THE GEYSERS CORING PROJECT

On August 28, 1996, in Santa Rosa, California, the Office of Geothermal Technologies of the Department of Energy (DOE) sponsored a one-day research symposium on the DOE-industry collaborative Geysers Coring Project (GCP). This gathering provided a forum for the project's 30-member science team to communicate significant results of its research directly to those in the best position to utilize those findings: The Geysers steam field operators. Representatives of all the major operating companies -- Unocal Corporation, Calpine Corporation, and the Northern California Power Agency -- were in attendance, as were officials from the California Division of Oil, Gas, and Geothermal Resources.

The GCP was a direct outgrowth of a series of DOE-industry working groups convened by Phillip M. Wright to address the reservoir-pressure declines which The Geysers had begun experiencing in the late 1980's. Among the groups' most urgent recommendations: retrieval and thorough characterization of a significant length of continuous core from the reservoir, with the aim of improving understanding of the field's porosity and permeability controls and fluid content. The drilling phase of the project, funded jointly by DOE and Unocal Corporation (and corporate partners) was completed in late 1994, with drilling operations managed by Unocal; actual coring done by Tonto Drilling Services; routine core handling and processing by Epoch Well Log Services; and scientific coordination by the Earth Sciences and Resources Institute (ESRI) of the University of Utah. Two hundred thirty-seven m of continuous core were obtained, triple the amount retrieved from The Geysers during its 35 year history prior to the project. The GCP corehole, SB-15-D, penetrated the uppermost Geysers steam reservoir and the lower part of its relatively impermeable caprock. A special coring system allowed on-site sealing of selected cores to preserve contained fluids. Two of these cores were obtained at simulated reservoir pressures and immediately frozen in dry ice at the surface to immobilize the fluids in their initial configurations at retrieval.

The research team, drawn from universities, national laboratories, and the U.S. Geological Survey (USGS) has been conducting detailed research on the core in the two years since its retrieval. Results of these studies, presented at the symposium, have supplied valuable new information about reservoir porosity, permeability, remaining indigenous fluid saturation, and various chemical and physical rock properties. These variables are critical to the operators for improving forecasts of steam supply and quality well into the 21st century, and for designing water-injection strategies by which future steam production can be significantly enhanced. The core studies have also permitted the investigators to learn a great deal more about the particular mechanisms leading to creation of large vapor-dominated geothermal systems like The Geysers.

Industry and DOE geoscientists applied a number of new technologies, and new applications of existing technologies, in their GCP core research. Unocal used nuclear magnetic resonance imaging (NMRI) to measure the miniscule quantities of indigenous water trapped in the microscopic pores of the rock: maximum values of 3-13% of available porosity (1-5%) were calculated. Lawrence Berkeley Laboratory used a new gas-pressure-pulse-decay apparatus to show that permeabilities of the metamorphosed sandstone reservoir-rock matrix in the rocks penetrated by this corehole are as low as a few *nano*darcies. Lawrence Livermore National

Laboratory and Stanford University used two different types of computer-tomographic X-ray scanning (CT scanning) to evaluate water movement in the core. Stanford also showed that the adsorption characteristics of the penetrated rocks were in general slightly different than their counterparts deeper in the reservoir. Distinct correlations between the mineralogy of the core and its electrical and acoustical properties were demonstrated by New England Research. LLL likewise demonstrated a correlation between core resistivity and pore pressure. Scientists from the University of New Mexico, Los Alamos National Laboratory, and the USGS discussed fluid-rock interaction and CO_2 generation in this sector of The Geysers. Those from ESRI presented evidence for hydrothermal influences in caprock formation; discussed the nature of porosity in fluid-transmitting and -storing fractures and veins; and integrated multiple mineral- and organic-based geothermometers to show that the penetrated steam-reservoir rocks have cooled from slightly more than 300°C to the currently estimated 230-235°C. The symposium's collected and edited research results will be submitted for publication in a special issue of the journal *Geothermics.*

The consensus of an open discussion following the formal presentations was that, following careful consideration by the operators of the reported results and their implications, there could be considerable merit in completion of another research corehole in The Geysers. This second hole, however, ideally would penetrate much deeper into the system than the uppermost steam reservoir tested by SB-15-D. The site for such a new corehole, and the full range of objectives to be addressed by its completion, would be debated during one or more DOE/industry workshops like those which led to completion of the current coring project. Proceedings of the August 28 symposium can be obtained by contacting Jeffrey B. Hulen, Earth Sciences and Resources Institute, 423 Wakara Way, Salt Lake City, UT 84108: (801)-581-8497; fax (801)-585-3540; e-mail jhulen@esrilan.esri.utah.edu.

FOR: ROCKY MTN. GEOCHEM

	Au	Ag	As	Sb	Hg	Tl	Te	Se	Cd	Bi	Cu	Mo	Pb	Zn	
GC-1 4480± '	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	DO JUST CIRCLED ELEMENTS IF NOT ENOUGH SAMPLE
GC-1 4480-81 '	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	"
GC-1 4474-75 '	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	"
BF-1 5346 '	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	"
SLM-43	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
SB-15-D 880.5-880.7 '	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
SB-15-D 1491 '	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	

SEND RESULTS TO:
JEFF HULEN
UNIV. of UTAH RSCH INST.
391-C CHIPETA WAY SLC UT 84108

584-4446

ORDER FOR DGSI: —— THE WOODLANDS, TX

SAMPLE:

SAMPLE:	TOTAL CARBONATE	LECO ORG. C & TOTAL SULF.		PYROLYSIS BY ROCK-EVAL II		VITRINITE REFL: KEROGEN TYPE		PYROLYSIS S1 & GC S2									
SB-15-D:																	
844'	✓	✓		✓		✓		✓									
1099'	✓	✓		✓		✓											
1287'	✓	✓		✓		✓											
1374'	✓	✓		✓		✓											
1491'	✓	✓		✓		✓		✓									
1547'	✓	✓		✓		✓											

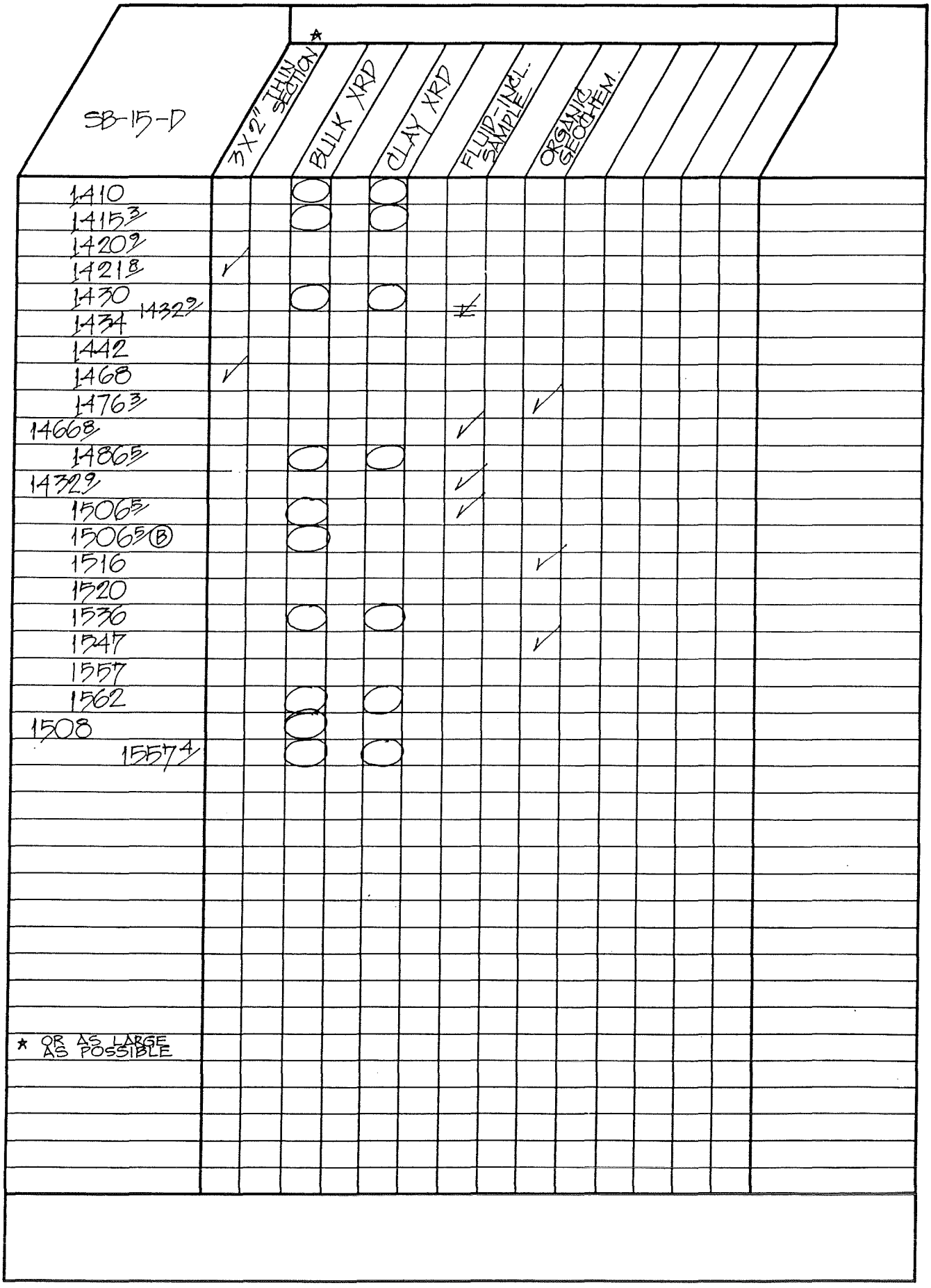
ALL ARE METASHALES FROM THE GEYSERS, CA & HAVE BEEN NATURALLY HEATED (AT LEAST BRIEFLY) TO 200-220°C

PLEASE SEND RESULTS TO JEFF HULEN
UURI
391-C CHIPETA WAY SLC UT 84108

(STANDING P.O. No.)

