2S was encountered in all of the CFSU wells. Only the Forminco #1 well produced high concentrations of H_2S (600 ppm). An extensive H_2S monitoring system was installed on each of the CFSU wells. Personnel were familiarized with H_2S safety equipment and procedures through training and drills. Fortunately no H_2S related injuries were experienced.

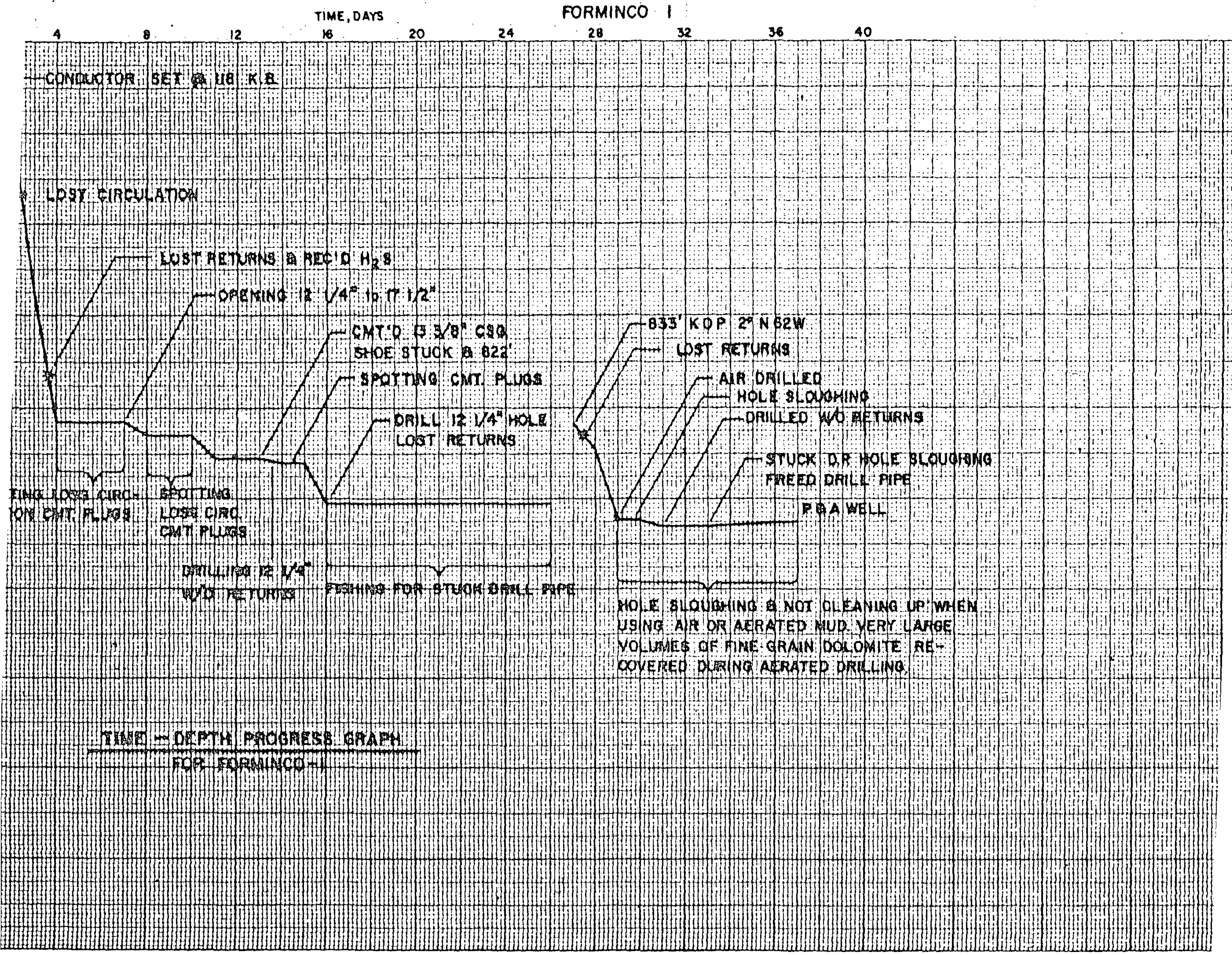
The following CFSU Drilling Data Well Comparison Table and the Time vs. Depth Progress Graphs can be used to compare the four wells drilled.

WELL	SPUD DATE	COMPLETION DATE	RIG #	TOTAL DEPTH (FT)	TOTAL DYS	TOTAL COST ($)	TOTAL COST/FT ($/FT)
Forminco #1	7/26/76	8/29/76 (Aban.)	Loffland Rig 15	1051	34	624,000	594
CFSU #42-7 Permit #0045	11/29/77	3/14/78	Loffland Rig #184	7735	105	2,056,000	266
CFSU #31-33 Permit #0049	5/24/78	7/27/78	Loffland Rig #5	5221	64	1,270,000	243
CFSU #14-29 Permit #0072	5/25/79	7/9/79 (Aban.)	Brinkerhoff Signal Rig #3	2620	45	1,065,000	407

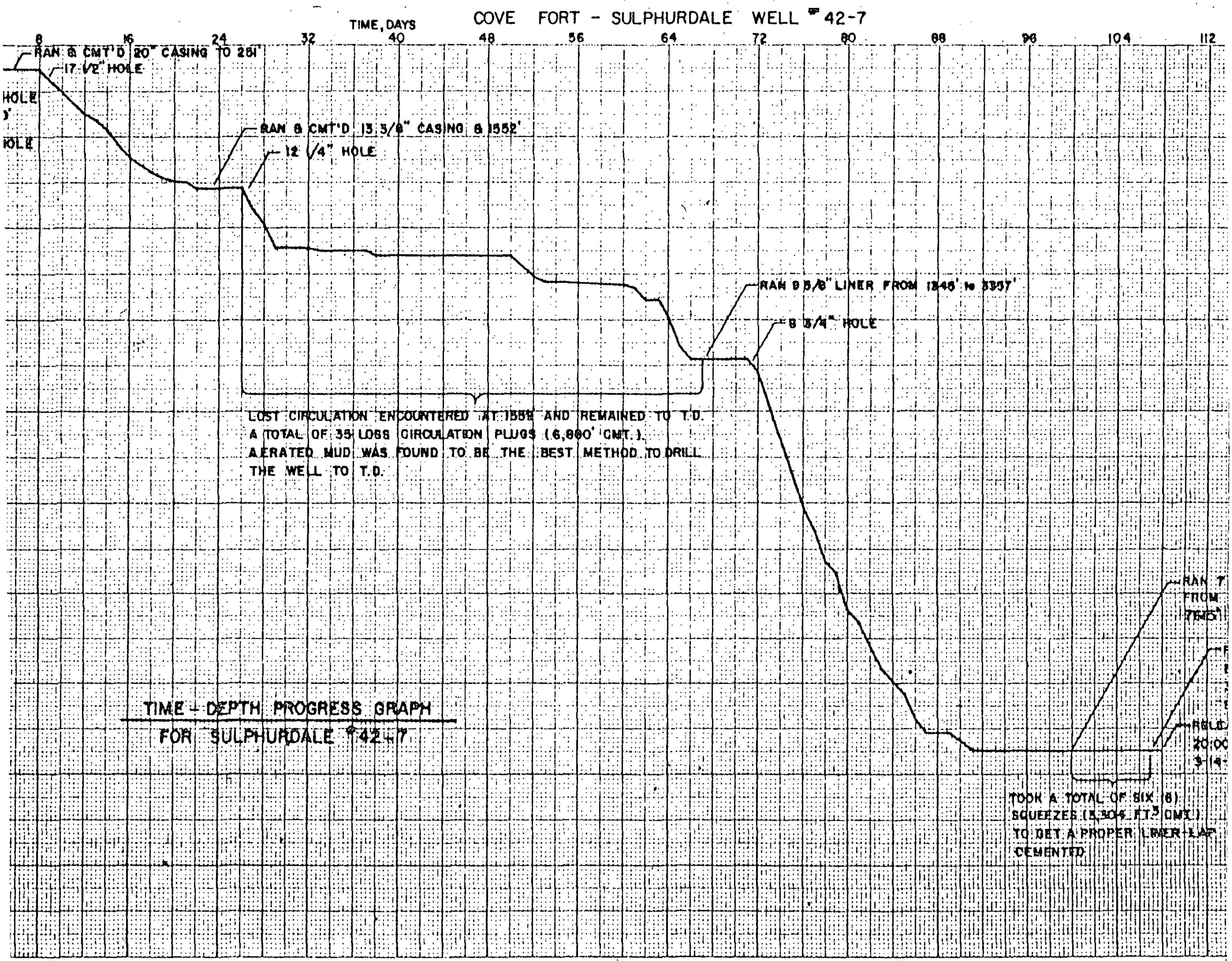
WELL	MUD COST	MUD COST/FT ($/FT)	CMT. PLUGS FOR LOST CIRCULATION	H_2S MAX. RECORDED CONCEN. (PPM)	FISHING JOBS	FISHING DAYS	MAX. TEMP. LOGGED
Forminco #1	44,025	42	9	600	1	10	--
CFSU #42-7 Permit #0045	182,889	24	37	<10	2	1	353°F @ 7320'
CFSU #31-33 Permit #0049	72,437	14	27	10	2	2	294°F @ 4700'
CFSU #14-29 Permit #0072	35,616	14	18	50	2	2	196°F @ 2180'

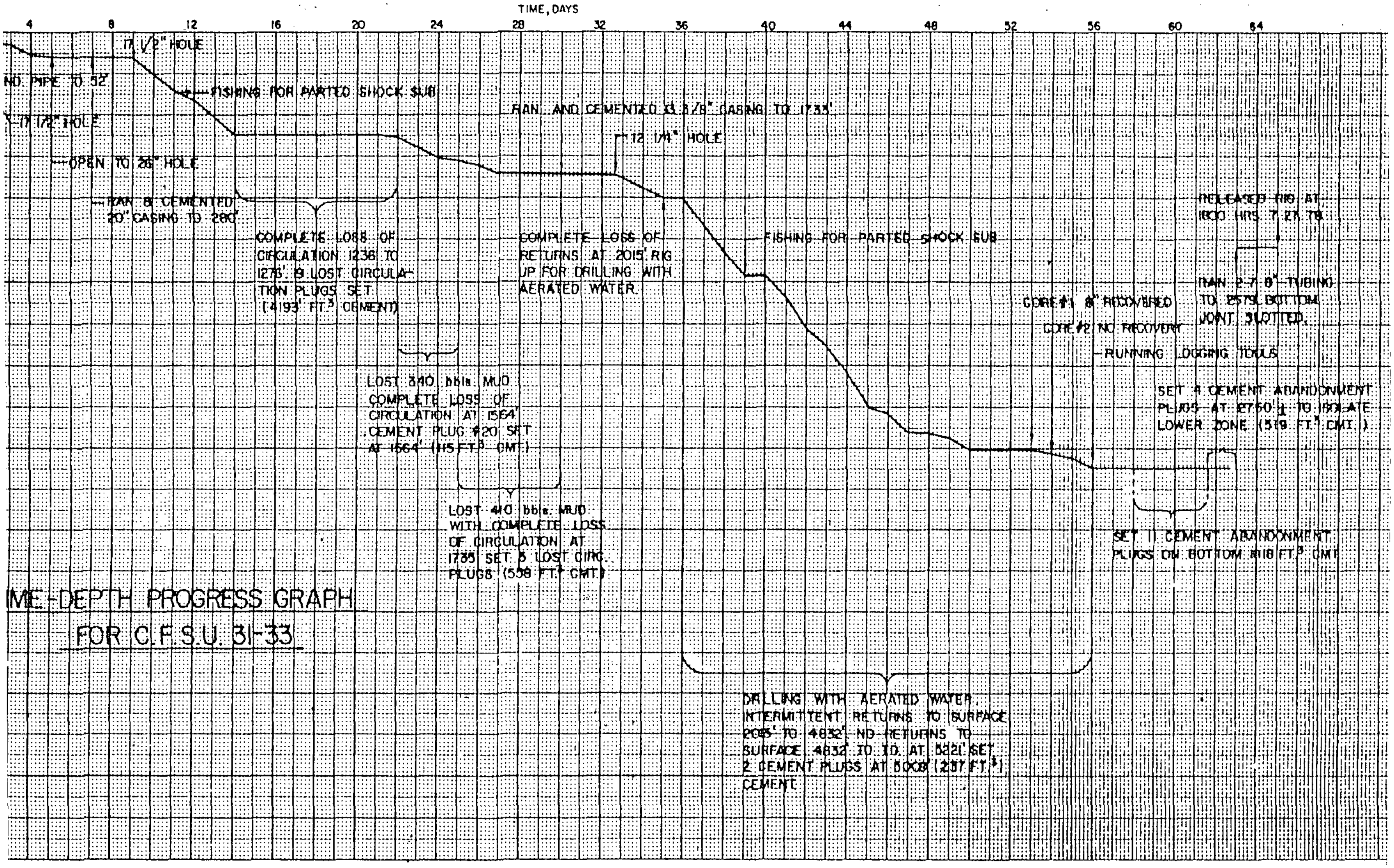
WELL	CASING PROGRAM (ALL DEPTHS RKB)					FINAL CONDITION
	CONDUCTOR CASING	SURFACE CASING	INTER-MEDIATE CASING	OTHER	OTHER	
Forminco #1	20" @ 120'	13-3/8" @ 822'	--	--	--	Abandoned due to inability to clean hole of unconsolidated "sanded dolomite".
CFSU #42-7 Permit #0045	30" @ 50'	20" @ 251'	13-3/8" @ 1552'	Liner 9-5/8": 1345' to 3357'	Liner 7" @ 7615' Tied Back	Suspended with 7" tied back to surface.
CFSU #31-33 Permit #0049	30" @ 52'	20" @ 280'	13-3/8" @ 1733'	Hanging Tubing 2-7/8" @ 2579'	--	Plugged back to 2600' to eliminate cross flow below that point and hung 2-7/8" tubing at 2579' to facilitate future temperature surveys.
CFSU #14-29 Permit #0072	30" @ 38'	20" @ 224'	13-3/8" @ 1240'	Liner 9-5/8": 998' to	--	Abandoned due to inability to clean hole and eliminate fill.

FORMINCO I

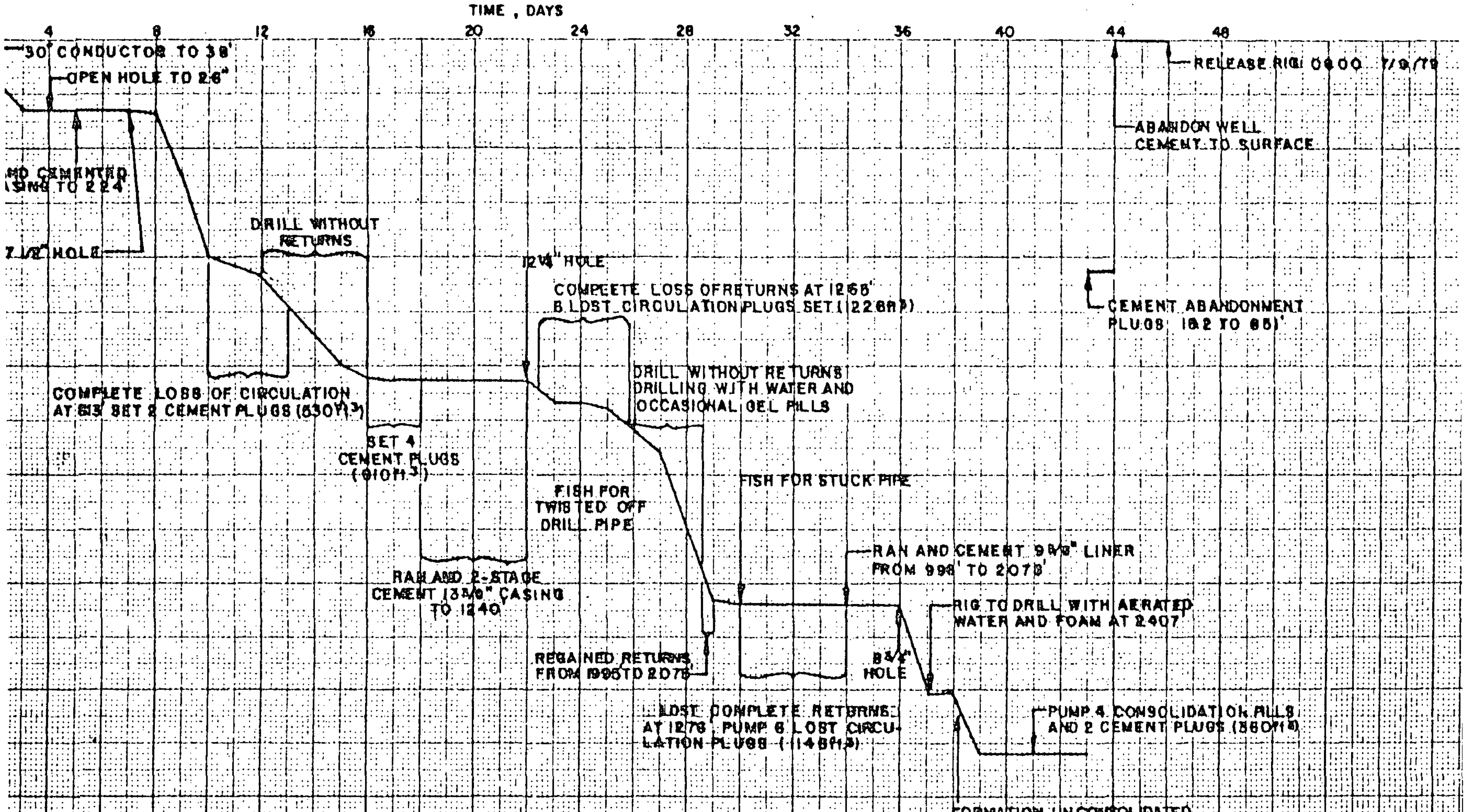


TIME - DEPTH PROGRESS GRAPH
FOR FORMINCO-1


COVE FORT - SULPHURDALE WELL # 42-7
TIME, DAYS
8 16 24 32 40 48 56 64 72 80 88 96 104 112
RAN & CMT'D 20" CASING TO 261'
17 1/2" HOLE
RAN & CMT'D 13 3/8" CASING @ 1552'
12 1/4" HOLE
RAN 9 5/8" LINER FROM 1346' to 3357'
8 3/4" HOLE
LOST CIRCULATION ENCOUNTERED AT 1559 AND REMAINED TO T.D.
A TOTAL OF 35 LOSS CIRCULATION PLUGS (6,880' CMT.).
AERATED MUD WAS FOUND TO BE THE BEST METHOD TO DRILL
THE WELL TO T.D.
TIME - DEPTH PROGRESS GRAPH
FOR SULPHURDALE #42-7
TOOK A TOTAL OF SIX (6)
SQUEEZES (5,304 FT.³ CMT.)
TO GET A PROPER LINER LAP
CEMENTED



