GL01651

UNION OIL COMPANY OF CALIFORNIA

GEOTHERMAL DIVISION

SANTA ROSA

TECHNICAL REPORT
ON
FORMINCO #1, UTAH

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FORMINCO #1

WELL SUMMARY

PREFACE

The well summary is as stated, a brief of the operation involved during the drilling of this well. All technical data is found within the contents of the main report.

The well summary gives a description of the problems encountered and procedures used to drill to depth.

Due to severe losses in circulation and extreme volumes of fine grain dolomitic hole sloughing when drilling with air at T.D., the hole was abandoned.

Hopefully, this summary will give you a guide to go by to pinpoint technical areas you want to review in depth within the main part of the report.

FORMINCO #1

SUMMARY OUTLINE

I General Information Sheet

II Drilling Operations

- A. Rig Information
- B. Preparation of Location and Setting Conductor
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    - e. Lost Circulation and H_2S at 797' (17-1/2" Hole)
      - (1) Resolution
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- D. 12-1/4" Hole Interval (1051')
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2. 12-1/4" Hole: Problems Encountered
   a. Lost Circulation and No Cement in Casing Shoe Joint
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      (1) Resolution
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      (1) Resolution
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      (1) Resolution
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      (1) Resolution

FORMINCO #1

WELL SUMMARY

GENERAL INFORMATION SHEET

LOCATION:

West 310.96' along section line and South 821.59' from Northeast corner of Section 29, T25S, R6W, S.L., B. & M., Millard County.

SPUD DATE:

7/26/76 at 2030 hours

COMPLETION DATE:

8/29/76

HOLE & CASING INTERVALS:

HOLE SIZE	HOLE DEPTH	CASING DATA	CASING DEPTH
26"	108' G.L.	20" x .251 W.T.	97' G.L.
17-1/2"	910' RKB	13-3/8" 54.50 K-55 Buttress Casing	822' RKB
12-1/4"	1051'	No Casing Run - Well Plugged and Abandoned	

M.D.:

1051'

T.V.D.:

1050.5'

TOTAL COST:

$623,955

COST PER FOOT:

$594

CONTRACTING SERVICES/AGENCIES:

Drilling:	Loffland Bros. Drilling
Mud:	Dresser Magcobar
Directional Drilling:	Eastman Whipstock, Inc.
H_2S Safety:	Oilind
Fishing:	A A A
Cementation:	Halliburton

FORMINCO #1

DRILLING OPERATIONS

A. RIG INFORMATION:

Loffland Brothers Rig #5. Self propelled rambler rig. Ideco model #H-1000. Rated to drill to 12,000'. The rig is powered with two General Motors 12V-71N and rated at 1434 INT, H.P. at 1800 RPM. The mast is Centelever Kwik-Lift 112' in height. The rotary table is an Ideco 23". The rig is limited to 350,000# casing capacity.

B. PREPARATION OF LOCATION AND SETTING CONDUCTOR: 26" Hole Section to 108' G.L. 20" Casing Interval to 97' G.L.

Roads were built to U.S. Forest Service specifications. The location was built to receive Loffland Rig #5. The sump was built to specifications.

On 7/25/76, on Forminco #1 drill site, Vic's Drilling Co. drilled a 26" hole. The hole was drilled to 108' G.L. Set and cemented to surface 20" x .251 W.T.. Welded joint casing to 97' G.L. Installed 8' x 8' x 6' cellar with drain.

Rigged up Loffland Rig #5 on location. Welded on 20" slip welded casing head onto 20" casing. Installed Hydril, diverter line and choke manifold in preparation to spud.

C. SPUDDING:

1. Description of Interval Drilled

17-1/2" Hole Interval to 910' RKB

13-3/8" Casing Interval to 822' RKB

Well was spudded on 7/26/76 at 2030 hours using a gel-water system. A 12-1/4" pilot hole was drilled to 829'. After encountering hole problems (as explained in the following section) and solving them, the 12-1/4" pilot hole was opened to 17-1/2" to 829' and drilled deeper to a depth of 910' RKB.

The 13-3/8" casing was attempted to be run to bottom at 910'. Casing became stuck at 822' while going in hole. Due to the fact of the previous hole problems and casing which would not move, the casing string was cemented in place at 822', some 88' off bottom.

2. Spudding: Problems Encountered

a. Lost Circulation

Drilled a 12-1/4" hole to 333' and lost returns.

(1) Resolution

Mixed lost circulation materials and regained returns.

b. Lost Circulation

Drilled 12-1/4" hole to 737' and lost returns.

(1) Resolution

Mixed lost circulation material and regained returns.

c. Lost Circulation and H_2S

Drilled 12-1/4" hole to 796' drilling limestone. Experienced drilling break and lost all returns. It was during this time that an H_2S gas blow was encountered. At one time, H_2S concentrations reached 600 ppm and saturated the detector. H_2S safety equipment was utilized during operation and full H_2S alert was observed. With lost circulation and intermittent blows of H_2S, the 12-1/4" hole was drilled to 829'. H_2S blow was contained at all times by slugging drilling pipe with mud, using B.O.E. and proper drilling practices.

(1) Resolution

Due to lost circulation, three cement plugs were attempted for a total of 1843 ft^3 of cement before a proper plug was established sealing off the lost circulation area and H_2S. Circulation was established and the cement plug was cleaned out to 721' with a 12-1/4" drilling assembly with complete circulation.

d. Lost Circulation and H_2S

Opened 12-1/4" hole to 17-1/2" to 792' and lost returns. Also immediately received H_2S blow saturating H_2S detector. Again H_2S alert and all precautions were observed. Dry drilled (using mud without returns) from 702' to 860' and hole began trying to stick drill pipe. H_2S was contained by slugging hole with mud, B.O.E. equipment and proper drilling practices.

(1) Resolution

Due to loss of circulation three cement plugs were attempted for a total of 1250 ft^3 of cement before the lost circulation area was sealed off.

e. Lost Circulation and H_2S

A 17-1/2" drilling assembly was used to drill cement with full returns from 400' to 797'. At 797' complete loss of returns and H_2S gas blow was again encountered. H_2S alert and precautions were observed.

Drilled 17-1/2" hole from 797' to 910' without returns or H_2S gas flow. H_2S blow was contained by slugging drill pipe, B.O.E. equipment and proper drilling practices.

(1) Resolution

Spotted 500 ft^3 cement plug and sealed off lost circulation and H_2S blow. Then dressed off cement with 17-1/2" drilling assembly from 516' to 910' with full returns.

f. Stuck Casing

Having established circulation and having a 17-1/2" hole to 910', the mud and hole were conditioned to run casing. An attempt to run 13-3/8" casing to 910' was foiled when the casing stuck going in hole at 822'.

(1) Resolution

Due to previous hole problems, the H_2S contaminate, and the fact the casing was stuck and full circulation was present, it was decided to cement the casing in place at 822'.

D. 12-1/4" HOLE INTERVAL (1051'): No Casing Run

1. Description of Hole Drilled

After cementing the 13-3/8" casing, the 12" casing head was installed. The double Shaffer, Hydril and Grant rotating head were nippled up. B.O.E.'s were tested to Union Oil specifications - O.K.

With a 12-1/4" drilling assembly, cement was drilled in the 13-3/8" casing to 807' and at this point loss

of returns was encountered. The hole was drilled from 822' to 913' without returns. H_2S gas blow at this point had been sealed off behind casing.

A cement plug was spotted and circulation established again. Drilling resumed and the 12-1/4" hole was drilled to 1004' with returns. At 1004' lost circulation was again encountered. Another cement plug was spotted, but during the operations the cement flash-set, sticking the drill pipe.

Fishing operations were attempted for nine days, after which they were discontinued due to economics and failure to free fish. At this point it was decided to sidetrack the 12-1/4" hole.

After two plug attempts with a total of 860 ft^3 of cement, a 12-1/4" hole was kicked off at 833' using a 7-3/4" Dynadrill. The K.O.P. had a drift angle of 2° and an azimuth of N62W. The 12-1/4" hole was Dynadrilled with mud to 855' at which point lost circulation occurred.

Air drilling with 12-1/4" drilling assembly was attempted from 885' to 1044' unsuccessfully due to sloughing hole.

A 12-1/4" hole was drilled from 1044' to 1051' using mud without returns after losing some 2700 bbls of mud.

Aerated mud drilling was unsuccessfully attempted. The hole was washed from 870' to 1020' getting good returns to surface. The returns were large volumes of fine grains of dolomite. Total returns including air were lost at 1020'.

Stuck pipe was experienced at this lost circulation point at 1020'. Pipe was successfully worked free and pulled out of the hole.

At this point, the well was abandoned. Due to loss of circulation, cement plugs to abandon well were difficult to spot. After several attempts, the hole was cemented from 836' to surface. The casing head was removed and a steel plate and dryhole marker installed. The rig was released at 1900 hours on 8/31/76.

2. 12-1/4" Hole: Problems Encountered

   a. Lost Circulation and No Cement in Casing Shoe Joint
      Cement was drilled in the 13-3/8" casing from 635' to 807' and loss of returns was encountered. Bit went free from 807' to 822' to top of shoe. Drilled out shoe. A 12-1/4" hole was drilled from 822' to 913' without returns.

(1) Resolution

A 694 ft^3 cement plug was spotted at 882' and established circulation. Top of cement was found at 632'. Drilled 12-1/4" hole to 1004' with returns.

b. Lost Circulation and Stuck Pipe

At 1004' lost circulation was encountered.

(1) Resolution

A 500 ft^3 cement plug was spotted at 1004'. After cement was displaced, the cement flash-set and stuck the drill pipe.

c. Stuck Pipe

The drill pipe was stuck after displacing lost circulation cement plug at 1004'. Proper procedures were used during cementing operations. Apparently cement set prematurely, seizing the drill pipe.

(1) Resolution (None)

Pipe was backed off with top of fish at 874'. Nine days were spent attempting to fish hole. (See fishing detail section.) Due to failure to get fish a decision was reached to side-track the well.

d. Sidetracking (Setting Plugs)

Due to loss of circulation, two attempts had to be made to set a cement plug for kick-off.

(1) Resolution

Two cement plugs for a total of 860 ft^3 were spotted before a suitable plug could be established for sidetracking.

e. Drilling Sidetracked Hole

After successful kick-off at 833', the 12-1/4" hole was drilled to 855' at which point complete loss of circulation occurred.

(1) Resolution (None)

Air drilling, aerated mud drilling, drilling with mud without returns were attempted without success. The 12-1/4" hole was drilled deeper from 855' to 1051' using mud without returns. This was discontinued after losing some 2700 bbls of mud. The hole continued sloughing. When using aerated mud, very large volumes of fine grained dolomite was circulated out of the hole.

f. Stuck Pipe Using Aerated Mud

While washing hole using aerated mud at a depth of 1020', a total loss of returns was encountered, that is both air and water were not returning. At this point the pipe stuck.

(1) Resolution

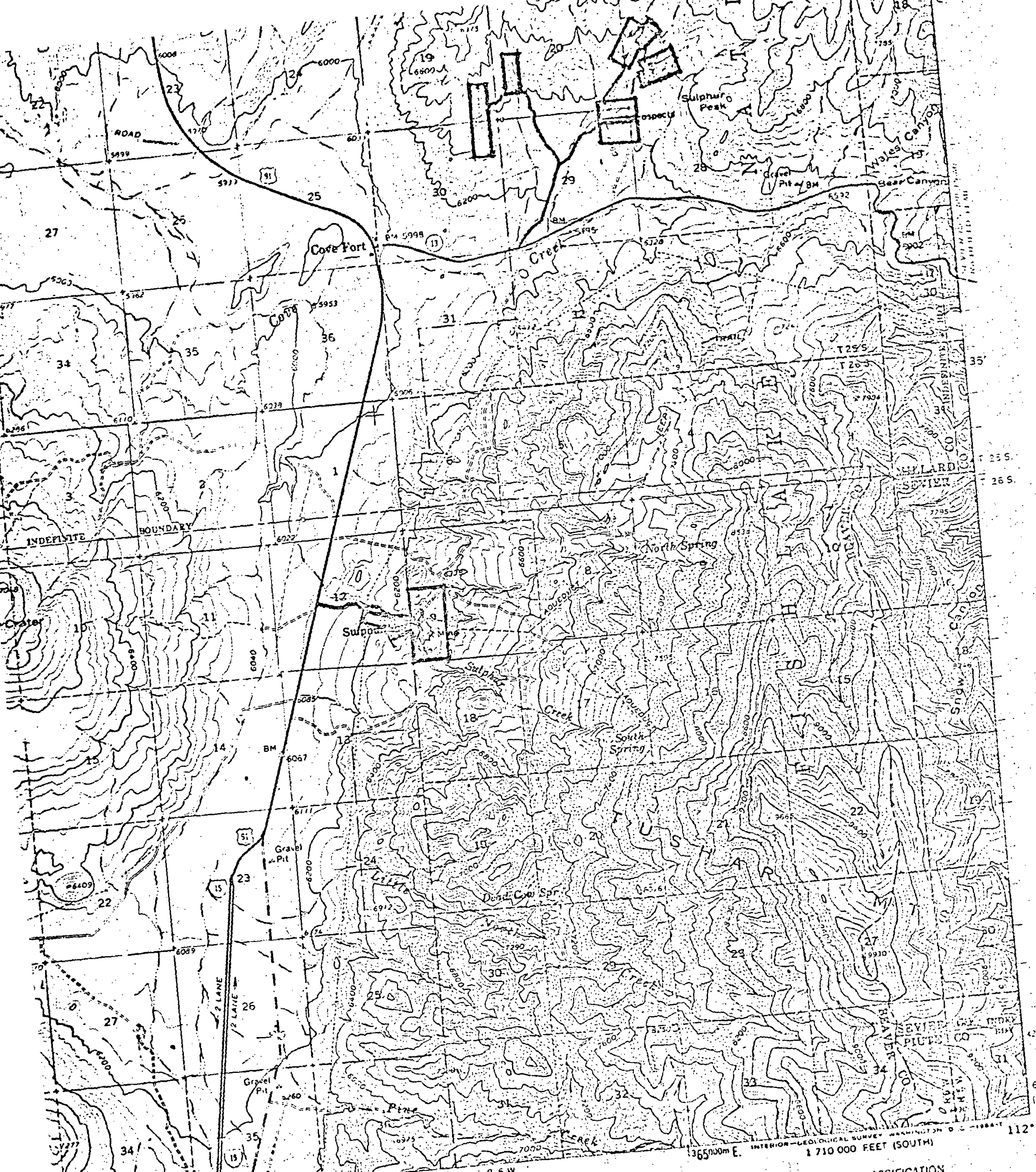
Using mud and soap, the drill string was worked free and pulled out of the hole.

g. Difficulty in Spotting Cement Plugs for Abandonment

Due to severe loss of circulation, it was difficult to set cement plugs for abandonment.

(1) Resolution

A 444 ft^3 of Thix-Set cement plug #1 was attempted to be spotted at 845'. Could not locate cement after W.O.C. 12 hours. Plug #2 consisting of 490 ft^3 of cement was spotted at 845'. This was followed by nine bales of hay, four sacks (200#/sk) sand, empty paper sacks, and chopped burlap. This material was shoved down to 836'. Spotted plug #3 consisting of 175 sacks of cement at 836'. Located top of this plug at 793'. Established circulation. Spotted 626 ft^3 cement plug #4 at 793'. Located top of plug #4 at 118'. The casing was then completely filled with cement plug #5 from 118' to surface.



INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1964

SCALE 1:62500

1 — 0 — 1 — 2 — 3 — 4 MILES

1000 0 3000 6000 9000 12000 15000 18000 21000 FEET

1 — 0 — 1 — 2 — 3 — 4 — 5 KILOMETERS

CONTOUR INTERVAL 40 FEET
DATUM IS MEAN SEA LEVEL

UTAH

QUADRANGLE LOCATION

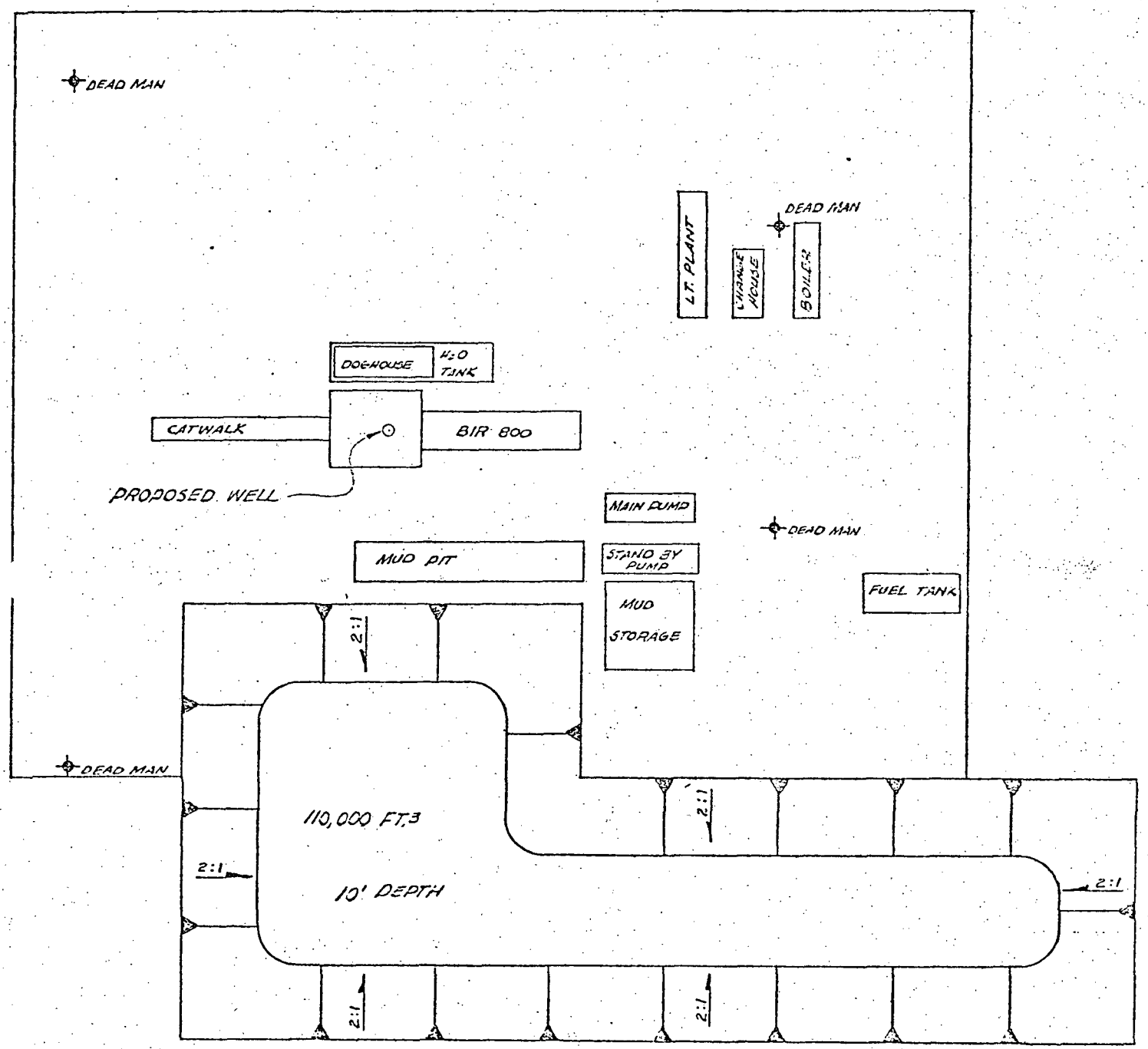
ROAD CLASSIFICATION

Heavy duty — Light duty
Medium duty — Unimproved dirt
Interstate Route — U. S. Route — State Route

COVE FORT, UTAH
N3830—W11230/15

1962

...TIONAL MAP ACCURACY STANDARDS
...OR WASHINGTON 25, D. C.