SB-15-D

	3" x 2" THIN SEC. *		BULK XRD		CLAY XRD		FLUID-INCL. SAMPLE		ORGANIC GEOCHEM.							
844			✓		✓				✓							
869.5	✓		✓													
881			✓		✓											
891	✓		✓		✓											
895			✓		✓											
916	✓															
927									✓							
933.5			✓		✓											
946.8							✓									
964	✓	VB					✓									
974.2																
975	✓		✓		✓											
985.6			✓													
990.4			✓		✓											
1033	✓		✓		✓		✓									
1058	✓		✓		✓											
1064.8			✓				✓									
1017			✓													
1065	✓		✓													
1073			✓		✓				✓							
1099	✓		✓		✓				✓							
1017.3							✓									
1132.4	✓															
1135.9			✓		✓											
1159.8	✓		✓		✓											
1191.8	✓		✓		✓				✓							
1229.8	✓		✓													
1258	✓		✓				✓									
1268																
1277.8	✓		✓		✓				✓							
1287.4	✓		✓		✓											
1247.8	✓		✓				✓									
1345	✓		✓		✓											
1370.4	✓															
1374.2			✓		✓				✓							
* OR AS LARGE AS POSSIBLE																


SB-15-D
3X2" THIN SECTION
BULK XRD
CLAY XRD
FLUID-INCL. SAMPLE
ORGANIC GEOCHEM.
1410
1415 3/
1420 2/
1421 8/
1430
1434 1432 2/
1442
1468
1476 3/
1466 8/
1486 5/
1432 2/
1506 5/
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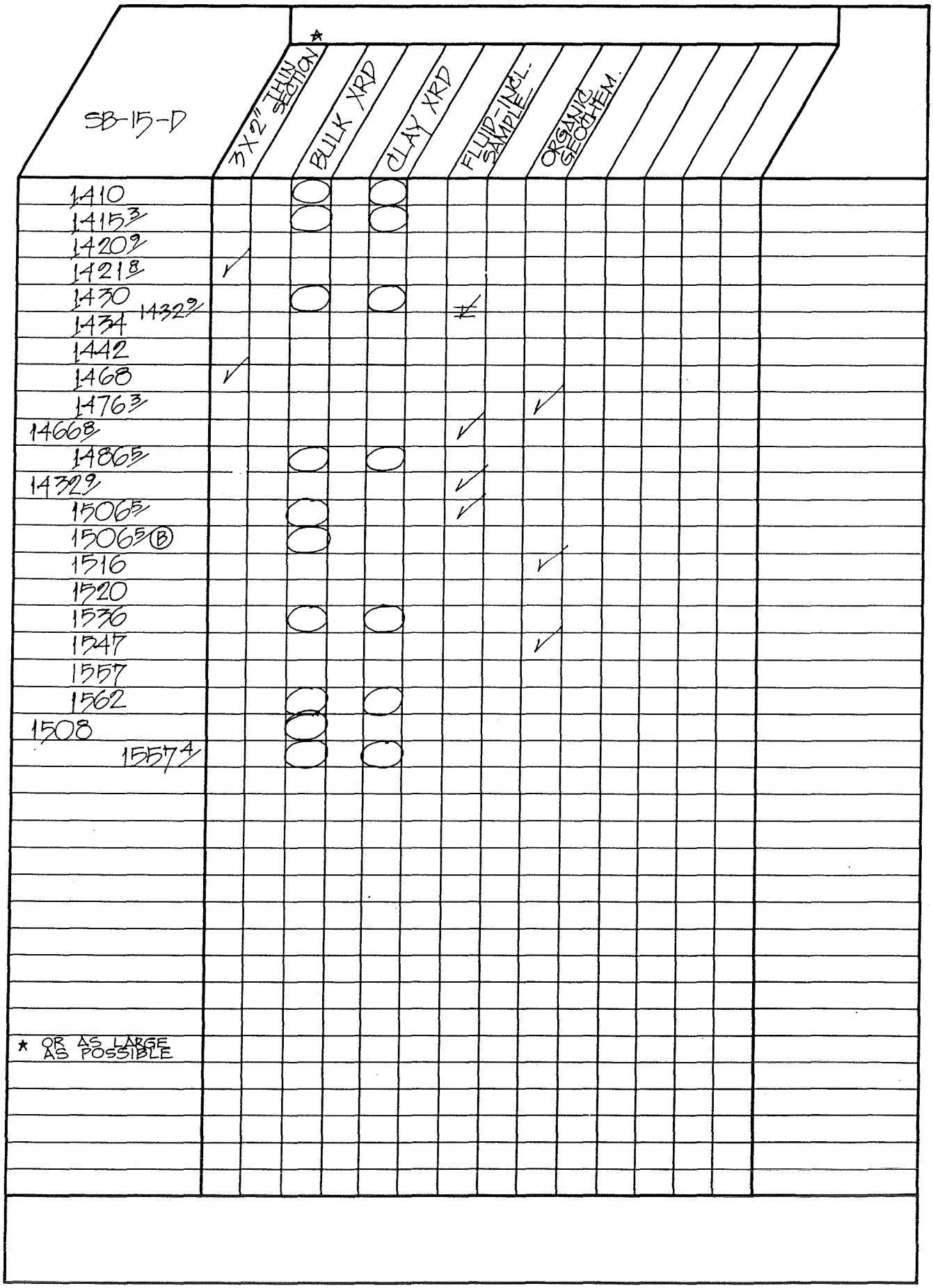
1557 4/
* OR AS LARGE AS POSSIBLE


SB-15-D
3X2" THIN SECTION
BULK XRD
CLAY XRD
FLUID-INCL. SAMPLE
ORGANIC GEOCHEM.
1410
1415 3/
1420 9/
1421 8/
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1432 9/
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1476 3/
1466 8/
1486 5/
1432 9/
1506 5/
1506 5/ (B)
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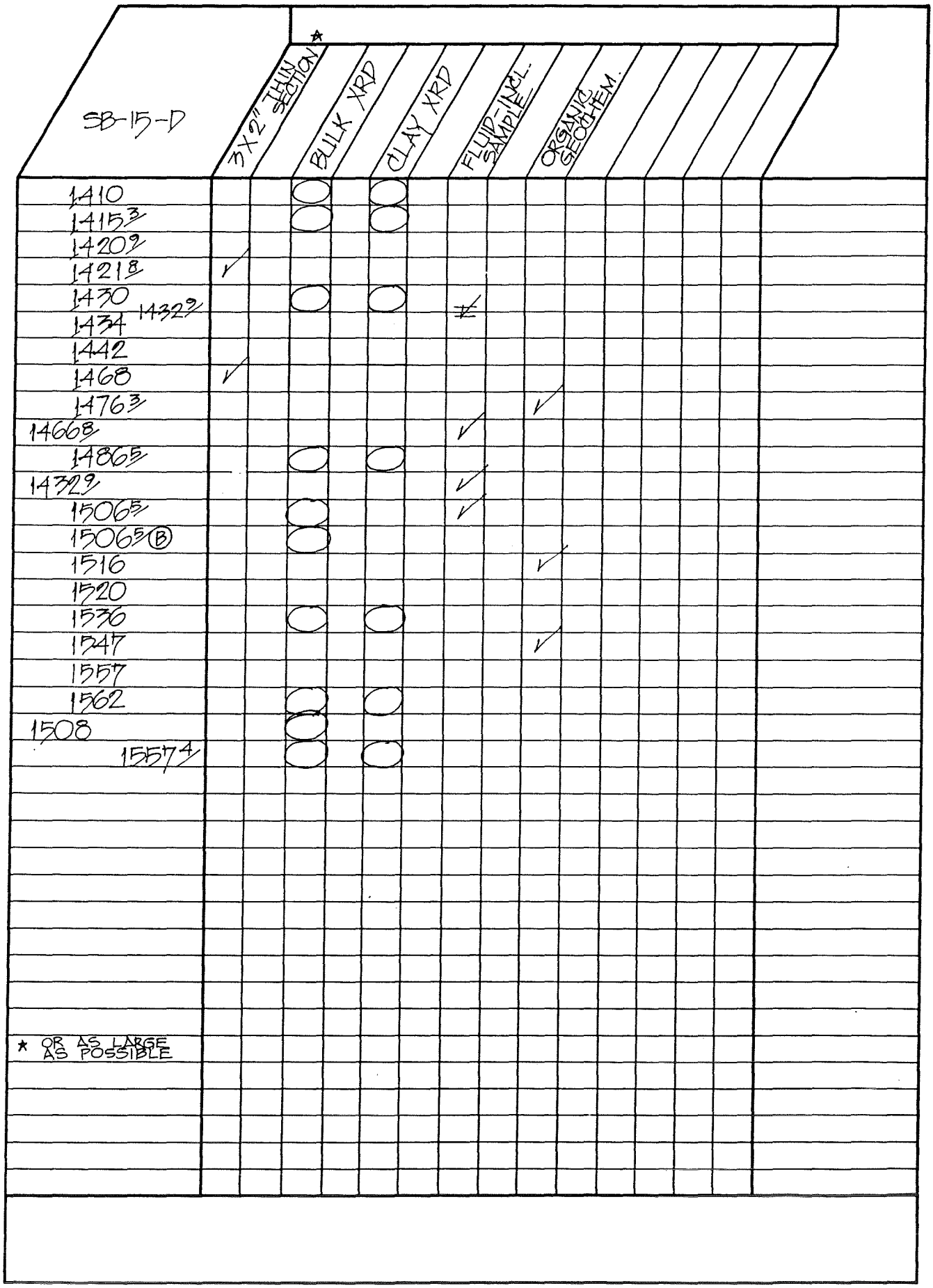
* OR AS LARGE AS POSSIBLE