TIME, DAYS
4
8
12
16
20
24
28
32
36
40
44
48
52
56
60
64
17 1/2" HOLE
NO PIPE TO 52'
FISHING FOR PARTED SHOCK SUB
17 1/2" HOLE
OPEN TO 26" HOLE
RAN & CEMENTED 20" CASING TO 280'
RAN AND CEMENTED 13 3/8" CASING TO 1735'
12 1/4" HOLE
COMPLETE LOSS OF CIRCULATION 1236 TO 1276'. 19 LOST CIRCULATION PLUGS SET (4193 FT.³ CEMENT)
COMPLETE LOSS OF RETURNS AT 2015' RIG UP FOR DRILLING WITH AERATED WATER.
FISHING FOR PARTED SHOCK SUB
RELEASED RIG AT 1800 HRS. 7 27 78
RAN 2-7/8" TUBING TO 2579' BOTTOM JOINT SLOTTED.
CORE #1 8' RECOVERED
CORE #2 NO RECOVERY
RUNNING LOGGING TOOLS
SET 4 CEMENT ABANDONMENT PLUGS AT 2750' ± TO ISOLATE LOWER ZONE (519 FT.³ CMT.)
LOST 340 bbls. MUD COMPLETE LOSS OF CIRCULATION AT 1564' CEMENT PLUG #20 SET AT 1564' (115 FT.³ CMT.)
LOST 410 bbls. MUD WITH COMPLETE LOSS OF CIRCULATION AT 1735' SET 5 LOST CIRC. PLUGS (558 FT.³ CMT.)
SET 11 CEMENT ABANDONMENT PLUGS ON BOTTOM 1118 FT.³ CMT.
TIME-DEPTH PROGRESS GRAPH FOR C.F.S.U. 31-33
DRILLING WITH AERATED WATER. INTERMITTENT RETURNS TO SURFACE 2015' TO 4832'. NO RETURNS TO SURFACE 4832' TO T.D. AT 5221' SET 2 CEMENT PLUGS AT 5008' (237 FT.³) CEMENT.



TIME-DEPTH PROGRESS GRAPH FOR C.F.S.U. 14-29

COVE FORT SULPHURDALE UNIT

LOST CIRCULATION SUMMARY

All of the CFSU wells encountered severe lost circulation zones. A wide range of lost circulation materials, including fiber, cellophane, cotton seed hulls, mica, walnut hulls, sodium silicate-calcium chloride, and diatomaceous earth, were attempted with virtually no success. Cement plugs consisting of a variety of slurry types met with very limited, often short term, success in regaining circulation. In some cases it became necessary to drill without returns providing the thief zone accepted drill cuttings and the hole was kept clean. Drilling with aerated water was often effective in competent formations but greatly increased corrosion rates and sometimes resulted in the production of large quantities of formation water causing disposal problems.

Since it is ultimately important to cement casing strings completely from shoe to surface, lost circulation problems were faced as they occurred. When efforts to regain circulation were abandoned and the decision was made to drill ahead, lost circulation problems were only postponed until the next casing point was reached. A total of 91 cement plugs were utilized to combat lost circulation while drilling the four CFSU wells. The following tables compare slurry compositions for each of the lost circulation cement plugs. Success of the cement plugs was very limited. There was no single slurry composition that proved conclusively to be the most effective.

Most of the lost circulation problems occurred in carbonate formations. In some cases extensive caverns were encountered as evidenced by the drill string abruptly falling 30'. A satisfactory solution to the more severe lost circulation problems in the CFSU remains to be found.

PLUG NO.	TOTAL DEPTH (FT)	OEDP DEPTH (FT)	FORMATION TYPE	SLURRY COMPOSITION							
				VOLUME (FT^3)	PERLITE RATIO	SILICA FLOUR (%)	GEL (%)	$CaCl_2$ (%)	CFR-2 (%)	LCM #/SK	OTHER
1	796	787	Sanded Dolomite	1000	2:1		4	3		½	
2	796	772	Sanded Dolomite	435	2:1		4	3		½	
3	829	776	Sanded Dolomite	408	2:1		4		3/4		Caustic Water Flush
4	860	819	Sanded Dolomite	500	2:1		4	2		½	Caustic Water Flush
5	860	713	Sanded Dolomite	250	1:1		2	3		½	Caustic Water Flush
6	860	855	Sanded Dolomite	250				3	½		
6	860	855	Sanded Dolomite	500	1:1		2			½	
7	910	786	Sanded Dolomite	500	1:1		2		½	½	
8	913	882	Sanded Dolomite	694							Thix-Set Cement
9	1004	976	Sanded Dolomite	500	1:1		2	2	½		

PLUG NO.	DEPTH (FT)	DEPTH (FT)	FORMATION TYPE	VOLUME (FT^3)	PERLITE RATIO	SILICA FLOUR (%)	GEL (%)	$CaCl_2$ (%)	CFR-2 (%)	LCM #/SK	OTHER
1	1494	1457	Andesite	198	1:1	40	3				0.3% Retarder
2	1494	1353	Andesite	200	1:1	40	3				0.3% Retarder
3	2244	2202	Sandstone	250	1:1	40	3				
4	2244	2046	Sandstone	120	1:1	40	3				
5	2244	2046	Sandstone	250	1:1	40	3				
6	2244	2060	Sandstone	150	1:1	40	3				
7	2244	2172	Sandstone	396	2:1	40	3				
8	2250	2205	Sandstone	142						½	Thix-Set and Gilsonite
9	2250	1829	Sandstone	142						½	Thix-Set and Gilsonite
10	2250	1860	Sandstone	240	1:1	40	3				
11	2250	2209	Sandstone	120	1:1		3				
12	2250	2169	Sandstone	193	2:1	40	3				
13	2250	2170	Sandstone	180	1:1	40	3				
14	2250	1946	Sandstone	100						½	Thix-Set and Gilsonite
15	2342	2108	Sandstone	223						1½	Thix-Set and Gilsonite
16	2342	2232	Sandstone	59				2		1½	Frac Gel Flush
17	2342	2232	Sandstone	118				2		1½	Frac Gel Flush
18	2342	2201	Sandstone	210				2		½	Frac Gel Flush
19	2342	2232	Sandstone	136				2		½	Frac Gel Flush
20	2342	2239	Sandstone	136				2		½	Frac Gel Flush
21	2342	2201	Sandstone	98				2		½	6% Gilsonite
22	2342	2232	Sandstone	88				2		½	12% Gilsonite
23	2342	2233	Sandstone	88				2		½	8#/sk Gilsonite
24	2342	2232	Sandstone	161	2:1	40	3				Frac Gel Flush
24	2342	2232	Sandstone	98				2		½	8#/sk Gilsonite
25	2342	2201	Sandstone	161	2:1	40	3	3			NaSi-$CaCl_2$ Flush
26	2342	2201	Sandstone	352	1:1	40	3	3			Frac Gel Flush
27	2606	2575	Sandstone	174				2			Thix-Set and Gilsonite
28	2606	2448	Sandstone	175				2			Thix-Set and Gilsonite
29	2606	2418	Sandstone	247	2:1		5	2			
30	2606	2248	Sandstone	367	2:1		5	2			
31	2606	2139	Sandstone	215	1:1		4	2			
32	2606	2046	Sandstone	250	1:1	40	3				
33	2606	1860	Sandstone	250	1:1	40	3				
34	2606	1675	Sandstone	250	1:1	40	3	2			
35	2606	1490	Sandstone	250	1:1	40	3				
36	2804	2765	Dolomite	312	1:1	40	3		½		

PLUG NO.	DEPTH (FT)	DEPTH (FT)	FORMATION TYPE	VOLUME (FT^3)	PERLITE RATIO	SILICA FLOUR (%)	GEL (%)	$CaCl_2$ (%)	CFR-2 (%)	LCM (%)	OTHER
1	1241	1230	Dolomitic Limestone/ Dolomite	375	1:1	40	3		½		
2	1241	1230	Dolomitic Limestone/ Dolomite	350	1:1	40	3		½		
3	1241	1230	Dolomitic Limestone/ Dolomite	240	1:1	40	3		½		Gel Mud-LCM Flush
4	1241	1230	Dolomitic Limestone/ Dolomite	125	1:1	40	3		½	15	
5	1241	1230	Dolomitic Limestone/ Dolomite	225	1:1	40	3		½	15	
6	1241	1230	Dolomitic Limestone/ Dolomite	305	2:1	40	3				Gel Mud-LCM Flush
7	1241	1230	Dolomitic Limestone/ Dolomite	305	2:1	40	3				
8	1241	1230	Dolomitic Limestone/ Dolomite	230	1:1	40	3			15	
9	1241	1230	Dolomitic Limestone/ Dolomite	230	1:1	40	3			25	
10	1241	1230	Dolomitic Limestone/ Dolomite	210	1:1	40	3	2		20	
11	1241	1230	Dolomitic Limestone/ Dolomite	210	1:1	40	3	2		20	
12	1241	1230	Dolomitic Limestone/ Dolomite	210	1:1	40	3	2		20	
13	1241	1230	Dolomitic Limestone/ Dolomite	166				2		1#/ sk	Thix-Set and Gilsonite
14	1257	1230	Dolomitic Limestone/ Dolomite	166				2		1#/ sk	25#/sk Gilsonite
15	1257	1230	Dolomitic Limestone/ Dolomite	210	1:1	40	3		½		
16	1257	1230	Dolomitic Limestone/ Dolomite	86	1:1	40	3	3			
17	1257	1230	Dolomitic Limestone/ Dolomite	200	1:1	40	3	3			
18	1257	1230	Dolomitic Limestone/ Dolomite	235							Gel-Gilsonite Flush
19	1276	1260	Dolomitic Limestone/ Dolomite	115	1 Perlite: 1 Sand: 1 Cement						Pal-Mix Flush
20	1564	1535	Dolomitic Limestone/ Dolomite	115							Pal-Mix Flush
21	1735	1649	Dolomitic	104				2		1#/	25#/sk Gilsonite

PLUG NO.	TOTAL DEPTH (FT)	OEDP DEPTH (FT)	FORMATION TYPE	SLURRY COMPOSITION							
				VOLUME (FT^3)	PERLITE RATIO	SILICA FLOUR (%)	GEL (%)	$CaCl_2$ (%)	CFR-2 (%)	LCM (%)	OTHER
22	1735	1229	Dolomitic Limestone/ Dolomite	104				2		1#/ sk	25#/sk Gilsonite
23	1735	1610	Dolomitic Limestone/ Dolomite	104	1:1	40	3		½		Pal-Mix Flush
24	1735	1550	Dolomitic Limestone/ Dolomite	101	1:1	40	3		½		Pal-Mix Flush
25	1735	1580	Dolomitic Limestone/ Dolomite	145	1:1	40	3	2			
26	5009	4926	Siltstone/ Sandstone	112	1:1	40	3		½		NaSi-$CaCl_2$ Flush
27	5009	4833	Siltstone/ Sandstone	125	1:1	40	3		½		

PLUG NO.	TOTAL DEPTH (FT)	OEDP DEPTH (FT)	FORMATION TYPE	SLURRY COMPOSITION: VOLUME (FT^3)	PERLITE RATIO	SILICA FLOUR (%)	GEL (%)	$CaCl_2$ (%)	CFR-2 (%)	LCM (%)	OTHER
1	833	830	Conglomerate	265	1:1	40	3	2	½	5	
2	866	866	Conglomerate	265	1:1	40	3	2	½	5	
3	1249	935	Limestone/ Dolomite/ Sandstone	203		20		3			22% Kolite, 8% D53
4	1249	893	Limestone/ Dolomite/ Sandstone	203		20		3			22% Kolite, 8% D53
5	1249	872	Limestone/ Dolomite/ Sandstone	203		20		3			22% Kolite, 8% D53
6	1249	861	Limestone/ Dolomite/ Sandstone	201		20		3			22% Kolite, 8% D53
7	1330	1330	Limestone/ Dolomite/ Sandstone	187				2			12% Kolite, 10% RFC
8	1330	1295	Limestone/ Dolomite/ Sandstone	181				2			12% Kolite, 10% RFC
9	1330	1245	Limestone/ Dolomite/ Sandstone	181				2			12% Kolite, 10% RFC
10	1345	1344	Limestone/ Dolomite/ Sandstone	181				2			12% Kolite, 10% RFC
11	1345	1343	Limestone/ Dolomite/ Sandstone	248				2			21% Kolite, 8% RFC
12	1429	1429	Limestone/ Dolomite/ Sandstone	248		20		2			26% Kolite, 8% RFC
13	2080	2070	Limestone/ Dolomite/ Sandstone	191		20		2			25% Kolite, 8.2% RFC
14	2080	1885	Limestone/ Dolomite/ Sandstone	191		20		2			25% Kolite, 8.2% RFC
15	2080	1698	Limestone/ Dolomite/ Sandstone	191		20		2			25% Kolite, 8.2% RFC
16	2080	1490	Limestone/ Dolomite/ Sandstone	191		20		2			25% Kolite, 8.2% RFC
17	2080	1543	Limestone/ Dolomite/ Sandstone	191		20		2			25% Kolite, 8.2% RFC
18	2080	1466	Limestone/ Dolomite/ Sandstone	191		20		2			25% Kolite, 8.2% RFC

COVE FORT SULPHURDALE UNIT

CORROSION SUMMARY

Oxygen corrosion at rates in excess of $40\#/ft^2/yr$ was experienced while drilling with aerated water in CFSU wells 42-7 and 31-33. During normal drilling with mud oxygen corrosion was effectively controlled by maintaining high pH with caustic and adding an oxygen scavenger, sodium sulfite, with cobalt as a catalyst. When severe lost circulation necessitated drilling with aerated water, oxygen corrosion was greatly accelerated.

After experimenting with a variety of inhibition programs in the field and laboratory, a sodium nitrite-caustic program proved to be the most effective. Laboratory tests with a water designed to duplicate drill water used on well CFSU 42-7 indicated that a sodium nitrite concentration of 2.6 #/bbl and a pH of 11.5 should provide an effective program. Corrosion rates were reduced from over $40\#/ft^2/yr$ to $8\#/ft^2/yr$. Although this was a considerable improvement, corrosion rates were still well above the acceptable limit of $2\#/ft^2/yr$.

Lack of success in reducing corrosion rates to acceptable levels using the sodium nitrite program was probably due to the following:

1) High concentrations of dissolved salts in the

drill water accelerated corrosion. (These concentrations varied from well to well.)

2) Upset conditions allowed concentrations of sodium nitrite and pH to fall below critical levels at times.

3) Reaction with drill cuttings, reaction with produced carbon dioxide, and dilution with produced formation water caused a reduction in pH.

Before introducing the sodium nitrite-caustic system, corrosion severely affected both casing and drill pipe. Casing caliper logs indicated casing corrosion. Drill pipe inspection downgraded 54% of the joints inspected in the CFSU well 42-7.

After introducing the sodium nitrite-caustic system on CFSU well 31-33, 14% of the joints inspected were downgraded. Chemical costs of $68,000 using the sodium nitrite-caustic system on this well were at a breakeven point with the estimated savings in drill pipe damage. Potential casing damage and fishing jobs due to drill pipe failures were avoided making the chemical costs economical.