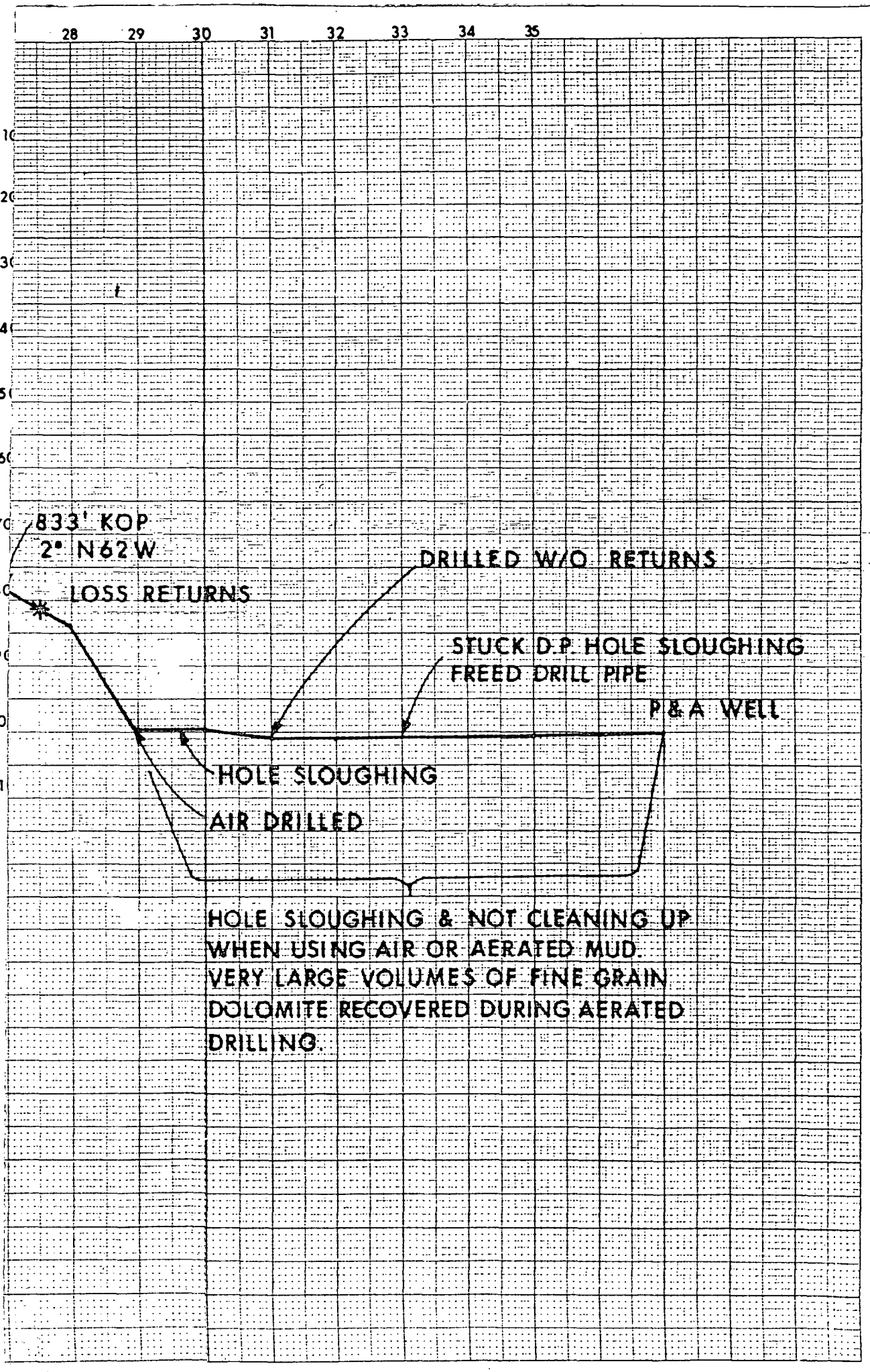
REVISED	DATE
1	

UNION OIL COMPANY OF CALIFORNIA - GEOTHERMAL DIVISION

FORMINCO WELL NO. 1

SECT. 29, T 25S, R 6W, SLM UTAH

DRAWN	
FOR:	R.E.C.
BY:	J.C.
DATE:	8/30/78
SCALE:	1"=20'
DRAWING NUMBER	1159


28
29
30
31
32
33
34
35
833' KOP
2° N62W
LOSS RETURNS
DRILLED W/O RETURNS
STUCK D.P. HOLE SLOUGHING
FREED DRILL PIPE
P&A WELL
HOLE SLOUGHING
AIR DRILLED
HOLE SLOUGHING & NOT CLEANING UP
WHEN USING AIR OR AERATED MUD.
VERY LARGE VOLUMES OF FINE GRAIN
DOLOMITE RECOVERED DURING AERATED
DRILLING.

UNION OIL CO. OF CALIFORNIA

GEOTHERMAL DIVISION

WELL RECORD

LEASE Forminco
WELL # 1
FIELD Cove Fort
LOCATION West 310.96' along section line and South 821.59' from Northeast corner of Section 29, T255, R6W, S.L., B. and M., Millard County
B.H.L.
DEPTH: T.D. 1050' T.V.D. 1051' E.T.D.

COMPANY ENGINEER Bob Rardin

SPUD DATE 7/26/76 COMP. DATE 8/29/76
CONTRACTOR Loffland Bros. Company
RIG # 5
ELEVATIONS: GROUND 6396'
K.B. TO GROUND 23.00'
K.B. TO LOWER CASING HEAD 21.50'

TYPE WELL: EXPL. DEV.
STM HOT WTR INJ
DRY HOLE X
APPROVED Don Ash

CASING RECORD

SIZE	WEIGHT	GRADE	THREAD	TOP	BOTTOM	REMARKS
20"	.251 wt.	H40	welded	surface	97'G.L.	
13 3/8	54.50	K-55	buttress	surface	822'RKB	

WELL HEAD ASSEMBLY

	MAKE	TYPE	SIZE	PRESSURE RATING
CASING HEAD SPOOL				
EXPANSION SPOOL	Abandoned w/Dry Hole Marker			
MASTER VALVE(S)	See Remarks			
CASING HEAD VALVES				
EXPANSION SPOOL VALVES				
SWAB VALVE				

STEAM ENTRIES: DEPTH LBS. INCREASE

	SLOTS		BLANK	
SLOTTED LINER	FROM	TO	FROM	TO

TEST DATA ORIFICE SIZE

RIG TEST DATE	WHP	FLP	TEMP	POUNDS/HOUR

REMARKS: Dry Hole Marker w/Surface Location and Well Designation Indicated. It was installed on top of 13 3/8" casing string. Hole filled with cement from 845' to surface.

Drilling Record
Union Oil Company of Cali[illegible]a

UNION

SHEET D

PAGE NO. 1

LEASE Forminco WELL NO. 1 FIELD Cove Fort

DATE	E.T.D.	DETAILS OF OPERATIONS, DESCRIPTIONS & RESULTS
7/25/76	0	Built road, sump and location. Set Racks for casing storage. Set 20", 0.25" wall, butt weld, conductor casing to 97' G.L. with Vic's Drilling Co. Cemented with cons't cement to surface. 26" hole drilled to 108' for conductor. Rigged up Loffland Bros. Drilling Co. Rig No. 5. Welded 20" slip weld casing head on conductor. Installed diverter choke line. Piped tanks and water storage to mud pumps.
7/26/76	173'	Installed and tested 20" hydril. Installed pitcher nipple. Drilled mouse hole and rat hole. Made up drilling assembly. Located top of cement in 20" casing at 108'. Spudded at 2030 hrs. Drilled 12-1/4" hole from 108' to 173'. Surveyed at 210'. (KB=21.50)
7/27/76	558'	Continued drilling 12-1/4" hole from 173' to 333'. Lost complete circulation. Mixed LCM. Regained full circulation. Drilled 12-1/4" hole from 333' to 558', with surveys at 355' and 545'.
7/28/76	829'	Drilled 12-1/4" hole from 558' to 737'. Lost partial returns. Regained circulation with LCM. Drilled 12-1/4" hole from 737' to 796'. Experienced a drilling break at 796'. Lost complete returns and all fluid in hole. Dry drilled 12-1/4" hole from 796' to 829'. Experienced medium blow of H_2S gas., 60 PPM at rig floor. Obtained air breathing apparatus. P.O.H. with drilling assembly. R.I.H. with wood plugged end on 4-1/2" drill pipe to cement.
7/29/76	829'	Encountered bridge at approximately 670'. P.O.H. Made up 12-1/4" drilling assembly. R.I.H. to bridge @ 762' hole caved. Stuck drilling assembly. Worked tools free. Mixed mud. P.O.H. R.I.H. with slick 12-1/4" drilling assembly. Cleaned out to 796' and broke through major bridge. Lost all fluid from hole. Dry drilled to 829'. P.O.H. R.I.H. with 4-1/2" drill pipe with wood plug in bottom to 787'. Oilind safety man present on location. 600 + PPM H_2S encountered at flow line.
7/30/76	829' 735' ETD	Halliburton cemented thru 4-1/2" OEDP @787' with 1000 ft.^{3} class "B" cement with 2-1 Perlite, .5# Cello Seal per sack, 3% $CaCl_2$ and 4% gel. CIP @ 0245 hours 7/30/76. Mild gas (H_2S) blow remained. R.I.H. with O.E.D.P. to top of cement @ 772'. Halliburton pumped 435 cu.ft. cement. Same as previous slurry. P.O.H. WOC 4 hours. R.I.H. with O.E.D.P., stopped on bridge @ 461'. P.O.H. R.I.H. with 12-1/4" bit on collars. Cleaned out to 735', hard cement. Gauged the amount of fluid loss. Spotted 10 barrels water on bottom. Fluid loss increased 300%. P.O.H. R.I.H. with 4-1/2" O.E.D.P. to 726'. Halliburton mixed and pumped 20 barrels caustic water, followed by 408 Ft.^{3} class "B" cement with 2-1 Perlite, 4% gel and 0.75% CFR-2. Displaced with 4 barrels water. CIP @ 1930 hours. P.O.H. WOC, mixed mud.

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DATE	E.T.D.	DETAILS OF OPERATIONS, DESCRIPTIONS & RESULTS
7/31/76	829' 538' ETD	R.I.H. with 12-1/4" bit on drilling assembly. Located top of cement at 380'. Drilled cement to 721'. P.O.H. R.I.H. with 17-1/2" 3 PT. pilot hole opener. Opened 12-1/4" hole to 17-1/2" hole from 97' to 538'. P.O.H. Made up button type 17-1/2" 3 PT. pilot hole opener.
8/ 1/76	860'	Opened 12-1/4" hole to 17-1/2" hole from 538' to 792'. Lost all fluid from hole. Mild gas blow of H_2S at a 600 PPM + concentration occurred following the loss. Opened 12-1/4" hole to 17-1/2" hole to 829' without circulation. Drilled 17-1/2" hole from 829' to 860' without circulation. P.O.H. R.I.H. with 4-1/2" O.E.D.P. with wood plug in bottom at 819'. HOWCO mixed and pumped 500 cu. ft. "B" cement, 2-1 Perlite, slurry with 4% gel, 2% $CaCl_2$, 1/2 lb./sack of cement flo cel. Preceded slurry with 20 barrels caustic water, displaced with 5 barrels water. C.I.P. at 2400 hours.
8/ 2/76	860'	Attempted to fill hole with mud with no success. R.I.H. with 4-1/2" O.E.D.P. to 713'. HOWCO mixed and pumped 250 cu. ft. "B" cement with 1-1 Perlite slurry with 2% gel. 3% $CaCl_2$, 1/2 lb./sack of mud fiber and chip seal. Preceded slurry with 20 barrels caustic water. Circulation established at close of job. Displaced with 2 barrels of water. C.I.P. at 0930 hours. P.O.H. W.O.C. Mixed mud. Kept hole full, 68 barrels mud required. R.I.H. with 17-1/2" hole opener assembly. Located top of cement stringer at 541'. Cleaned out cement to 807'. Lost returns. Cleaned out to 855'. P.O.H. R.I.H. with 4-1/2" drill pipe. HOWCO mixed and pumped 250 cu. ft. "B" cement with 3% $CaCl_2$ and 0.5% CFR-2, followed by 500 cu. ft. "B" cement with 1-1 Perlite, 2% Gel, 1/2 lb. Flo-Cel per sack of cement. C.I.P. at 2400 hours.
8/ 3/76	860'	W.O.C. Mixed mud. R.I.H. with 12-1/4" drilling assembly. Located top of cement at 400'. Drilled soft cement to 471' and hard cement to 550'. P.O.H. R.I.H. with 17-1/2" drilling assembly. Drilled cement from 550' to 755'.
8/ 4/76	910'	Drilled hard cement from 755' to 797'. Lost mud returns. H_2S gas to surface in 35 minutes. Cleaned out cement to 860'. Dry drilled 17-1/2" hole to 910'. P.O.H. Cleaned rocks out of mud pits. Mixed mud. R.I.H. with 4-1/2" O.E.D.P. to 786'. Halliburton mixed and pumped 12 barrels water, followed by 500 cu. ft. "B" cement, 1-1 Perlite slurry with 2% Gel and 0.5% CFR-2 with 1/4 lb./sack Cellocele per sack of cement. C.I.P. at 1800 hours. Pulled drill pipe to 546'. Pumped 200 barrels mud above cement. P.O.H. R.I.H. with 17-1/2" drilling assembly. Mixed mud.
8/ 5/76	910'	R.I.H. with 17-1/2" drilling assembly. Located top of cement at 516'. Drilled hard cement to 786'. Drilled fill and contaminated mud to 910' with full circulation. P.O.H. Rigged up and ran 18 joints, 13-3/8", 54.5#, K-55 buttress casing with guide shoe and DV collar. Placed four cement baskets below DV cementer at 635'. Centralized casing from joint 1 thru 14. Total length, 822,50'. Casing stuck due to caving with top of joint 18, .50' above kelly bushing. Attempted to free pipe without success. Lost circulation. Landed casing on slips in rotary table at 822', 88' off bottom. Prepare to cement first stage.

LEASE Forminco WELL NO. 1 FIELD Cove Fort

DATE	E.T.D.	DETAILS OF OPERATIONS, DESCRIPTIONS & RESULTS
8/ 6/76	910'	HOWCO mixed and pumped 60 cu. ft. "B" 1-1 Perlite cement slurry with 2% gel and 0.5% CFR-2, followed by 150 cu. ft. "B" cement with 40% Silica Flour, 2% Gel and 0.5% CFR-2. Preceded slurries with Tannathin wash. Displaced slurry with 120 barrels water. Bumped plug with 900 psi, O.K. C.I.P. at 0100 hours. Mixed 20 barrels gel-water to pump ahead of second stage cement job. Dropped DV opening bomb. Mixed and pumped 1650 cu. ft. "B" 1-1 Perlite cement slurry with 2% gel and 0.5% CFR-2. Staged and varied pump rates. Good cement returns to surface during job. Dropped closing plug and displaced with 99 barrels water. Closed DV, experienced small leak. Held pressure with HOWCO cement head. C.I.P. at 0330 hours. W.O.C. Cleaned mud pits and pump suctions. Built flow pipe for revised BOP assembly. Washed cement out of 20" hydril. Cut off casing. Removed BOP and diverter line. Found cement had dropped in 20" x 13-3/8" annulus. Ran 1-1/4" tubing to cement at 222'. Circulated 177 cu. ft. "B" cement with 40% Silica Flour and 0.5% CFR-2 to surface. Nippled up 12" - 900 BOP stack.
8/ 7/76	913'	Tested blind rams to 1150 psi, Pipe rams to 1000 psi, and hydril to 600 psi. R.I.H. with 12-1/4" stripped drilling assembly. Drilled DV cementer at 635'. Float insert at 787' and cement from 787' to 807'. Void from 807' to 910'. Lost all circulation at 807'. Drilled junk and 12-1/4" hole from 910' to 913'. Attempted to regain circulation with 1200 barrels Hi-Vis mud with 20% to 30% lost circulation material without success. P.O.H. Made up stabilized drilling assembly. Cleaned mud pits. Mixed mud. Cleaned rig and location.
8/ 8/76	913'	Cleaned rig and location. Waited on Halliburton. R.I.H. with 4-1/2" O.E.D.P. to 882'. Mixed and pumped 694 cu. ft., 101 lb/cu. ft. slurry, HOWCO "THIK-SET" cmt. Displaced with 2 barrels water. P.O.H. Pumped 7.5 barrels mud on top of slurry. W.O.C. 8 hours. R.I.H. with 12-1/4" bit, to cement top at 632'. Approximately 360 cu. ft. slurry entered the lost circulation areas. Cleaned out soft cement to 735'. W.O.C.
8/ 9/76	1004'	W.O.C. Cleaned out hard cement from 735' to 913'. Changed to stabilized drilling assembly. Drilled 12-1/4" hole from 913' to 978'. Surveyed at 950'. Drilled 12-1/4" hole from 978' to 1004'. Lost returns. Mixed LCM and mud. Unable to regain circulation. P.O.H. Rigged up HOWCO. R.I.H. with 4-1/2" "X" hole O.E.D.P. to 1004'. Pulled and hung drill pipe at 976'.
8/10/76	1004'	HOWCO mixed and pumped 500 cu. ft. "B" cement premixed 1-1 Perlite, with 2% Gel, 2% $CaCl_2$, and 0.5% CFR-2. Preceded with 10 barrels gel-water. Worked pipe while cementing. C.I.P. at 0130 hours. Displaced with 2 barrels water. Drill pipe stuck while cementing and removing HOWCO lines, pulled 126,000# over weight of drill pipe, (26,000#). Circulated out cement with HOWCO pump and both mud pumps. Pumped 200 barrels down annulus. Unable to work pipe free. Rigged up GO-International. Ran free point indicator and back off shot. Found pipe movement at 915'. Backed off drill pipe at 784', inside 13-3/8" casing. P.O.H. R.I.H. with screw-in sub on bumper sub, jars and 8" drill collars. Jarred on fish for 3 hours with no success.

Drilling Record
Union Oil Company of Cali...a

UNION

SHEET D

PAGE NO. 4

LEASE Forminco WELL NO. 1 FIELD Cove Fort

DATE	E.T.D.	DETAILS OF OPERATIONS, DESCRIPTIONS & RESULTS
8/11/76	1004'	P.O.H. with fishing string. Backed off at wrong break. Re-ran string. Screwed into fish. Backed off, recovered screw-in sub. P.O.H. Made up 9-5/8" washover string with 9-5/8" x 11" washover shoe no. 1 to top of fish at 784'. Worked over fish. Washed over drill pipe from 822' to 845'. P.O.H. Changed washover shoe. Shoe indicated flaring from drill pipe tool joints. R.I.H. with washover shoe no. 2. Washed over drill pipe from 845' to 872'.
8/12/76	1004'	Washed over drill pipe from 872' to 896'. P.O.H. Changed washover shoe. R.I.H. with 9-5/8" x 11-1/2" T.C. washover shoe no. 3. Worked over top of fish at 784'. Washed over drill pipe to 906'. Washover pipe parted, leaving 3 joints in hole with top at 817'. P.O.H. R.I.H. with "screw-in" sub, bumper sub, and jars with 8" drill collars. Attempted to jar drill pipe free, without success. Backed off 4-1/2" drill pipe at 885'. P.O.H. with 3 joints of 4-1/2" drill pipe.
8/13/76	1004'	R.I.H. with Bowen 9-5/8" releasing spear to top of 9-5/8' washover pipe at 817'. Set spear at 820'. Pulled and jarred on washpipe to 100,000# above string weight without success. Attempted to circulate through fish to 1500 psi. Backed off drill pipe at 885'. Ran 3 joints (94') 7-3/8" O.D. flush joint wash pipe with tungsten carbide rotary shoe to top of fish at 885'. Washed to 910'. Found 6' fill inside of 9-5/8" wash pipe.
8/14/76	1004'	Washed over 4-1/2" drill pipe. Fish from 910' to 957'. Lost circulation. Stuck 7-3/8" wash pipe at 945'. Worked stuck pipe for 2 hours. Worked free. P.O.H. Cleaned and mixed pit of mud. R.I.H. with O.E.D.P. Screwed into fish at 885'. Jarred and worked fish, moved up 18". Backed off 4-1/2" drill pipe at 885'.
8/15/76	1004'	R.I.H. with 4-1/2" O.E.D.P. to 885'. Screwed into fish. R.I.H. with "GO" wire line bridge plug to 970'. Plug would not set. Pumped 40 barrels mud through drill pipe. Ran 3-1/2" metal petal basket, set at 952'. Laid 10' Cal-Seal plug on top of metal petal basket. Tested plug with 500 psi pump pressure, O.K. Backed off drill pipe. R.I.H. with one joint of 7-3/8" wash pipe, rotary washover shoe and fishing assembly.
8/16/76	1004'	Washed down from 915' to 945'. Unable to washover top of drill pipe fish at 945'. Laid down wash pipe. R.I.H. with 9-5/8" spear. Engaged 9-5/8" wash pipe at 819'. Jarred on wash pipe without success. Cut 9-5/8" wash pipe at 867'. Unable to jar section free. Cut wash pipe at 839'. Recovered 21.50' 9-5/8" wash pipe.
8/17/76	1004'	R.I.H. with 12-1/4" bit to 839'. Circulated. Cut wash pipe at 854'. Recovered 14.64' of wash pipe. R.I.H. with spear. Caught fish at 854'. Jarred and recovered 12.75' 9-5/8" wash pipe. R.I.H. with spear to 867'. Jarred and recovered 8' of 9-5/8" wash pipe. Top of wash pipe at 874'.
8/18/76	1004'	Unable to recover additional wash pipe. R.I.H. with 12-1/4" bit. Cleaned out to 874'. Mixed mud and LCM. No circulation possible. Ran 9-5/8" spear. Engaged wash pipe at 874'. Jarred and pulled on wash pipe without success.