SB-15-D
3X2" THIN SECTION
BULK XRD
CLAY XRD
FLUID-INCL. SAMPLE
ORGANIC GEOCHEM
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1420 2/
1421 8/
1430
1432 2/
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1476 3/
1466 8/
1486 5/
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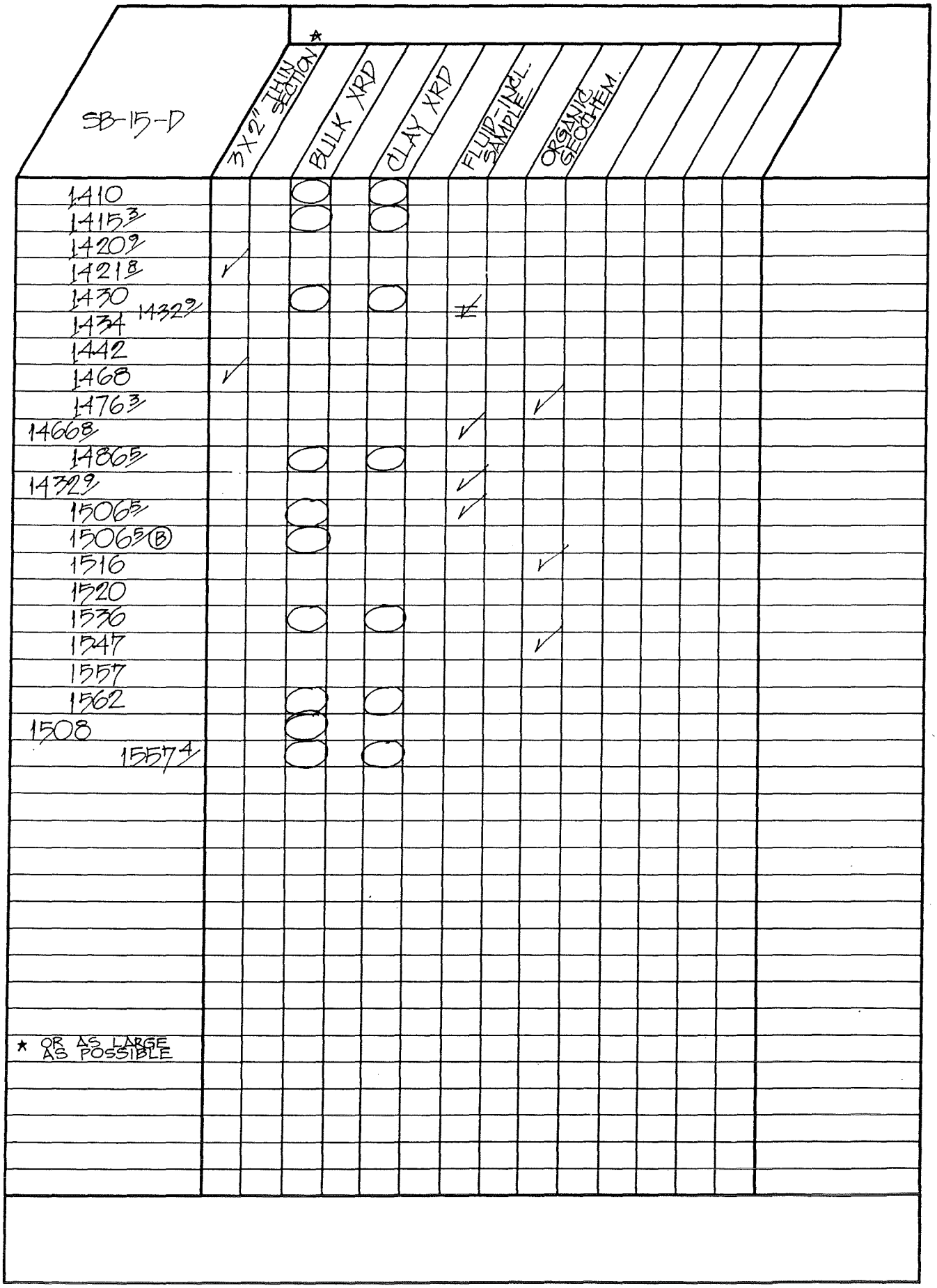
★ OR AS LARGE AS POSSIBLE


SB-15-D
3X2" THIN SECTION
BULK XRD
CLAY XRD
FLUID-INCL. SAMPLE
ORGANIC GEOCHEM.
1410
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1432 2
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1476 3
1466 8
1486 5
1432 9
1506 5
1506 5 (B)
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1562
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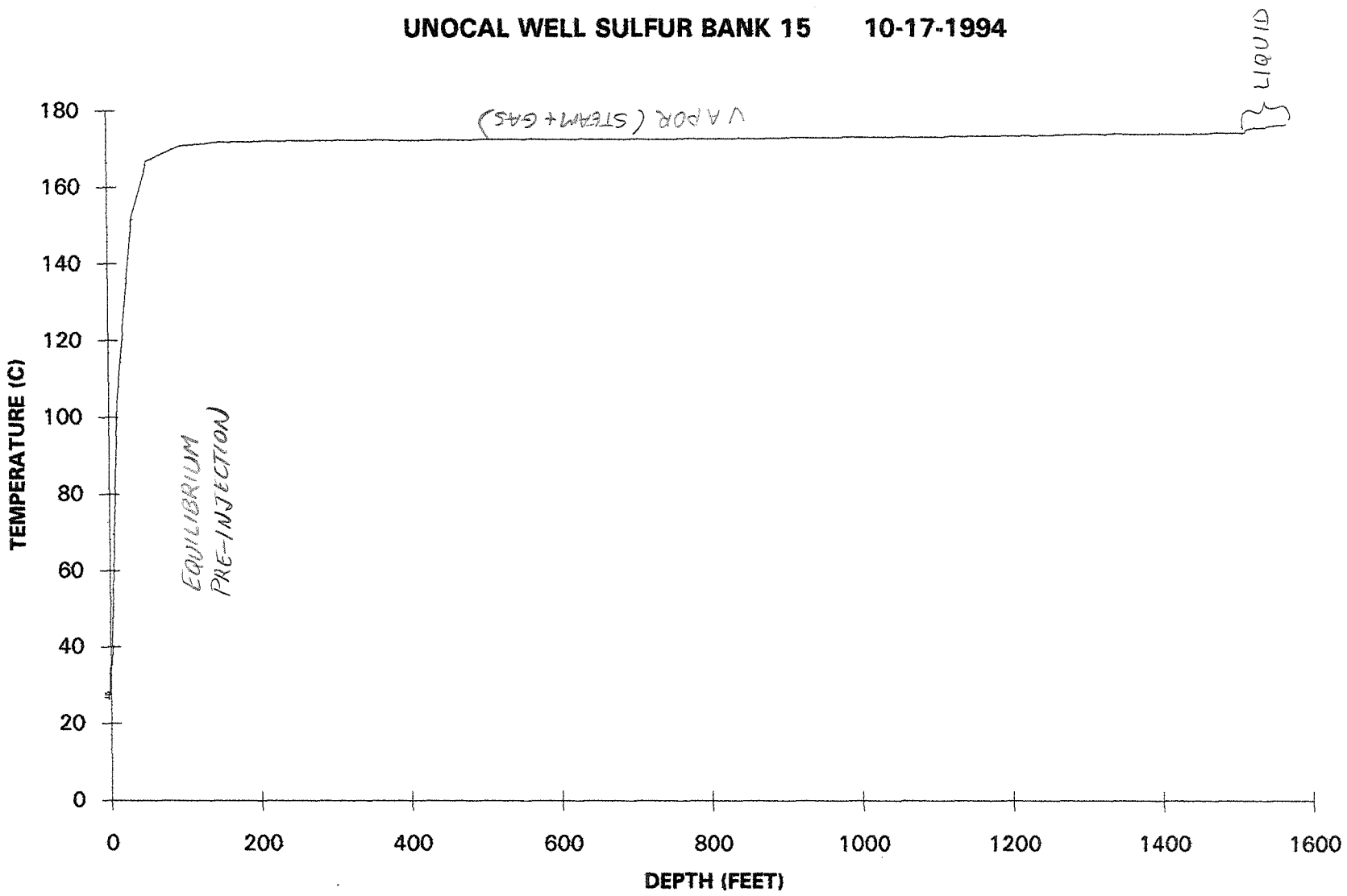
1557 4
★ OR AS LARGE AS POSSIBLE