Although the sodium nitrite-caustic program did not reduce the corrosion rate to an acceptable limit, it appears to be the best practical chemical inhibition system available. A variety of other corrosion control methods were considered and rejected during the drilling of the CFSU wells. Union is currently considering using nitrogen in place of air to eliminate the problem of oxygen corrosion. A new type of nitrogen generator may overcome some of the logistical and economic problems that have precluded the use of this method to date.

GEOLOGIC SUMMARY OF THE COVE FORT-SULPHURDALE UNIT

The four geothermal exploration wells drilled by the Geothermal Division of Union Oil within the Cove Fort-Sulphurdale Unit area failed to establish the existence of a geothermal resource of sufficient temperature and productivity needed for electrical power utilization. The wells penetrated an underpressured, highly fractured, moderate to low temperature (178°C to 93°C), highly permeable geothermal reservoir consisting of contact metamorphic and sedimentary carbonate rock in a geologically complex area. The lack of production was due to the low temperature and low pressure which together with problems of toxic H_2S gas, lost circulation and fractured and unstable formations, lead to the abandonment of the project.

Figures 3 through 6 summarizes the geology of the four exploratory wells. Lost circulation and blind drilling has prevented the identification of parts of the geologic column.

Summary of the geochemical analyses which best represents the geothermal waters encountered is presented in the following table. Like the geology, the geochemical data is complex. The wide variety of water, ranging from 1320 ppm TDS to

10,000 ppm TDS was unexpected in the highly permeable reservoir that was thought to be well mixed and geochemically similar throughout the prospect.

The four wells penetrated a variable thickness of surface volcanics of Mid-Tertiary age (200 to over 2000 feet) which lies, with angular unconformity, over highly faulted and folded Lower Mesozoic and Upper Paleozoic sedimentary rocks. Superimposed over a portion of this geologic framework is an aureole of contact metamorphism and mineralization related to a Mid-Tertiary intrusive event.

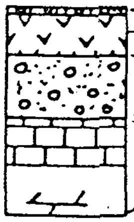
Static fluid levels in the wells are present between 1200 to 1400 feet below the surface. Very high temperature gradients (13 to 16°F/100 ft.) are present from the surface to the static water level of the reservoir. Below the top of the reservoir, the temperature profiles become nearly isothermal in the highly fractured and permeable geothermal reservoir. These isothermal sections are 300° to 310°F in the #42-7 well, 270° to 275°F in the #31-33 well, and 190° to 195°F (not stable) in the #14-29 well. The maximum temperature measured in the prospect was 353.5°F at 7320 feet in the #42-7 well. The area around the #42-7 well appears to be near the source of the geothermal anomaly, as defined by the deep drilling. The rapid termination of the shallow well temperature anomaly east, south and

and west of the #42-7 well leave little room for the presence of higher reservoir temperatures, considering the highly convective nature of the reservoir. Therefore, the geothermal anomaly has been evaluated and the reservoir judged to be inadequate for development.

:LL #	#42-7	#42-7	#31-33	#31-33	#14-29
l	9.98	9.54	9.79	7.44	7.41
)S	9405	4775	10,000	1320	4776
kalinity as CO_3	2380	470	1440	200	158
ı	3460	1310	4000	355	1220
	225	585	443	56.2	41.5
ı	26.4	32.0	14.4	74.4	332
	2450	1820	3900	502	2060
$)_4$	1280	560	760	187	900
	4.7	2.3	3.6	1.03	2.5
O_2	180	170	79	64.5	92
l	12.0	4.8	3.36	19.2	115.2
	- -	- -	13.31	1.16	265
$:O_3$	1322	265.9	658.8	244	192.8
$)_3$	- -	252	540	0	0
	0.8	0.30	0.5	0.2	6.4
	6.08	2.88	5.71	2.99	0.75
	0.324	0.271	0.166	0.914	0.010
	- -	0.022	0.420	0.006	0.005
	0.493	0.007	0.975	- -	0.085
	0.015	0.011	0.037	- -	- -
	0.075	1.811	0.041	0.104	0.350

GEOCHEMISTRY OF FORMATION WATERS ENCOUNTERED IN THE COVE FORT-SULPHURDALE UNIT AREA

Generalized Lithologic Log
Well Forminco *1

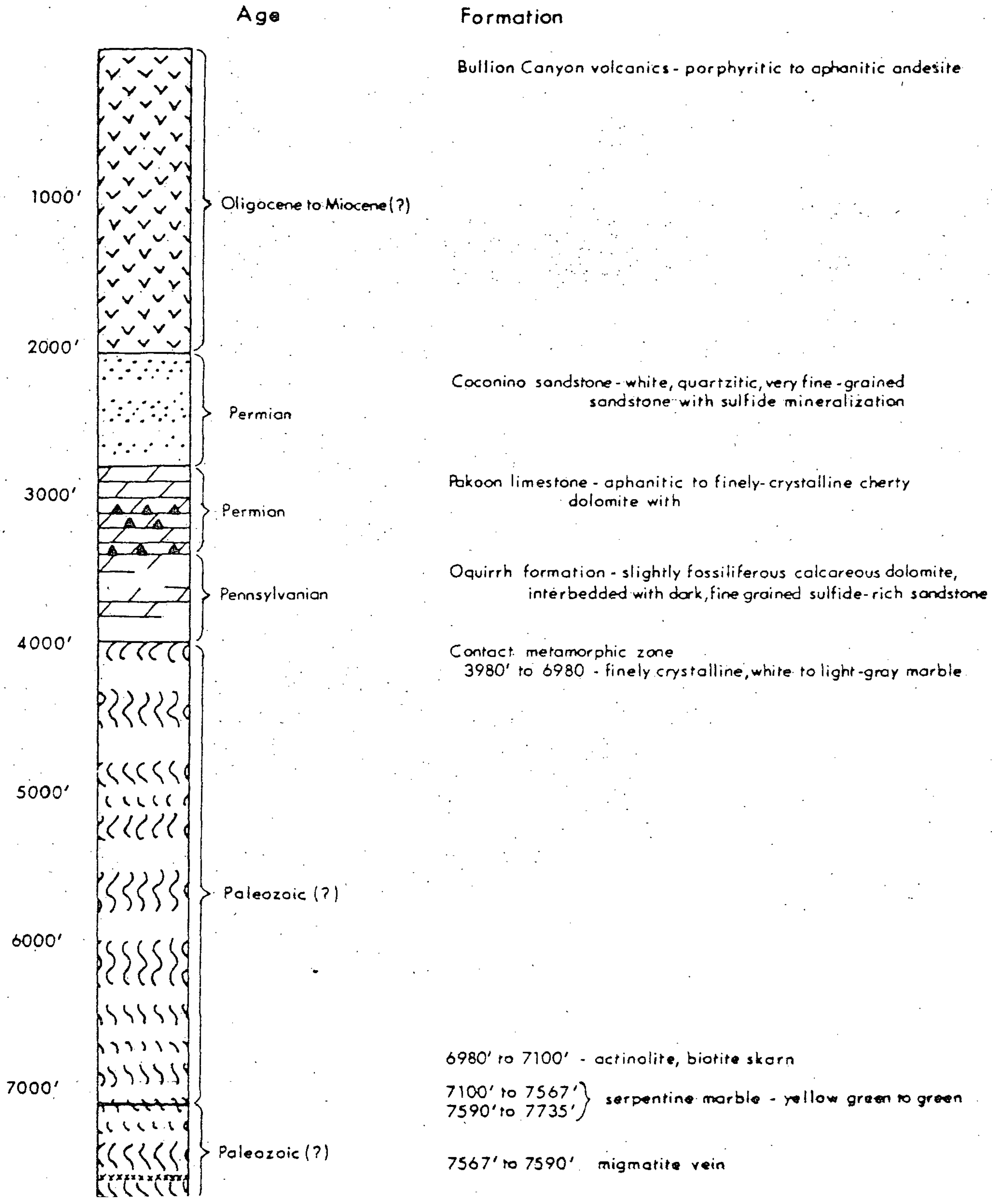


Age	Formation
Recent	Alluvium
Oligocene to Miocene (?)	Bullion Canyon volcanics, porphyritic andesite with argillic alteration
Upper Cretaceous to Paleocene (?)	Claron formation, quartzose boulder conglomerate
Paleozoic	Limestone, microcrystalline, with crinoid fragments
	Dolomite, poorly cemented, very fine to finely-crystalline "sanded" dolomite

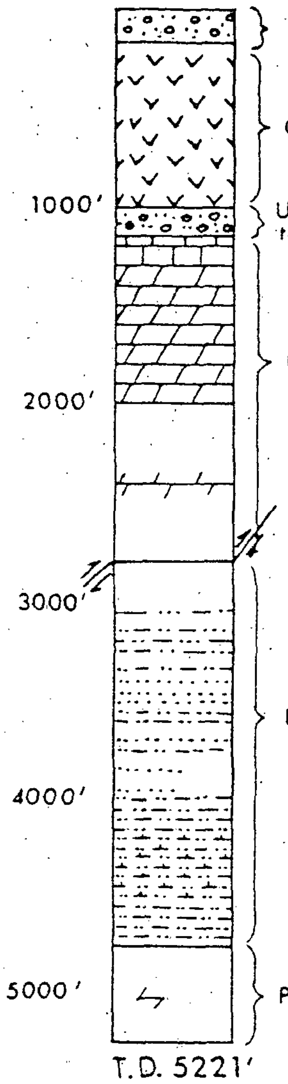
1000'

T. D. 1051'

Generalized Lithologic Log
Well ※42-7

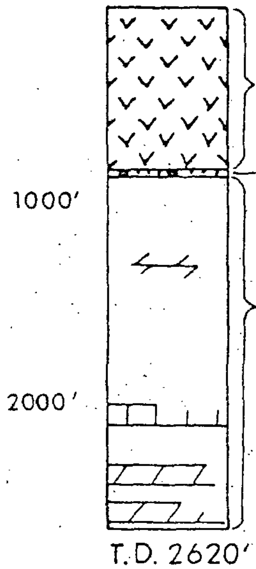


Generalized Lithologic Log
Well #31-33



Age	Formation
Recent	Alluvium
Oligocene to Miocene (?)	Bullion Canyon volcanics - porphyritic to aphanitic andesite with Chlorite and argillic alteration and sulfide mineralization
Upper Cretaceous (?) to Paleocene (?)	Claron formation - poorly sorted conglomeratic red siltstone
Upper Paleozoic	Unidentified - 1150' to 1300' medium grained dolomitic limestone with minor sandstone and chert 1300' to 2885' aphanitic, cherty dolomite and medium-grained calcareous dolomite with scattered sulfide mineralization
	Fault at 2886'
Lower Triassic	Moenkopi formation - red, calcareous, micaeous siltstone, and white, fine-grained sandstone
Permian	Kaibab limestone - no returns. Core at 5015' to 5021', recovered 8 inches. Dolomite, dark gray, fractured, brecciated

Generalized Lithologic Log
Well #14-29



Age	Formation
Oligocene to Miocene(?)	Bullion Canyon volcanics - porphyritic to aphanitic andesite to latite with hydrothermal alteration
Upper Cretaceous to Paleocene (?)	Claron formation - red calcareous silty conglomerate
Paleozoic (?)	Unidentified formation - dolomitic limestones, dolomites, with minor sandstones and quartzites, with sulfide mineralization

DOWNHOLE LOGGING TABLES

The following tables summarize downhole logging runs in the CFSU wells. Logs will be available from:

Rocky Mountain Well Log Service

P.O. Box 3150

Denver, Colorado 80201

(303) 825-2181

COVE FORT-SULPHURDALE #42-7

SCHLUMBERGER LOGGING DATA

DATE	TYPE OF LOG RUN	LOGGED INTERVAL	TOTAL DEPTH
1 Feb. 78	Dual Induction-Laterolog with linear correlating log; SP	1520' - 3444'	3447'
1 Feb. 78	Compensated Neutron Log: GR	50' - 3428'	3445'
1 Feb. 78	Temperature Log	1320' - 3447'	3447'
4 Feb. 78	Cement Bond Log	162' - 3314'	3323'
4 Feb. 78	Temperature Log	0' - 3058'	3065'
28 Feb. 78	Dual Induction-Laterolog with linear correlation log; SP	3358' - 7692'	7695'
28 Feb. 78	Borehole Compensated Sonic Log; GR	3358' - 7674'	7681'
28 Feb. 78	Compensated Neutron-Formation Density with GR, Caliper	3358' - 7679'	7680'
28 Feb. 78	Temperature Log	300' - 7550'	7680'
1 Mar. 78	Four-arm continuous Dipmeter	3358' - 6003'	6004'

"GO-INTERNATIONAL" LOGGING DATA

DATE	TYPE OF LOG RUN	LOGGED INTERVAL	TOTAL DEPTH
26 Feb. 78	Temperature Log	3450' - 7327'	7332'
26 Feb. 78	Temperature Log	300' - 7327'	7332'
27 Feb. 78	Temperature Log	300' - 7327'	7332'
27 Feb. 78	Temperature Log	1200' - 7320'	7332'

COVE FORT - SULPHURDALE #31-33

LOGGING DATA

DATE	TYPE OF LOG RUN	LOGGED INTERVAL	TOTAL DEPTH
	Schlumberger		
7/18/78	Temperature Log (malfunction suspected) [two maximum reading thermometers run simultaneously]	0' - 4858'	4858'
	Dipmeter and Four Arm Caliper [three maximum reading thermometers run simultaneously]	5207' - 1735'	5207'
7/19/78	Dual Induction - Laterolog [three maximum reading thermometers run simultaneously]	5207' - 1735'	5207'
	Compensated Neutron - Formation Density [three maximum reading thermometers run simultaneously]	5206' - 1735'	5206'
	Temperature Log	0' - 4858'	4858'
	Geotex		
7/19/78	Temperature, Spinner and Water Aquifer Log	0' - 4858'	4858'
	Radioactive Tracer and Spinner Log	0' - 4858'	4858'
	R. F. Smith Corporation		
5/24/78 to 7/24/78	Geothermal Data Log (includes engineering data related to drilling, geological, and other data)	52' - 5221'	5221'

COVE FORT-SULPHURDALE UNIT #14-29

LOGGING DATA

TYPE OF LOG RUN	TOTAL DEPTH	LOGGED INTERVAL	MAXIMUM READING THERMOMETERS	HOUR FLUID
SCHLUMBERGER				
Dual Induction-Laterolog 8	2080'	2080'-1240'	121°F	2-
Formation Density-Compensated Neutron	2080'	2080'-1240'	127°F	3-
Dipmeter and Four Arm Caliper	2080'	2080'-1240'	134°F	5-
Temperature Log	2620'	2452'-220'	186°F	4-
Dual Induction-Laterolog 8	2620'	2462'-2078'	185°F	6-
Formation Denisty-Compensated Neutron	2620'	2468'-2078'	194°F	7-
Dipmeter and Four Arm Caliper	2620'	2469'-2078'	198°F	9-
Temperature Log	2620'	2464'-220'	198°F	2

RESERVOIR ANALYSIS

The reservoir analysis of Cove Fort-Sulphurdale Unit is based on the following tests:

1. Well #42-7: Flow test, injection test, temperature surveys, pressure surveys, and spinner surveys.
2. Well #31-33: Temperature and pressure surveys.

The important reservoir characteristics of the Cove Fort-Sulphurdale reservoir are that it is (1) a low temperature, and (2) a low pressure system. Reservoir permeability-thickness product is about 23,000 md-ft.

The wells will make poor producers because of the low pressure. The pressure at 5,000 ft. datum is about 1540 psi which is less than the hydrostatic head of fresh water. The free water surface in the wells is about 1500 ft. below the wellhead.

Well #42-7 produced at a rate of 47,000 lbs/hr at 3 psig wellhead pressure and 200°F± wellhead temperature.

Low temperature resource also reduces the flow rates of the wells. At high temperatures, a larger fraction of the fluid will vaporize in the well-bore thus reducing the bottomhole flowing pressure and increasing the flow from the reservoir.

Permeability of the reservoir is fairly high. We calculated a kH product of around 23,000 md-ft. from the production/injection tests. High permeability and low pressure make these wells good injectors. The wells are capable of taking 1,000,000 lbs/hr at 0 psig wellhead pressure.

Based on the current economics, the resource discovered in the Cove Fort-Sulphurdale Unit is sub-commercial.

ENERGY SERVICES
INCORPORATED
Affiliated with Forsgren-Perkins Engineering
Energy Engineering and Development
Two Airport Plaza 1084 North Skyline Drive
Idaho Falls, Idaho 83401
(208) 529-3064

RECEIVED SEP 1982

September 22, 1982
JFK-142-82

Dr. P. M. Wright, Associate Director
Earth Science Laboratory
University of Utah Research Institute
420 Chipeta Way, Suite 120
Salt Lake City, Utah 84108

COVE FORT WELL TEST 42-7

Dear Mike:

Thank you for your willingness to talk to the State Air Pollution personnel with me, and to be interested in the Cove Fort Well Test.