Drilling Record
Union Oil Company of Cal...ia

UNION

SHEET D

PAGE NO. 5

LEASE Forminco WELL NO. 1 FIELD Cove Fort

DATE	E.T.D.	DETAILS OF OPERATIONS, DESCRIPTIONS & RESULTS
8/19/76	1004'	Released and laid down fishing tools. R.I.H. with 4-1/2" O.E.D.P. to 854'. Mixed and pumped 492 cu. ft. class "B" cement with 40% Silica Flour for a balanced plug. Fluid level was 90' from surface. P.O.H. Cement on pipe at 564'. Filled hole with mud, (30 barrels). Hole filled. C.I.P. at 1900 hours. W.O.C.
8/20/76	1004'	R.I.H. with 12-1/4" bit and drilling assembly. Hit stringer at 715' and 825'. Lost returns. Cleaned out to 850'. P.O.H. R.I.H. with 4-1/2" O.E.D.P. to 850'. Mixed and pumped 368 cu. ft. class "B" cement with 40% Silica Flour, 0.5% CFR-2 to a 15 lb/gal slurry. C.I.P. at 1115 hours. Filled hole with 28 barrels water. W.O.C. R.I.H. with 12-1/4" bit and drilling assembly. Found top of cement at 798'. Washed and drilled soft to medium hard cement to 833', with good circulation. Measured tools and drill pipe.
8/21/76	885' P.B.DEPTH	W.O.C. R.I.H. with 7-3/4" Dynadrill to 833'. Dynadrilled 12-1/4" hole from 833' to 885'. Surveyed. Lost circulation. P.O.H. Rigged to air drill. Made up 12-1/4" drilling assembly.
8/22/76	1044'	Drilled 12-1/4" hole from 885' to 1044' with air. Surveyed. P.O.H. Changed stabilizer position. R.I.H. Found hole bridged and sloughing at 840'. H_2S gas entry noted while surveying. Five hours required to clean out from 850' to 870'. Injected sulfatex, ammonia, and Unsteam with water at 20 barrels/hour. Used various mixes, recovered large quantities of sloughing dolomite. Cleaned out to 945'. Unable to clean out below 945', due to fill caused by sloughing. Discontinued air system.
8/23/76	1044'	Mixed and pumped 790 barresl Hi-Vis gel, 25% LCM mud while drilling and washing to 950'. Pumped 450 barrels of mud while washing and drilling to 972', without circulation. Mixed LCM-gel-mud.
8/24/76	1051'	Washed and drilled from 972' to 1002' without circulation using 450 barrels of gel-LCM-mud. Drilled to 1028' as above. Drilled and washed to 1044' as above. Drilled 12-1/4" hole from 1044' to 1051' with no circulation. (2100 total barrels gel-LCM-mud used). Rigged to use stiff foam system.
8/25/76	1051'	Mixed mud-chemicals for use with air for stiff foam system. R.I.H. with 12-1/4" drilling assembly to 789'. Injected and stabilized foam consistency. Staged in hole with drill string to fluid at 850'. Displaced fluid. Staged in hole to bridge at 890'. Drilled out bridge from 890' to 892'. Lost circulating pressure and returns. Stabilized flow of foam. Washed and foam drilled to 928'. Attempted to make a connection for 8 hours without success. Hole sloughed, sticking tools. Increased air rate from 380 CFM to 1100 CFM . Cleaned up fill above tools. Stabilized foam. P.O.H. to 847'. Attempted to wash below 847' without success. P.O.H. to 730' (inside casing).

LEASE Forminco WELL NO. 1 FIELD Cove Fort

DATE	E.T.D.	DETAILS OF OPERATIONS, DESCRIPTIONS & RESULTS
8/26/76	1051'	R.I.H. to 865'. Broke circulation with aereated mud. Washed from 865' to 926' with Fischer mix. Lost all returns of both air and mud. Hole sloughing - sticking pipe. Unable to work below 990' or regain returns. P.O.H. Laid down all drill collars and tools except two 8" collars. Mixed gel-water-LCM. (10 PH mud). Pumped 150 GPM mud, 2230 cu. ft. air with soap, and mixed 20 gallons to 10 barrels ammonia, pumped at a 32 barrel/hour rate. Good aerated foam mud resulted, and carried large amounts of fine dolomite cuttings to surface.
8/27/76	1051'	Washed down to 949' with good returns, but lost continuous returns to surface at 949'. Pulled to 917'. Staged back in hole to 949'. Regained intermittent circulation. Washed 12-1/4" hole to 1020'. Lost circulation completely. Pipe sticking due to sloughing dolomite. Pulled to 952'. Stuck pipe. Worked free after 4 hours. Pumped mud and soap plus 2230 CFM of air while working free. P.O.H. R.I.H. with O.E.D.P. to 814'. Mixed 350 barrels gel-LCM-mud into hole. Hung O.E.D.P. at 845'. HOWCO mixed and pumped 200 sacks "B" "THIK-SET" cement with 16% Gilsonite. P.O.H. Laid down drill pipe, collars, and tools.
8/28/76	1051'	Continued to rig down. R.I.H. with O.E.D.P. to 845'. No cement contacted. HOWCO mixed and pumped 492 cu. ft. "B" cement with 40% Silica Flour, 0.5% LCM, and 2% Gel. C.I.P. at 0630 hours. P.O.H. Pushed 9 bails of hay, four 200 lb sacks of sand, paper mud sacks, and chopped burlap down hole to 836'. Spudded on material with drill pipe string and 12-1/4" bit. P.O.H. Pumped 400 barrels sump mud down hole with no returns. R.I.H. with O.E.D.P. to 836', top of LCM. HOWCO mixed and pumped 175 sacks "B" 1-1 Perlite cement with 1.5% $CaCl_2$, 2% Gel, and 40% Silica Flour. C.I.P. at 1930 hours. P.O.H. Found evidence of fluid on drill pipe at 700'. W.O.C.
8/29/76	0'	W.O.C. to 0130 hours. R.I.H. with O.E.D.P. to hard cement at 783'. Filled hole with 75 barrels of wtr. HOWCO mixed and pumped 282 sacks "B" cement 1-1 Perlite with 40% Silica Flour, 2% Gel, and 1.5% $CaCl_2$ as an abandonment plug in two stages with drill pipe hung at 434' for second stage. Filled 13-3/8" casing to 90'±. C.I.P. at 0330 hours. Laid down 4-1/2" drill pipe. Broke Kelly subs.
8/30/76	0' Well cmtd to surface	Rigged down BOP's. Laid down derrick. Rigged down all equipment. Filled 13-3/8" casing to surface with cement. Built dry hole marker.
8/31/76	0' Well cmtd to surface Abandon	Released rig for de-mobilization, as per Loffland contract at 1900 hours.
9/ 1/76	0' Well cmtd to surface Abandon	Returned all rental equipment. Cleaned location at Forminco no 1. Covered sump at Forminco No. 1 location. Stacked Loffland rig No. 5, at Forminco No. 6 location. Hauled miscellaneous tools to Howard Construction Yard. Installed dry hole marker, Forminco No. 1, 9/1/76.

SURVEY INFORMATION

The following tables illustrate the surveys taken while drilling Forminco Well #1. Extreme hole problems prevented taking more surveys. However, as one can see, the hole was a "straight hole".

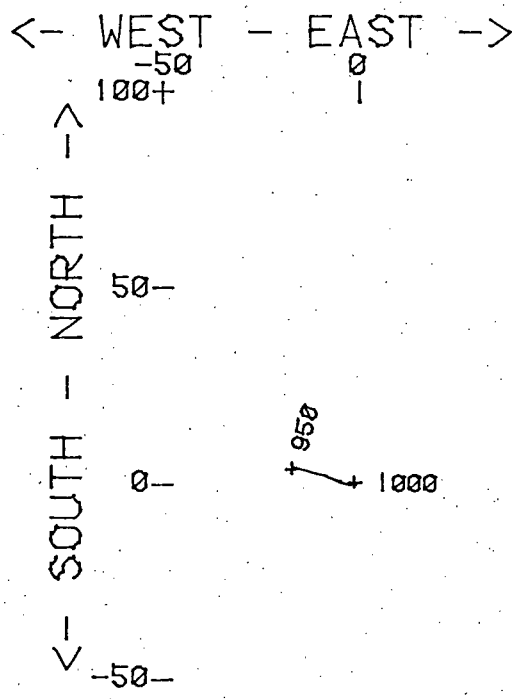
The maximum drift angle was 3°, and this was after sidetracking the original hole.

FORMINCO #1
STANDARD SURVEY TABLE

STA	MEAS. DEPTH	VERT. DEPTH	DRIFT ANGLE	DRIFT BEARING	CUMULATIVE COORDINATES N S(-)	CUMULATIVE COORDINATES E W(-)
1				S86W		
2	210	210	1.00	S86W	-0.13	-1.83
3	355	355	1.00	N64W	0.36	-4.31
4	545	545	1.00	N69W	1.68	-7.35
5	950	950	1.50	N82W	3.89	-15.91

APR 18,1978 WEIGHTING FACTOR: 0.50

FORMINCO #1



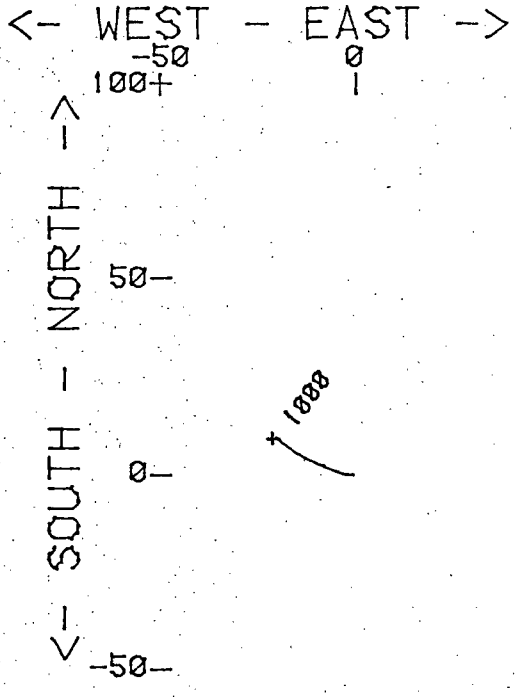
INTERPOLATED ON MEASURED DEPTH

FORMINCO #1 - SIDETRACK 1
STANDARD SURVEY TABLE

STA	MEAS. DEPTH	VERT. DEPTH	DRIFT ANGLE	DRIFT BEARING	CUMULATIVE COORDINATES N S(-)	E W(-)
1				S86W		
2	210	210	1.00	S86W	-0.13	-1.83
3	355	355	1.00	N64W	0.36	-4.31
4	545	545	1.00	N69W	1.68	-7.35
5	833	833	2.00	N62W	4.80	-14.21
6	1000	1000	3.00	N47W	9.03	-20.14

APR 18,1978 WEIGHTING FACTOR: 0.50

FORMINCO #1 - SIDETRACK 1



INTERPOLATED ON MEASURED DEPTH

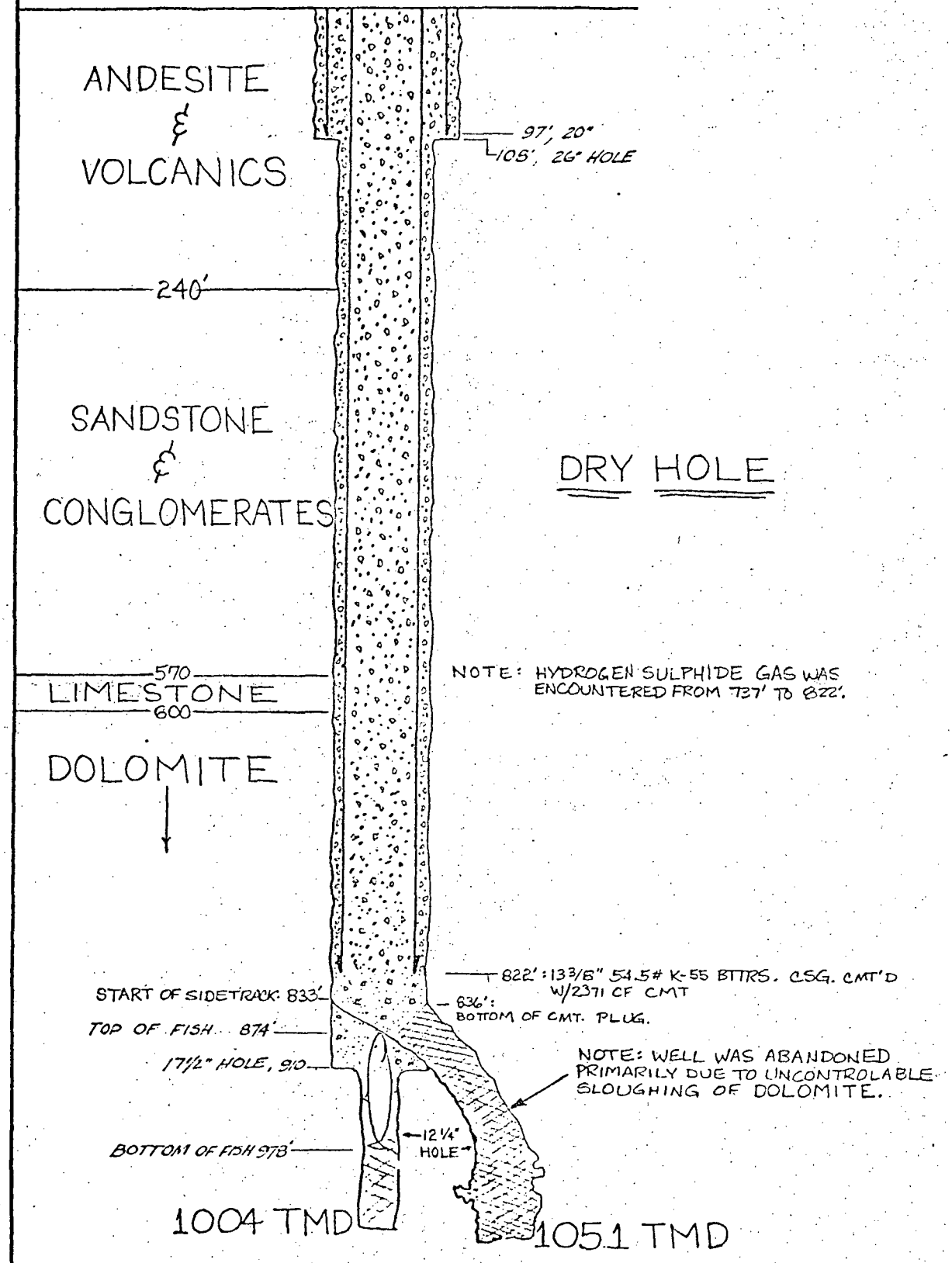
Forminco 1
Cove Fort
CASING DETAIL

13-3/8" Casing
(KB-21.50)

	NO. JTS	DESCRIPTION	BOTTOM	TOP	LENGTH FT.
	-	13-3/8" B & W Guide Shoe	822.00	820.70	1.30
	4	13-3/8", 54.5#, K55, Butt Casing	820.70	638.72	181.98
	-	HOWCO DV Cementer	638.72	635.32	3.40
	14	13-3/8" 54.5#, K55, Butt Casing	635.32	-.50	635.82
Total:	18	Casing Landed w/.50' above rotary			822.50

ABANDONED: 8-29-76

KELLY BUSHING: +11'
GROUND LEVEL:



REVISED	DATE	UNION	DRAWN
		UNION OIL COMPANY OF CALIFORNIA - GEOTHERMAL DIVISION	FOR: DLA
		DIAGRAMMATIC SKETCH	BY: GCS
		FORMINCO # 1	DATE: 9-1-76
		EXPLORATORY MILLARD CO., UTAH	SCALE: 1" = 100'
			DRAWING NUMBER 2223

BIT RECORD PM-683

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

FILE NO. _____ SALESMAN: _____ Page 1 of 1

CONTRACTOR Loffland RIG NO. 5
COMPANY UNION OIL CO. OF CA FIELD _____
LEASE Forminco WELL NO. #1 82-29
STATE Utah COUNTY Millard
SEC./T'SHIP/RANGE Sec. 29, 25 South - 6 West

RIG MAKE _____
RIG SIZE _____
PUMP NO. 1 _____
PUMP NO. 2 _____
MUD TYPE LSND Magcobar

COLLARS: OD X ID X LENGTH
_____ x _____ x _____
_____ x _____ x _____
DRILL PIPE _____
TOOL JOINT _____

	MO. / DAY / YR.
SPUD	7 / 26 / 76
UNDER SURFACE	8 / 7 / 76
UNDER INTER.	/ /
TOTAL DEPTH	8 / 27 / 76

T.P.-DRILLERS Buddy Bowen
WATER SOURCE _____
FUEL SOURCE _____

RUN NO.	SIZE	MAKE	TYPE	SERIAL NO.	JETS - 32nds Req. R or RO 1	2	3	DEPTH OUT	FEET	HOURS	FEET PER HOUR	CUM. HOURS	WT. '000 LBS.	R.P.M.	PUMP PRESS	PUMP NO. 1 Liner	SPM	PUMP NO. 2 Liner	SPM	MUD PROPERTIES Wt.	W.L.	F.V.	P.V.	Y.P.	Vert. Dev.	Dull Cond. ¼ ⅛ T	B	G	RC		Date
1	12¼	HTC	OSC1G	NV096	18	18	0	108-460	352	17.5	20	17.5	20/58	20/60	200	6½	64			9		40			1°	6	4	I	N	volcanics; lost circ.	7/26
2	"	Sec.	M4N	610327	24	24	24	558	98	6.0	16	23.5	55	65	200	"	64			9		40			1°	7	4	I	N	volcanics lost circ.	7/27
3	"	STC	4JS	118DF	20	20	20	829	271	8.0	33.8	31.5	60	60	200	"	64			9		40			1°	1	1	I	N	qtzit; lm	7/28
RR3	"	STC	4JS	118DF	20	20	20		CLEAN OUT BRIDGES																					clean out cement	7/29
RR1	"	HTC	OSC1G	NV096	0	0	0		CLEAN OUT BRIDGES																	7	5	I	N	"	7/29
HO-1	17½	Reed		1018	0	0	0	538	441	6.0	73.5		15	40	150	6½	64			9		40			1°	4	2	I	N	open hole	7/31
4	12¼	Reed	Y13J	781094	0	0	0	721	380	3.0		CLEAN	OUT	CEMENT		"	64			9		40			1°	1	1	I	N	clean out cement	7/31
HO-2	17½	STC			0	0	0	860	322	17.75	19		15/40	20/20	150	"	64			9		40			1°	2	2	I	N	bottom hole opener	8/1
RR "	"	STC			0	0	0	860	CLEAN OUT CEMENT						150	"	64			9		45			1°	2	2	I	N	bottom hole opener	8/2
RR3	12¼	STC	4JS	118DF	24	24	24		CLEAN OUT CEMENT																				N	clean out cement	8/3
5	17½	HTC	OSC1G	SA339	15	15	0	910	50	3.0	16.6	34.5	20/40	50/50	200	"	64			9		45			1°	4	2	I		rounded gauge teeth	8/5
6	12¼	HTC	OSC3	WL982	24	24	24	823-1044	211	6.75			30		200	"	64															

*DENOTE BY (N)-NO, (L)-LIGHT, (M)-MEDIUM OR (H)-HEAVY ROUNDING OF GAGE

FORMINCO NO. 1

MUD HISTORY

Magcobar's Suggested Mud Program

In March, 1967, Magcobar Drilling Fluid Services submitted to Union Oil Co. of California, Geothermal Division, a suggested mud program for drilling in the Cove Fort Prospect. The suggested mud program called for three distinct muds to be used. The intervals during which each was to be used coincided with the proposed casing program.

The intention was to drill a 17-1/2" hole from 0 to 700'. In this interval Magcobar suggested using a gel-water system with small amounts of asbestos fiber for additional carrying capacity. In anticipation of hydrogen sulfide intrusion and associated embrittlement problems, the use of zinc carbonate as a neutralizor was suggested. For additional corrosion protection, injecting an oxygen scavenger in the pump suctions and a coating agent for use during trips was advised. Standard bridging agents were to be used in the event of lost circulation.