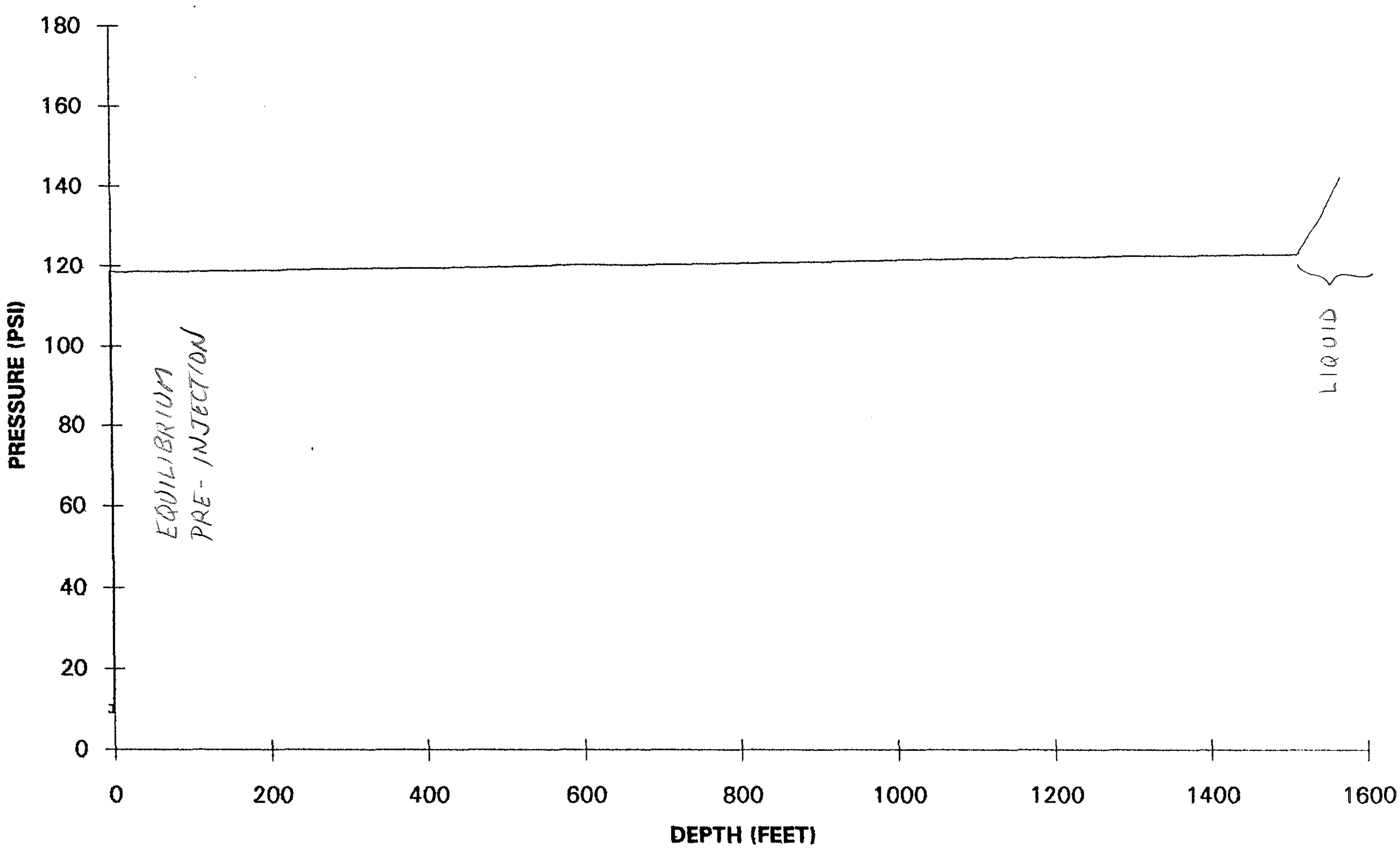
SB-15-D

	3"x2" THIN SEC. *	BULK XRD	CLAY XRD	FLUID-INCL. SAMPLE	ORGANIC GEOCHEM.
844		✓	✓		✓
869.5	✓	✓	✓		
881		✓	✓		
891	✓	✓	✓		
895		✓	✓		
916	✓				
927					✓
933.5		✓	✓		
946.8				✓	
964	✓ VB			✓	
974.2					
975	✓	✓	✓		
985.6					
990.4		✓	✓		
1033	✓			✓	
1058	✓	✓	✓		
1064.8				✓	
1017		✓			
1065	✓				
1073		✓	✓		✓
1099	✓	✓	✓		✓
1017.3				✓	
1132.4	✓				
1135.9		✓	✓		
1159.8	✓	✓	✓		
1191.8	✓	✓	✓		✓
1229.8	✓	✓			
1258	✓	✓		✓	
1268		✓			
1277.8	✓	✓	✓		✓
1287.4	✓	✓	✓		
1247.8	✓	✓		✓	
1345	✓	✓	✓		
1370.4	✓				
1374.2		✓	✓		✓

* OR AS LARGE AS POSSIBLE

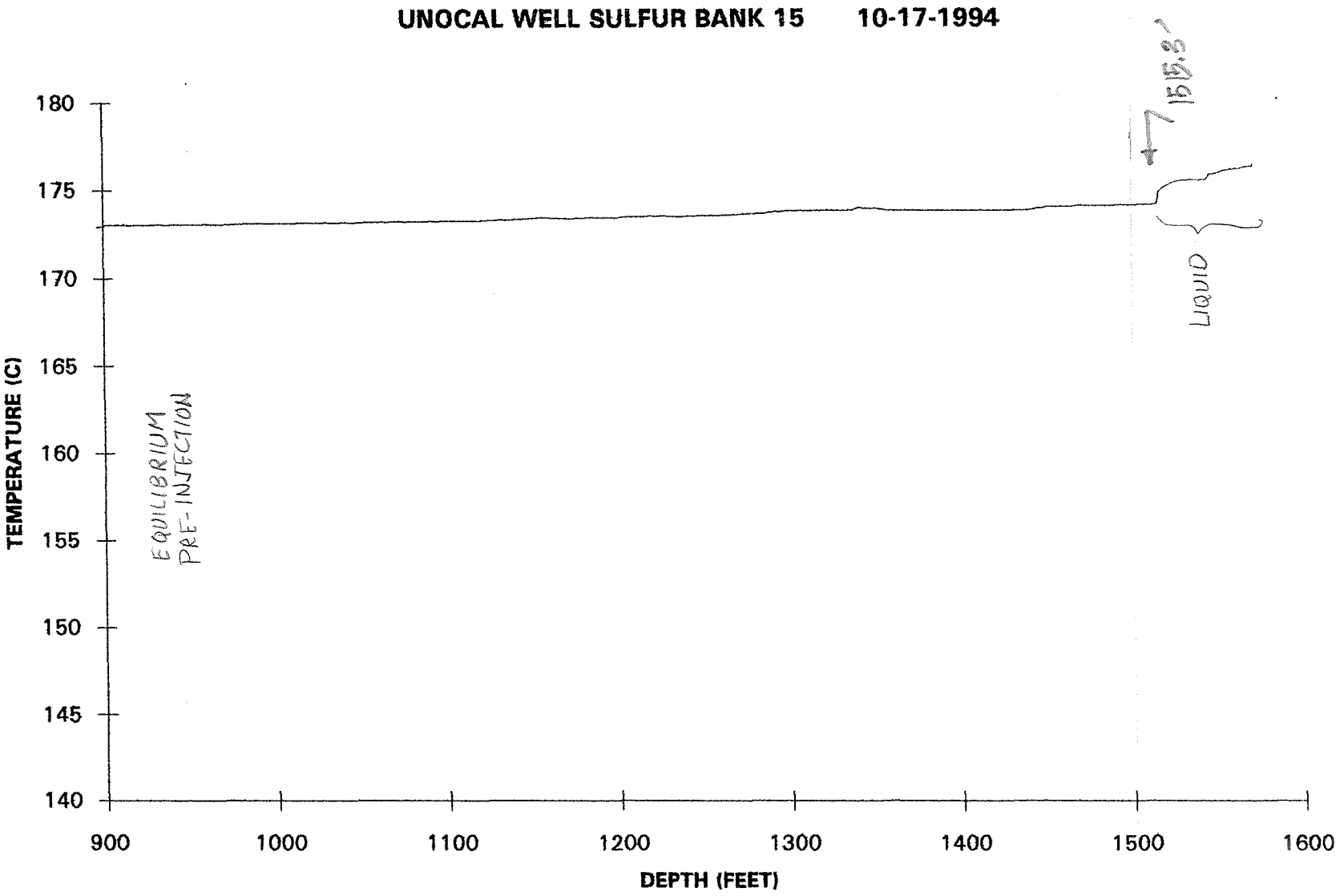

UNOCAL WELL SULFUR BANK 15 10-17-1994
TEMPERATURE (C)
180
160
140
120
100
80
60
40
20
0
0
200
400
600
800
1000
1200
1400
1600
DEPTH (FEET)
VAPOR (STEAM + GAS)
LIQUID
EQUILIBRIUM
PRE-INJECTION