Enclosed is a copy of the various analyses and test plans that may be of interest.

We have never received the UURI document on log analyses of that well. (We requested a copy 2 weeks ago.) , Could you have your secretary arrange to have a copy sent to us.

Sincerely,

ENERGY SERVICES, Inc.

Jay

Dr. Jay F. Kunze, P.E.
President

db

Enclosure

... the supervisor must approve this permit prior

5. SURFACE MANAGER: BLM ( ) Other ( )

4. WELL TYPE: PRODUCTION (X) INJECTION ( ) HEAT EXCHANGE ( ) OBSERVATION ( ) OTHER ( )
Production

6. UNIT AGREEMENT NAME
N/A

5. WELL STATUS:
Shut-in

7. WELL NO.
42-7

8. PE

NAME OF LESSEE/OPERATOR
Mother Earth Industries, Inc.

9. FIELD OR AREA
Cove Fort-Sulp

ADDRESS OF LESSEE/OPERATOR
45 Buckfield lane, Greenwich, CT. 06830

10. SEC, T., R., B.& M.
7, 26S, 6W, Sal

13. LOCATION OF WELL OR FACILITY
SE ¼ NE¼ NW¼

11. COUNTY
Beaver

12. STATE
Utah

14. TYPE OF WORK

GEOTECHNICAL WORK	(X)	CONVERT TO INJECTION	( )	PULL OR ALTER CASING	( )
SITE AND ROAD CONSTRUCTION	( )	FRACTURE TEST	( )	MULTIPLE COMPLETE	( )
CONSTRUCT NEW PRODUCTION FACILITIES	( )	SHOOT OR ACIDIZE	(X)	ABANDON	( )
ALTER EXISTING PRODUCTION FACILITIES	( )	REPAIR WELL	( )	CHANGE PLANS	( )
				OTHER	( )

15. DESCRIBE PROPOSED OPERATIONS (Use this space for well activities only. See instructions for current well conditions on reverse)

The well is cased to total depth, with slotted casing beginning at the 4300 ft level. See attached analysis report for casing depths and sizes.

When the well head is opened the well does not produce any fluids. Fluid level is app 950 ft. depth.

Proposed operations:

1) Perforate the 9-5/8 inch casing with 600 shots (1/2-inch holes) between 2500 and 28

2) Perform flow test using nitrogen lift with a coiled tubing unit to a depth of nomin 2500 ft. Use existing reserve pit for holding produced fluids.
If flow initially appears unsatisfactory, and is is surmised that fluids are enteri the 2700 ft level and flowing down the well to below the 4300 ft level, then it may be decided to drop a temporary plug on the 7-inch liner hanger (3064 ft) and perfor repeat nitrogen lift test.

3) Log the well for temperature after the nitrogen lift tubing is removed.

16. DESCRIBE PROPOSED OPERATIONS (Use this space for all activities other than well work)

See attachments provided by Enery Services, Inc.

(Use reverse side if needed)

17. I hereby certify that the foregoing is true and correct

SIGNED W.B. Portanova TITLE Pres. DATE August 27,

(This space for Federal use)

APPROVED BY ____ TITLE ____ DATE ____
CONDITIONS OF APPROVAL, IF ANY:

This permit is required by law (30 U.S.C. 1023); regulations: 30 CFR 270.14, 30 CFR 270.35, 30 CFR 270.45, 30 CFR 270.71-1, 30 CFR 270.72; Federal Geothermal Lease Terms and Stipulations and other regulatory requirements. The United States Criminal Code (18 U.S.C. 1001) makes it a criminal offen to make a willfully false statement or representation to any Department or Agency of the United States as to any matter within its jurisdiction.

COVE FORT, UTAH

GEOTHERMAL WELL 42-7

ANALYSIS AND EVALUATION

Based upon the reported results of the Union testing in May 1978 and the R&R Energy testing in July 1980. Certain data has been obtained from private communications with various persons involved with the testing or observers: - Mr. Bull of the USGS, Robert Helber of R&R Energy, Gary Foster of Instrument Service, Gordon Ford of Forminco, and Ron Schroeder of the Berkeley Group.

Report prepared by: ENERGY SERVICES
TWO AIRPORT PLAZA
IDAHO FALLS, ID 83402
August 1982

COVE FORT WELL 42-7

BACKGROUND

The well was drilled by Union Oil Company, in the SE, NE, NW corner of Section 7, T 26 S, R 6 W within a few miles of the intersection of Interstate Highways 15 and 70 in southern Utah. The well was spudded on November 29, 1977 and completed at the end of February, 1978 at a reported cost of $2,056,000. Total depth when drilled was 7635 ft from Kelly bushing, with a finished depth of 7610 ft. In May of 1978, Union Oil Co. performed both a production and a re-injection test on the well.

In July, 1980, R&R Energy performed some production testing on the well. They had planned to perforate the liner near the 2800 ft level, but such was not done. The 3000 ft of tie-back 7-inch diameter casing that Union had left in the well was removed.

In Novemeber, 1981, Energy Services logged the well with a temperature tool to the 4300 ft depth, and with a caliper tool to the 2300 ft depth.

The present condition of the well is as follows(all depths G.L.):

30 inch casing to depth of 10 ft, cemented

20 inch casing from G.L. to 231 ft, cemented

13-3/8 inch casing, G.L. to 1532 ft, cemented

9-5/8 inch casing, 1325 ft to 3337 ft, cemented

7 inch casing, 3064 ft to 7595 ft, with some cementing from the 3064 ft level to 4000 ft level

solid to 4333 ft, and with alternating sections of slotted and solid casing from there to the bottom.

The static water level is approximately 950 ft., and production zone temperatures are in the range of 310 to 330 F.

WELL CAPABILITY

Even once stimulated to produce fluids by using a gas lift, it is not likely that the well will produce steam indefinitely, though it apparently will continue to produce steam carrying some water at a combined rate of nominally 40,000 lb/hour for at least a few hours. Shutting-in of the well immediately "kills" it.

Union Oil calculated the permeability-thickness of the formation as 23 darcy-ft, a rather high value for a geothermal well.

Fluid quality of the water/steam produced by the well is 6000 to 7000 parts per million total dissolved solids (TDS), with some results showing water as low as 4000 ppm, some as high as 9000 ppm TDS. However, hydrogen sulfide content of the water was measured as approximately 100 ppm (a dangerous level), and ammonia concentrations of about 50 ppm.

CONCLUSIONS

The production capability of the well, measured in terms of the rate of fluid production vs. well drawdown from static conditions- - i.e the productivity index, appears to be nominally the same for the results from the R&R Energies test as it was from the Union Oil test. However, neither test was able to gather data which would enable one to determine, quantitatively, a productivity index, except for the injection test by Union Oil, which gave a result of approximately 0.3 psi per gallon per minute (0.7 ft per gallon per minute). That result is not particularly outstanding for a water well, but nomianlly typical for a geothermal well in this type of formation. It is suspected that the zone between 2500 and 2800 ft could provide a substantially higher productivity index for the well, based on the production of fluids from that zone during drilling (about 500 gallons per minute were reported as being produced).

The above results indicate that a pump setting depth of at least 1500 ft would be needed to produce 300 gpm of fluids that would retain the carbon dioxide and other gases in solution until the fluids reached the flash tank at the well head. In its present condition the well cannot be relied upon to produce steam without pump assist. Even if the production might continue indefinitely after once being stimulated, such flow would not exceed 40,000 lb/hr over the long term.

COVE FORT GEOTHERMAL WELL 42-7

PROPOSED REMEDIAL WORK

AND

WELL TEST PLAN

Prepared by:

ENERGY SERVICES
TWO AIRPORT PLAZA
IDAHO FALLS, IDAHO
83402

August 1982

PROPOSED ACTION AND DESIRED RESULTS

It is proposed that three basic operations be undertaken on the well, with a fourth operation being proposed as optional, depending on the results of the first three operations.

1) Perforate the casing in the range of 2500 to 2800 ft, with 600 shots, each making a 0.49 inch diameter hole, and each shot capable of penetrating both the casing and up to 17 inches of cement. Log the well for temperature profile, to the 4000 ft level.

2) Perform a nitrogen lift flow test, for a period of approximately 24 hours, or until the reserve pit is filled with fluids. Adequate protection from hydrogen sulfide poisoning must be taken during this test period.

3) Log the well to determine the temperature profile after the nitrogen lift tubing is removed (whether or not the well is flowing).

4) Use the wire line for the perforating service company to set a bridge plug just at the liner hanger for the 7-inch tubing (3040 ft). Air lift the well to determine productivity from the perforated region, 2500 to 2800 ft.

The need for conducting Task 4 will depend on the results of measured production from Task 2. If this measured flow is substantially better than the results of the Union or R&R ttests, it will not be considered necessary to conduct Task 4.

1) Perforation and logging - $15,000

2) Nitrogen lift, using 250,000 scf of nitrogen, and lifting from 3000 ft

- $17,500

3) Logging the well for temperature to 5000 ft

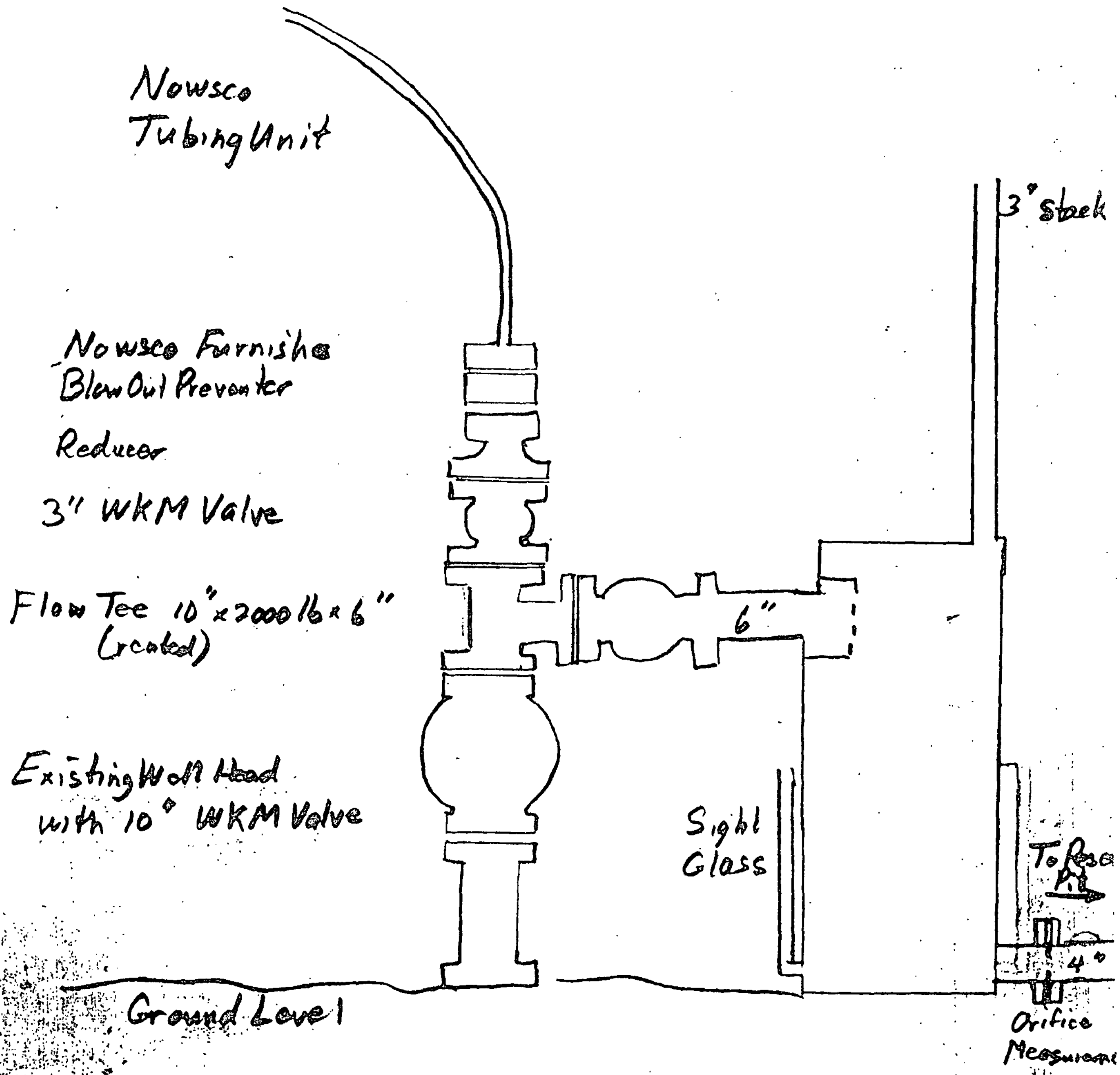
- $4,000 ($5,500 if flowing)

4) (Optional) Installation of bridge plug. Will depend on whether or not a retrievable plug is used. Includes flow meter measurements.

- $18,000 (very approximate)

Note: Option 4 may vary in costs if data gathered in the previous steps indicate a dual completion for this well might be feasible, such as producing from above the 3,000 foot level and injection below this depth.

Cove Fort Well Test	BY JFK	DATE 9/20/82	PROJECT NO. 2062
SUBJECT Configuration at Well Head	DISTRIBUTION		SHEET OF



DRILL SITE RECOMMENDATIONS

for

MOTHER EARTH INDUSTRIES, INC. PROPERTIES

COVE FORT-SULPHURDALE KGRA

MILLARD AND BEAVER COUNTIES, UTAH

by

Joseph N. Moore
Howard P. Ross

December 1982

Executive Summary

The geoscientific data collected to date points to the existance of a large, moderately high temperature geothermal system in the Cove Fort/Sulphurdale area. Potentially productive portions of the field are located in the southwestern portion of the property currently held by Mother Earth Industries, Inc. (MEI). Drilling depths to the geothermal reservoir in this area are estimated to be between 2000 and 3000 feet, based on data from well 42-7 and existing electrical resistivity surveys. Two drill sites have been targeted on Sec. 12, R7W T26S. One additional site is located in Sec. 7, R6W T26S. The reservoir lithologies and temperature, and drilling difficulties which may be encountered in this area are described in this report.

Introduction

During the last few years a large amount of geoscientific data has been collected on the Cove Fort-Sulphurdale area. Together, these data suggest that the Cove Fort-Sulphurdale area contains a potentially large, moderately high temperature geothermal system. This report summarizes the geotechnical data which bear on the siting of a deep geothermal production well on property held by Mother Earth Industries, Inc.

The reservoir rocks penetrated in deep wells consist mainly of limestone and dolomite capped locally by a thick succession of volcanic rocks. These sedimentary and volcanic rocks were thermally altered approximately 24 million years ago by a large body of quartz-monzonite, which is located beneath the southern portion of the prospect area. Although this intrusive is too old to supply any heat to the present thermal system, chemical analyses of fluids discharged from well 42-7 (unpub. data, Appendix I) suggest that intrusive rocks may be an important host to the thermal fluids at depth.

Fluid flow through the relatively dense metamorphic and igneous rock at depth is restricted to faults and fractures. The major faults within the area are steeply dipping northerly and easterly trending structures. These structures are responsible for the formation of the dominant topographic features within the area, and today are marked locally by the alignment of sulphur deposits, altered ground, and fumeroles. Movement along the faults that bound the Tushar Mountains created the Cove Fort-Beaver graben, a deep basin now capped by recent basalt flows. Faulting was accompanied by large scale landsliding along the northwestern edge of the range. These landslide blocks form a relatively impermeable cap to the geothermal system between Cove Fort and Sulphurdale.

Although the geometry of the geothermal system is not yet well understood, several geologic and geophysical observations led Ross and others (1982) to conclude that the exploration to date has concentrated on the peripheral portions of the thermal field. These observations include: 1) decreasing temperatures from Sulphurdale to Cove Fort, 2) generally increasing resistivity values northward and eastward from Sulphurdale and c) anhydrite mineralization in the deep part of well 42-7. This mineralization was interpreted as resulting from the influx of cool water into the thermal system. Recent flow tests of well 42-7 (unpub. data, 1982 report by Energy Services) which indicate that fractured rocks near 3000 feet are transmitting cooler water into well 42-7 further support this model.

Implicit in the definition of our target zone is our model for the overall Cove Fort-Sulphurdale-Dog Valley thermal occurrences. We envision high temperature fluids rising along deep seated young structures which bound this northern limit of the Cove Fort-Beaver graben and cut the Cinder Crater. The intersection of these zones with older, major east-west structures provide the primary conduits for thermal fluids which migrate north along basin and range faults and eastward along the base of glide blocks and easterly trending structures. The thermal waters are increasingly diluted by recharge areas in the Tushar and Pavant range.

General Area of High Temperature Potential

It is expedient to define a broad area of high temperature geothermal potential within the MEI property block prior to recommending specific drill sites. This has been done based upon our understanding of previous exploration data and reports (Moore and Samberg, 1979; Ross, 1979; Ross, Moore and Christensen, 1982). This information has been supplemented by a limited review of the geologic and geophysical data specific to the MEI land position. The resultant area considered to have potential for high temperature water (similar to, or greater than well CFSU 42-7) is shown on Plate I. The area is essentially limited to section 12, T26S, R7W, and section 7, T26S, R6W.