For the 12-1/4" hole a deflocculated gel-water system was proposed. Magcobar suggested use of a lignosulfonate as a deflocculant. A lignin as a chemical thinner for viscosity control and a high molecular weight polymer to reduce water loss were advised. The corrosion and H_2S control programs were to be continued in the 12-1/4" hole. Initial attempts to control circulation by pills

of bridging agents were suggested. In the event of continued lost circulation a procedure for squeezing the loss zone with a high solids, high water loss slurry was also outlined in the proposal. Barite was to be used for weight if required.

For the 8-3/4" hole Magcobar recommended the use of a brine water system. Corrosion inhibitors were to be continued as before. To neutralize hydrogen sulfide, ammonia was to be injected in the standpipe if necessary. If mud-up was required, two possible systems were proposed.

Mud Drilling

Initial mud-up was done according to the proposal. No problems were encountered until the third day of drilling when circulation was lost at 333'. With the addition of various bridging agents the hole was drilled with partial returns to a depth of 797'. All returns were lost at that depth. Drilling continued without returns to 829'. Volume was built up with the initial mud-up mixture and bridging agents for lost circulation material (LCM). During this lost circulation hydrogen sulfide was encountered up to 600 PPM.

During operations over the next several days the mud was continually contaminated with cement from circulation plugs. LCM was retained in the mud to approximately 15 lbs/bbl. By this time it had become apparent that the primary function of the mud would be to carry LCM. For the duration of the mud drilling the mud

was mostly a gel-water-LCM mix. Over thirty-one days of drilling, about 8200 barrels of mud were lost.

Mist Drilling

After sidetracking a fish, an attempt was made to gain returns by drilling with mist. An initial mixture of 3 gallons soap, 3 gallons ammonium hydroxide and 4 gallons "Unisteam" to 10 barrels of water was injected at a rate of 10 to 20 bbls/hr. Two compressors were used to deliver 2350 CFM air. For two days various chemical mixtures were tried. Attempts at air drilling were discontinued because of inability to clean the hole of large quantities of sloughing dolomite.

Stiff Foam Drilling

In a further attempt to clean the hole and establish circulation drilling with stiff foam was attempted. A mud mixture of bentonite, lignite thinner and Benex was injected with 4.5 gallons soap and 3.5 gallons ammonium hydroxide to 10 barrels water at 20 GPM in 300-500 CFM air. After drilling out a bridge at 890 feet, all returns were lost. The hole sloughed and stuck the tools while trying to make the next connection. Increasing the air circulation to 1100 CFM cleaned the hole above the tools. No further attempts to drill with stiff foam were made.

Aerated Mud

After failing to keep hole clean with stiff foam, drilling with

aerated mud was tried. After breaking circulation with a 43 to 1 ratio and cleaning 60 feet of hole, all circulation was lost. A second full pit of mud was pumped away at the same ratio without returns. The hole continued sloughing and sticking the pipe. A third pit of mud was pumped at 230 GPM. This was aerated with 2230 CFM air injected with a mixture of 20 gallons soap and 4 gallons of ammonium hydroxide to 10 barrels water at a rate of 23 GPM. This aerated mud met with some success, carrying large amounts of dolomite to the surface intermittently. After washing the hole to a depth of 1020 feet circulation was totally lost and the hole sloughed in. Four hours were spent freeing the pipe and pulling out of hole. Preparations were made to plug and abandon the hole.

Conclusions

Loss of circulation coupled with H_2S intrusion caused problems in the first stage of drilling. Cement plugs and finally the 13-3/8" casing shut off the H_2S zones.

The hole below 13-3/8" casing, caving-in and hole sloughing coupled with loss circulation caused serious drilling problems including fishing, side-tracking and final hole abandonment. Solution to drill through the sloughing dolomites was not found. However, shortly after abandonment of the hole a technique was devised to control the sloughing dolomite. This technique is now awaiting a field test.

DRESSER INDUSTRIES

OILFIELD PRODUCTS GROUP, DRESSER INDUSTRIES, INC. 475 17TH STREET, SUITE 1600 DENVER, COLORADO 80202

September 27, 1976

DAILY OPERATIONS LOG

UNION OIL COMPANY OF CALIFORNIA
Forminco #1 82-29
Section 29, 25 South - 6 West
Millard County, Utah

DATE	MIDNIGHT DEPTH	REMARKS
7/26/76	170'	Drilling - no problems
7/27/76	680'	05:45 - Lost circulation at 333'; drilling with partial returns at times, full returns at times
7/28/76	829'	Losing returns on and off to 797' 08:42 - Lost complete returns at 797'; drilled to 829' without returns 08:42-10:00 - Building volume 10:30 - Detected 16 ppm H_2S at shaker; notified drilling crew and evacuated immediate vicinity of bore hole 14:25 - Ran poly-flow sniffer line from extractor through rotary table into well head - 10 ppm H_2S 14:25 - 14 ppm; 14:30 - 16 ppm; 14:35 - 14 ppm; 14:40 - 13 ppm: 14:45 - 14 ppm; 15:00 - 2 ppm; 15:15 - 5 ppm, thereafter - 0 ppm 23:23 - Shut down power in Unit to allow Oilind to be hooked up to power plant
7/29/76	829'	00:17 - Power on 00:17-06:30 - Oilind detected 600 ppm at bell nipple, sometime between 00:17 and 06:30; 06:30 - Checked on floor and on ground by rat hole for H_2S - 4 ppm; the sniffer poly-flow was pulled from casing at the rotary table and dropped to the ground near the rat hole. Ran poly-flow tubing back into well head, H_2S detection in DATA Unit went off scale immediately (50 + ppm) 16:00 - Halliburton on location; building mud volume 19:00 - Building mud volume to circulate; stuck 60' off bottom; could not rotate. 19:05 - Circulated-pulled loose - very tight 19:15 - Start out of hole 19:25 - Three stands out; pick up kelly and circulate to work out tight spot.

DATE	MIDNIGHT DEPTH	REMARKS
7/29/76 (cont.)	829'	22:30 - Start in hole 22:53 - Pick up kelly 24:00 - Running in hole slowly, circulating Losing returns
7/30/76	829'	00:15 - Start to pull out of hole 01:00 - Run in hole -- all drill pipe no drill collars 01:20 - Start pumping cement (180 bbls.) 01:30 - H_2S - 20+ ppm 02:25 - Start to pull out of hole 03:00 - pH 10.5 in shaker tank; 12-1/2 stands out, H_2S is coming out 600+ ppm at the head; plan on cementing again at 06:00 03:50 - H_2S: 20+ ppm; 04:05 - 14 ppm; 04:07 - 20+ ppm; 04:15 - 0 ppm; 04:20 - 13 ppm; 05:00 - 18 ppm; 05:30 - 15 ppm 05:45 - 20 ppm at rotary table; 20+ ppm at shaker tank 06:15 - 0 ppm; rig up Halliburton; cement 07:30 - Finish cementing 08:30 - H_2S check under the floor at the bell nipple - 600 ppm 10:30- 11:30 - Run in hole; bridge at 461'; pull out of hole 11:30- 12:00 - Run in hole with 6" drill collars to 461' 12:00- 16:00 - Wash 461' to 650' 16:00 - Waiting on cement at 650' 17:00 - Checked on the floor for H_2S; nothing 17:45 - Drilled into the cement 4-6'; still losing mud; going to pull out of hole and cement again 18:30 - Out of hole 18:45 - Start in hole 19:15 - On bottom - pump cement 19:30 - Start out of hole; rig sample line to bell nipple per Oilind hands request; no H_2S 19:55 - Out of hole; wait on cement 24:00 - Wait on cement

DATE	MIDNIGHT DEPTH	REMARKS
7/31/76	829'	03:15 - Start in hole - 129' of drill collars
		04:15 - Tag cement at 380'; pick up kelly; drilling on cement; full returns
		04:15 -
		09:20 - Drilling cement
		09:20 -
		09:45 - Circulating at 721'
		09:45 - Pull out of hole to pick up 17-1/2" hole opener, reamers and stabilizers; run in hole
		13:00 - Start reaming 17-1/2" hole; switched sample line to bell nipple, from shaker
		17:56 - Lost circulation at 436'; mix lost circulation material; installed extra H_2S detector now one at bell nipple and one at shaker; H_2S 50+ ppm -- 0 on spot check by Oilind -- 0 on toxic gas alarm by Oilind
		18:45 - Started reaming again
		23:00 - Start to pull out of hole -- 538'
		24:00 - Out of hole
8/1/76	860'	00:00 -
		02:00 - Pick up button reamers and stabilizers
		02:00 -
		03:00 - Go in hole
		04:15 - Partial loss of circulation; mix lost circulation material; regain full returns
		17:30 - Reaming at 773'
		19:05 - Lost returns at 795'; continue reaming with no returns
		19:19 - Switch sample line from shaker to bell nipple, both detectors monitoring at bell nipple
		19:28 - H_2S alarm - 5+ ppm at bell nipple
		19:32 - H_2S - 20+ ppm at bell nipple
		20:30 - Set kelly back; start trip out at 860'
		22:00 - Out of hole
		23:00 - Run in hole with 13 stands to cement
		23:30 - Start cementing
8/2/76	855'	00:00 - Pumping cement at 860'
		00:20 - H_2S at nipple 600+ ppm
		00:25 - Finish pumping; start trip out
		00:55 - On bank until 06:00
		06:00 - Start to run in hole; H_2S 600+ ppm on floor.

DATE	MIDNIGHT DEPTH	REMARKS
8/2/76 (cont.)	855'	06:20 - Tag cement at 733'
		06:45 - Wait on water
		09:00 - Pumping cement
		09:15 - Trip out
		09:45 - Out of hole; waiting on cement
		11:45 - Pump 50 bbls. mud to keep hole full
		12:50 - Pump 13 bbls. to fill hole
		15:00 - Trip in; tag cement at 541'; drill on cement
		19:00 - Detect 10 ppm H_2S at shaker; probable gas pocket in cement, as only lasted one minute
		19:30 - Lost circulation at 800'$\pm$; reaming with no returns
		20:45 - Trip out at 855'
		22:55 - Start to run in hole
		23:14-
		23:55 - In the hole; cement; start to trip out
8/3/76	860'	00:10 - On bank
		00:10-
		08:00 - Clean pits and mix mud
		08:00-
		09:25 - Run in hole with 12-1/4" bit (BHA) = 258.45'
		09:25 - Build volume
		10:00 - 855'; build volume
		10:30 - Working on pumps
		12:00 - Fill hole; resume trip in; tag cement at 400'; drill on cement
		14:00 - Trip put to change bottom hole assembly
		16:00-
		17:00 - Trip in with 17-1/2" bit
		17:00-
		18:30 - Wash and ream 465-530'
		18:30-
		21:15 - Wash 550-620'; drill cement 620-
		21:15 - Reaming cement approximately 690'
		21:15-
		24:00 - Drilling cement - 747'
8/4/76	910'	00:00-
		02:42 - Drilling cement 747-792'
		02:42-
		03:00 Lost circulation on connection at 797' installed third H_2S monitor on floor.

DATE	MIDNIGHT DEPTH	REMARKS
8/4/76 (cont.)	910'	03:00 - Drilling blind; 03:30 - 5 ppm H_2S; 03:35 - 20+ ppm at bell nipple; made connection at 830'
		04:50 - Break off kelly (856')
		05:05 - Make kelly back up; rotate; 15-20 ppm H_2S at bell nipple
		06:30 - Reamed to 910'; 20+ ppm H_2S; 06:45 - 20+ ppm at bell nipple
		07:00 - Continue to mix mud, work on pumps and rotate; 20+ ppm H_2S at bell nipple
		09:00 - As above with 20+ ppm H_2S at bell nipple
		12:15 -
		15:30 - Pull four stands and mix mud
		15:30 -
		16:00 - Trip out
		16:00 -
		18:00 - Pump 500 cu. ft. cement
		18:00 -
		20:10 - Pump 200 bbls. of mud on top of cement and trip out
		20:10 - Wait on cement
8/5/76	910'	00:00 -
		00:30 - Wait on cement
		00:30 -
		01:35 - Trip in the hole with 17-1/2" bit and circulate
		01:35 -
		02:15 - No circulation
		02:15 -
		02:44 - Got circulation
		03:20 - 16 ppm H_2S at bell nipple
		02:44 -
		06:00 - Drilling cement
		06:00 -
		06:15 - Stop drilling because of high torque on table
		06:15 -
		06:30 - Smooth torque out; drill cement again
		06:52 - at 616'
		07:55 - Connection at 641'±
		09:08 - at 667' -
		10:00 - Drilling cement
		11:40 - Lost circulation at 787'; lost 20 bbls.; regained circulation
		12:10 - Tag bottom; maintaining circulation

DATE	MIDNIGHT DEPTH	REMARKS
8/5/76 (cont.)	910'	14:30 - Running 13-3/8" casing 16:30 - Trouble getting DV tool through table; modify and continue running casing 23:59 - Failed to get casing to bottom
8/6/76	910'	00:00-00:30 - Rig up Halliburton 00:30-03:30 - Cement casing at 822'; 1st plug down at 01:00; 2nd plug down at 03:30 03:30-24:00 - Waiting on cement
8/7/76	910'	00:01-06:00 - Waiting on cement 06:00 - Making up bottom hole assembly and running in hole; drilling out cement 13:00 - Drilled out of casing to 910'; lost returns immediately when depth of 910' was reached
8/8/76	910'	00:01-12:00 - Wait on cement truck 12:00-12:30 - Run in hole to 886' open-ended 12:30-13:00 - Cementing 13:00-13:30 - Pull out of hole 13:30-22:00 - Run in hole to top of cement at 632.31'; not set up 22:00-24:00 - Waiting on cement
8/9/76	910'	00:00 - Waiting on cement 08:15 - Drilling on cement 10:30 - Drilling fresh hole 11:00 - Pull out of hole for rest of bottom hole assembly and strap out (914') 15:42 - Back on bottom drilling 22:00 - Lost returns at 1003'; notified driller; pumps were changed and 49 bbls. lost before shutting down. Pull up into casing and mix lost circulation material.
8/10/76	1003'	01:00 - Pumping cement 02:15 - Stuck in hole after cementing; established circulation; waiting on back-off and wash-over tools. Rigging sensors up for blooey line; monitoring for H_2S 08:00 - Waiting on fishing tools 09:30 - Notified that DATA Unit is on standby

DATE	MIDNIGHT DEPTH	REMARKS
8/10/76 (cont.)	1003'	17:00 - "Go International" is on location with fishing tools
		19:30 - Back-off shot; pull out of hole; top of fish at 784' -- bottom at 976' -- all drill pipe; top of fish 10' from bottom of casing
		20:00 - Pick up set of jars and start to trip in hole
		21:37 - On top of stuck pipe; jar it with 119,000+ lb. -- nothing
		22:45 - Back off and pull out of hole
		23:48 - On bank; left sub and jars in hole
		24:00 - Wait on free point logger "Go International"
8/11/76	1003'	00:00-03:00 - Wait on free point logger
		03:00-08:00 - Run free point log and pick up 9-5/8" over-shot pipe to drill around stuck pipe
		09:15 - Start washing over stuck pipe
		13:24 - Notified driller of slow loss in pits (10 bbls. over 1/2 hr.) and very slight decrease in flow 60-55 bbls.
		15:00 - Trip out to change wash-over shoe
		18:00 - Back on bottom washing over pipe at 844'
		22:46 - Connection at 863'
		24:00 - 872'
8/12/76	1003'	00:01 - Washing slowly - 1-3'/hr.
		06:50 - Set kelly back; start to pull out of hole (894') for new wash-over shoe
		08:00 - Tripping out for wash-over shoe
		09:00 - Out of hole; pick up wash-over shoe; start in hole
		11:00 - Back on bottom washing over
		18:30 - Trip out to change shoe
		19:45 - Out of hole; twisted off 2-1/2 joints of 9-5/8" wash-over pipe
		20:00 - Pick up fishing tool to try to screw into original fish. Original drill pipe fish is above wash-over fish. Run in hole with open-ended drill pipe and jars. Screw on and jar pipe -- no luck.
		21:00-21:45 - Work jars and circulate

DATE	MIDNIGHT DEPTH	REMARKS
8/12/76 (cont.)	1003'	22:30 - Run in hole with back-off shot to back off 3 joints below jars on fish
		23:05 - Shot back-off
		23:05-24:00 - Pull out of hole
8/13/76	1003'	00:00 - Pull out of hole; retrieved 3 joints; 3 left
		01:00-03:00 - Waiting on a spear to use on wash-over pipe
		03:00-04:45 - Pick up spear; run in hole; set spear
		04:45-08:00 - Cannot work pipe; stuck; wait on "Go International"; wait on orders
		08:00 - Fishing; worked spear loose
		10:00 - Trip out; pick up 6" drill collars
		14:00 - Trip in
		14:45 - Start jarring on fish
		15:20 - Trip out
		20:00 - Out of hole -- waiting on tools
		21:00 - 7-3/8" wash-over tool was picked up and run in hole to free the 90' of drill pipe stuck in hole
		22:05 - Start circulating and washing cement at 885' (94'± to drill)
		24:00 - 915' - Washing cement or fill around drill pipe
8/14/76	1003'	00:00 - Washing over drill pipe
		00:31-00:35 - Connection - 916'
		04:30 - Continue washing over cement; slowly losing mud; notified driller, who started mixing lost circulation material
		06:17 - Connection - 948'
		08:00 - Washing over 4-1/2" drill pipe
		10:00 - Lost circulation; stuck with 6" wash-over pipe
		11:00 - Pulled loose; picked up 4 stands; waiting on orders; build mud volume
		18:00 - Trip out to change bottom hole assembly
		19:00 - Trip in; catch 4-1/2" drill pipe
		19:30 - Jarring on drill pipe
		20:00 - Out of hole; back off below jars; sub unscrewed on jar end and not on drill pipe end

DATE	MIDNIGHT DEPTH	REMARKS
8/14/76 (cont.)	1003'	20:25 - Start to run in hole to screw back on --- Fish is three joints of 4-1/2" drill pipe and 4-40' joints of 9-5/8" wash-over pipe. Work on pump #2; mix mud
8/15/76	1003'	00:00 - Mix mud 01:15 - Shoot and back off; rig down; start to pull out of hole at 01:45 01:45- 02:34 - Chain out of hole; got sub; checked for H_2S under floor at bell nipple - nothing 02:34 - Wait on plug from Farmington, NM 05:30 - Plug arrived; won't go through kelly; have to use drill pipe; make up on fish with slips 06:30 - Plug won't go past 950'; put kelly hose on; pick up kelly; screw into fish 07:30 - Pump 15.5 bbls. in; no returns 07:35 - Set kelly back; pick up drill pipe; screw on fish; try plug again; won't go; lift pipe and rotate with tongs -- OK 08:15 - Apparently, the plug was run too deep and jerked off the "Go International" line on the bottom of the drill pipe - didn't set 08:30 - Working on plug 17:30 - "Go International" rigging back-off charge 19:30- 20:00 - Waiting on cement plug to set up 20:15 - Shoot back-off; hopefully at tool joint between #2 and #3 20:45 - Pull out of hole 22:45 - Pick up 7-3/8" wash-over and jars; run in hole 24:00 - On fish; ready to wash over; fluid level at approx. 450'

DATE	MIDNIGHT DEPTH	REMARKS
8/16/76	1003'	00:00 -
		01:10 - Pick up kelly
		01:10 - Wash over 4-1/2" drill pipe
		01:22 - 23% returns at 30 spm; wash over continued
		04:34 -
		04:40 - Set kelly back; started to pull out of hole; run in hole to try to get 4-1/2" drill pipe (fish); pull out of hole; no fish; pick up spear and run in hole to try to get the three of 9-5/8" over-shot pipe lost on 8/12/76; cannot get the over-shot pipe or the spear to break loose; work it. Full returns while trying to wash over fish.
		08:00 - Release spear; pull out of hole
		08:15 - Tripping out
		09:45 - Trip in with spear for 9-5/8" wash-over pipe
		10:30 - Trip out
		11:00 - Trip in; spear 9-5/8" wash-over pipe; pulling on wash-over pipe
		14:30 - Trip out
		17:25 - H_2S detector showed 2-3 ppm increase over background in a 10 minute period, then went back to 0. Notified company hand
		18:00 - Cut 22' of wash-over pipe and pulled it out; working on fishing tools
		20:30 - Run in hole to top of over-shot fish
		21:30 - Circulate
		21:45 -
		22:15 - Spear fish and try to work loose; no go; pull out of hole; pick up 12-1/4" bit
		22:15 -
		24:00 - Run in hole; circulate
8/17/76	1003'	00:00 -
		04:30 - Circulate
		04:30 - Trip out with spear
		05:30 - Trip in and circulate
		07:30 - Trip out

DATE	MIDNIGHT DEPTH	REMARKS
8/17/76 (cont.)	1003'	08:30 - Pick up used spear; hang in derrick; lay down over-shot tool; wait on new cutters
		11:30 - Fishing
8/18/76	1003'	Lost grapple in hole
8/19/76	1003'	Released "Go International"; decided to sidetrack the fish
		18:00 - Pump cement plug; wait on cement

DATE	MIDNIGHT DEPTH	REMARKS
8/11/76	1003'	Fishing
8/12/76	1003'	Fishing
8/13/76	1003'	Fishing
8/14/76	1003'	Fishing
8/15/76	1003'	Fishing
8/16/76	1003'	Fishing
8/17/76	1003'	Fishing
8/18/76	1003'	Fishing
8/19/76	1003'	Fishing
8/20/76	1003'	00:00 - Sidetracking 06:00 - Drilling on cement; lost all mud; plug ineffective; unable to sidetrack 10:30 - Pump another plug 12:00 - Finish cementing; wait on cement 21:00 - Drill to top of fish and wait on cement plug to harden
8/21/76	1003'	10:00 - Pick up Dyna Drill; run in hole to whipstock at 833'
8/22/76	1043'	Rig up to mist drill; drill to 1043'; hole falling in
8/23/76	1043'	01:00 - Rig up to drill with mud; change DATA probes to mud operation 05:30-24:00 - Re-establish partial returns; mixing mud and washing to bottom; lost approximately 2200 bbls. mud, washed to 972'
8/24/76	1052'	07:30-10:30 - Washed to 1016'; lost 800 bbls. 10:00-11:00 - Drill from 1044-1052' 11:00-24:00 - Mixed 400 bbls. slurry of Magcogel, Benex, Tannathin for stiff foam drilling.