UNOCAL WELL SULFUR BANK 15   10-17-1994

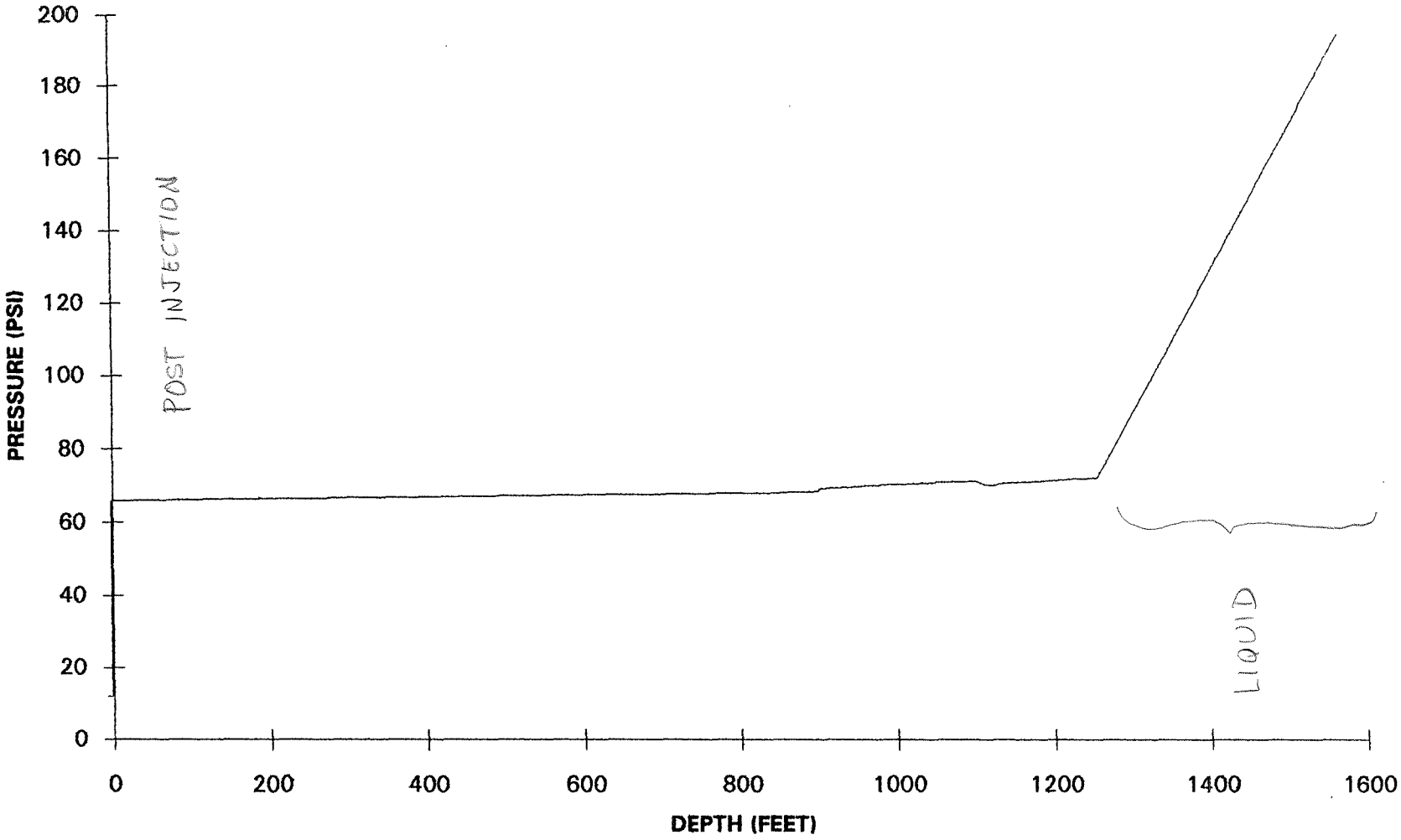


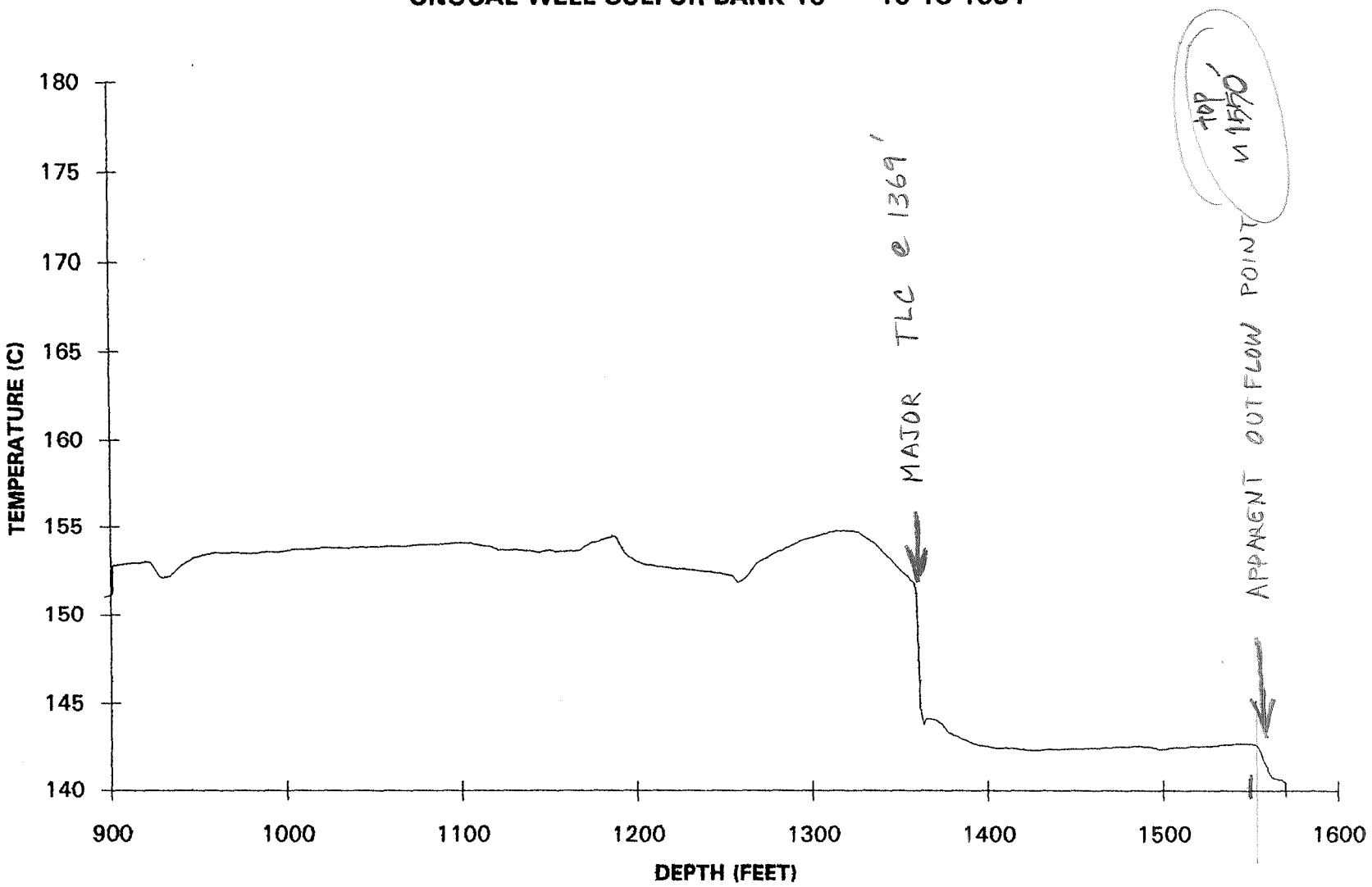
442/X 412/1600

1514


UNOCAL WELL SULFUR BANK 15 10-17-1994
TEMPERATURE (C)
180
175
170
165
160
155
150
145
140
900
1000
1100
1200
1300
1400
1500
1600
DEPTH (FEET)
EQUILIBRIUM
PRE-INJECTION
LIQUID

UNOCAL WELL SULFUR BANK 15 10-18-1994




UNOCAL WELL SULFUR BANK 15 10-18-1994
TEMPERATURE (C)
180
175
170
165
160
155
150
145
140
900
1000
1100
1200
1300
1400
1500
1600
DEPTH (FEET)
MAJOR TLC @ 1369'
APPARENT OUTFLOW POINT
Top @ 1550'

Calculation Record

UNOCAL 76

PREPARED BY	CHECKED BY	DATE	PAGE
			OF

SUBJECT	W.O/A.F.E. NO.

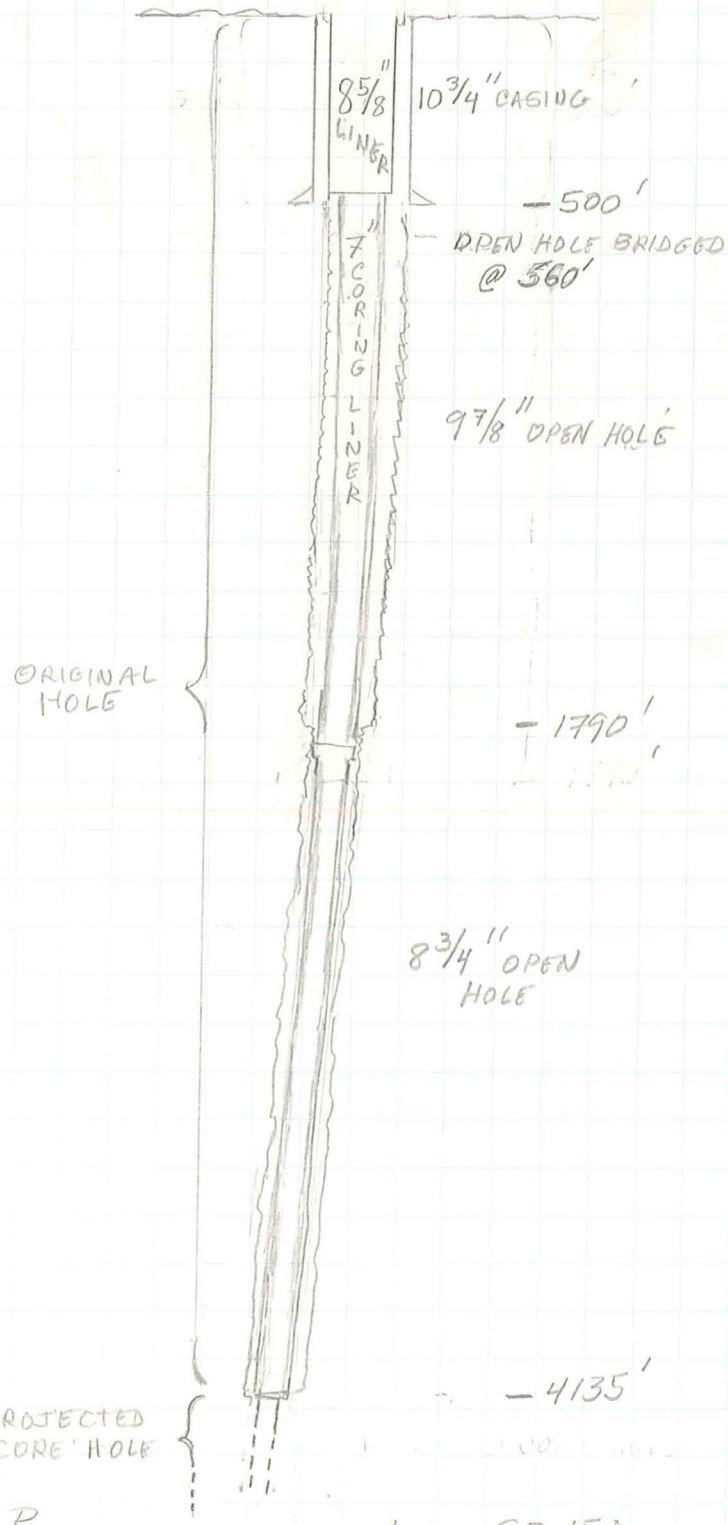


FIGURE A. PLANNED CONFIGURATION OF SB 15D AT THE BEGINNING OF CORING OPERATIONS

Calculation Record

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SUBJECT	W.O/A.F.E. NO.

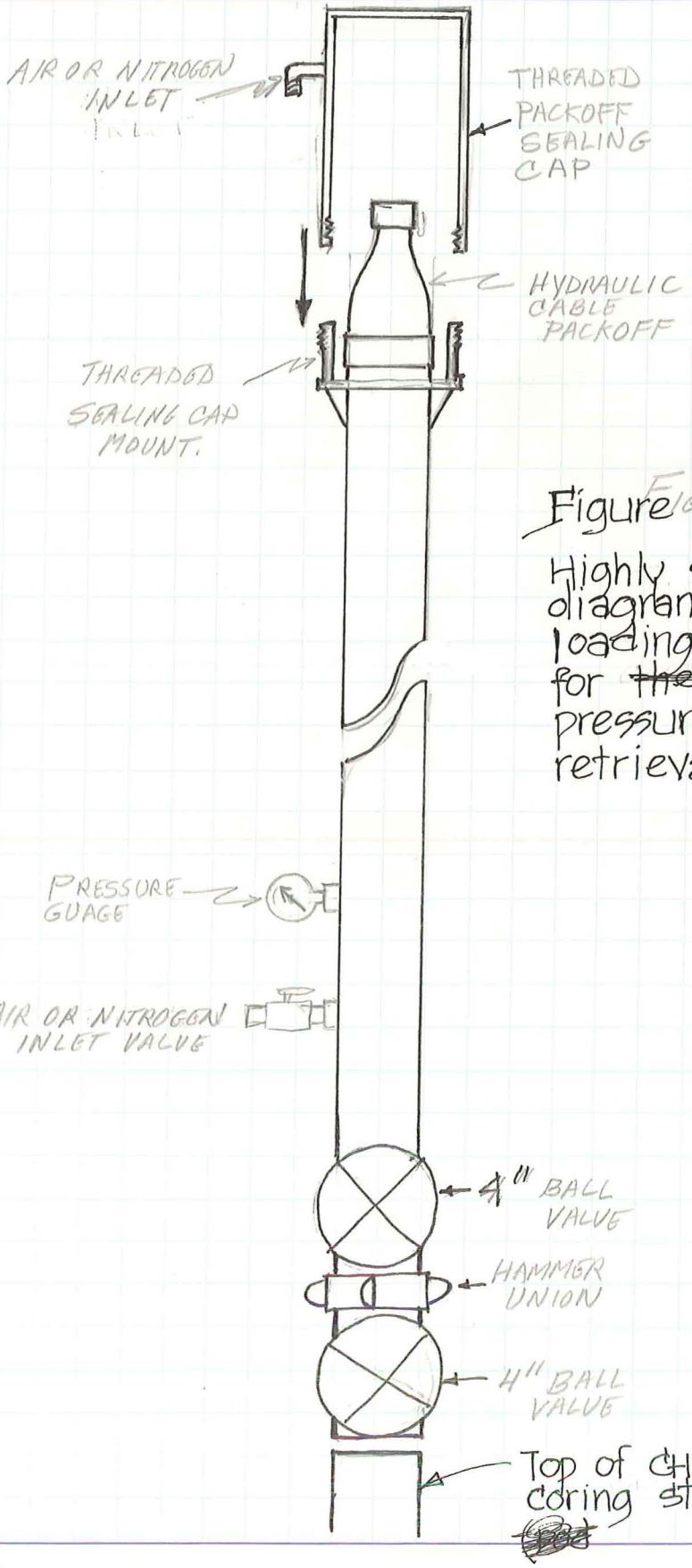
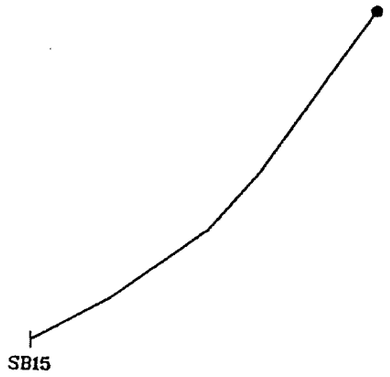