The target area is characterized by a large volume of low resistivity earth as recorded by Union Oil Co. lines AA', and BB', and by Earth Science Laboratory line 4 to the north. The extensive hydrothermal alteration at Sulphurdale is a visible manifestation of proximity to a major hydrothermal system. The area includes one or two north-northeast trending basin and range faults which form the eastern border of the Cove Fort-Beaver graben, and as such probably extend to great depth. These faults are seen in outcrop and are evident in both gravity and magnetic data. The northern limit is jointly defined by the MEI property border in section 1, the resistivity cutoff on line AA' and higher resistivities on line 4 to the north, and by the apparent decrease in temperature (from well results) to the north. The target area is open to the south.

An eastern limit is provided by resistivity data, geologic structures and probable increased distance from deep seated faults thought to act as the primary conduits for high temperature fluids intersected in well CFSU 42-7. The low resistivity zone is open to the west so the property border and geologic considerations provide a western limit.

We also note areas of exploration interest in the north central part of S1, T25S R7W and S6, T25S R6W. A narrow zone of 5 ohm-m resistivity occurs along the projection of a NNE trending fault in section 1; this is thought to indicate the leakage of thermal waters some distance from the thermal center. Much of section 6 is of interest as an area sealed by the landslide block (Moore and Samberg, 1979) adjacent to CFSU 42-7.

General Considerations

Three drilling targets were selected and prioritized within the property boundaries. The prioritization was based on several factors including: 1) the probable existence of geothermal fluids at moderate depths (less than several thousand feet), 2) the location of zones of high structural permeability, 3) probable reservoir rock types, 4) possibility of encountering extremely difficult drilling conditions, and 5) an evaluation of fluid geochemistry.

We stress, however, that the work conducted on MEI property by Union Oil Co. and the Dept. of Energy has been largely exploratory in scope, and much additional information is needed before reservoir temperatures and productivities can be determined. A systematic exploratoration program consisting of additional detailed geophysical techniques (including gravity and electrical resistivity surveys) and drilling of three to four deep thermal gradient wells could provide this information at a cost substantially less than a single deep exploration well.

Location of Thermal Waters

To date electrical geophysical techniques have provided the most reliable method of predicting the existance of thermal fluids at shallow to moderate depths. While we believe that the low resistivities accurately reflect the presence of conductive, thermal fluids along the western edge of the property held by MEI, the data are not sufficiently detailed to allow definition of individual upwelling centers. Consequently we have relied extensively on mapped relationships and supporting data from other geophysical techniques in siting these drillholes.

Permeability and Reservoir Lithologies

The shallow portions of the thermal reservoir near Sulphurdale include metamorphosed limestone and dolomite and hypabyssal igneous rocks which occur as pipe like to irregular shaped bodies. It is anticipated that the highest fracture permeability will be encountered in the metamophosed sedimentary rocks adjacent to steeply dipping faults which can tap thermal fluids at depth. Dissolution of limestone adjacent to fractures by circulating groundwaters and fracturing of the metamorphosed rocks in the vicinity of major intrusive bodies may serve to further enhance the initial fracture permeabilities near Sulphurdale. In contrast water-rock interactions in glassy intrusives, such as those which crop out in the Sulphurdale area, may lead to a decrease in permeability as a result of clay formation along fractures.

Volcanic rocks ranging in age from 19-27 m.y. and recent alluvial deposits may also occur within the graben. These rocks are exposed on the flank of the Tushar Mountains. Lithologic descriptions of the volcanic rocks and their stratigraphic relationships have been detailed by Moore and Sandberg (1979) and summarized by Ross and others (1982). Fluid movement through these rocks may occur along both steeply dipping faults and laterally along bedding planes, permeable sands, flow breaks, and at the base of individual landslide blocks.

The distribution of steeply dipping faults and intrusive rocks near Sulphurdale has been mapped in detail using a combination of geologic and geophysical techniques. Major faults which could provide zones of high structural permeability occur near the contact of a large deeply buried intrusive near Sulphurdale. These have been chosen as the highest priority sites within the target area. The location of these sites is discussed more fully below.

Drilling Conditions

A variety of severe drilling conditions have been encountered in this area by Union Oil Co. and other operators. The most severe problems occurred during the drilling of Forminco #1. These problems are related to intense decomposition of the reservoir rocks by downward percolating acid-rich water which forms in areas where hydrogen sulphide discharges at the surface. Similar conditions are likely to occur within the Sulphurdale pit.

Consequently we suggest that drilling in the pit be avoided.

Other problems have included the discharge of hydrogen sulphide gas and frequent zones of lost circulation. Hydrogen sulphide discharges have been encountered during drilling of all deep wells in the area. While we do not anticipate a continuous discharge of high levels of hydrogen sulphide at any of the targeted sites, the penetration of local pockets of gas, particularly near the water table, is possible.

Methods to accurately predict the location of lost circulation zones have not yet been developed. Although zones of extreme lost circulation and "running dolomite" are not likely to be penetrated, lost circulation related to fracturing should be anticipated. The sealing of lost circulation zones has proven to be extremely difficult and costly in this area. Thus it may be prudent to drill these zones "blind" to avoid both additional costs and the possibility of formation damage to potential productive zones.

Evaluation of Fluid Chemistry

The analytical data for two fluid samples collected by Dr. J. Kunze during an October, 1982 flow test of well 42-7 are presented in Appendix I. The fluids are sodium-chloride brines with a total dissolved solids content of approximately 4000 ppm.

Although the predominant rock type within the well 42-7 is limestone, the chemistry of the discharged waters suggest that they have also interacted with other rock types. For example, the relatively high sodium and potassium contents of the fluids are typical of waters which contact more silicic rocks such as the igneous rocks which underlie the Sulphurdale area. Calcium contents of 50-70 ppm, are on the other hand, consistent with water rock interactions involving limestone.

Estimates of the reservoir temperatures near Sulphurdale can be made by applying various cation geothermometers to the fluid analyses. The results of these calculations are presented in Appendix I, and suggest that reservoir temperatures in excess of 200°C are possible. The relatively high contents of boron (B) and fluoride (F) which are frequently enriched in high temperature thermal waters is, we believe, consistent with the geothermometry estimates.

Drill Site Recommendations

All of the Union Oil Company exploration wells encountered extreme drilling difficulty and as a result were very costly. Forminco #1 was abandoned at 1050 ft and CFSU #14-29 was abandoned at 2620 ft. Our detailed drill site recommendations are based on our understanding of specific structures with the intent of intersecting structurally prepared zones at depths below the water table in an attempt to minimize drilling problems while simultaneously testing logical thermal conduits.

Drill Site 1. Our highest priority drill site is located near the center of S12, T26S R7W (Plate 1). The site is 200 to 400 feet north of an east trending fault believed to dip at a steep angle to the north, and 300-1000 feet west of a steeply dipping north-trending Basin and Range fault. The exact dip and position of the fault planes at a given depth are unknown. We would hope to intersect one or both fault planes at depths greater than 1000 feet and test both faults and the intersection zone with this drill hole. Resistivity data on Union Oil Co. lines AA' and BB' indicates a large area of low (4-5 ohm-m) resistivity extending to depths greater than 2000 feet near the site. A second northeast trending fault occurs west of the proposed drill site. The site should be a sufficient distance west of the high voltage transmission line to ensure safe drilling operations.

Drill Site 2. Site 2, located north of the Sulphurdale pit will, we anticipate, produce fluids of a quality slightly better than those discharged from well 42-7. Site 2 is located on the eastern edge of the area likely to contain moderately high temperature thermal fluids at relatively shallow depths, near a major structural intersection.

Drill Site 3. The third priority drill site is located near the southcentral edge of S12, T26S, R7W. The site should be 200 to 600 feet west of the northeast trending Basin and Range fault. The intent of this drill hole would be to intersect the fault plane at depths greater than 1000 feet. The site is inferred to lie within the broad low resistivity zone at depth. The nearest cross-structure control line, Union Oil Co. Line AA', is 5000-6000 feet to the north. Low resistivities are indicated on Union Oil Co. Line BB' approximately 1500 feet to the east.

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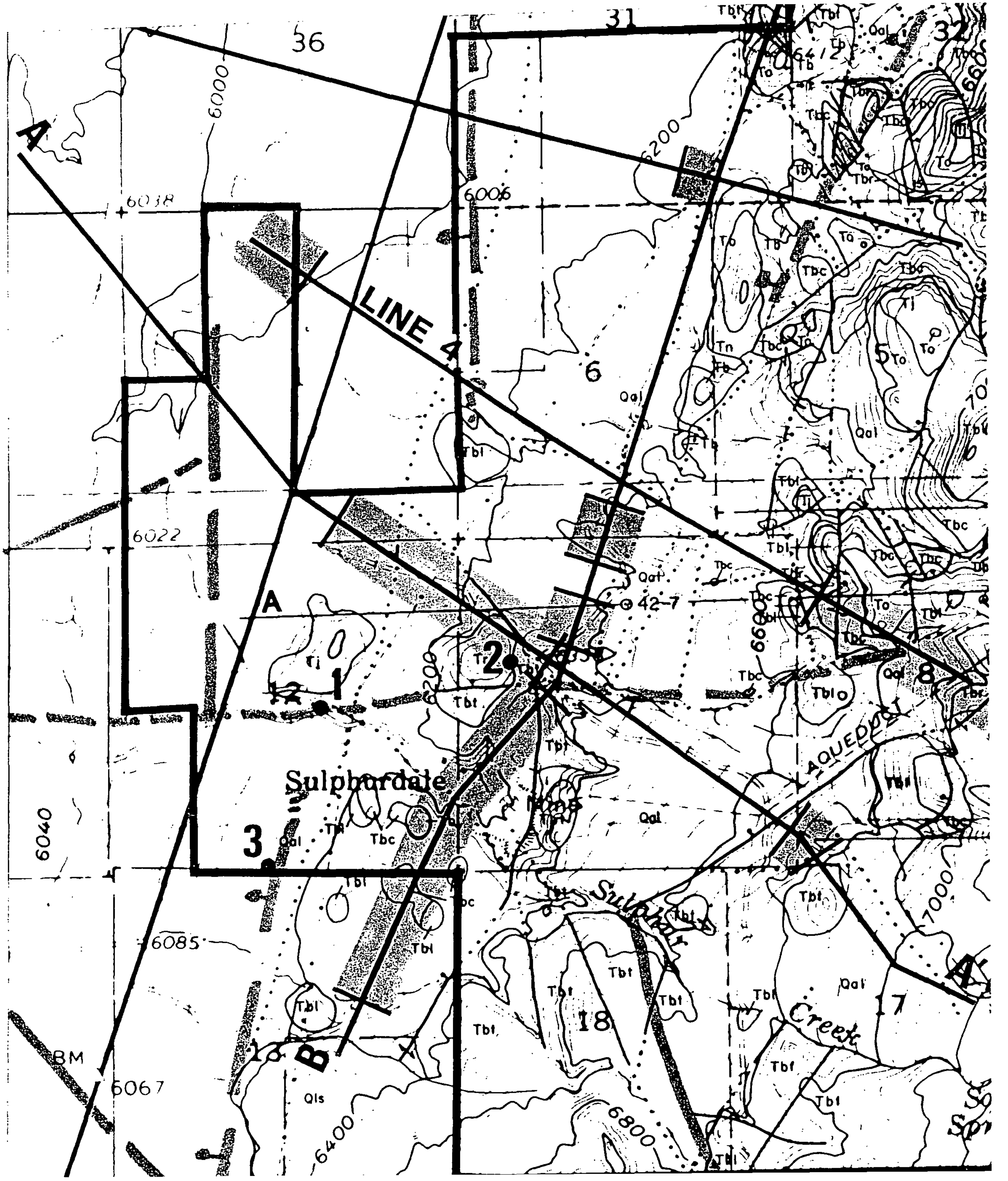
Ross, H. P., 1979, Numerical modeling and interpretation of dipole-dipole and IP profiles, Cove Fort-Sulphurdale KGRA, Utah, Univ. Utah Res. Inst., Earth Sci. Lab. report, 26, 22 p.

Ross, H. P., Moore, J. N., and Christensen, O. D., 1982, The Cove Fort-Sulphurdale KGRA - A geologic and geophysical case study: ESL/UURI Report, ESL-90, 47 p.



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APPENDIX I

CHEMICAL ANALYSIS OF FLUID

SAMPLES FROM CFSU #42-7

Sample Number (Company): F/2

Sample Number (ESL): 5

Company: FORMINCO

Analytic Date: 1982

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	Concentration (ppm)	Analytic Method	Detection Limits	Concentration (Moles/Liter)
Na	1417.00	1	1.20	0.616E-01
K	280.00	1	2.50	0.716E-02
Ca	50.00	1	0.20	0.125E-02
Mg	2.00	1	0.50	0.823E-04
Fe	0.92	1	0.02	0.165E-04
Al	< 0.60	1	0.60	< 0.222E-04
SiO2	281.00	1	0.43	0.468E-02
B	10.50	1	0.10	0.971E-03
Li	5.61	1	0.05	0.808E-03
Sr	2.39	1	0.01	0.273E-04
Zn	0.30	1	0.10	0.459E-05
Ag	< 0.05	1	0.05	< 0.464E-06
As	1.00	1	0.60	0.133E-04
Au	< 0.10	1	0.10	< 0.508E-06
Ba	< 0.60	1	0.60	< 0.437E-05
Be	< 0.01	1	0.01	< 0.555E-06
Bi	< 2.50	1	2.50	< 0.120E-04
Cd	< 0.06	1	0.06	< 0.534E-06
Ce	< 0.20	1	0.20	< 0.143E-05
Co	< 0.02	1	0.02	< 0.339E-06
Cr	< 0.05	1	0.05	< 0.962E-06
Cu	< 0.06	1	0.06	< 0.944E-06
La	< 0.10	1	0.10	< 0.720E-06
Mn	< 0.20	1	0.20	< 0.364E-05
Mo	< 1.20	1	1.20	< 0.125E-04
Ni	< 0.10	1	0.10	< 0.170E-05
Pb	< 0.20	1	0.20	< 0.965E-06
Sn	< 0.10	1	0.10	< 0.843E-06
Sb	< 0.70	1	0.70	< 0.575E-05
Te	< 1.20	1	1.20	< 0.940E-05
Th	< 2.50	1	2.50	< 0.108E-04
Ti	< 0.10	1	0.10	< 0.209E-05
U	< 6.20	1	6.20	< 0.260E-04
V	< 1.20	1	1.20	< 0.236E-04
W	< 0.10	1	0.10	< 0.544E-06
Zr	< 0.10	1	0.10	< 0.110E-05
Total Alkalinity as HCO3	94.00	2	10.00	0.154E-02
SO4	426.00	4	2.00	0.443E-02
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Measured	3996.00	4	4.00
Calculated	4087.72	6	
100xMeas/Calc	97.76		

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Analytical Methods:

1. Inductively Coupled Plasma Spectrometer
2. Titration (in laboratory)
3. Titration (in the field)
4. Gravimetric
5. Specific Ion Electrode
6. Method of Hem (1970, USGS water supply paper 1473)
7. pH meter (laboratory)
8. pH meter (field)
9. Colorimetric
10. Atomic Adsorption

****
****

CATIONS	
Na	61.63550
K	7.16076
Ca	2.49501
Mg	0.16453
Fe(+3)	0.03295
Li	0.80847
Sr	0.05455
Zn	0.00918
As	0.04004
Sum of Cations:	72.40094
ANIONS	
HCO3	-1.53972
CO3	0.00000
SO4	-8.86946
Cl	-51.33992
PO4	0.00000
F	-0.36842
Sum of Anions:	-62.11752
CATION-ANION BALANCE:	10.28342
Balance/Larger Sum	14.20

****

	$\frac{\text{Milliequivalents}}{\text{Liter}}$	Percent (Millieq./Liter)
CATIONS		
Na	61.63550	86.26
K	7.16076	10.02
Ca	2.49501	3.49
Mg	0.16453	0.23
Total Cations	71.45576	100.00
ANIONS		
HCO3	1.53972	2.49
CO3	0.00000	0.00
SO4	8.86946	14.36
Cl	51.33991	83.14
Total Anions	61.74908	100.00

GEOTHERMOMETERS

Geothermometer	Temperature (Degrees C)	Reference
Quartz (no steam loss)	204.	Fournier (1981)
Quartz (maximum steam loss)	188.	Fournier (1981)
Chalcedony	187.	Fournier (1981)
alpha-Cristobalite	156.	Fournier (1981)
beta-Cristobalite	106.	Fournier (1981)
Amorphous Silica	80.	Fournier (1981)
Na/K (Fournier)	283.	Fournier (1979)
Na/K (Truesdell)	275.	Fournier (1981)
Na-K-Ca	259. (beta=1/3)	Fournier&Truesdell (1974)
Na-K-Ca with Mg correction	256. (R= 1.7)	Fournier&Potter (1979)
Na/Li	169.	Fouillac&Michard (1981)
Li	225.	Fouillac&Michard (1981)

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References:

Fouillac, C. and G. Michard, 1981, Sodium/Lithium ratio in water applied to geothermometry of geothermal reservoir: Geothermics, v. 10, p55-70.