DATE	MIDNIGHT DEPTH	REMARKS
8/25/76 (cont.)	1052'	00:00-02:00 - Circulate pits
		02:00 - Tripping
		06:30 - Hit bridge at 890'; tried to circulate, no returns
		09:15 - Circulating with stiff foam
		09:35 - PVT shows 307 bbls.
		12:00 - PVT shows 281 bbls.
		12:30 - Hole shoughing
		14:30 - Circulating with foam; caught one good sample from approximately 830 to 860, high porosity dolomite
		15:15 - Could not get back to bottom; bridge at approximately 920'; set back one joint in mouse hole; no foam just air returning
		16:00 - PVT shows 218 bbls.
		16:30 - Partial returns of foam
		17:00-20:30 - Full returns of foam, lost depth each time picked up
		20:30-24:00 - Pull out of hole to casing shoe
8/26/76	1052'	00:00-08:00 - Mixed mud to attempt to clean hole with aireated mud
		08:00 - Rotate down with mud and air; no returns; lose approximately 80 bbls. per joint
		09:55 - Returns through flowline and shaker
		11:00 - Lost returns
		12:30 - Start to pull out of hole to shoe
		12:50 - Mixing volume
		14:15 - Start pumping with mud and air; no returns; reaming to 865'
		16:20 - Out of mud; no returns
		16:20-16:55 - Mixing volume
		16:55 - Start pumping mud with mud and air; no returns; pull out of hole; lay down drill collars -- all but two joints of 8" collars; mixing volume; run in hole; try circulating; no returns
8/27/76	1052'	00:00-08:00 - Wash to 1020' with good returns at times; start to pull out of hole; got stuck
		08:00-11:30 - Work free and pull to 757'
		Plug and abandon; DATA Unit released

DRESSER INDUSTRIES

OILFIELD PRODUCTS GROUP, DRESSER INDUSTRIES, INC. 475 17TH STREET, SUITE 1600 DENVER, COLORADO 80202

September 27, 1976

AIR DRILLING REPORT

for

UNION OIL COMPANY OF CALIFORNIA
Forminco #1 82-29
Section 29, 25 South - 6 West
Millard County, Utah

DATE	REMARKS
8/21/76	Ream; Dyna Drill; run with 2 C Compressors (2350 cfm); mist 10-20 bbls./hr. Injection mixture of 3 gal. soap plus 3 gal. ammonium hydroxide, 10 bbls. water, 4 gal. unisteam.
8/22/76	Try to mist drill same as above -- poor results due to poor returns. Large amount of sand; hole caved.
8/23/76	Changed meter-run
8/24/76	Lay bleed-off line; get ready to stiff foam
8/25/76	Stiff foam with mixture out of mud pit plus 4.5 gal. soap, 3.5 gal. ammonium hydroxide per 10 bbls. water -- injected at rate of 23-16 gal. per min. with 300-500 cfm air. Two hours to pack hole with foam -- good returns with a lot of sand for 2 hours. Mist pump screen plugged several times; lost returns for 3 hours. Made few connections; clean old hole. Pull out of hole for lack of results.
8/26/76	Mix mud for aerated mud
8/27/76	First pit used with ratio 43:1 -- got good returns. Made 3 or 4 connections; clean out hole. Mud lost in 3 hours. Mix second pit

DATE	REMARKS
8/27/76 (cont.)	mud and used same ratio -- no returns. Also used all fluid in reserve pit. Mixed third pit -- 5-1/2 x 16 pump on 30-35 spm; two air compressors; mist pump injecting 20 gal. soap, 4 gal. ammonium hydroxide mixture for 10 bbls. at rate of 23 gal./min. Good returns for short time. Pull out of hole; suction on mud pump covered with sand.

DRESSER INDUSTRIES

OILFIELD PRODUCTS GROUP, DRESSER INDUSTRIES, INC. 475 17TH STREET, SUITE 1600 DENVER, COLORADO 80202

September 27, 1976

MUD LOSS LOG

UNION OIL COMPANY OF CALIFORNIA
Forminco #1 82-29
Section 29, 25 South - 6 West
Millard County, Utah

Following is a summary of mud losses during the drilling of Union Oil Company of California's Forminco #1 82-29, Millard County, Utah:

DATE	DEPTH	MUD LOSS
7/26/76	--	--
7/27/76	333'	160 bbls.
7/28/76	797'	850 bbls.
7/29/76	--	--
7/30/76	--	--
7/31/76	436'	slight
8/1/76	--	--
8/2/76	860'	slight
8/3/76	--	--
8/4/76	--	slight
8/5/76	787'	20 bbls.
8/6/76	--	--
8/7/76	911'	800 bbls.
8/8/76	--	--
8/9/76	1003'	49 bbls.
8/10/76	--	--
8/11/76	1003'	slight
8/12/76	--	--
8/13/76	--	--
8/14/76	1004'	400 bbls.
8/15/76	--	--
8/16/76	--	--
8/17/76	--	--
8/18/76	1004'	300 bbls.
8/19/76	1004'	900 bbls.
8/20/76	1004'	400 bbls.
8/21/76	--	--
8/22/76	--	--
8/23/76	1044'	2200 bbls.
8/24/76	1060'	1200 bbls.
8/25/76	--	--
8/26/76	988'	900 bbls.
	TOTAL:	8179 bbls.

Operator Union Oil of Calif. Location Sec T. R. 29-25S-6w

Well Forminco # 1 82-29 County Millard

Contractor Loffland #5 State Utah

Engineer Gene Matthews Elevation 6400

Co. Man; Bob Bardin Tool Pusher" Buddy Bowen

MAGCOBAR PRODUCTS

DRILLING MUD LOG

Surface Casing 13 3/8 inch 822 ft.

Hole Size 17½ inch

Intermediate Casing 9 5/8 inch ft.

Hole Size 12¼

Spud Date 7-26-76

Under Surface Date 8-7-76

Finish Date 8-27-76

Total Depth 1052 ft.

Mud Cost $ 40,786.88

DATE	DEPTH	MUD PROPERTIES																		MATERIALS													COST	
		WT. LBS./GAL.	SAMPLE TEMP.	VISC. SEC./QT.	CPS	PLASTIC VIS.	YIELD POINT	GELS INITIAL	GELS 10 MIN.	pH	ALKALINITY Pf	ALKALINITY Mf	FILTRATE API	HI-HP API	CHLORIDE PPM	CALCIUM PPM	OIL % VOL.	SOLIDS % VOL.	#/bbl. Bentonite	#/bbl. Drill Solids	SAND % VOL.	L.C.M. #/bbl.	MAGCOBAR	MAGCOGEL	SPERSENE	CAUSTIC SODA	TANNATHIN	LIGQUIK	Hulls	FIBER	CHIPSEAL	BICARB	DRAYAGE	PER DAY	TO DATE	REMARKS
7-26	160	8.7		37		7	4	2	3	11.5	1.3	1.6	18		500	Tr		4	33			½											2	134	134-	
7-27	500	8.9		44		10	9	4	11	11.2	9	1.5	15.2		400	Tr		4½	12			½												881÷	1015-	
28	829	8.9		58		23	17	5	11	12.5	1.3	1.9	10.8		500	Tr		3½	18			½					35	30	40	40			4	4399	5414-	H_2S
29	829	8.4								10.5				WATER IN PITS													15		30	30			4	2645	8059-	
30	829	8.9		38		12	10	2	4	12.2	4.6	5.8	N/C	12,000'	Tr		6				5	½	5					5	15	15			1	759	8818	
31	446	8.5		38		11	9	3	7	12.3	3.5	4.8	N/C		60		3	10			15			72		8		15	10	10				982	9800	Reaming
8-1=	762	8.7		41		14	11	5	13	12.0	3.2	4.8	N/C	11,500	420	2	3/4	10.5			15	½	15			20		2		1			5		297	10,097	
2	800	8.8		42		25	19	8	20	12.2	2.7	2.8	N/C		800	Tr		3	10			3	15					1			9	21	11	2		563	10660	
3	745	8.8		40		18	16	4	9	11.9	1.7	1.8	N/C		800	540		3.5	10.5			NA	15			50		3		15		35	28		1	1321	11982	
4	910	8.9		60		34	29	12	26	12.8	3.2	4.8	N/C		800	240		3.5	10			NA	14			103		2			8	30	30			1387	13368	
5	910	8.8		62		38	30	12	26	12.6	3.3	4.9	N/C		900	180		3	10			NA	15	40		143		8		8	25	40	44			2365	15733	
6	910	8.9				W.O.C.		CSG STUCK @ 822'																		42		4		2	5	20	20		1	1037	16770	
7	910					NO MUD IN PITTS																														0	16770	
8	660	8.8		50		22	17	5	13	12.2	1.4	2.6	N/C		700	800			10			NA	20			61		5		3	14	22	22		2	1321	18091	
9	945	8.9		40		16	15	4	12	12.2	2.0	2.6	N/C		800	720		3.5	10			NA	20	0		10				2	5	20	20	1		643	18734	
10	1004					STUCK PIPE																																
11	1004	8.9		38		12	9	3	5	12.8	1.8	2.4	N/C		900	420		3.5	40			NA	8-10			25	3		3	2		8	8			465	18078	
12	1004	8.8		39		10	18	5	14	12.3	1.6	2.3	N/C		900	360		3.75	10			NA	13			50				1	5	10	10			567	18645	
13	1004	8.6		39		13	14	4	10	12.4	1.2	1.6	N/C		800	240		2.5	10			NA	10			7							1			61	18706	
14	1004	8.6		37		9	6	2	5	9.3	.4	.8	18.8		800	80		2	14			TR	15											1	62	18768	
15	1004	8.6		46		16	12	4	11	8.7	.5	1.2	16.6		800	160		3	12			TR	17			115		2			10	15	15	2		1154	19922	
16	1004	8.7		40		14	9	3	8	8.8			20.4		900	60		3	10			TR	8-10			72		1		1	14	14	14			947	20869	
17	1004	8.7		40		15	11	3	6	7.5	.4	.9	22		800	120		3	10			¼	8-10													0	20869	
18	1004	8.6		47		18	12	4	9	8.3	.2	.4	16.4		800	80		2	12			o	10			60					10	5	14		2	766	21,635	

BIT NO.	MAKE	SIZE	TYPE	SERIAL NO.	DEPT FROM	DEPT TO	FOOTAGE	TIME	BIT WT.	BIT R.P.M.	PUMP DATA: PRESSURE P.S.I.	PUMP DATA: OUTPUT Gals./MIN.
1	HTC	12¼	OSC1G	NV096	108	460	352	17½	20/58		200	
2	SEC	12¼	M4N	610327	460	558	98	6	55		200	
3	STC	12¼	4JS	118 DF	558	829	271	8	60		200	
3RR	STC	12¼	4JS	118DF	1	CLEAN OUT BRIDGES						
1RR	HTC	12¼	OSC1G	NV096	1	CLEAN OUT BRIDGES:						
H.O.	REED	17½	Pilot	10188		538	441	6	15		150	
4	REED	12¼	YBJ	781094		721	380	3			150	
HO#2	STC	17½	Pilot HO			860	322	17 3/4	15/40			
RR HO	STC	17½	"			860	322					
3RR 3	STC	12¼	4JS	118DF		/					150	
5	HTC	17½	OSC1G	SA339		910	50	3	20/40		200	
6	HTC	12¼	OSC3	WL982	833	1044	211	6 3/4	30		200	

HYDRAULIC DATA

Pump: Make EMSCO Model D-500

Size 6½ X 16

Drill Pipe Size—Wt: 16.60 - 4½

T. J. Size—Type: 6" XH Grade E

Drill Collar: No. 5 Length 240

8" O.D. X I.D. 3" X 30

GEOLOGICAL DATA

FORMATION	DEPTH
822' to T.D. Dolomite with 40-70% porosity.	

ADDITIONAL REMARKS: 7-27 Lost Returns @333' Lost approx. 160 bbls. Off & on returns to 797' where we lost 850 bbls. At this time we noticed the presence of H_2S @ 16-20 ppm. Oilind was called in and reported in excess of 600 ppm. @Bullnipple 7-28 cemented lost zone. WE had off and on returns to 860' where we set the 4th cement plug. H_2S was never out of control during this interval and was never noticed while the hole was full. 8-6-76 by this time we had a 17½ hole drilled to 910' and had lost/ approx 5000 bbls of mud. We tried to run 13 3/8 CSG. to 910' but got stuck. Backed off 8-12-76 @ 784' Go In hole with 9 5/8 wash pipe. 8-12- Washing over @ 905' with full returns and 20% LCM 8-13-76 Had only 3 joints 4½ D.P. in hole 8-14-76 lost 400 bbls and got wash pipe stuck. * 15-76 Going to back off all but bottom joint of D.P. and set wire line plug in #3 O.P. leaving 4 joints of wash pipe. Fluid level @ 450 FT 8-15 retrieved 2 joints of DP 8-16 Retrieved 22 ft. of 9 5/8 washpipe with full returns. 8-17 lost 300 bbls mud 8-19 lost 900 bbls fluid and trying to jar fish loose. 8-20 Decided to cement fish whipstock around it. Took 2 cement plugs to cement fish. 8-21 whipstock @ 831' . 831' Full returns while sidetracking. 8-22 trying airmist with 4½ gal soap with 5 gals unisteam, 1½ gal ammonia per 10 bbls H_2O injected,

Operator Union Oil of Calif. Location Sec T.R. 29-25S- 6w

Well Forminco #1 82-29 County Millard

Contractor Loffland #5 State Utah

Engineer Gene Matthews Elevation 6400

Co. Man; Bob Bardin Tool Pusher; Buddy Bowen

MAGCOBAR PRODUCTS

DRILLING MUD LOG

Surface Casing _____ inch _____ ft.
Hole Size _____ inch
Intermediate Casing _____ inch _____ ft.
Hole Size _____

Spud Date _____
Under Surface Date _____
Finish Date _____
Total Depth _____ ft.
Mud Cost $ _____

DATE	DEPTH	MUD PROPERTIES																			MATERIALS														COST		REMARKS
		WT. LBS./GAL.	SAMPLE TEMP.	VISC. SEC./QT.	CPS	PLASTIC VIS.	YIELD POINT	GELS INITIAL	GELS 10 MIN.	pH	ALKALINITY Pf	ALKALINITY Mf	FILTRATE API	Hr - HP API	CHLORIDE PPM	CALCIUM PPM	OIL % VOL.	SOLIDS % VOL.	#/bbl. Bentonite	#/bbl. Drill Solids	SAND % VOL.	L.C.M. #/bbl.		BENEX MAGCOBAR	MAGCOGEL	SPERSENE	CAUSTIC SODA	TANNATHIN	FIBER	CHIP SEAL	HULLS	VISQUIK	ALUM STEARATE	SULFATEX	AMMON. HYD	DRYAGE	PER DAY	TO DATE	
19	1004	8.6		37		10	6	2	4	9.5	3	.6	25		800	40		2	10			25			180		2		60	68	18	8				2		2935	24570	
20	1004	8.6		40		12	18	2	7	9.0	.2	.4	38.8		1100	240		2	10		1/8	10			30											1		205	24775	
21	831	8.7		51		22	14	4	14	10.5	.6	.9	26		1000	160		2.75	12			6			61		2		20	20	10	2						873	25648	
22	1044								10		AIR MIST														5	1	5					1	BICARB 1					266	25914	
23	1044	8.6		45		12	18	9	18	13	2.8	3.6	N/C		900	180		2			Tr	25%														3		1640-	27554	
24	1052	8.6		30		2	1	2	3	10	.3	.5	12.6		900	60		2	8		0	0			239				85	98	Lime 10	Hulls 48						3982	31536	
25	1052	8.6		30		3	1	2	3	10	.3	.6	11.6		900	60		2	8		0	0			165		2	14	78	73	22		BENEX 48	Lime 10				3747	35283	
26	1052	8.5		39		5	2	2	4	10.5	.8	1.2			900	60		2	10		½				32	45		3	10					3	2	3		3290	38573	
27	1052				P&A THIS HOLE																				16	135		12		20	18	9	25	9	4	1	9 GEL 40		5456	44025	

GEOTHERMAL ENGINEERING PLOT

Magcobar
DRILLING FLUID SERVICES

DATE	COMPANY	WELL
FROM 7-26 8-28-76	UNION GEOTHERMAL	FORMINCO " 1

DIGITAL D.A.T.A. NUMBER	FIELD	COUNTY	
DBT-3	TIGHT HOLE	MILLARD	UTAH

MUD ☒
AIR ☐
FOAM ☒
MIST ☒

AMBIENT TEMPERATURE .....
TEMPERATURE IN -.-.-
TEMPERATURE OUT ------

DEPTH AND BIT REC.	"D" "DCS"	GAS	TEMPERATURES: AMB. IN OUT	REMARKS
	0.5 1.0 1.5		0° 50° 100° 200° 400°	

20" CSG.

400

TOTAL OF
6 BITS AND
2 HOLE OPENERS
USED TO DRILL HOLE
13 3/8" CSG.

800

600+ PPM
H_2S @ 797'

ATTEMPTED TOTAL AND PARTIAL LOSS OF RETURNS MIST & STIFF FOAM DRLG. TO CURE LOST CIRC.

LOST RETURNS AND P. & A. @ 1052'

1200

1600

2000

2400

PRINTED IN U.S.A.