Figure ~~FIGURE~~ C

Highly schematic diagram of ~~the~~ loading chamber for ~~the Unocal~~ pressurized core retrieval

SB-15- DEVIATION SURVEY

550 —	1°	no az.
800 —	8°	
1600 —	15° 45'	
1790 —	19° 15'	534° W
2200 —	18° 30'	546° W
2790 —	16°	560° W
7538 —	17° 30	560 W ("extrapolated")
4135 —	15°	



Well Courses: S.B. 15

SCHEMATIC

DESCRIPTION

-28', 20" Conductor Pipe. Cemented.

-499', 10-3/4" 32.75# & 40.5# Casing. Cemented To Surface.

-1790', T.D. 9-7/8" Open Hole (Original T.M.D.).

-4135', T.D. 8-3/4" Open Hole.

STEAM ENTRIES

1085'	1538'	3280' - 5#
1105'	1559'	3516' - 10#
1125'	1570'	3848' - 20#
1200'	1652'	
1467'		
1498'		

SIDE TRACKS

None

REMEDIAL WORK

1-7-77 Caliper Survey
9-24-77 Clean Out, Sloughing Hole F/548'-1109' Test-53,000#/HR, 67 PSIG, 318°F, 4-1/2" Orifice.
4-8-79 Caliper Survey
6-9-80 Deepen Well To 4135'. Test-135,000#/HR, 118 PSIG, 363°F, 5-1/2" Orifice.

LOST CIRCULATION ZONES

None

MISCELLANEOUS

RIG: HUNNICUTT & CAMP

LOCATION: 480' North And 884' East Of The Southwest Corner Of Section 12, T11N, R9W, M.D. B&M.

B.H.: 632' South And 618' West Of Surface.

Revised 1/87

UNION

SULPHUR BANK-15

Units 1-6

GROUND ELEVATION:	1880'	SPUD DATE :	9-9-64	T. M. DEPTH:	4135'
KELLY BUSHING :	17'	COMPLETION DATE:	9-17-64	T. V. DEPTH:	4027'
TOTAL FOOTAGE :	4135'	RIG TEST :	10-13-64 184,000#/HR, 120 PSIG	E. T. DEPTH:	4135'

Calculation Record

UNOCAL 76

09/15/94

PREPARED BY	CHECKED BY	DATE	PAGE
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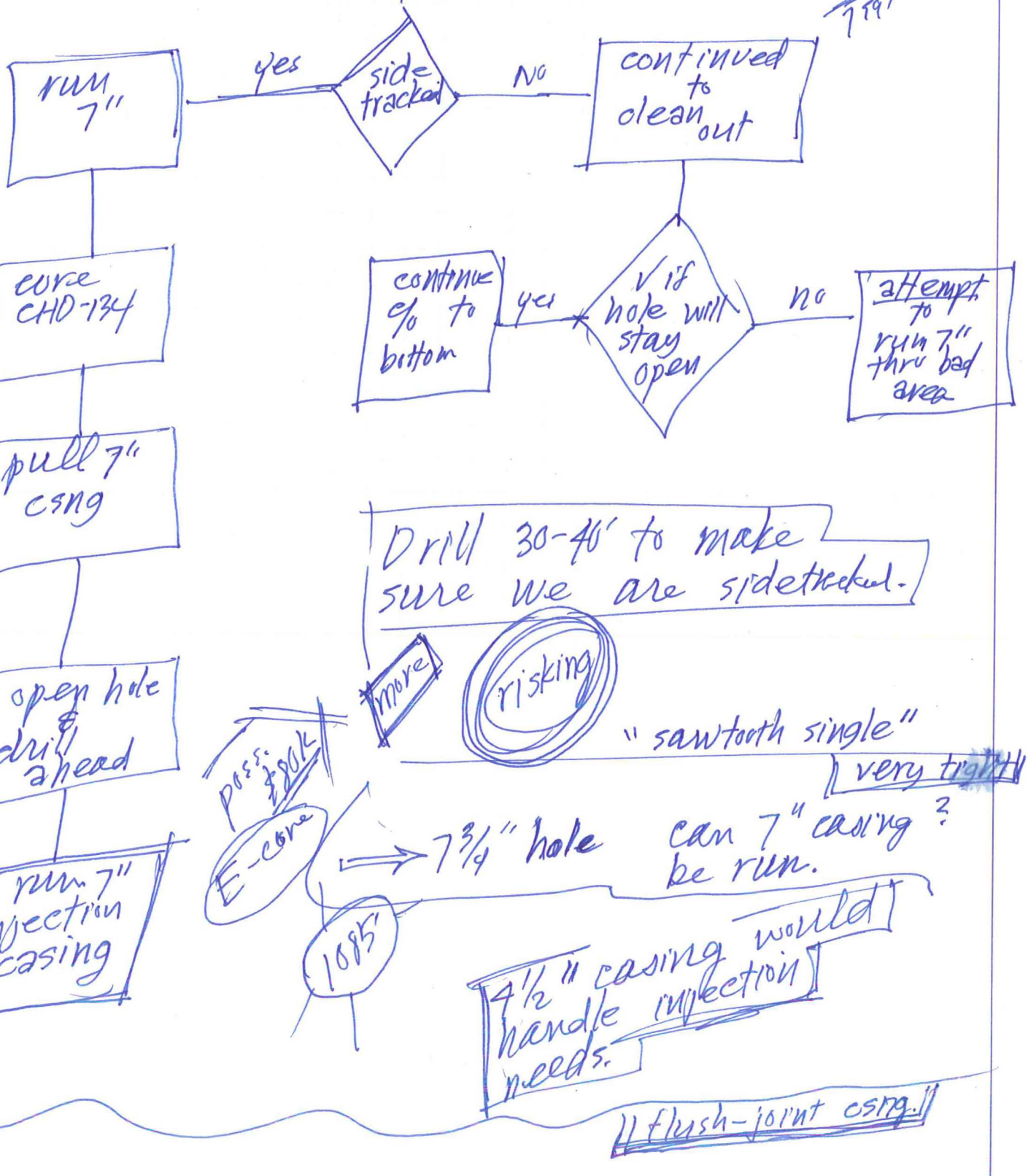
SUBJECT

W.O./A.F.E. NO.

POH & return w/ stabilizer

Option Tree

~~946~~ 759



Sulphur bank 15
Coring / CTI
Program

Casing Detail

20'	28'
10-3/4"	499'

Open Hole

9-7/8"	1790'
8-3/4"	4135'

1. Perform U.T.I. on exposed surface casing and well head.

2. Run minimum I.D. from 700' to surface.

3. Run 10-3/4" casing caliper from 480' to surface.

4. Move in and rig up coring rig.

5. Install and function test 10" 2M B.O.E. including double gate with pipe and blinds, annular, rotating head with flow line, and choke and kill lines.

   5.1 Notify D.O.G. 24 hrs before function testing B.O.E..

6. Kill the well with water and R.I.H. with 6-1/4" Baker P.I.P.

   6.1 Set the P.I.P.in the bottom of 10-3/4" casing at 499'+ -.

   6.2 Place 25' sand and 50' cement on the P.I.P. plug.

   6.3 Using a 9-7/8" bit polish off the cement to 460' + - leaving a minimum of 25' cement above the sand.

7. Rig, run and cement 8-5/8" 36# K-55 BTC SCC casing from the top of the cement plug at 460' + - to surface.

8. Remove the 10-3/4" casing head and install a 8-5/8" X 10" - 400 casing head on the 8-5/8" casing.

   8.1 Install a 10" - 400 donut hanger spool, a 10 - 400 WKM master valve and two 3-1/8" 2M wing valves.

9. Reinstall the B.O.P.E. and test the casing , well head and B.O.E. to 500 psi surface.

10. Using a 7-3/4" bit drill out the 8-5/8" casing, clean out the cement and circulate out the sand.

10.1 P.O.H. and pick up the P.I.P. retrieving tool.

10.2 Run the retrieving tool and recover the 6-1/4" Baker P.I.P..

NOTE: *It may be necessary to continually pump water into the 8-5/8" casing to keep steam zones in well from flowing to surface.*

11. R.I.H. with 7-3/4" bit on cleanout assembly to 4135'.

11.1 Clean out bridges or fill with coring fluid.

11.1.1 See coring mud program.

11.1.2 A high volume pump may be needed to effectively clean out to T.D.

Note: Running of the 7" liner may be postponed if a pressure core is required. Check with the Domestic B.U. office before starting step 12..

12. Rig and run 7" 20# K-55 LTC SCC liner from 2000' to T.D. at 4135' + - .

12.1 Use a float type guide shoe and pump down the 8-5/8" casing while running the 7" liner.

12.2 Land the casing on bottom using a left hand release thread on top of 10' X 7-5/8" stab-in receptacle.

13. Run the 7" hang down casing with S.C.couplings from surface to the top of the 7" liner at 2000' + - .

13.1 Use a 7" float insert valve above the stab-in mandrel for well control and pump down the 8-5/8" casing while running the 7" casing.

13.2 Engage the 7" liner at 2000' + - while hanging the 7" casing from the 10" donut hanger.

13.2 Use 7" pup joints to space the stab-in mandrel in the middle of the stab-in receptacle.

14. Using a 6-1/8" milltooth bit drill out the float insert in the 7" hangdown and shoe of the 7" liner and drill five foot of new hole.

15. P.O H. and rig for coring operations.

16. Core with CHD 134 rods and 5.625" core bit from existing T.D. until hole problems or approved funding require termination of coring operations.