Fournier, R.O., 1979, A revised equation for the Na/K geothermometer: Geoth. Res. Council Tran., v. 3, p221-224.

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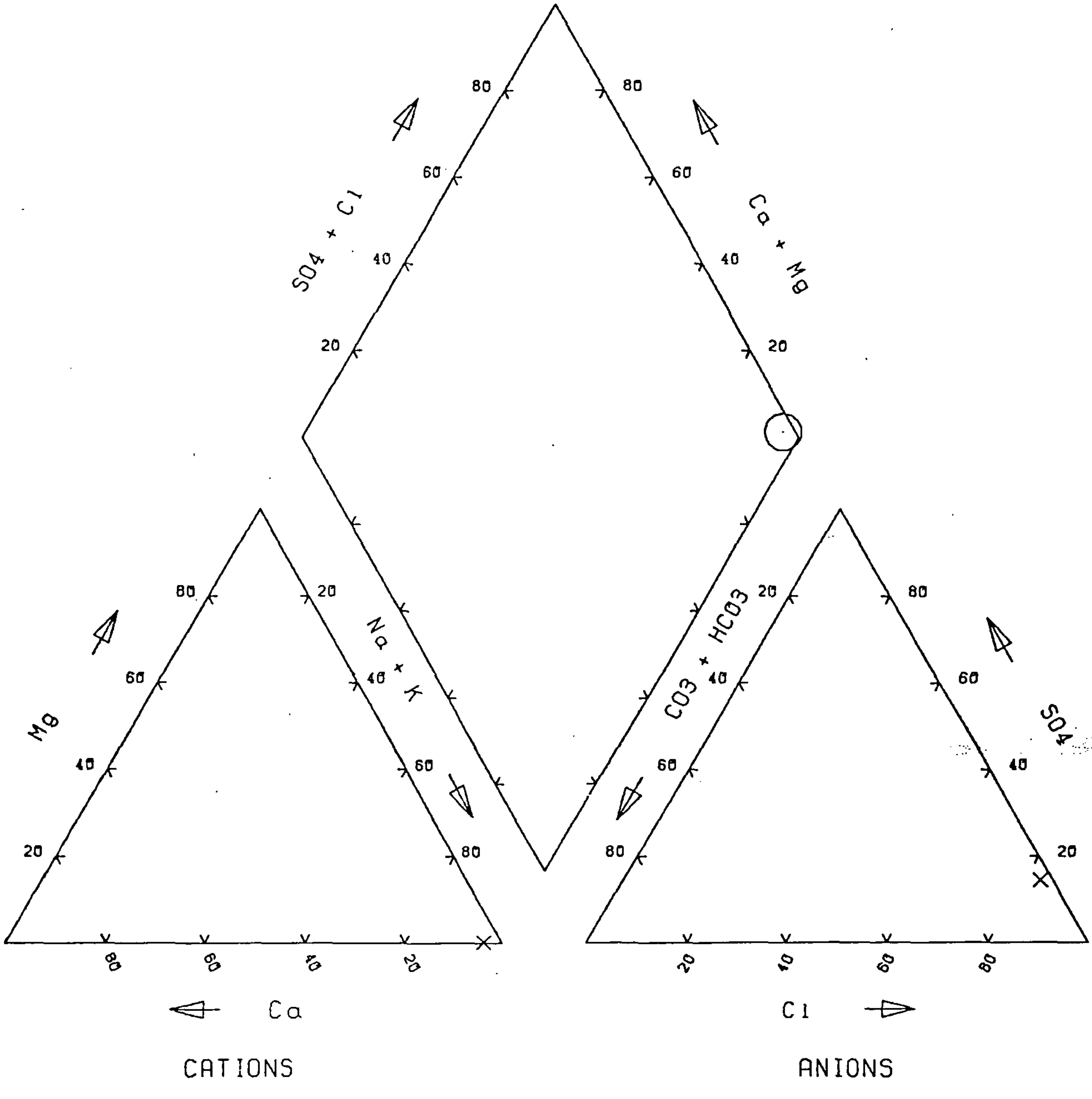
Collection date:

Analytical Date: 1982



PERCENT OF TOTAL
MILLIEQUIVALENTS PER LITER

Sample Number (Company): F/3

Sample Number (ESL): 6

Company: FORMINCO

Analytic Date: 1982

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	Concentration (ppm)	Analytic Method	Detection Limits	Concentration (Moles/Liter)
Na	1574.00	1	1.20	0.685E-01
K	331.00	1	2.50	0.847E-02
Ca	72.00	1	0.20	0.180E-02
Mg	9.00	1	0.50	0.370E-03
Fe	2.59	1	0.02	0.464E-04
Al	< 0.60	1	0.60	< 0.222E-04
SiO2	291.00	1	0.43	0.484E-02
B	12.40	1	0.10	0.115E-02
Li	6.61	1	0.05	0.953E-03
Sr	2.20	1	0.01	0.251E-04
Zn	1.70	1	0.10	0.260E-04
Ag	< 0.05	1	0.05	< 0.464E-06
As	0.90	1	0.60	0.120E-04
Au	< 0.10	1	0.10	< 0.508E-06
Ba	< 0.60	1	0.60	< 0.437E-05
Be	< 0.01	1	0.01	< 0.555E-06
Bi	< 2.50	1	2.50	< 0.120E-04
Cd	< 0.06	1	0.06	< 0.534E-06
Ce	< 0.20	1	0.20	< 0.143E-05
Co	< 0.02	1	0.02	< 0.339E-06
Cr	< 0.05	1	0.05	< 0.962E-06
Cu	< 0.06	1	0.06	< 0.944E-06
La	< 0.10	1	0.10	< 0.720E-06
Mn	< 0.20	1	0.20	< 0.364E-05
Mo	< 1.20	1	1.20	< 0.125E-04
Ni	< 0.10	1	0.10	< 0.170E-05
Pb	< 0.20	1	0.20	< 0.965E-06
Sn	< 0.10	1	0.10	< 0.843E-06
Sb	< 0.70	1	0.70	< 0.575E-05
Te	< 1.20	1	1.20	< 0.940E-05
Th	< 2.50	1	2.50	< 0.108E-04
Ti	< 0.10	1	0.10	< 0.209E-05
U	< 6.20	1	6.20	< 0.260E-04
V	< 1.20	1	1.20	< 0.236E-04
W	< 0.10	1	0.10	< 0.544E-06
Zr	< 0.10	1	0.10	< 0.110E-05
Total Alkalinity as HCO3	148.00	2	10.00	0.242E-02
SO4	375.00	4	2.00	0.390E-02
Cl	2130.00	2	2.00	0.601E-01

Calculated   4575.20   6
100xMeas/Calc   98.14

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Analytical Methods:

1. Inductively Coupled Plasma Spectrometer
2. Titration (in laboratory)
3. Titration (in the field)
4. Gravimetric
5. Specific Ion Electrode
6. Method of Hem (1970, USGS water supply paper 1473)
7. pH meter (laboratory)
8. pH meter (field)
9. Colorimetric
10. Atomic Adsorption

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CATIONS	
Na	68.46455
K	8.46504
Ca	3.59281
Mg	0.74038
Fe(+3)	0.09275
Li	0.95259
Sr	0.05022
Zn	0.05201
As	0.03604
Sum of Cations:	82.44632
ANIONS	
HCO3	-2.42424
CO3	0.00000
SO4	-7.80762
Cl	-60.08463
PO4	0.00000
F	-0.35789
Sum of Anions:	-70.67439
CATION-ANION BALANCE:	11.77193
Balance/Larger Sum	14.28

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	Milliequivalents / Liter	Percent (Millieq./Liter)
CATIONS		
Na	68.46455	84.25
K	8.46504	10.42
Ca	3.59281	4.42
Mg	0.74038	0.91
Total Cations	81.26276	100.00
ANIONS		
HCO3	2.42424	3.45
CO3	0.00000	0.00
SO4	7.80762	11.10
Cl	60.08463	85.45
Total Anions	70.31648	100.00

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Geothermometer	Temperature (Degrees C)	Reference
Quartz (no steam loss)	207.	Fournier (1981)
Quartz (maximum steam loss)	190.	Fournier (1981)
Chalcedony	190.	Fournier (1981)
alpha-Cristobalite	159.	Fournier (1981)
beta-Cristobalite	109.	Fournier (1981)
Amorphous Silica	82.	Fournier (1981)
Na/K (Fournier)	290.	Fournier (1979)
Na/K (Truesdell)	284.	Fournier (1981)
Na-K-Ca	262. (beta=1/3)	Fournier&Truesdell (1974)
Na-K-Ca with Mg correction	217. (R= 5.8)	Fournier&Potter (1979)
Na/Li	174.	Fouillac&Michard (1981)
Li	233.	Fouillac&Michard (1981)

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References:

Fouillac, C. and G. Michard, 1981, Sodium/Lithium ratio in water applied to geothermometry of geothermal reservoir: Geothermics, v. 10, p55-70.

Fournier, R.O., 1979, A revised equation for the Na/K geothermometer: Geoth. Res. Council Tran., v. 3, p221-224.

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Fournier, R. O., and R. W. Potter, II, 1979, Magnesium correction to the Na-K-Ca chemical geothermometer:Geochim. Cosmochim. Acta, v. 43, p1543 - 1550.

Fournier, R. O., and A. H. Truesdell, 1974, Geochemical indicators of subsurface temperature - Part 2, Estimation of temperature and fraction of hot water mixed with cold water: Jour. of Research, U.S. Geological Survey, v. 2, p263-270.

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Collection date:

Analytical Date: 1982

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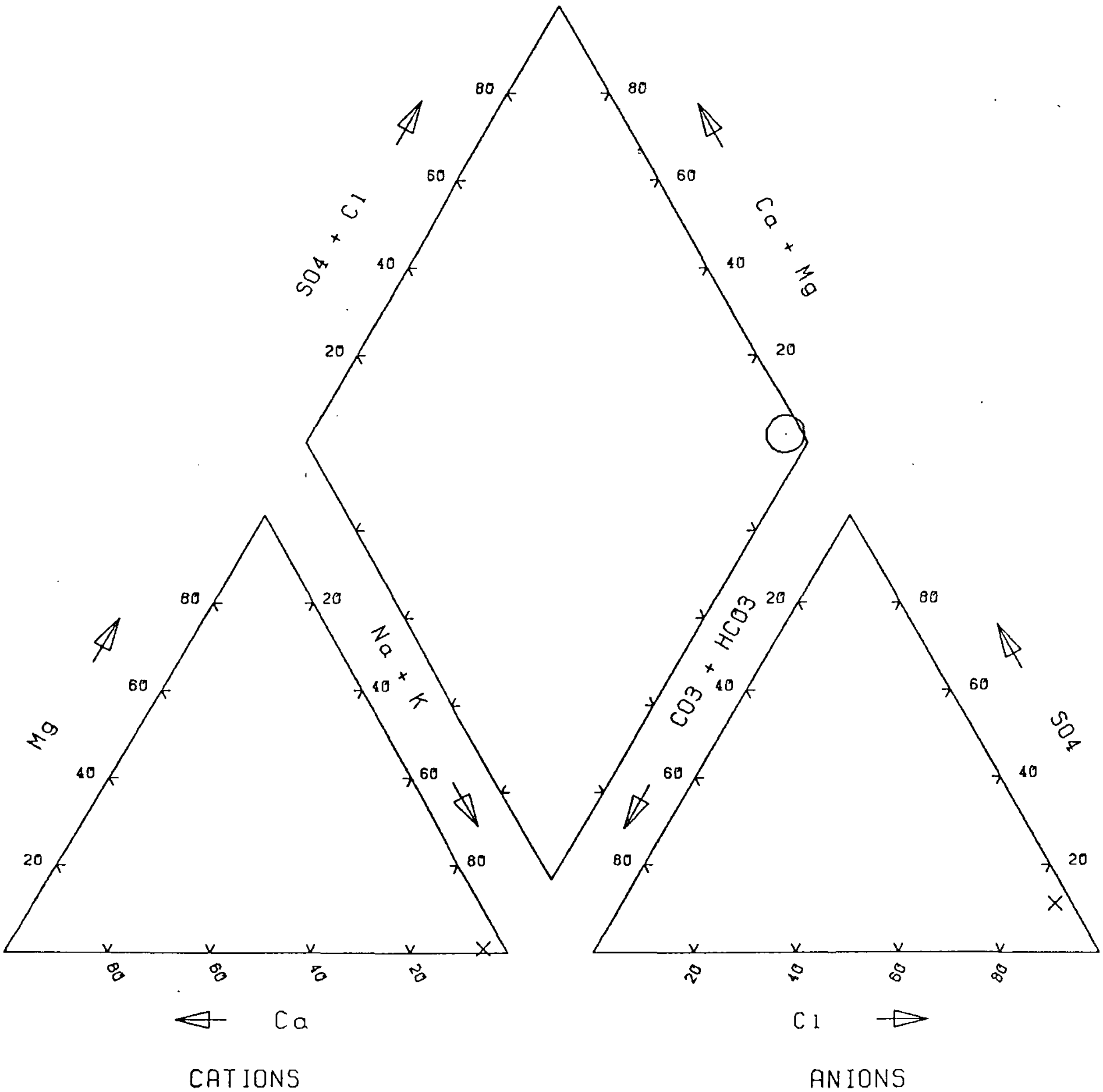

PERCENT OF TOTAL
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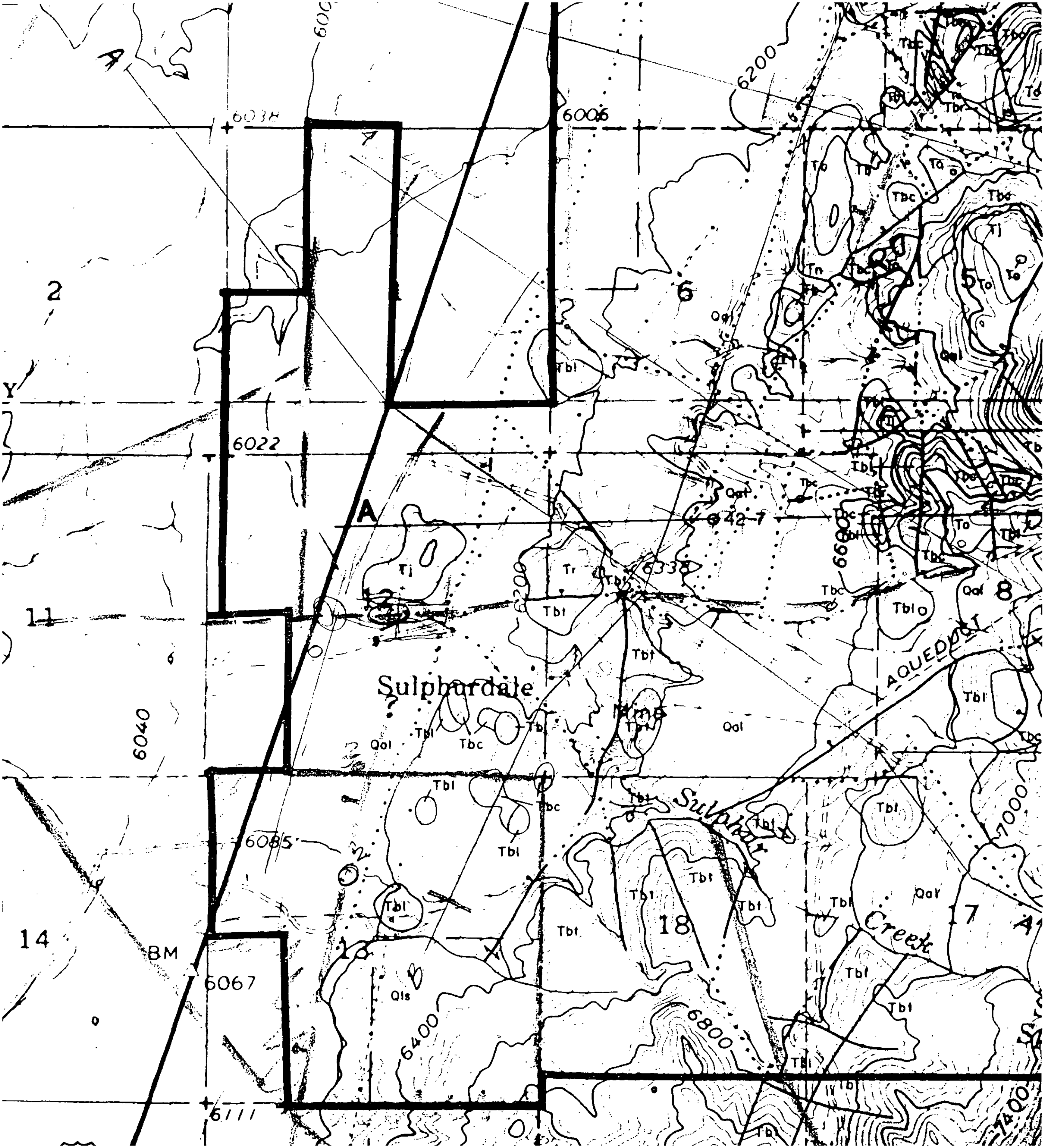