GEOTHERM NGINEERING PLOT

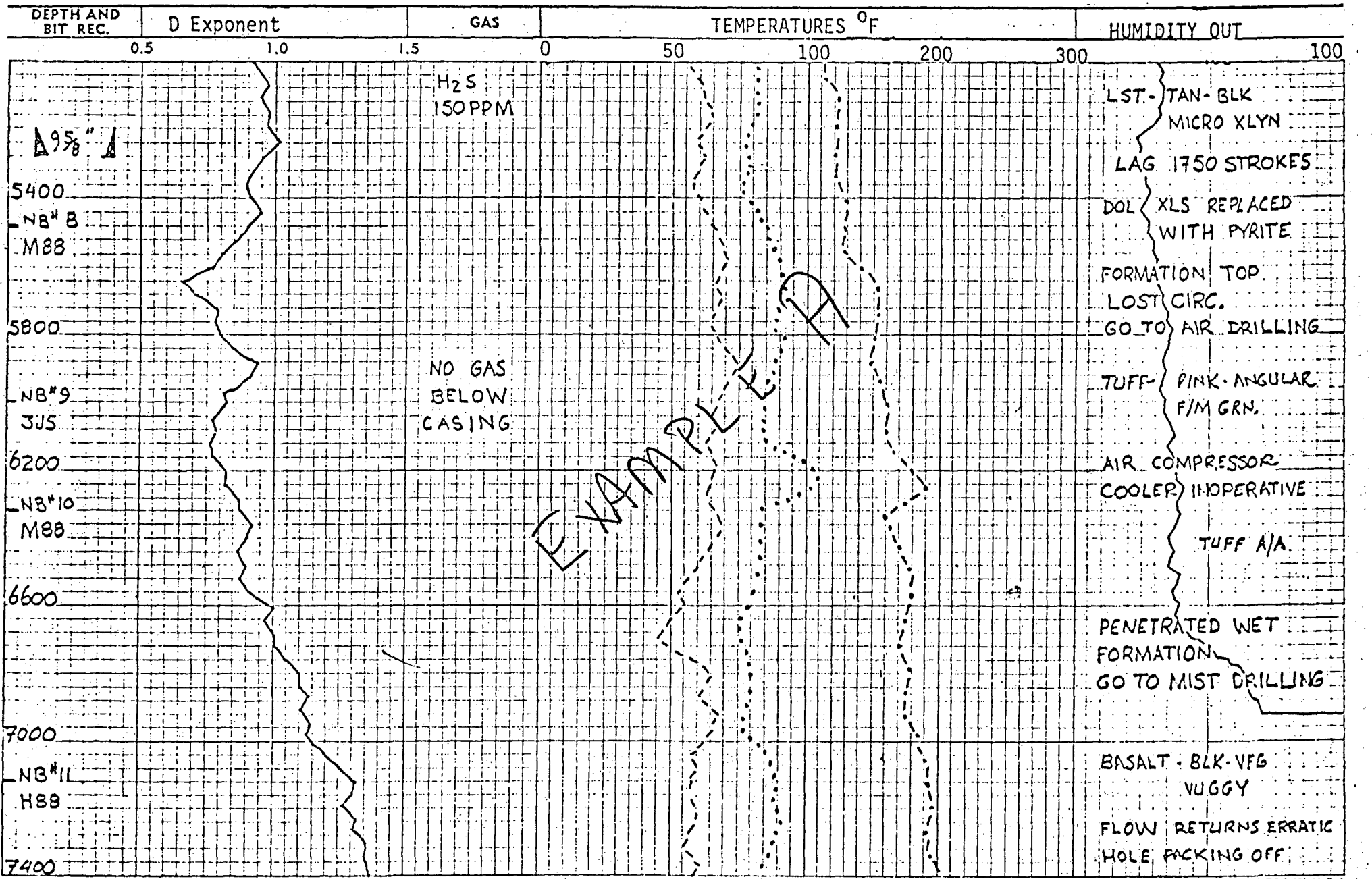
Magcobar
DRILLING FLUID SERVICES

FROM | COMPANY | WELL

DIGITAL D.A.T.A. U... | ...BER | FIELD | COUNTY

AIR
MIST
FOAM
MUD

AMBIENT AIR TEMPERATURE _ _ _ _ _ _ _ _
TEMPERATURE IN .....
TEMPERATURE OUT _ . _ . _ . _



DRESSER INDUSTRIES

OILFIELD PRODUCTS GROUP, DRESSER INDUSTRIES, INC. 475 17TH STREET, SUITE 1600 DENVER, COLORADO 80202

September 27, 1976

SUMMARY OF DRILLING PROBLEMS

for

UNION OIL COMPANY OF CALIFORNIA
Forminco #1 82-29
Section 29, 25 South - 6 West
Millard County, Utah

PROBLEM: H_2S gas intrusion into borehole after losing complete circulation at 797'.

SEQUENCE OF EVENTS:

1. Lost complete returns at 797' and drilled with no returns to 822'.
2. While shut down to build volume, DATA Unit detected 16 ppm H_2S at shaker two hours after pumps shut down.
3. Approximately 18 hours after pumps shut down, Oilind engineer (H_2S specialist) detected 600 ppm H_2S in atmosphere below floor.

PROBABLE CAUSE:

Mud level in borehole dropped to point where formation pressure was higher than hydrostatic head of mud column.

REMARKS:

The normal formation pressure in non-marine deposition is .433 psi/ft. -- equivalent to 62.31 lb/ft^3 (8.33 #/gal.). The normal formation pressure in marine deposition is .468 psi/ft. -- equivalent to 67.32 lb/ft^3 (9.0 #/gal.). Normal fracture pressure in naturally fractured carbonates should be 50 psi above the formation pressure at this depth. Two geological theories have been advanced as to why fracture pressures are lower than normal in this well:

1. The formation outcrops to the atmosphere and is interconnected. Atmospheric pressure = 15 psi. 15 psi +

50 psi = 65 psi pressure required before the formation takes drilling fluid. The equivalent density at 800' before the formation takes fluid = 11.70 lb/ft^3 (1,6 #/gal.).

2. Tectonic uplifting after deposition and erosion relieved the overburden pressure causing expansion of the rock matrix...thus yielding formation pressure and fracture pressures lower than normal. This activity also caused fracturing of the carbonates.

Although the information gathered is not sufficient to estimate formation pressure with accuracy, the "d" exponent plot indicates that the drillability of the formations penetrated is somewhat higher than in normally pressured formations. This increased drillability indicates lower than normal formation pressures. On 8/15/76, it was observed that the fluid level was at 450', thus leaving a hydrostatic pressure of 166 psi against the formation below 822'.

$$(822 - 450)(.00695)(64.32) = 166 \text{ psi}$$

$$\frac{166}{(822)(.00695)} = 29.11 \text{ lb/ft}^3$$

It can be concluded from the information developed that the maximum equivalent mud density the fractured carbonates can withstand is 29.11 lb/ft^3 (4.0 #/gal.).

SOLUTION:

Drill with Sulfatex-Sol and H_2S scavenger through the loss zone (suggested procedure by Dresser Air Drilling Dept.) -- 1-1/2% Sulfatex-Sol per 10 bbls. water with sufficient ammonium hydroxide to control H_2S. Inject this solution in air stream of 300-375 cfm at 12 gal./min. Density of the mixture should be 2.0-2.5 lb/ft^3.

PROBLEM: How to contain the hydrogen sulfide gas

CAUSE:

H_2S intrusion from depths shallower than 822'

REMARKS:

Documentation shows that H_2S was detected only once after setting 13-3/8" casing at 822' -- 2-3 ppm were monitored for 10 minutes eleven days after setting the casing. This indicates that the intrusion would be above the 822' depth.

SOLUTION:

Drill with the air mixture specified through the loss zone -- probably through the fractured dolomite -- and set casing. If the H_2S becomes uncontrollable, displace the bottom part of the hole with OilFaze (approximate density of 56.85 lb/ft^3 - 7.5 #/gal.) to give the equivalent of 29.11 lb/ft^3 (4.0 #/gal.) against the formation at 822'...and run casing. Continue to drill with the air mixture through the productive zone unless formations other than carbonates are encountered or until the air does not clean the hole adequately.

FUTURE PROSPECTS:

SUGGESTED CASING DESIGN

20" casing through conglomerates (approx. 600')
13-3/8" casing through loss zone (approx. 1200')
9-5/8" casing through production zone

SUGGESTED DRILLING FLUID DESIGN

0-600' - Magcogel, lime, water; wt. 64.33 lb/ft^3 (8.6 #/gal.)
600-1200' - 1-1/2% Sulfatex-Sol per 10 bbls. water with sufficient ammonium hydroxide to control H_2S. Inject mixture at 12 gal./min. into 300-375 cfm
1200-T.D. - Air mixture as above. If necessary, and mud up is required, the following is suggested:

(See "Mud Program Review")

DRESSER INDUSTRIES

OILFIELD PRODUCTS GROUP, DRESSER INDUSTRIES, INC. 475 17TH STREET, SUITE 1600 DENVER, COLORADO 80202

September 27, 1976

DRILLING PARAMETERS MONITORED BY DATA UNIT

UNION OIL COMPANY OF CALIFORNIA
Forminco #1 82-29
Section 29, 25 South - 6 West
Millard County, Utah

Following are the drilling parameters monitored by the DATA Unit on oil and gas wells. The method of monitoring has been adjusted to provide applicability to geothermal and/or air drilling. It should be noted, however, that most geothermal drilling is accomplished using drilling muds.

The drilling parameters are displayed in digital readouts, are calculated, and/or are hand-drawn, as indicated for each parameter.

1. "d" exponent - no adjustment - calculated and hand-drawn

2. PVT (Pit Volume Totalizer) - digital readout; charted

   (a) Drilling mud - no adjustment

   (b) Air drilling - The normal trend for compressor pressure, back-pressure (if applicable), and air volume pumped need to be established and monitored. Alarm to be set at $\pm$ 10 psi and $\pm$ 10 ft^3/min. Loss or gain of air mixture should be detectable.

3. Flow (percent flow through flowline) - digital readout and charted

   (a) Drilling mud - no adjustment

   (b) Air drilling - Install a flow sensor in the blooey line. With minor adjustments, the air flow can be measured and a trend established and correlated with the air volume. Alarm to be set at $\pm$ 1%

4. Flowline, suction pit, and ambient temperatures - readout

   (a) Drilling mud - no adjustment

(b) Air drilling - minor adjustments - Install a thermometer in the blooey line as close to the borehole as is practicable.

Install a thermometer in the air line as close to the compressor as is practicable.

5. Pump pressure - digital readout; charted

(a) Drilling mud - no adjustment

(b) Air drilling - Monitor the compressor pressure

6. Pump strokes - digital readout; charted

(a) Drilling mud - no adjustment

(b) Air drilling - monitor the air volume

7. Gas analysis - charted

(a) Drilling mud - Monitor H_2S at the shaker, at the bell nipple, and on the floor; alarm to be set at $\pm$ 3 ppm.

(b) Air drilling - minor adjustments - Divert the air stream from the blooey line to a modified gas trap.

8. Lithological samples - observed and hand-drawn

(a) Drilling mud - no adjustment

(b) Air drilling - Divert the air stream from the blooey line into the sample catcher.

9. Sample lag - calculated

(a) Drilling mud - no adjustment - pump strokes always used

(b) Air drilling - Use time lag instead of pump stroke lag

10. Mud analysis

    (a) Drilling mud -
        (1) Chloride, calcium, pH, and alkalinity checked every two-thirds circulation to determine intrusion of salt water from geothermal production zones
        (2) H_2S scavenger checked every two-thirds circulation to determine if the scavenger is reacting chemically with H_2S
        (3) All other checks on a tourly basis for mud treatment

    (b) Air drilling - moisture content in and out

11. Rotary rpm, hook load, bit weight, rate of penetration, torque (diesel electric rigs only) - all displayed; bit weight and rate of penetration charted

12. Hydraulics - calculated

    (a) Drilling mud - no adjustments

    (b) Air drilling - no adjustments

These twelve parameters are presently displayed digitally; eight can be charted depending on the customer's wishes.

Listed below is a description of the hand-drawn logs designed for geothermal drilling using drilling muds.

1. Geothermal Engineering Log - 1"/400' scale - Example A

    (a) "d" exponent can be used to establish normal trends. Deviation from normal can help determine (1) lost circulation zones, and (2) tops of temperature anomalies (drillability of formations should change with a drastic change in formation temperature).

    (b) Gas

    (c) Temperature: this could help determine if a drillability change is due to a change in temperature and productive zones.

    (d) Humidity out

2. DATA Lithology Log - 5"/100' scale - Example B

    (a) Mud data, rig mechanics, bit data, and date

    (b) Rate of penetration

(c) Depth

(d) Porosity

(e) Lithology

(f) Formation description

(g) "d" exponent

(h) Ambient temperature

(i) Temperature in

(j) Temperature out

UNION 76

GEOTHERMAL DIVISION

COMPANY Union Oil Company of California
FIELD Cove Fort - Sulphurdale
WELL Formisco #1
COUNTY Millard
STATE Utah
LOCATION Sec. 29
T. 25 S., R. 6 W. EL. 6418 K.B. 6396 G.L.

TOTAL DEPTH 1051 ft.
SPUD DATE 26 Jul 76
COMPLETION DATE 29 Aug 76
DRILLING CONTRACTOR Loffland
ENGINEER R. Rardin
GEOLOGIST Steven J. Maione

CASING RECORD

20" @ 97'
13 3/8" @ 822

EXPLANATION

DRILLING
NB - NEW BIT
RRB - RERUN BIT
CB - CORE BIT
LC - LOST CIRCULATION
DEV - DEVIATION
DST - DRILL STEM TEST

ROCK
SHALE, SILTSTONE, SANDSTONE, CONGLOMERATE, LIMESTONE, DOLOMITE, GYP, ANHYD., CHERT, VOLCANICS, INTRUSIVE, TUFF, METAMORPHIC, Sulphur, _____

MINERALS
C - CALCITE, CHL - CHLORITE, CEL - CELADONITE, CL - CLAYS, D - DOLOMITE, E - EPIDOTE, F - FELDSPAR, K - KAOLINITE, P - PYRITE, Q - QUARTZ, Z - ZEOLITES, V VEINS, DIS. DISSEMINATED

PHYSICAL - CHEMICAL
D.H. - DOWN HOLE, B.H. - BOTTOM HOLE, F.L. FLOW LINE, T. TEMPERATURE, P. PRESSURE, T.C. TIME SINCE CIRCULATION, W.H. WELL HEAD, PPM - PARTS PER MILLION

DEPTH	PENETRATION DATA (□ FT./HR. ⊠ MIN./FT.)	LITHOLOGY: PRIMARY LITH (100 % 0)	SECONDARY MINERALS	DESCRIPTION	PHYSICAL - CHEMICAL DATA (°F)	MISC.
	200 180 160 140 120 100 80 60 40 20		S	No samples! Alluvium and soil, altered w/ sulphur mineralization	80 90 100 110 120 130 140	
				AA		
				AA		

H_2S KICK AT FORMINCO #1

On July 28, 1976, circulation was lost while drilling 12-1/4" hole at 796'. An additional 33' of hole, to 829', was drilled in fifteen minutes without returns. Total of 850 bbls of mud was lost to formation and fluid in the hole drained away.

Dresser Data Unit Gas Detector monitored 16 ppm H_2S at shale shaker and poly flow sniffer line from extractor monitored 10 ppm H_2S level at wellhead.

Mild H_2S gas blow developed. Pump and colormetric tubes type portable monitor detected 16 ppm H_2S level on derrick floor and 5 ppm at shale shaker.

Respiratory equipment was needed to enter sub-base under derrick floor. The test ampule turned dark brown at hydril in less than 30 seconds.

Choke lines were extended beyond sump by additional 150'. One hundred fifty barrels of mud of 12.5 pH was pumped down hole without any apparent effect on H_2S concentration.

Wind socks were installed around location. Personnel were instructed by Oilind representative on the use of protective equipment, like back packs and work packs. Personnel were checked by local doctors for punctured ear drums.

Safety trailer with cascade system, first aid kit, resuscitator and Hi & Lo stage compressor was installed.

An H_2S level of 60 ppm was monitored on the derrick floor with Oilind fixed system type detectors. Rig personnel experienced inconvenience in working while wearing breathing equipment.

Water was pumped thru the kill line into the hole. The hole bridged off at 670'. 12-1/4" drilling assembly was run in hole to 762'. The string stuck due to casing-in of hole. Tools were worked free and hole was cleaned out to total depth of 829' without returns.

With open end drill pipe at 787', 772', and 726', three cement plugs were placed with 1000 cu. ft., 435 cu. ft. and 408 cu. ft. of class "B" cement slurry. After waiting on cement the hole was cleaned out from 380' to 721' with 12-1/4" drilling assembly. The 12-1/4" hole was opened to 17-1/2" from 97' to 792'.

At 792' total circulation was lost. The fixed-system-type detector on the derrick floor monitored 600 ppm H_2S level and personal/portable detectors monitored 100 ppm H_2S concentration at head level.

Water was pumped into hole and the hole was opened from 12-1/4" to 17-1/2" to 829' and 17-1/2" hole was drilled to 860' without circulation returns. Due to excessive torque drilling was discontinued and 500 cu. ft. class "B" cement plug was placed with open end drill pipe hung at 819'.

Two more plugs were placed with open end drill pipe at 713' and 849'. A 250 cu. ft. class "B" cement plug was placed at 713' and a total of 1000 cu. ft. class "B" cement plug was placed at 849'.

After waiting on cement, the cement plug was tagged at 400' and was drilled out to 797' where returns were lost. 15-20 ppm H_2S level was monitored at bell nipple. Mud was mixed and hole was drilled to 910' without returns.

With open end drill pipe at 786', HOWCO mixed and pumped 500 cu. ft. class "B" cement slurry. After waiting on cement, the cement was drilled with full returns to 910' and 13-3/8" x 54.5#, K-55 buttress casing was run.

DISCUSSION & CONCLUSION

To establish the zone of H_2S entry, the loss circulation cases are reviewed.

First, total loss of circulation occurred at 333' in Andesite; however, the circulation was regained by circulating mud loaded with LCM.

Circulation was lost again at 737' in limestone and regained with LCM treated mud.

The losses at both the above depths were not heavy, indicating that the thief zones were minor fractures duly cured with loss-circulation additives. There were no indications of H_2S at any of these loss circulation occurrences.

At the drilling break, in limestone, at 796' total mud with 30% LCM was lost and also the hole fluid was lost. Even without returns, 33' of hole, from 796' to 829' was drilled in fifteen minutes. This indicates a cavernous fracture possibly in softer beds of limestone.

While drilling at this depth, with total loss of fluid into formation, H_2S was monitored at surface.

This is thus the established zone for H_2S influx and the reason for H_2S influx is the absence of water table or hydrostatic head to counter the influx.

The sudden jump in H_2S concentration from the level of 10 to 20 ppm to 600 ppm is hard to explain. As this rise in concentration has been noticed after drilling out cement or during cementation, it can be conjectured that sudden rise in level should be attributed to the extra head caused by cement column. It is felt that extra head of cement column caused the fractures to open up further thereby permitting more of H_2S to enter and increase the concentration. This explanation may only be partially true or there may be an altogether different explanation.

The fact cannot be overlooked that awareness of the hazard, preparedness of personnel and timely actions in counteracting the blow of toxic gas, has saved serious losses including lives.

FISHING

Well Depth : 1004'

Casing : 13-3/8" x 822'

Dates : 8/10/76 to 8/19/76

Cause of Fishing : Stuck pipe during placement of cement plug to cure loss of circulation

Final Result : Fish left in hole from 978' to 874'

DETAILS OF OPERATIONS

At drill depth 1004', in a 12-1/4" hole, severe loss of circulation occurred. With open ended drill pipe, 4-1/2" X-H at 978', on 8/10/76, 500 CFT class "B" cement with Perlite, Gel, CFR-2 and 2% $CaCl_2$ was pumped into the hole. Drill pipe stuck while removing "Halliburton" cementing lines.

An extra pull of 126,000 lbs over the weight of pipe, failed to release the stuck pipe. The hole was circulated with two mud pumps discharging approximately 800 gpm of mud of weight 8.9 ppg and viscosity 40 seconds at 500 psi pump pressure. Only 50 bbls, less than half the annulus volume, of thick mud with LCM followed by nearly neat cement, returned to surface. Circulation was lost and 200 bbls of mud was pumped without returns.

"GO-International" ran Free Point Indicator. Free Point was located at 915'. Stuck pipe was backed off at 784' - inside 13-3/8" casing.

Screw-in sub was run in with jar, bumper-sub and 8 - 8" drill collars. Fish was screwed into and jarred on without success.

Fishing assembly was backed off leaving the screw-in sub on top of fish, in the hole. Tools were re-run into the hole and screwed into the fish. The screw-in sub was recovered leaving the fish in the hole with top at 784'.

Wash-over string with 9-5/8" x 11" wash-over shoe #1 was run into top of fish at 784'. Worked over fish and washed over drill pipe from 822' to 845'. P.O.H. Changed wash-over shoe. Shoe indicated flaring from drill pipe tool joints as the fish was sticking against the wall of the hole (Fig. #1). Wash-over string (9-5/8") with wash-over shoe #2 was run in hole and fish was washed over from 845' to 889'. Wash-over shoe was pulled out of the hole. A tungsten carbide 9-5/8" x 11-1/2" wash-over shoe #3 was run in the hole.

Top of fish at 784' had to be worked over and the fish was washed over from 889' to 906'. Heavy torque was experienced and 9-5/8" wash pipe parted. Three joints of 9-5/8" wash pipe were left in the hole with top of parted joint at 817' (Fig. #2).

Screw-in sub on bumper sub and jars with 8" drill collars was run in hole and screwed into top of fish at 784'. The fish could not be jarred free and was backed off at 885'. Three joints of 4-1/2" drill pipe were recovered from fish #1 leaving the top of (drill pipe) fish #1 at 885' and (9-5/8" wash-over pipe) fish #2 at 817' (Fig. #3).

A Bowen 9-5/8" casing spear with bumper sub and jars was run in and the spear was set at 820', i.e., 3' below the top of wash-over pipe at 817'. Jarring and pull of 100,000# above string weight failed to release the fish. The fishing assembly was pulled out of the hole. Another unsuccessful attempt with screw-in sub was also made.