17. Remove the 7" hang down casing string.

    17.1 Before pulling the 7" hangdown install a wireline plug in the bottom on the 7" hangdown casing.

    17.2 Keep well dead by pumping down the 7" X 8-5/8" annulus.

18. Install a bridge on top of the 7" liner at 2000' + - .

    18.1 Place 50' of cement on established bridge.

    18.2 Confirm the top of the cement plug.

19. Rig and run 500' 7" perforated SCC casing and 1500' + - 7" SCC blank casing to 50' above the cement plug at 1950'+ -.

    19.1 Use safety subs while running the 7" injection liner.

    19.2 Pump down the 8-5/8" X 7" annulus while running the injection liner.

    19.3 Land the 7" casing hang down in the 10" hanger spool. and secure the well.

    19.2 Check and tighten all W.H.E.

20. Rig down, release and move the rig.

flw/6-17-94

OEDP - Open-ended drill pipe
BPM - Barrels per minute
CIP - Cement in place

8. Remove the 10-3/4" casing head and install a 8-5/8" X 10" - 400 casing head on the 8-5/8" casing.

8.1 Install a 10" - 400 donut hanger spool, a 10 - 400 WKM master valve and two 3-1/8" 2M wing valves.

9. Reinstall the B.O.P.E. and test the casing , well head and B.O.E. to 500 psi surface.

10. Using a 7-3/4" bit drill out the 8-5/8" casing, clean out the cement and circulate out the sand.

10.1 P.O.H. and pick up the P.I.P. retrieving tool.

10.2 Run the retrieving tool and recover the 6-1/4" Baker P.I.P..

NOTE: *It may be necessary to continually pump water into the 8-5/8" casing to keep steam zones in well from flowing to surface.*

11. R.I.H. with 7-3/4" bit on cleanout assembly to 4135'.

11.1 Clean out bridges or fill with coring fluid.

11.1.1 See coring mud program.

11.1.2 A high volume pump may be needed to effectively clean out to T.D.

Note: Running of the 7" liner may be postponed if a pressure core is required. Check with the Domestic B.U. office before starting step 12..

12. Rig and run 7" 20# K-55 LTC SCC liner from 2000' to T.D. at 4135' + - .

12.1 Use a float type guide shoe and pump down the 8-5/8" casing while running the 7" liner.

12.2 Land the casing on bottom using a left hand release thread on top of 10' X 7-5/8" stab-in receptacle.

13. Run the 7" hang down casing with S.C. couplings from surface to the top of the 7" liner at 2000' + - .

    13.1 Use a 7" float insert valve above the stab-in mandrel for well control and pump down the 8-5/8" casing while running the 7" casing.

    13.2 Engage the 7" liner at 2000' + - while hanging the 7" casing from the 10" donut hanger.

    13.2 Use 7" pup joints to space the stab-in mandrel in the middle of the stab-in receptacle.

14. Using a 6-1/8" milltooth bit drill out the float insert in the 7" hangdown and shoe of the 7" liner and drill five foot of new hole.

15. P.O H. and rig for coring operations.

16. Core with CHD 134 rods and 5.625" core bit from existing T.D. until hole problems or approved funding require termination of coring operations.

17. Remove the 7" hang down casing string.

    17.1 Before pulling the 7" hangdown install a wireline plug in the bottom on the 7" hangdown casing.

    17.2 Keep well dead by pumping down the 7" X 8-5/8" annulus.

18. Install a bridge on top of the 7" liner at 2000' + - .

    18.1 Place 50' of cement on established bridge.

    18.2 Confirm the top of the cement plug.

19. Rig and run 500' 7" perforated SCC casing and 1500' + - 7" SCC blank casing to 50' above the cement plug at 1950'+ -.

    19.1 Use safety subs while running the 7" injection liner.

    19.2 Pump down the 8-5/8" X 7" annulus while running the injection liner.

    19.3 Land the 7" casing hang down in the 10" hanger spool. and secure the well.

    19.2 Check and tighten all W.H.E.

20. Rig down, release and move the rig.

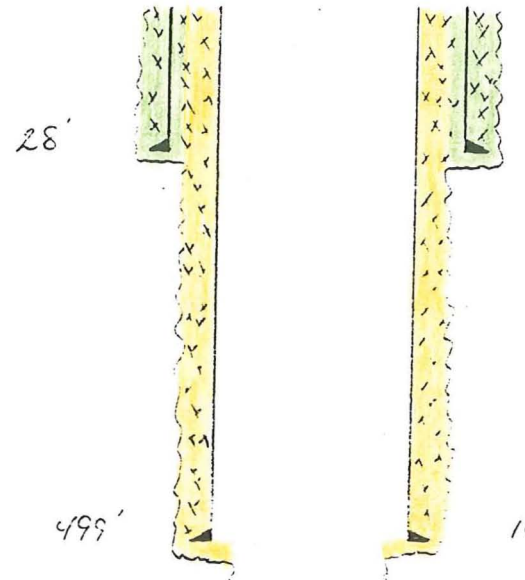
flw/6-17-94

Calculation Record

UNOCAL 76

PREPARED BY	CHECKED BY	DATE	PAGE
			1 OF 4

SUBJECT	W O/A.F.E. NO
Current Completion - Sulphur Bank 15	



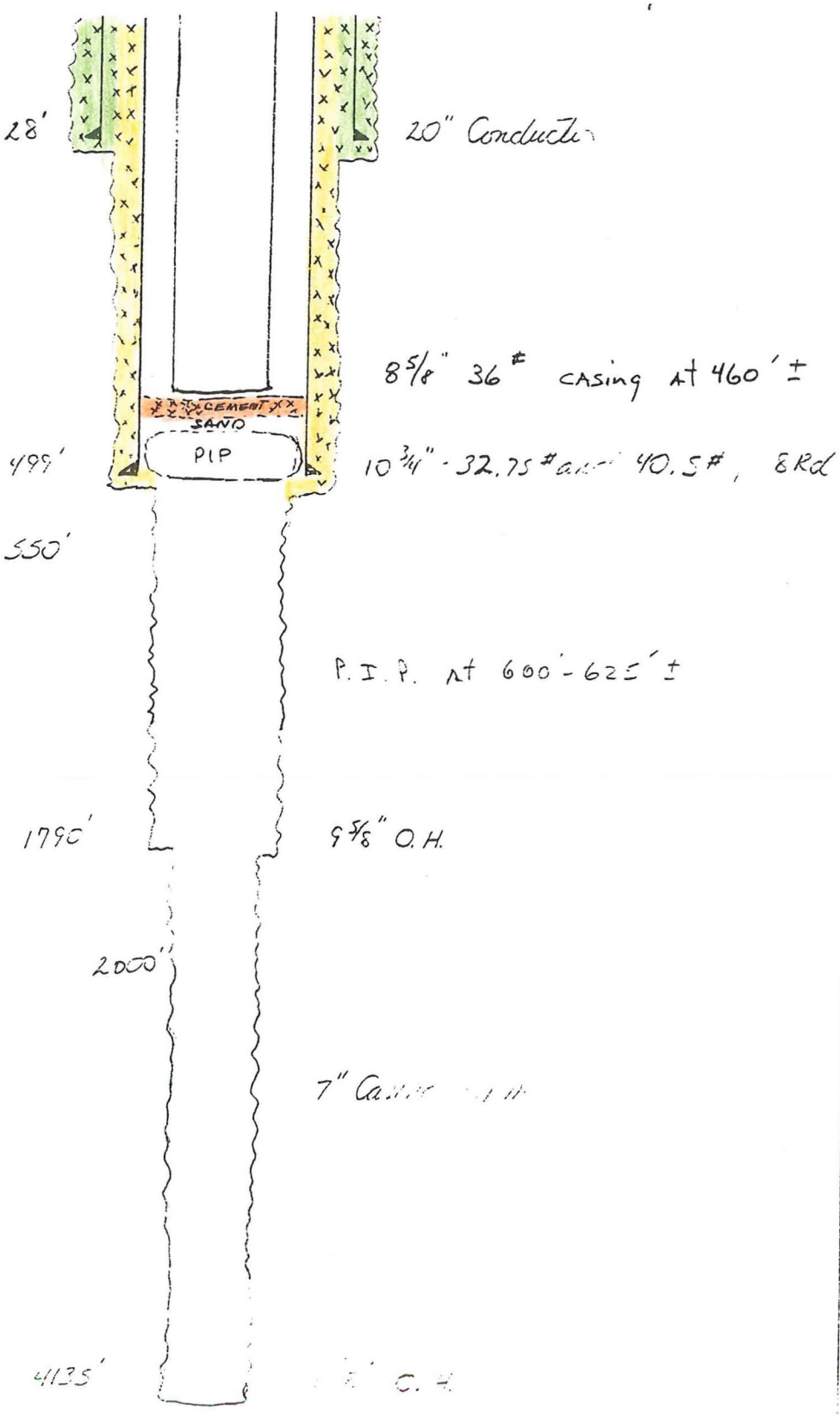
Calculation Record

UNOCAL 76

PREPARED BY	CHECKED BY	DATE	PAGE
			2 OF 4

SUBJECT: 7" w/ mandrel and 8 5/8"-36# Casing w/ new casing head

W O/A F E. NO:



Calculation Record

UNOCAL 76

PREPARED BY	CHECKED BY	DATE	PAGE
			3 OF 4

SUBJECT: 7" Hanger Liner in Casing

W.O./A.F.E. NO

9540 Mark

Rob Emslie
Fax ~~510~~ 707-527-0163
707-525-9614
Elizabeth Way

17th

Wad Ent

28'

20" Conductor

8 5/8" 36# casing at 460' ±

499'

10 3/4" - 32.75# and 40.5# - 8Rd

1790'