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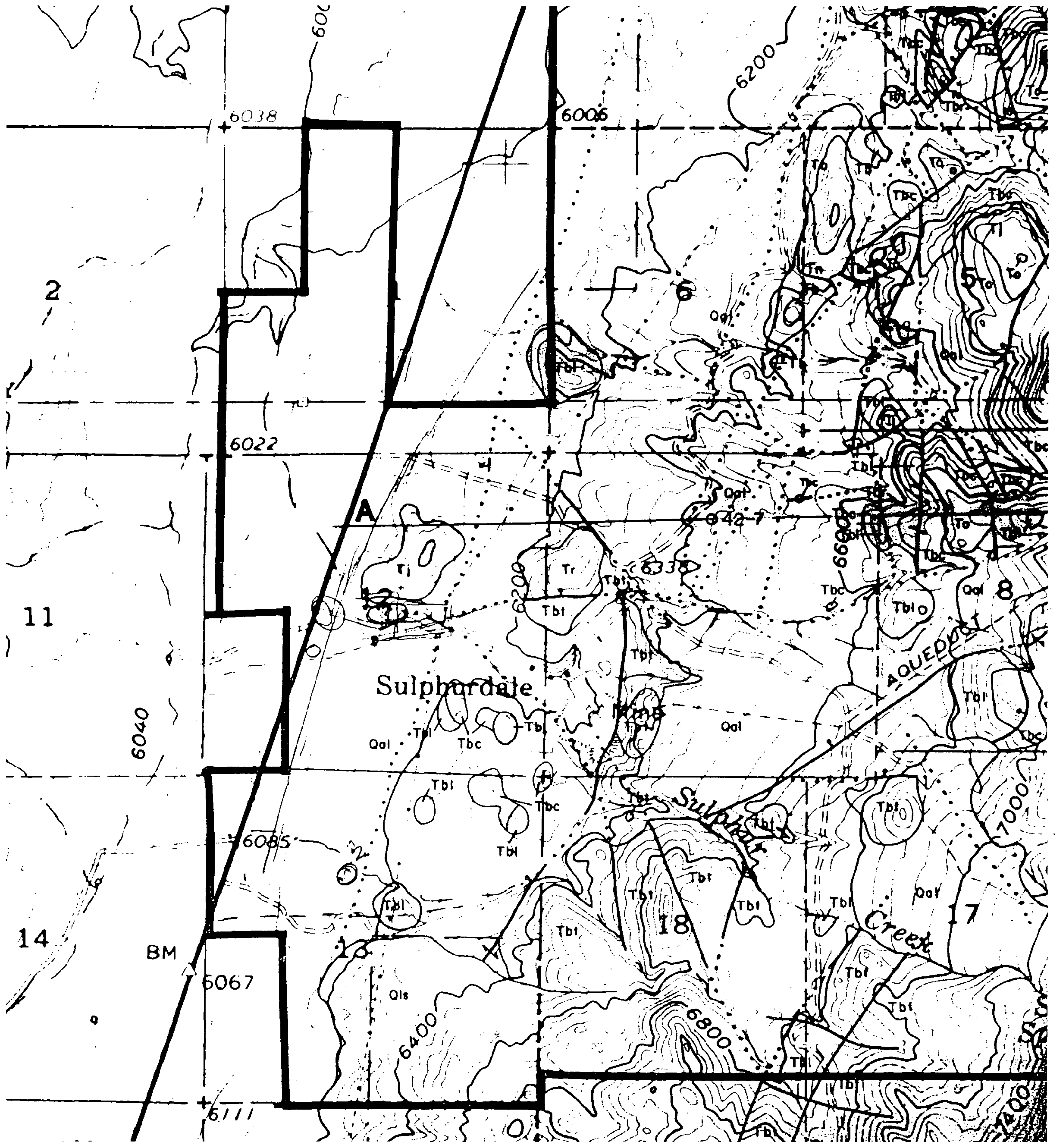

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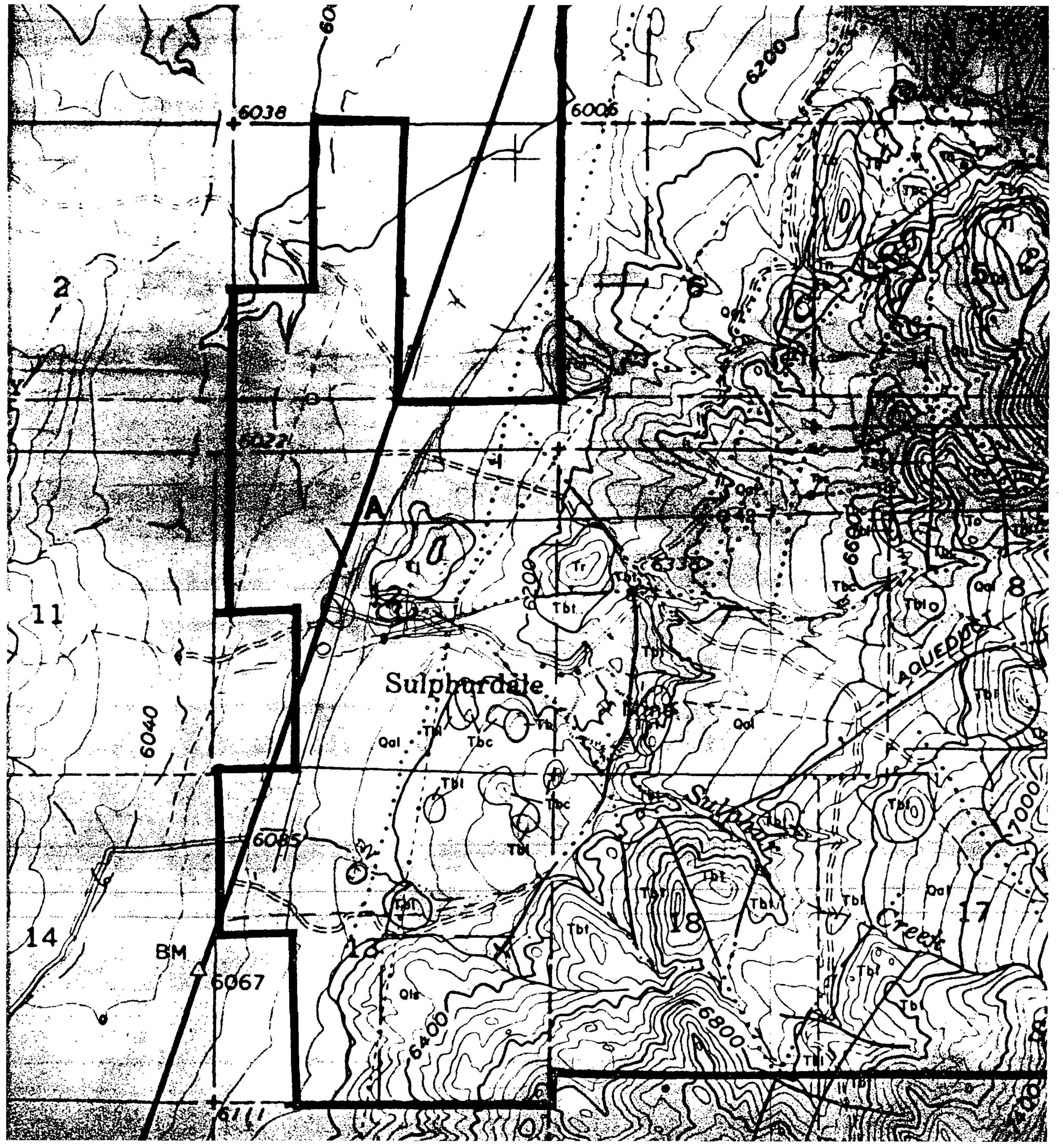

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Geothermal Site

Well Unexpectedly Hits High-Pressure Steam

By Mike Gorrell
Tribune Staff Writer

BEAVER — High-pressure steam in a reservoir of undetermined size was struck unexpectedly Monday at a geothermal well site 20 miles north of here, the president of the drilling company said Tuesday.

Wayne Portanova, president of Mother Earth Industries, said crews have been working to cap the well at the Cove Fort drill site since the "steam pocket or reservoir" was tapped around 1 a.m. Monday.

"We have no idea what this animal is," Mr. Portanova said, adding that the discovery was made within an area where geologic studies and previous drill tests had not shown any concentration of high-pressure steam.

Looks Like Major Site

"I couldn't be happier, if we get it capped safely," Mr. Portanova said. "It looks like one of the major geothermal resources in the western United States," he added.

The volume of the pressure and its limited depth below the surface were the major surprises. Based on early calculations, he projected the well could produce 5 to 10 megawatts of steam energy in a regular generator or 15 to 20 megawatts on a specially constructed binary steam generator.

Company officials contacted the Beaver County sheriff and emergency medical officials shortly after 1 a.m. Monday, asking the sheriff to close the main road to the well site and to evacuate hunters from a two-mile area surrounding the drill site.

Initial reports indicated the blockade was initiated because poisonous hydrogen sulfide gas was leaking from the well.

Mr. Portanova acknowledged that a "low-level concentration" of hydrogen sulfide gas had been detected at the well, but said it did not represent a health threat to crews trying to cap the well or to others in the area.

About 40 men are trying to put a control system into place to cap the well. Those working near the well are wearing emergency air packs to protect their eyes and lungs from the hot steam, not from poisonous leaking gas, Mr. Portanova said.

"There's one-tenth of the lethal dosages right next to the well. There's none probably 100 feet away," he said.

'Containing Mechanism'

The well probably will be capped in the next 24 hours. Pumping cold water into the pocket has proved an "efficient containing mechanism," but a lack of equipment at the well site has prevented cold water from being pumped underground steadily enough to permit the well to be capped, he added.

The discovery was made at a well site less than 1,400 feet from one of four wells previously drilled by Union Oil Co., Mr. Portanova said. None of the Union Oil tests found underground steam reserves of 350 degrees or more.

"The geologists' reports said the same thing, then bingo, surprise," he said.

Mother Earth Industries is a small, family-owned private drilling company developing a 1.8 megawatt generator at the site. The company discovers geothermal resources for sale to Provo City's power company, said Mr. Portanova of Greenwich, Conn.

UURI
EARTH SCIENCE LABORATORY
420 CHIPETA WAY, SUITE 120
SALT LAKE CITY, UTAH 84108
TELEPHONE 801-581-5283

PROPOSED PRESS RELEASE

On October 24 a geothermal well being drilled by Mother Earth Industries in the Cove Fort/Sulphurdale KGRA in central Utah encountered a substantial amount of high-temperature steam from a depth somewhat less than 1200 feet. The well flowed out of control until approximately November 20, when it was capped. This well is especially signficant because it represents the first high-volume, high-temperature production from the Cove Fort area, and it therefore indicates a substantial potential for commercial development in the area.

The well was sited for Mother Earth by scientists from the Earth Science Laboratory of the University of Utah Research Institute (ESL/UURI). Essentially all of the geological and geophysical information used to site the well was public information that had been developed previously through an exploration cost-sharing agreement between Union Geothermal, who held the property at that time, and the U.S. Department of Energy (DOE). Joseph N. Moore and Howard P. Ross of ESL/UURI refined the geothermal target concept and summarized their conclusions in a report to Mother Earth Industries in which they recommended the drill site to test for a higher-temperature reservoir. The discovery well was specifically sited to penetrate buried fault zones which are believed to form the plumbing system for the resource by conducting steam and hot water upward from greater depths.

Future Plans ------

UURI

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Future Plans ------

EARTH SCIENCE LABORATORY
UNIVERSITY OF UTAH RESEARCH INSTITUTE

PROPOSED GEOLOGICAL AND GEOPHYSICAL WORK AT COVE FORT, UTAH

I. ESL plans to write an unsolicited proposal to the U.S. Department of Energy (DOE) for research work in the Cove Fort/Sulphurdale KGRA in central Utah. The work we will propose will have the scientific objective of studying the area as a potential major resource and can be categorized as follows:

<u>Geology/Geochemistry</u>

1. Mineralogic study of the new Mother Earth Industries well along with work on other geothermal exploration wells to develop volcanic stratigraphy for the area.
2. A surface soil mercury survey to determine whether or not faults and fractures can be defined with this technique.
3. Sampling and chemical analysis of gases from wells and fumaroles in the area to study their variation in relation to models of the subsurface reservoir.
4. Detailed geologic mapping of the 10 square miles surrounding the discovery well for the purpose of better defining structures, rock types and hydrothermal alteration.

<u>Geophysics</u>

1. Dipole-dipole resistivity surveying using 500-foot dipoles to better define faults and fractures carrying geothermal fluids.
2. Detailed gravity surveying along profiles crossing suspected fault locations and graben-bounding structures to help define these structures.

3. A spontaneous-potential (SP) survey of the 6 square miles surrounding the discovery well to determine if subsurface fluid movement can be mapped using this technique.

II. We plan to ask DOE for about $200,000 to do this work.

III. We need the cooperation of Mother Earth Industries in this proposed work. Specifically we would like to have:

1. Access to the property
2. Permission to publish results of these studies
3. A letter indicating this support that we can send to DOE along with our proposal.

Strategy

1. Ask for
   (a) Access
   (b) Publication of Data with review
      what can be published?
      surface geology, geoph, geochem -
      subsurface - publish what we generate -
      fluid entries, what ever we generate
2. New Name - Cove Creek GeoThermal -

3. Ask for
   doubtable geologic - fluid entries -

4. Geology / Geochemistry
20 { 1. Mineralogic study of New well - chemistry
   2. volcanic stratigraphy using other wells
      42-7, 34-7
30 3. Surface mercury survey
20 4. Gas sampling from wells and all fumaroles -
20 5. Detailed geologic mapping around pit
90

Geophysics
35 1. Dipole-dipole resistivity (500 foot)
30 2. Detailed gravity profiles
25 3. SP Survey
90

20 Interpretation and Reporting

$200

AROUND
THE WEST

Crews working to cap huge geothermal well

BEAVER (UPI) — Engineers are importing equipment from Oklahoma in their attempts to cap a huge, surprise geothermal strike emitting a flume of high-pressure steam.

Engineers hope to cap the high-pressure stream this week, but Ray Gould, drilling engineer at the Cove Creek well site, said he is moving slowly to make sure the volatile well hurts no one.

"It looks like Tuesday or Wednesday before it's capped, but that could change," he said. "We're going cautiously, making sure nobody gets hurt."

The huge Oct. 24 geothermal strike was an unexpected delight for the drilling company, Mother Earth Industries. Earlier drilling tests supported geological reports that no such large geothermal reserves existed so close to the ground.

Gould said the company plans to build a power plant eight to 10 times the size originally planned for the area. He says the plant will be ready by August 1984. Mother Earth was searching for geothermal energy to generate power for Provo.

"It (the size of the geothermal reservoir) made us change our total plan. But it's still pretty early to assess the whole picture," he said.

Gould said special "snubbing" equipment is being brought in from Oklahoma to cap the well. Once that equipment is in place, crews will install a casing through which concrete will be poured to bring the well under control.

The company now discounts earlier reports that hydrogen sulfide gas contained in the superhot steam poses a threat to public health.

Mother Earth President Wayne Portanova says the low concentrations of the toxic gas do not threaten the workers at the site.

Gould said the flow is being monitored constantly, with readings showing a slight but constant decrease in the concentrations. He said safety engineers are still at the site, but 90 percent of the time they do not need to wear protective suits with air units.

Initially, workers tried to bring the strike under control by pumping cool water into the hole.

"We did that for about 48 hours and then found out everything you put in came right back out," Gould said. Hence, he decided to send to Oklahoma for the heavy equipment.

He said once the well is capped, other wells will be drilled to determine more precisely the actual size of the underground reservoir.

VITAL STATISTICS

Marriage licenses Salt Lake County

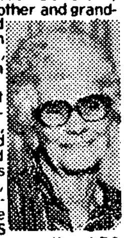
WILSON-BOOTHE: Frank Marion, IV, 21, Salt Lake City; Cindy, 20, West Valley City.

WURSTEN-STEELE: Bryce Hansen, 21; Karen Ann, 23, both Salt Lake City.

OBITUARIES

Nila Faye Darton

Nila Faye Merrell Darton, 79, beloved wife, mother and grandmother, passed away quietly on November 5, 1983 in a Utah valley hospital.



Born August 1, 1904 in Colonia Dublan, Chihuahua, Old Mexico. Married Klin James Darton April 9, 1923; later solemnized in the Mesa LDS Temple. Life long active LDS member. Completed a temple mission with her husband to New Zealand. She was active in gardening, music and handcraft.