Three joints (94') of 7-3/8" O.D. flush joint wash pipe with tungsten carbide rotary shoe were run in hole and worked over the top of fish at 885'. The fish was washed over to 957'. Circulation was lost and 7-3/8" wash pipe was stuck at 945'. Stuck wash pipe was worked free after two hours and was pulled out of the hole.

Screw-in sub was run in again and 4-1/2" drill pipe fish was engaged. Jarring on fish moved the fish 18" up the hole. Further jarring failed to move the fish up or down the hole. The pipe was backed off, leaving the screw-in sub on top of 4-1/2" drill pipe fish with top of fish at 884'. The screw-in sub was recovered in next back-off attempt leaving the rest of fish in the hole with top of fish at 885'.

Open ended drill pipe was run in hole and screwed into the fish. GO-International wire line bridge stopped at 970' while running in and failed to set. Bridge plug was run in to 975' in next attempt. The plug malfunctioned and the plug with setting tool dropped to the bottom of the drill pipe during pull out.

A 3-1/2" metal-petal basket was run and set inside drill pipe at 952'. A 10' Cal-Seal plug was placed on top of metal-petal basket. W.O.C. 2 hours. Plug was tested with 500 psig. The string was backed off recovering 2 joints of 4-1/2" drill pipe leaving the top of fish at 945' (Fig. #4).

A 7-5/8" rotary shoe was run on 7-3/8" wash pipe and fishing assembly. Unsuccessful attempts were made to wash over the drill pipe fish at 945'. Wash pipe was laid down and 9-5/8" casing spear was run in the hole. The 9-5/8" wash pipe fish was engaged at 819'. Attempts to release the fish failed.

A 9-5/8" internal casing cutter was run and casing was cut at 867', but could not be retrieved with the spear. A cut was made at 839' and a 21.50' section of 9-5/8" wash pipe was recovered. Attempts at jarring out the fish with casing spear failed.

Another cut was made with casing cutter at 854' and the cut section from 839' to 854' was recovered. In two more attempts, cut sections of 12' and 8' respectively were recovered. The top of the 9-5/8" wash pipe fish in hole was 874'.

A 9-5/8" wash pipe was cut with casing cutter at 890', however, the attempts to recover the cut section with releasing spear failed. Spear grapple was left inside the 9-5/8" wash pipe and was pushed down to 915'.

One more unsuccessful attempt was made to jar out the stuck 9-5/8" wash pipe. Fishing operations were abandoned and fishing tools were laid down. A cement plug was placed with open ended drill pipe at 854' on top of fish left in hole (Fig. #5). The hole was sidetracked.

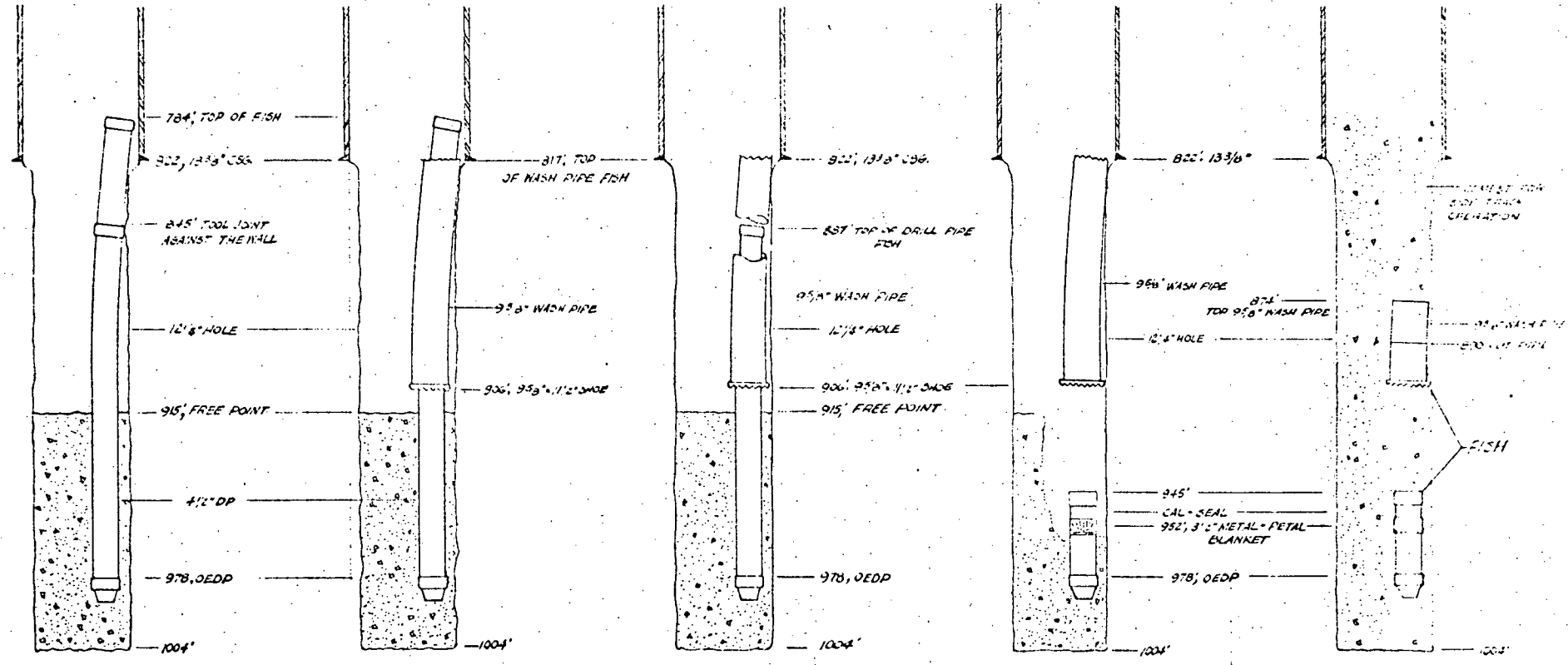


FIG. # 1

FIG. # 2

FIG. # 3

FIG. # 4

FIG. # 5

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FORMINCO #1 FISHING

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FOR:	
BY:	
DATE:	
SCALE:	
DRAWING NUMBER	

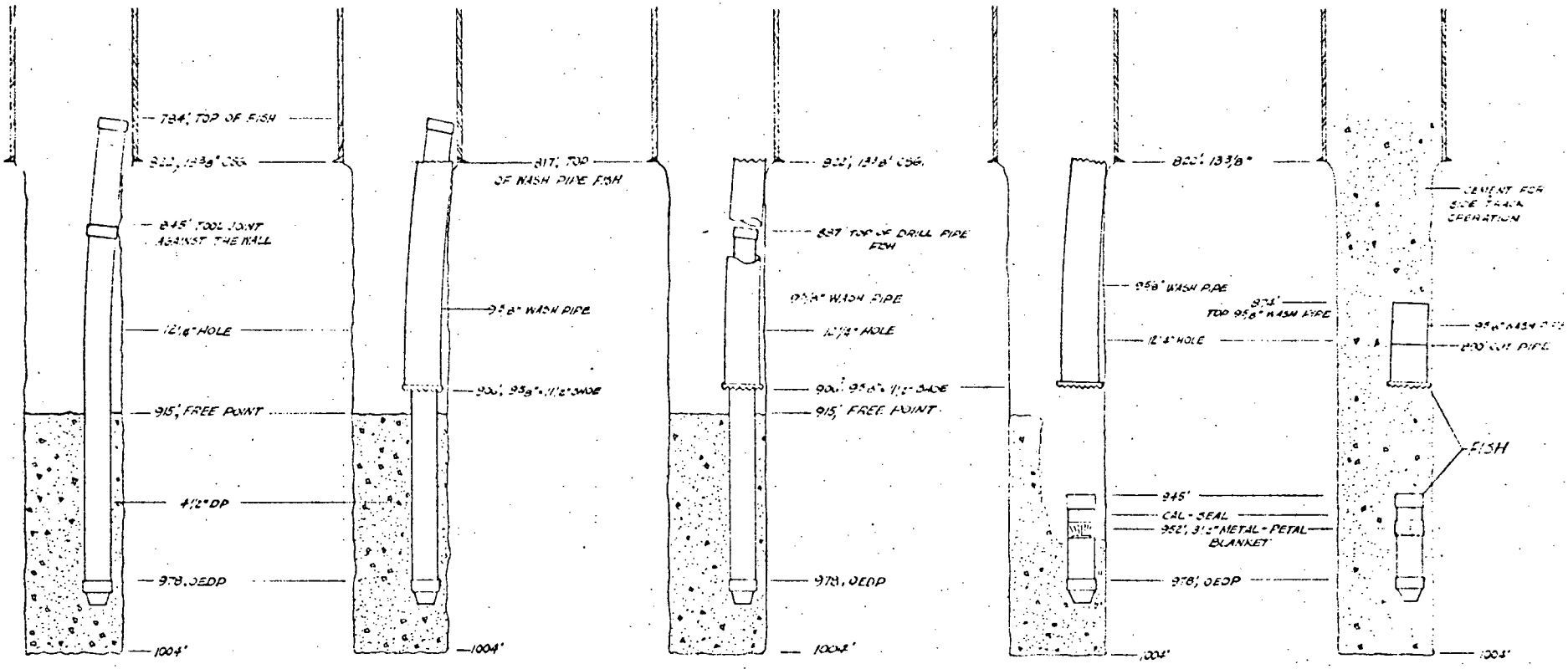

FIG. # 1 FIG. # 2 FIG. # 3 FIG. # 4 FIG. # 5

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CEMENTATION AT FORMINCO #1

In a drilling well, the problem encountered and the expected results, generally dictate the formulation of cement program, slurry composition and procedure of cementation.

At Forminco #1, the specific jobs (or problems) and expected results are tabulated below:

JOB/PROBLEM	SLURRY TYPE	EXPECTED RESULTS
1. Loss Circulation	Light-Viscous Slurry w/loss circulation additives, and, if possible, accelerated.	Seal-off fracture or loss circulation zone.
2. Casing Cementation against Loss Circulation Zones	Stage I: Light-Viscous Slurry followed by Heavy Slurry. Stage II: Light-Viscous Slurry.	Well cemented shoe. Cement to surface.
3. Side-Track Plug	Hard Setting Slurry w/ out Gel and loss circulation additives.	Successful kick-off and side-tracking the hole.
4. Abandonment Plug	Hard Setting Slurry w/ Gel, LCM and accelerator.	Shut off sub-surface activity beneath the plug.

DISCUSSION: PLUG JOBS IN 17-1/2" HOLE

The loss of circulation at 796' and the H_2S entry through possible fractures between the depths 796' and 829' required the cement plug job.

The 12-1/4" hole had yet to be opened to 17-1/2" when the problem occurred. Three plugs, of composition and volumes as noted in Appendix, were placed before the opening of 12-1/4" hole to 17-1/2" could be initiated.

The theoretical hole volume was 793 CFT or, say, 800 CFT. The Plug #1 was 1000 CFT or 25% excess of the hole volume.

The plug #1 was placed with open ended drill pipe at 787'. However, the plug failed to fill the hole and as seen from the results, cement top at 772', the plug was lost to fractures.

The plug #2 of 435 CFT slurry volume was placed with O.E.D.P. at 772'. The cement top, instead of 300' as expected per the volume pumped, was encountered at 735'. Most of the cement, like plug #1, was lost to formation.

The slurry composition for Plug #1 and #2, as shown in Appendix, was the same. Cement class "B" was mixed with Perlite in the ratio of 2:1 by volume, i.e., two sacks of Perlite to one sack of cement. The Perlite, acting as a loss circulation additive, also reduced the density of slurry thereby reducing the effective hydrostatic head of cement column against formation. Cello-Seal was added in the ratio of 0.5 lbs per sack of cement. This acted as a loss circulation additive. Gel (Bentonite) was mixed in the ratio of 4% by

weight of cement. This was added to give a more viscous body to the slurry and for absorption of excess water. Calcium Chloride in the ratio of 3% by weight of cement acted as an accelerator to expedite the cement setting.

The slurry composition for Plug nos. 1 and 2 would have provided a yield of 1.80 CFT slurry, of density 101.80 lbs/CFT, per sack of cement. The head against formation at 829' with slurry for Plug #1 would have been 585 psi as against that of water being 360 psi. However, the plug was lost as formations failed to withstand the head caused by cement column. The slurry only filled in the fractures, perhaps partially.

The Plug #2, if successful, would have caused a total head of 479 psi, including 375 psi created by cement column and rest by water. But this plug was also lost, though not totally. Hard cement was located at 735', however, the hole continued taking fluid.

The Plug #3 of 408 CFT was pumped with O.E.D.P. at 726'. The composition of this plug varied slightly from #1 and #2. Cello-Seal and Calcium Chloride were not mixed this time. CFR-2 in the ratio of 0.75% by weight of cement was added to enhance ease of pumpability. This slurry had the same yield and density as Plug #1 and #2. The head created against the formation this time was very nearly the same as Plug #2. The formation withstood the pressure and a successful plug, with top at 380', was obtained.

The opening of hole from 12-1/4" to 17-1/2" caused the loss of circulation once again at 797'. The hole was dry-drilled without returns to 860'.

As shown in Appendix, the open ended drill pipe was hung at 819'. Two plugs, #1 and #2, of the composition, as shown were pumped one behind the other in quick succession.

Each plug was 500 CFT in volume or 300 linear feet of cement column per plug. The expected top of cement, for 1000 CFT of slurry, should have been around 260'. However, cement top was tagged at 733' leading to conclusion that most of the plug (#1 and #2) was lost to formation.

The composition of Plug #1 was the same as the two plugs (#1 and #2) placed earlier for the 12-1/4" diameter hole drilled to 829', except that Flo-Seal (a loss circulation additive) substituted Cello-Seal. This 500 CFT of plug would have provided 212 psi hydrostatic head against the formations.

Coupled to Plug #1 was the Plug #2 of the same volume but different composition as shown in Appendix. The cement to Perlite ratio, instead of 2:1, was changed to 1:1. This would have decreased the yield from 1.80 CFT to 1.67 CFT per sack of cement while, at the same time, increasing the density from 101.80 lbs/CFT to 103.40 lbs/CFT. With this density the hydrostatic head created by this plug was 216 psi.

Total head caused by these two plugs was 428 psi for 600 linear feet of cement column (or 1000 CFT of the total volume of plugs). The formations failed to withstand the head and, as indicated earlier, nearly the total plug was lost to fractured formations.

Plug #3 placed with O.E.D.P. at 713' provided 150 linear feet of head or 107 psi against formation. The composition of this plug was similar to that of Plug #2 with extra loss circulation additives and accelerator.

This plug gave better results. The cement top was located at 541' and cement was cleaned out to 807' when the circulation was lost again. Hole was cleaned out, without returns, to 849'.

With O.E.D.P. at 849' a total of 1000 CFT of slurry in three batches of: Plug #4 - 250 CFT, Plug #5 - 250 CFT and Plug #6 - 500 CFT was pumped down the hole.

The composition of Plug #4 and #5 was same except that Plug #5 contained 3% $CaCl_2$. Plug #6, like earlier plugs, contained Perlite, Gel and Flo-Seal.

The total head created by 1000 CFT or 600 linear feet of slurry against the formations was 760 psi. Plug #4 and #5 contributed 405 psi and 215 psi was created by Plug #6.

The results of this plug looked encouraging initially as the top of cement was tagged at 400'. However, the loss of circulation and H_2S gas kick at 797' proved that fracture still remained open. The hole was dry-drilled, without returns, to 910'.

At 910' only one plug of 500 CFT or 300 linear feet was placed. The composition of plug was similar to earlier slurry, i.e., 1:1 cement - Perlite ratio.

The top of this plug was encountered at 516' instead of 610'. Also the cement was drilled to 786' and 'fill' was cleaned out to 910' with full returns. The loss circulation zones were sealed off and plugging job was successfully completed.

CASING CEMENTATION

In the 17-1/2"hole with total depth at 910', the 13-3/8" casing shoe was landed at 822' and D.V. multi-stage cementing collar at 635'.

The casing was cemented in two stages to reduce the cement column, and thereby the hydrostatic head on weaker formations, in the first stage as well as to ensure rise of cement to surface in second stage. This also avoided handling of large volume of cement slurry, of varying compositions, in one operation.

The first stage slurry composed of 60 CFT of light slurry of weight 101.80 lbs/CFT composed of class "B" cement with 40% Silica Flour. This was to provide a well cemented shoe with hard set cement of high compressive strength.

The second stage slurry was light weight, composed of class "B" cement with Perlite. Cement slurry returned to surface during cementation however the level in the annulus dropped to 222' after completion of operation. This indicated that weaker formations

failed to withstand the head of cement column. Depth of thief zone cannot be specified as it is possible that original fractures had reopened or new fractures had developed.

PLUG JOB IN 12-1/4" HOLE

After cementing of 13-3/8" casing with shoe at 822', no cement was encountered inside casing from 807' to shoe. Returns were lost. The 12-1/4" hole was dry drilled from 910' to 913'. With O.E.D.P. at 882' a cement plug of 694 CFT was placed.

Apparently, first stage cement of 13-3/8" casing was lost to formations and casing from 807' to shoe remained un-cemented.

694 CFT of "Thick-set" cement of 118 lbs/CFT density cured the loss circulation problem and cement top was tagged at 632'. It was cleaned out to 913' with full returns.

Loss circulation occurred again at 1004'. With O.E.D.P. at 978' a light weight slurry of cement and Perlite was pumped. Total volume of slurry was 500 CFT. The slurry carried only 2% $CaCl_2$ however the cement flash set, sticking the pipe. The hole had to be sidetracked.

SIDE TRACKING PLUGS

At well depth 1004' and with a fish in hole cement plugs had to be placed to side track the hole and bypass the fish.

Plug #1 of class "B" cement with 40% Silica Flour was placed by pumping 492 CFT of slurry with O.E.D.P. at 854'. The top of plug

was located at 715' however the returns were lost while cleaning out at 847'.

The plug job was repeated by placing Plug #2 with O.E.D.P. at 850'. A slurry volume of 368 CFT of class "B" cement with 40% Silica Flour of weight 115 lbs/CFT was pumped in hole.

Cement top was located at 798'. The plug had developed the desired high compressive strength, likely 3000 psi and hole was successfully side-tracked at 833'.

ABANDONMENT PLUGS

At well depth 1051', due to sloughing dolomites and the impossibility of drilling, the decision was made to plug and abandon the hole.

Total of three plugs were placed. Plug #1 was heavy slurry of class "B" cement with 40% Silica Flour of approximately 118 lbs/CFT density. 490 CFT of slurry was pumped in with O.E.D.P. at 845'.

Plug #1 was followed by Plug #2 of lighter slurry of class "B" cement with Perlite and Silica Flour. 370 CFT of slurry was pumped and cement top was tagged at 793'.

Plug #3 was placed with O.E.D.P. at 793' at start and moved up to 434' at completion. 600 CFT of slurry of composition same as that of Plug #2, was pumped. The top was tagged at 188' and rest of hole was filled to surface with slurry of neat class "B" cement.

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APPENDIX — CEMENT PLUGS – 17½ IN HOLE S. [illegible]

DATE	WELL DEPTH	OEDP DEPTH	HOLE DIA.	PLUG	SLURRY VOL.	PLUG COMPOSITION	RESULTS
7.30.76	829'	787'	12¼"	#1	1000 CFT	CLASS 'B' CEMENT : PERLITE – 2:1, GEL 4% CELLO SEAL ½ LB/SK, $CaCl_2$ 3%,	CEMENT TOP AT 772'. NO SUCCESS.
		772'		#2	435 CFT	——— DITTO ———	HARD CEMENT AT 735'. HOLE TAKING FLUID.
		726'		#3	408 CFT	CLASS 'B' CEMENT : PERLITE – 2:1, GEL 4% CFR-2 – 0.75%	CEMENT TOP AT 380'. PLUG SUCCESSFUL.
8.1.76	860'	819'	17½"	#1	500 CFT	CLASS 'B' CEMENT : PERLITE – 2:1, GEL 4% FLO SEAL ½ LB/SK, $CaCl_2$ 2%	LOCATED CEMENT TOP AT 733'. UNABLE TO FILL HOLE. PLUG UNSUCCESSFUL.
				+			
				#2	500 CFT	CLASS 'B' CEMENT : PERLITE – 1:1, GEL 2% FLO SEAL ½ LB/SK $CaCl_2$ 2%	
8.2.76		713'		#3	250 CFT	CLASS 'B' CEMENT : PERLITE – 1:1, GEL 2% ½ LB/SK FLO SEAL, ½ LB/SK MUD FIBRE & CHIP SEAL, 3% $CaCl_2$.	CEMENT TOP AT 541'. CLEANED OUT TO 807'. DRY DRILLED TO 849'. PARTIAL SUCCESS.
		849'		#4	250 CFT	CLASS 'B' CEMENT & 0.5% CFR-2.	CEMENT TOP AT 400'. SOFT CEMENT TO 471'. FIRM CEMENT TO 550'. DRILLED OUT CEMENT TO 797'. LOST RETURNS. GAS SURFACED. DRY DRILLED TO 910'. PARTIAL SUCCESS.
				+			
				#5	250 CFT	CLASS 'B' CEMENT, 0.5% CFR-2 & 3% $CaCl_2$	
				+			
				#6	500 CFT	CLASS 'B' CEMENT : PERLITE – 1:1, GEL 2% ½ LB/SK FLO SEAL	
8.4.76	910'	786'		#7	500 CFT.	CLASS 'B' CEMENT : PERLITE – 1:1, GEL 2% CFR-2 – 0.5%, CELLO-SEAL ½ LB/SK	CEMENT TOP AT 516'. DRILL OUT CEMENT TO 786'. CLEAN OUT FILL TO 910' WITH FULL RETURNS. SUCCESSFUL PLUG JOB.