Survivors: Husband, sons, daughters, Helen Kankel, Texas; Florence Green, Mona Madsen, Lawrence Darton, Ramon Darton, Ruth Joy Burr, Klin J. Darton Jr. and Arlene Oulette of California, 39 grandchildren; 64 great-grandchildren.

Funeral services will be Tuesday, Nov. 8, 11:00 a.m., at the West Jordan 46th Ward chapel, 7350 So. 1300 West, where friends may call one hour prior. Interment Lake Hills Memorial Park. Funeral directors Deseret Mortuary in Sandy.

T 11/07 N3 11/07

Irene J. Beal

Irene Jensen Beal, age 93, beloved mother, grandmother and great-grand-mother, passed away November 6, 1983, in Salt Lake City.

Born August

Mabel Chapman

RICHFIELD-Mabel Sinclair Chapman, 86, died November 3, 1983, in Richfield.

Born October 14, 1897, Bancroft, Nebraska, to Willard Francis Sinclair and Johanna Hensey. Married Irving Harold Chapman, in 1917 in Weiser, Idaho, this marriage was later dissolved by divorce; one child was born of this union.

She was reared and educated in Emmitt, Idaho, where she graduated from High School.

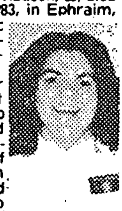
Survivors: one daughter, Mrs. Merrill (Marguerite) Hatch, Richfield, Utah; three grandchildren; Mrs. Ramon (Marilyn) Edmisten, Sandy, Utah; Mrs. Christopher (Tina) Kearns, Arlington, Texas; Gary L. Hatch, Orem, Utah; four great-grandchildren; two sisters, Mrs. Paul (Zella) Parks, Boise, Idaho; Mrs. Robert (Madeline) Felts, Eugene, Oregon; preceded in death by two sisters, and one brother, Mrs. "Buddy" (Gertrude) Harriman, Mrs. F.F. (Anna) Brown and Millard G. Sinclair.

Graveside services will be held Saturday, November 12, 1983, at 2:00 p.m. in the Richfield City Cemetery. Directed by the Neal S. Magleby & Sons Mortuary.

N1 11/7 T 11/8

Stacy E. Madsen

Stacy Emma Madsen, 25, died November 4, 1983, in Ephraim, Utah of cardiac arrest aggravated by an asthmatic attack.



Born October 14, 1958, in Salt Lake City to Hazen and Maurine Madsen. Graduate of Murray High School. Served on a mission to the Navajos and Hopis in the Holbrook, Arizona LDS Mission, returning home Sept. 11, 1983. Worked as a service representative for Mountain Bell.

Survived by her parents of Murray; brothers and sisters, Mrs. Dale Lee (Linda) Bennett, Carla Madsen, both of West Jordan; Mrs. William (Karen) West, Guam; Harlan Madsen, West Valley City; nieces and nephews, Shane, Travis and Liberty Bennett; Heath, Ryan and Jacob Andrus Madsen; Shelly and Jacob Lloyd West. Preceded in death by Valerie and Jennifer West.

Funeral services will be held Tuesday at 11:00 a.m. at the Murray Second Ward Chapel,

Ted C. Hansen

RICHFIELD — Teddie Carlos "Ted" Hansen, age 77, died November 6, 1983 at his residence.

Born December 1, 1905, Richfield, Utah to Hans James and Sarah Christensen Hansen. Married, Vera Jepsen, December 31, 1934, Richfield, Utah. He was a lifetime resident of Richfield, Utah. He graduated from Richfield High School and from BYU. He was a member of the LDS Church, serving in the scouting program and in the Sunday School Superintendency. He was with the Utah Highway Patrol for 26½ years. He was a member of the Utah State Retired Employees Association.

He is survived by Wife, Richfield; two sons, two daughters, Ted Lee Hansen, Richfield, Utah; James Carlos Hansen, Salt Lake City; Mrs. Leland (Betty) Valdez, Loomis, California; Mrs. Bud (Valeria) Ivie, Holden, Utah; brother, Elbert Hansen, Richfield, Utah; two sisters, Mrs. Horace (LaVonda) Christensen, Salt Lake City; Mrs. Lawrence (Mildred) Edwards, Ogden; 19 grandchildren; 22 great-grandchildren; preceded in death by three brothers, two sisters, James Orvil, Don Lamar, Norman Utah, Lue Sarah and Ireta Marie.

Funeral services will be held Wednesday, November 9, 1983 at 12:00 Noon in the Richfield Eight LDS Ward Chapel. Friends may call at the Neal S. Magleby and Sons Mortuary, Tuesday evening from 7-9 p.m. and Wednesday morning from 10:30 to 11:30 a.m. Burial: Richfield City Cemetery under the direction of the Neal S. Magleby and Sons Mortuary.

N1 11/7 T 11/8

Ruth S. Hansen

Ruth Anona Showell Hansen, 79, passed away on November 6, 1983, following a lingering illness.

Born December 12, 1903, to Albert and Florence Showell in Salt Lake City. Married Edgar W. Hansen, November 29, 1924. He preceded her in death. Member of the LDS Church. Throughout her life she was very active teaching ceramic arts and china painting and was known as one of Utah's leading china painters. Operated her own school and shop 'Ceramics

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November 10, 1983

Proposed Press Release

GEOTHERMAL STEAM WELL NOT LUCK - JUST GOOD SCIENCE

Scientists of the Earth Science Laboratory, University of Utah Research Institute (ESL/UURI) announced today that the Cove Fort geothermal steam well was not really as surprising as indicated in recent press and TV news coverage. The scientists strongly objected to comments attributed to drilling supervisors that "geologists reports had not indicated a geothermal reserve at that location so close to the surface." They admitted some surprise at the shallow depth of the steam entry but explained that the well was specifically sited in an attempt to tap such a resource.

Dr. Joseph Moore and Dr. Howard Ross, Section Heads for the Laboratory's Geochemistry and Geophysics groups, respectively, began their studies of the Cove Fort-Sulphurdale KGRA (Known Geothermal Resource Area) in 1978 through funding by the Department of Energy/Division of Geothermal Energy's Industry Coupled Program. In this program the DOE cost shared geothermal research and exploration projects in Utah and Nevada with industry. Government expenditures for the programs exceeded $14,000,000 between 1978 and 1981 but industry contributed a greater amount, and all the basic exploration and engineering data from the program were made available to the public (academic, government and industry).

The initial Cove Fort exploration and drilling program, a joint venture between Union Oil Company and DOE, was the most costly single project in the program because three deep exploration well tests were completed, indicating an underpressured reservoir of approximately 350°F.

The Earth Science Laboratory - UURI assisted the DOE in the management of the Industry Coupled Program and undertook a series of in depth studies of the area. Dr. Moore completed a detailed geologic mapping of 40 square miles surrounding the area and studied fluid geochemistry and mineralogy of the system. He eventually concluded that the geothermal reservoir drilled by Union Oil Company (maximum temperature 350°F and uneconomic) was peripheral to a higher temperature reservoir and was probably leakage from the main thermal system. Dr. Ross conducted a series of geophysical surveys which helped define the complex geologic structure (extensive faulting) and gave an indirect indication of the geothermal reservoir. Ross and Moore presented their results before the Society of Exploration Geophysicists annual meeting in Houston, Texas in November 1980 and published their reports to DOE in June 1982. They indicated the presence of a higher temperature reservoir west of the area drilled by Union Oil Company, probably linked to very deep seated faults. These reports encouraged Mr. Wayne Portanova (Mother Earth Industries) and other industry groups to continue their exploration on a low cost basis.

Moore and Ross refined their target concept in later studies and summarized their conclusions in a report to Mother Earth Industries in which they recommended three drill sites to test for a higher temperature reservoir. The discovery well was specifically sited to intersect one or two buried fault zones near their intersection, at the suspected depth of the water table (about 1200 feet). Their report also anticipated the presence of local hydrogen sulfide pockets near the water table, and of difficult drilling problems.

While the penetration of a high pressure-high temperature steam conduit at 1200 feet was not specifically anticipated, this was clearly the target sought. Ross and Moore feel that their interpretation of a large high temperature reservoir has been confirmed, and that the fault(s) penetrated are high permeability conduits which directly tap the deeper reservoir, and essentially act as a deep extension of the present well.

The scientists were less surprised at the intersection of the steam zone than they were at the drilling program. They noted that blow out preventors (BOP - specialized plumbing hardware) are routinely used in all geothermal drilling operations and are generally required by regulatory agencies such as the BLM and USGS. They proved the point by noting that ESL is currently supervising two geothermal drilling ventures for the Air Force, one near Lackland, Texas and one on Ascension Island in the South Atlantic, and blow out preventors were in place for all holes being drilled.

The drilling supervision at Cove Fort was termed "irresponsible" and detracted from an otherwise highly successful exploration effort by Mother Earth Industries. The scientists indicated that the concern over the blowing well, the great expense of capping it (over $300,000) and the loss of all that thermal energy could easily have been avoided by professional drilling supervision.

On the bright side, what may be one of the countries largest high temperature geothermal reservoirs has been discovered, and this low cost non-polluting energy supply will soon be available to Utahns.

To Cap Spewing Well

BEAVER, Beaver County (AP) — Drillers were trying Thursday to come up with a way to cap scalding-hot steam gushing from a well unexpectedly discovered near Beaver, officials said.

The Beaver County sheriff's department said no work on the well was being done Thursday. A spokesman said the well's owners were trying to come up with a way to cap the well.

Wayne Portanova, president of Mother Earth Industries, had said late Wednesday that the steam pocket, discovered at a relatively shallow depth of less than 1,200 feet, could produce between five and 10 megawatts of electricity if harnessed.

"It's ferocious," Portanova said.

Portanova said the steam was found at a much shallower depth and is much hotter than is typical. He said the temperature of the steam is estimated at 500 degrees to 600 degrees Fahrenheit.

Portanova said the steam pocket was discovered in an area where previous drill tests had not shown any concentrations of high-pressure steam. Another well, less than a mile away, produced steam at about 350 F at a depth of about 2,000 feet, which is normal, Portanova said.

He said he ordered his crews away from the well to discuss methods of capping it.

The well was spewing poisonous hydrogen sulfide gas into the air, but there appears to be no danger, Portanova said.

Workers 100 feet from the well weren't being required to wear gas masks, he said, and the gas wasn't considered a health hazard to people in the area.

The blow-out occurred Monday as the Greenwich, Conn., company was drilling a geothermal well to power a 1.8 megawatt generator to supply electricity to the city of Provo.

2B The Salt Lake Tribune Thursday, October 27, 1983

Gas Well Safe, Could Be Top Geothermal Source

BEAVER, Utah (UPI) — A poisonous gas-spewing well that forced the evacuation of deer hunters from a remote area around a drilling site has been determined not to be hazardous — and was hailed as a major geothermal strike.

"I couldn't be happier, if we get it capped safely," said Wayne Portanova, president of the drilling company, Mother Earth Industries. "It looks like one of the major geothermal resources in the western United States."

Portanova said the Monday strike contained poisonous hydrogen sulfide gas. The Beaver County Sheriff was asked to close the main road and evacuate hunters from a two-mile area surrounding the drill site.

But Portanova said the high-pressure steam contained only "low-level" concentrations of the ... There's none probably 100 feet away," he said.

Speaking of the geothermal strike, he said, "We have no idea what this animal is." The well is less than 1,400 feet from one of four wells drilled earlier by Union Oil Co., Portanova said. None of the Union Oil tests found underground steam reserves of 350 degrees or more. wrong

"The geologists' reports said the same thing, then bingo — surprise!" the company president said. ?

He said the volume of the pressure and its limited depth below the surface were the major surprises. Early calculations show the well could produce 5 to 10 megawatts of steam energy in a regular generator or 15 to 20 megawatts on a specially constructed binary steam generator.

Mother Earth Industries is a ...

Salt Lake Tribune, Saturday Nov. 5,

Crews Likely to Cap 'Gusher' At Geothermal Well Soon

Special to The Tribune

BEAVER — A geothermal well that has been emitting high-pressure steam and a small concentration of hydrogen sulfide gas since Oct. 24 probably will be capped by Tuesday or Wednesday, according to an engineer at the drill site 20 miles north of here.

Special capping equipment being brought in from Oklahoma is expected to arrive Saturday, said Ray Gould, drilling engineer at the Cove Creek well site. Once the "snubbing" unit is in place, crews will install a casing through which concrete will be poured, essentially bringing the well under control, Mr. Gould said.

"It looks like Tuesday or Wednesday before it's capped, but that could change," Mr. Gould said. "We're going cautiously, making sure nobody gets hurt."

Dangerous Implications

Initial reports indicated the Oct. 24 strike could have dangerous implications because of the release of hydrogen sulfide gas. But Wayne Portanova, president of the Greenwich, Conn.-based Mother Earth Industries, which drilled the well to provide power for Provo, said the concentration of gas was not a threat to the safety of workers at the site.

Mr. Gould said Friday the gas flow is being monitored constantly, with readings showing a slight but constant decrease in the concentra... drill site, but 90 percent of the time workers do not need to wear protective suits with air units, he added.

The temperature and pressure of the geothermal reservoir proved greater than expected in the days after the unexpected strike was made, Mr. Gould said. Those two factors foiled the first attempt to bring the well under control by pumping cool water into the hole.

Couldn't Hold It Down

"We did that for about 48 hours and then found out everything you put in came right back out," the drilling engineer said.

When that method failed, Mother Earth Industries was required to bring in heavy equipment from Oklahoma, he added.

Mr. Gould said he expects a power plant — with eight to 10 times the capacity of the original plant — to be in operation by August 1984. "It made us change our total plan. But it's still pretty early to assess the whole picture," he added.

Once the well is capped, the rig will be put back into place. Other wells will be drilled to help determine more precisely the actual size of the underground reservoir, Mr. Gould noted.

The strike came as a surprise, Mr. Portanova said previously, because other drill tests and geologists' reports had not indicated a geother...

November 10, 1983

Proposed Press Release

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UURI

EARTH SCIENCE LABORATORY
420 CHIPETA WAY, SUITE 120
SALT LAKE CITY, UTAH 84108
TELEPHONE 801-581-5283

November 7, 1983

MEMORANDUM

TO: Dick Wood, DOE/ID

FROM: Mike Wright, UURI

SUBJECT: Proposed Topics for Study at Cove Fort

There are a number of topics that could be addressed that would constitute work useful to the development of Cove Fort that Mother Earth Industries may not undertake, at least in depth, themselves. These are discussed briefly below. As I have told you on the phone, Wayne Portanova told me that (1) his first hope would be for cost-sharing with DOE of 3 new wells, (2) he would need a quick decision from DOE on proposed work there or he would go ahead with what he needed on his own and not consider future offers for help, and (3) he is interested only in "significant" help, i.e. assistance that would cost of the orders of hundreds of thousands as opposed to tens of thousands, i.e. it would have to be well worth his while to allow DOE to come in and use his discovery as a study area.

Geologic mapping and interpretation, gravity, magnetic and electrical resistivity data have all played an important role in developing the target concept for a high temperature (+200°C) reservoir adjacent to the area explored by Union Oil Company. These data sets, together with geologic mapping, were used to define fault structures which were thought to bound the high temperature reservoir. The discovery hole was in fact, sited to intersect either a north-trending basin and range fault or a major east-trending fault, or their intersection. Drill cuttings and the shallow intersection of a mjaor steam conduit confirm these interpretations. Much additional work could be done to define the reservoir and to improve the success ratio for future drill holes, since the area is large and the data base is almost reconnaissance scale in detail. We propose the following added studies:

Studies aimed at better understanding of subsurface geology. Detailed mineralogic and geochemical studies of the samples from the Mother Earth well and Union's well 42-7 would be aimed at developing an understanding of the volcanic stratigraphy in the area. This would help greatly in locating faults.

Dipole-dipole resistivity: 5 additional lines, 3 at 1000 foot electrode separation, 2 at 500 foot electrode separation, to better define conduits (faults) at depths of 1000 to 2500 feet.

Detailed gravity profiles: Ten east west profiles, five miles long, station interval 1000 feet or less to better define basin and range fault structures. Four north-south profiles, five miles long, to better define east-west structures.

Self-potential survey: The shallow occurrence of major conduits, and evidence of leakage along these structures suggests that self-potential traverses may aid in delineating those fractures/faults which are carrying fluids. No self-potential data are presently available for the area.

Self-potential survey during production: The shallow occurrence of at least one major conduit which was intersected by the discovery well suggests that this may be an optimum case for mapping producing fractures with the self-potential method. It is important to know if the east-west or north-south fault is producing (or both). Background surveys after shut-in and later during production would be required.

Approximate Cost Estimate:

Geologic work	$ 30,000
Electrical resistivity	$ 18,000
Detailed gravity	$ 12,000
Self-potential, survey	$ 10,000
Self-potential, production	$ 14,000
Refined interpretation, modeling, integration with geochem, geol.	$ 15,000
Reporting	$ 5,000
Total Study Cost	$104,000

Mike

PMW/jp