APPENDIX CEMENTATION - 13 3/8 in CASING & CEMENT - 12¼ in HOLE

DATE	WELL DEPTH	OEDP DEPTH	HOLE DIA.	PLUG	SLURRY VOL.	PLUG COMPOSITION	RESULTS
		CASING					
8.6.76	910'	13 3/8" x 822	17½"	CSG - CMT.			
				I-STAGE	60 CFT.	CLASS 'B' CEMENT: PERLITE - 1:1, GEL 2% &	
					+	CFR-2 - 0.5%	
					150 CFT	CLASS 'B' CEMENT, 40% SILICA FLOUR &	
						0.5%. CFR-2.	
		D.V. COLLAR					
		@ 635'		II-STAGE	1650 CFT	CLASS 'B' CEMENT: PERLITE - 1:1, GEL 2%	GOOD CEMENT RETURNS TO SURFACE.
						& 0.5% CFR-2	CEMENT TOP AT 822' IN ANNULUS.
		1¼" TUBING					
		@ 822'	13 3/8" ANNULUS	TOP JOB.	177 CFT	CLASS 'B' CEMENT, 40% SI. FL & 3% CaCl₂	CEMENT TO SURFACE.
8.8.76	913'	882'	12¼"	#1	69¼ CFT	THICK-SET CEMENT. 10 LBS/CFT DENSITY	CEMENT TOP AT 632'. CLEAN OUT TO 913'.
							SUCCESSFUL PLUG JOB.
8.10.76	1004'	978'		#1	500 CFT	CLASS 'B' CEMENT: PERLITE - 1:1, GEL - 2%,	STUCK PIPE. SIDE TRACKED
						0.5% CFR-2 & $CaCl_2$ - 2%	THE HOLE.

APPENDIX CEMENT PLUGS FOR SIDE TRACK & ABANDONMENT

DATE	WELL DEPTH	OEDP DEPTH	HOLE DIA.	PLUG	SLURRY VOL.	PLUG COMPOSITION	RESULTS
				SIDE TRACK			
5.19.76	1004'	854'	17½"	#1	492 cft	Class 'B' cement & 40% Silica Flour	Top at 715'. Clean out to 847'. Lost returns
		850		#2	366 cft	Class 'B' cement & 40% Silica Flour (115 lbs/cft)	Cement top at 795'. Drill out to 833'. Side tracked.
				ABANDON.			
7.26.76	1051'	845'	17½"	#1	490 cft	Class 'B' cement, 40% S. Fl, 2% Gel, ½% CFR	
		836'		#2	370 cft	Class 'B' cement, Perlite-1:1, S. Fl 40%. Gel. 2%, $CaCl_2$ 1.5%.	Cement top at 793'.
		793 & 434	13¾" Casing	#3	600 cft	Class 'B' cement, Perlite-1:1, S. Fl. 40% Gel. 8%, $CaCl_2$ 1.5%	Cement top at 118'. Filled to surface with cement. Abandoned well.

UNION OIL COMPANY OF CALIFORNIA
Geothermal Division

FORMINCO #1

GEOLOGIC REPORT

I. Well Samples and Observations

From surface to 55 feet the well penetrated Recent alluvium, consisting of hydrothermally altered volcanic boulders, gravel, sand and clay. Native sulphur mineralization was common in this interval.

From 55 to 248 feet the well penetrated the lower part of the Bullion Canyon volcanics (Upper Oligocene age), consisting of porphyritic andesite. Argillic alteration was common in the upper 50 feet of the interval.

From 248 to 560 feet the well penetrated the Claron formation (Upper Cretaceous-Lower Tertiary age). This formation consisted of a quartzose boulder conglomerate. Fragments of carbonate boulders were also noted. Finely disseminated pyrite was common throughout the interval.

From 560 to 797 feet the well penetrated a light to dark brown, microcrystalline limestone of uncertain age and correlation. This crinoid mudstone may be correlated with the Kaibab formation (Permian age).

From 797 to 1051 feet the well penetrated a poorly-cemented very fine to finely-crystalline dolomite. Pyrite was present in the interval as scattered grains and clusters. The loose dolomite "sand" consisted of near-perfect individual crystal rhombs.

No static temperatures or down hole logs were obtained from the well. Flow line temperatures (prior to lost circulation at 737 feet and 797 feet) reached a maximum of 110°F at 736 feet. (See lithology log for flow line measurements.)

Hydrogen sulphide gas was encountered when all returns and hole fluid were lost at 797 feet and 1044 feet. The gas is under very low pressure, and is thought to fill the dry fractures above the water table which was not reached by the well.

II. Geological Comments

The Union Oil Company No. 1 Forminco wildcat located within the Cove Fort-Sulphurdale geothermal unit was abandoned at 1051 feet total depth because of extreme and unusual problems encountered during drilling. Specifically, four problems combined to abort the test:

1. Occurrence of H_2S gas above the water table.
2. Lack of formation pressure to the depth drilled.

3. High permeability of the rocks penetrated below the volcanics.
4. Development of a totally unconsolidated granular dolomite with the properties of a loose sand (sanded dolomite).

Problems attendant with stabilizing the bore hole may have been aggravated by dips approaching the angle of repose of the "sanded" (unconsolidated) dolomite.

Following plugging the challenge was to develop techniques to cope with the problems when encountered or preferably to find a suitable location that would obviate their occurrence. A location was therefore sought at which the surface volcanics, anticipated to be stable and relatively tight, would extend to depths below the ground-water table and an attempt was made to determine depth to ground water. At such a location the first three listed problems would hopefully be manageable or not even exist. It has yet to be determined whether the "sanded" dolomite will occur below the water table. In order to understand the problems associated with such dolomites a study was prepared of the geologically comparable Tintic mining district, Utah.

III. Sanded Dolomites

The "sanded" dolomite encountered by Union Oil in drilling the Forminco No. 1 well is similar to the sanded dolomite

encountered in the Tintic mining district, Utah (Zn-Cu-Ag ore bodies). Interestingly, the geology of the Tintic mining district and the Cove Fort geothermal prospect are very similar. Both areas have extrusive rock units of Mid-Tertiary age that overlie, with angular unconformity, a thick sequence of folded and faulted Paleozoic carbonate and clastic formations.

Hydrothermal Geology

The hydrochemical alteration history of the Tintic mining district is well documented by Lovering's (1949) classic paper, "Rock Alteration as a Guide to Ore--East Tintic District, Utah." Lovering identified five stages of hydrochemical alteration. These stages are graphically presented in Figure 1.

The early barren stage of hydrothermal alteration resulted in hydrothermally formed dolomite. In the Tintic district, as at Cove Fort, its occurrence is very widespread. Many cubic miles of Paleozoic limestones have been altered into secondary dolomite with marked changes in the textures and fabrics of the original limstone. These beds of hydrothermal dolomite should not be confused with the unconsolidated "sanded" dolomite which formed during a later acid ground water leaching stage (mid-barren stage).

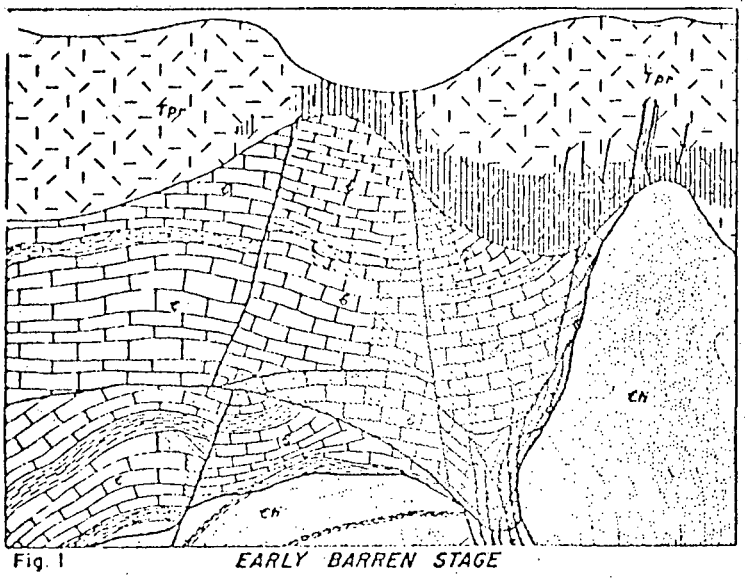

Fig. 1 EARLY BARREN STAGE

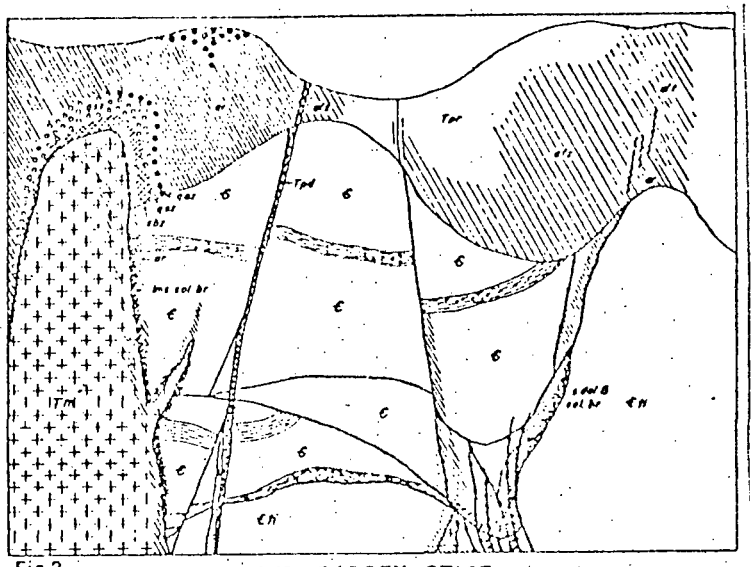

Fig. 2 MID—BARREN STAGE

Rock Units
- Tpr Packard rhyolite
- Limestone & shale
- Ch Tintic quartzite

Contacts
- Contacts
- Faults
- Fissure

- Hydrothermal dolomite
- Chloritic rhyolite
- Quartz-chlorite veinlets

Textures
- Tm Monzonite
- Tpd Pebble dike
- Sanded dolomite
- Solution breccia
- Argillized rock
- Argillic fringe zone
- Quartz—alunite zone
- Quartz—sericite zone
- Sericite—kaolinite zone

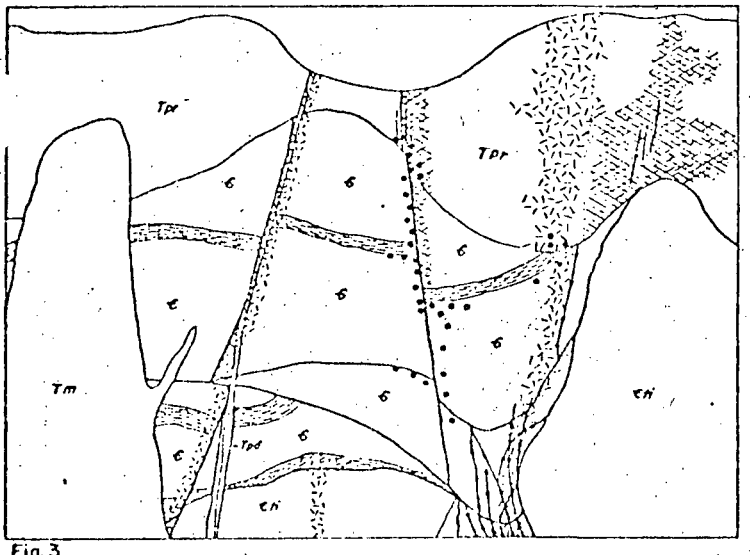

Fig. 3 LATE BARREN STAGE

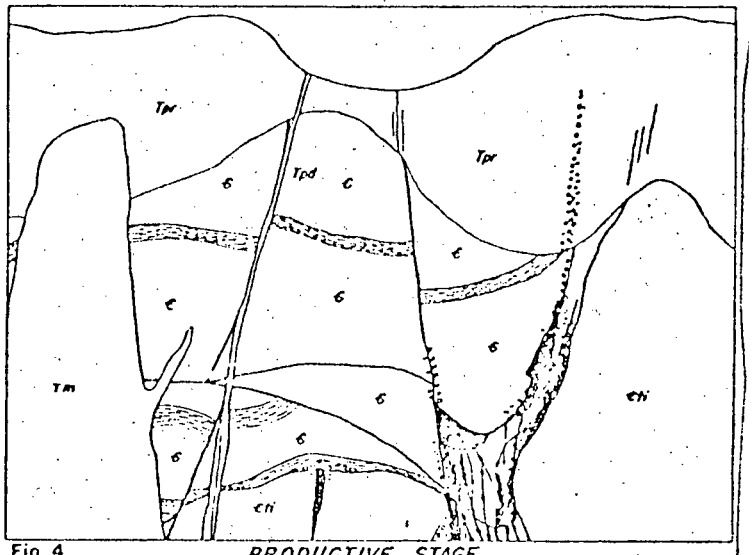

Fig. 4 PRODUCTIVE STAGE

- Jasperoid and Quartz with Allophane
- Pyritic Alteration
- Manganese replacement
- Calcitic Alteration
- Potassic alteration
- Ore

NOTE: ABOVE DIAGRAMS REPRODUCED FROM "ROCK ALTERATION AS A GUIDE TO ORE — EAST TINTIC DISTRICT, UTAH"

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UNION OIL COMPANY OF CALIFORNIA - GEOTHERMAL DIVISION

STAGES OF HYDROTHERMAL ALTERATION
EAST TINTIC DISTRICT, UTAH

DRAWN	
FOR:	
BY:	
DATE:	
SCALE:	
DRAWING NUMBER	Fig. 1

Locally, the hydrothermal dolomite exhibits complex stratigraphic and structural controls with the most extensive developments occurring in the footwalls of low-angle faults. At this stage the dolomites still had sufficient calcite cement to retain stability even though they developed good permeability. Warm ground waters rich in magnesium and circulating through an extensive system of solution channels were probably responsible for the widespread dolomitizing of primary limestones. The common association of hydrothermal dolomite overlain by chloritized Packard rhyolite is evidence that the Mg-rich thermal ground waters which dolomitized the limestone were also the fluids which chloritized the volcanic rocks.

The mid-barren stage is characterized by widespread argillic alteration of the volcanic rocks. It was during this time period that (1) dikes and stocks of quartz monzonite were emplaced, (2) acid ground waters leached the rocks, (3) hydrothermal dolomite was "sanded" and, (4) pebble dikes were formed. Removal or alteration of all remaining calcite cement was so completely effected during this process that the hydrothermal dolomites became totally incompetent "sanded" dolomites, comparable to a pile of loose dolomite grains. Surface geothermal activity was likely at its maximum during this stage with hot springs and fumaroles at the paleosurface.

The Mid-Tertiary volcanics affected by the mid-barren stage contain intense argillic alteration. The alteration is strongest near the base of the volcanics and along vertical fracture zones and other secondary openings. Similar alteration is present in the underlying sediments and in the intrusive rocks but is much less extensive. The volcanics were mainly reduced to montmorillonite with subordinate kaolinite, and occasional dickite clays. The ground waters which attacked the rock were mainly sulfuric and hydrochloric acid. The sulfuric acids were formed from the fumarolic H_2S gases associated with the several monzonite intrusives found in the district. Where argillic alteration of the volcanic rocks is encountered in exploration drill holes and adits sanded dolomite can usually be expected in the underlying Paleozoic carbonates.

The late barren stage is characterized chiefly by jasperiod, barite, pyrite and chlorite in the sediments and by allophane quartz, barite, pyrite and calcite in the overlying volcanics.

Formation of "Sanded" Dolomite

Competent hydrothermal dolomite can be turned into a mass of unconsolidated crystal mush by either primary or secondary acid ground water leaching processes. Volumetrically, primary acid ground water leaching is the most important event which occurred in the East Tintic district to "sand" the hydrothermal

dolomite. In this process, the abnormally high heat flow and fumarolic activity associated with the intrusive center both increased the temperature and lowered the pH of the ground water to generate a strong acidic solvent which dissolved many tons of carbonate rock in the zone of water saturation. The presence of many cubic miles of carbonate rock, however, prevented the acids from sanding the dolomite on a regional scale because the acid waters were neutralized by the solution of carbonates. The extent of sanding, therefore, was a function of the amount and dispersion of acidic ground waters. The vagaries of distribution and intensity of sanding in the various structural and stratigraphic units are also a function of many chemical and physical variables. Intense sanding is generally found along margins of monzonite stocks and along fault zones where fumarolic activity and acid concentrations were strongest (Fig. 2). The sanding of the hydrothermal dolomite was an important "ground preparation" which was selectively followed by later ore-bearing solutions during the early and late productive stages, thereby forming the close association of sanded dolomite with lead-zinc-silver ore bodies of the East Tintic district.

Secondary sanding occurs primarily above the water table by the oxidation of sulfide minerals and/or fumarolic gases, such as H_2S and HF. This secondary process can locally form acids which are capable of sanding the dolomites as effectively as

the primary process, but the total volume is smaller. Creation of acids can also occur in the upper portion of an oxygenated ground water system where free oxygen is available to oxidize the sulfide minerals. This process can occur long after the abnormal heat flow and volcanic activity has terminated. Sanding of the Leadville limestone in the Leadville mining district, Colorado, is a good example of this secondary process under non-thermal conditions.

Extrapolation of the Tintic Area Data to the Cove Fort Geothermal Prospect

Many geologic similarities exist between the Tintic and Cove Fort areas which can be used in predicting the occurrence of sanded dolomite in the Cove Fort area.

First, both areas are lithologically similar with Mid-Tertiary volcanics overlying structurally complex Pre-Tertiary sediments dominated by carbonate formations. The outcrops of finely crystalline dolomites in the Cove Fort area are identical to the hydrothermal dolomites in the Tintic district. However, the Cove Fort area lacks evidence of the quartz monzonite intrusives, pebble dikes, sulfide mineralization and extensive surface hydrothermal alteration common to the east Tintic area.

Second, the ground-water hydrology is similar. Permeable dolomite and limestone units underlie both areas. Deep and

relatively level water tables, indicative of high permeabilities, exist in the Tintic district (Lovering and Morris, 1965) and are probably present in the Cove Fort area, too.

Third, in comparing the types of hydrothermal alteration found in the Tintic district and Cove Fort, the latter has apparently been subjected to what is comparable to the early barren and the first stage of the mid-barren periods of hydrothermal alteration of the Tintic district. In essence, the Cove Fort geothermal area may be a young Tintic district which may be undergoing dolomite sanding below the water table if the ground waters are acidic. We know that H_2S gases are active in the area and that fault zones have been intensely argillized. Presence of fluorite in one fault zone indicates that HF gases are also present. Therefore, the geologic conditions for forming acidic ground waters and sanding of the hydrothermal dolomite are present.

Conclusions

1. Localized sanded dolomite zones will be encountered within the thick carbonate section most likely adjacent to major fault zones and solution cavities. Competent limestone and hydrothermal dolomite is expected between the sanded dolomite zones.

2. Sanded dolomite is most likely to occur beneath volcanics which shows the effects of argillic alteration.

3. The zones of sanded dolomite are most likely to be vertically oriented. Stratigraphic correlation of the sanded hydrothermal dolomite is not possible due to structural controls on the occurrence.

4. The sanded dolomite encountered at 797 feet in the Forminco No. 1 well can be explained by the secondary sanding process which would rapidly dissipate below the water table (projected to be at +5000 feet, MSL, or 1500 feet below the surface). The oxidation of H_2S gas emanating along faults may alone have caused the secondary sanding of the hydrothermal dolomite. Prima facie evidence for extensive primary sanding below the deep ground-water table has not yet been established, but the right geologic conditions for such development appear to be present.

REFERENCES

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