7 5/8" O.H

7" Liner Hanger

7" Casing w/ Mandrel

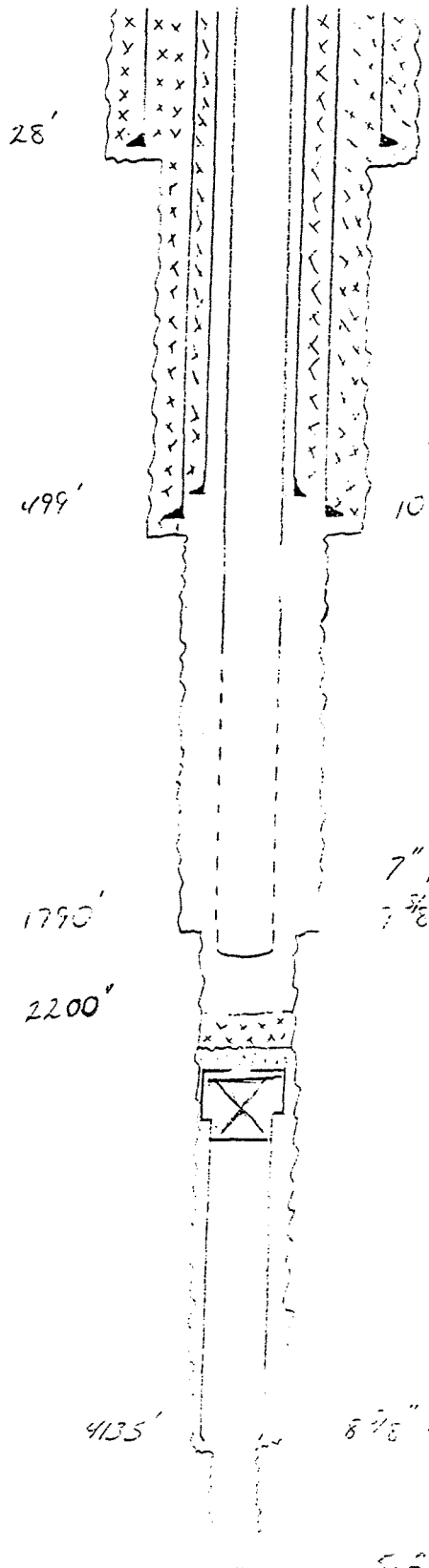
Calculation Record

UNOCAL 76

PREPARED BY	CHECKED BY	DATE	PAGE
			4 OF 4

SUBJECT: SB-15 Completion w/ 7" Perf Hangdown

W.O./A.F.E. NO: 7" PERF HANGDOWN



CHP

PQ size core —— rods — 127 mm
hole in 5 5/8"

134 mm —

Universal 5000'

MEETING W/ TOUTO 08/05/93

D. Nielson
L. Pistone
G. McClaren
N. Pardee

Philipines pre-cored to 2700'

60'/day core to 500'

PQ SIZE

same

FLS 3 1/2" tool

could get in 1500 ft of PQ core (under ideal conditions)

small annulus.

normal inner tube prepared with caps

in $105.00/per tube

trace in drilling mud? to

TOUTO MEETING 08/5/93

doesn't add mud

2/2

split tube → stainless — $300

transfer to Lucite

for fluid preservation

→ air coring? can it be done?

right after L circ. → clean hole

increase cost

can change readily.

Marsh Pardee → aluminum liners (triple tube)
w/O-ring caps ~ $50 for 5-footer

UNIVERSITY OF UTAH RESEARCH INSTITUTE
UURI
391 CHIPETA WAY, SUITE C
SALT LAKE CITY, UTAH 84108-1295
TELEPHONE 801-524-3422

MEMO TO: GEYSERS COREHOLE PARTICIPANTS

FROM: MIKE WRIGHT

SUBJECT: MEETING ON 26 MAY 1993

May 24, 1993

The main purpose of this meeting will be to explore options for preservation of and measurements on the core that we plan to obtain in The Geysers reservoir rocks. Results of the meeting will be used to help pull together the science plan for the core. This science plan must be solidly based with specified objectives, approaches and potential benefits so that those who will make commitments for in-kind contributions will be able to justify their efforts. Each of you should come to the meeting ready to talk about specific recommendations for the science plan.

A drilling plan will be needed as well as a science plan. Since the hole will be on Unocal property, the bulk of the drilling plan and the bulk of the in-kind contribution to the coring will fall to them. The drilling plan will form the basis for a proposal to the Geothermal Drilling Organization, which Sandia will use to contract with Unocal. DOE's contribution, $400K, is in the Sandia program, and it is my understanding that this amount will be available for coring.

We will have one day to get a lot done. Let's make it happen!

BEN BARKER
SUMMARY OF
05/26/93
GEYSERS
COREHOLE MEETING/SANTA ROSA

Measurement

Questions

1. Saturation (weight) - Paul + Brian — Variation? "air" time? → core preservation?
2. Heterogeneity — CAT?
3. Visual logging - Jeff — who? photos? CD?
4. k, ϕ, P_c @ room temp — lab? $?
5. k, ϕ, P_c @ reservoir T, P — Marco — lab? $?
6. k_r @ reservoir T, P — lab? $?
7. Fluid samples f/hole — sampler? lab?
8. Electric logging of hole - Colin
9. " " " core
10. TPS survey of hole - Bill

To Jeff
B4 7/12/93

11. Fluid samples f/core
12. Leachable salts f/core - Bob
13. Rock geochem. - Jeff
14. Petrography (fluid inclusions, etc.) - Jeff
15. Adsorption - Roland
16. Core preservation - Mike

Drilling plan - Mitch

- Budget.
- Timing/drlg.
- Vendors/sup.
- Pre-Test.
- Description of work.
- Current practice
- Deliverables

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391 CHIPETA WAY, SUITE C
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TELEPHONE 801-524-3422

MEMO TO: GEYSERS WORKING GROUPS

FROM: MIKE WRIGHT

SUBJECT: NOTES FROM GEYSERS COREHOLE MEETING

June 9, 1993

As you know, the Geology Working Group at The Geysers has recommended coring in reservoir rocks as a means of obtaining rock samples for measurement of parameters of interest in better understanding and simulating the reservoir. On May 26, 1993, a meeting of a group working on this recommendation was held at the Unocal offices in Santa Rosa. Attached is a copy of notes from this meeting.

In summary, the current status of this project is as follows: (1) The $400,000 that DOE will contribute to the coring project will come through the Geothermal Drilling Organization via an agreement between Unocal and Sandia; (2) The project will require scientific and drilling plans, which are being worked now and will be completed around the first of August, with drilling starting as soon as practical after that; (3) More conventional geological, geochemical and geophysical measurements on the core will be obtained by DOE researchers but also by outside contractors; (4) One important objective of the coring project will be to test methods of obtaining information on the reservoir liquid saturation, which will require core preservation.

We intend to hold another meeting of the coring group in late July to discuss progress on the scientific and drilling plans and fine-tune them.

1/7

GEYSERS CORE HOLE MEETING

26 MAY 1993

UNOCAL OFFICES, SANTA ROSA, CA

A meeting of the working group interested in coring at The Geysers field was held in the Unocal offices in Santa Rosa, CA on 26 May 1993. Those in attendance are shown in Appendix 2.

Miscellaneous Notes

Mitch Stark is taking responsibility on behalf of Unocal for working with Bill Smith in selecting the well to be used for coring. Mitch stated that the final selection has not been made, although a good candidate has been identified -- well LF-1. It has limited production with a steam entry at 5,249 ft, and is currently used as a producer. It has 9 5/8" casing to 2,700 ft, 7" cemented liner to 3,542 ft and 8 3/4" open hole to TD at 5,570. Other wells may also be available. Coring in LF-1 would start near the top of the hornfels zone may be able to reach the felsite with the available money.

A question was raised about the original idea of coring graywacke reservoir rocks. Jeff Hulen noted that the difference between normal reservoir graywacke and hornfels is that in the graywacke the vein calcite has been dissolved, whereas in the hornfels it has been converted to calc-silicate minerals. Ben Barker stated that the main objective should be to get core out in usable condition, with the rock type being secondary. Bob Fournier said he would like to see at least two rock types. Paul Kasameyer suggested that someone should see if there are chips from LF-1, and if so, they should be logged.

The meeting then began to focus on the types of measurements that would be made on the core and on getting the science plan written. It is important that the scientific work is well planned to ensure success of the project in terms of helping the operators to understand the reservoir better, and because the in-kind contribution that Unocal will make, for permitting and supervising the drilling as well as the use of a production well, will be substantial.

It was agreed that we should focus on trying to develop innovative ways of determining in-situ (reservoir) liquid saturation levels, and porosity and permeability values for the core. In order to do this, we will have to take a careful look at the options for preservation of the core, either downhole before retrieval, or at the surface. More conventional geological, geochemical and geophysical measurements would also be made on the core, but will not be so dependent on preservation. We felt that core could be obtained --

from depth in about 20 minutes through wireline retrieval. LLNL will use some of their simulation capabilities to determine the preservation requirements once the core reaches the surface. They will also look into the types of core barrels available for core preservation. UURI will independently work on methods of core preservation.

Mark Walters suggested that we may want to look into use of aluminum core barrels that could be sealed immediately upon arrival at the surface. Jeff Hulen stated that for the Valles Caldera coreholes, they sealed the core will beeswax at the surface. Mark said that Rob Emslie had successfully drilled with plastic liners in deep coring in the British nuclear repository. The group agreed that we probably only have enough money to preserve selected samples, and that most of the core would have to be retrieved in the usual way at the surface.

Brian Bonner submitted an outline of some of the measurements LLNL may be able to make and the expected results (Appendix 1). Brian noted that they will try some of the LLNL CAT-scan x-ray techniques, using high-powered equipment previously classified, on NEGU-17 core to see how well a CAT-scan maps the internal systematics of core. If successful, LLNL could potentially build a vessel to CAT-scan core at Geysers reservoir temperature and pressure.

Brian also discussed the electrical tomography being developed by Bill Daley at LLNL, and its application to core studies at Yucca Mountain. In one test, core was dried, then instrumented, measured and resaturated while further measurements were being made. It was found that the water migrated first into the pores, not into a major fracture that ran through the piece of core.

Bob Fournier suggested that we could dope the drilling fluid with something detectable with x-rays. If we find that the core is well penetrated by the doped drilling fluid, we may conclude that the rock was not saturated in the reservoir.

Ben Barker emphasized that we need to know the length of time we have to work with core at the surface before all traces of reservoir saturation are erased.

Joe Beall pointed out that if the coring hits a steam entry, the core tube will be pushed up and jammed, with the result that no core will be obtained from the entry.

Plans

In order to expedite the project, it was decided that Jeff Hulen would be responsible for putting the science plan together. The schedule was established as follows:

Deadline	Event
1 July 1993	Written material for science plan to Hulen.
7 July 1993	Material assembled at UURI and mailed out to committee.
23 July 1993	Draft science plan assembled by UURI.
27-30 July 1993	One- or two-day meeting of core committee in Santa Rosa to discuss and fine-tune science plan and discuss drilling plan.
6 August 1993	Science plan finalized and distributed.

The material to be delivered to Hulen by 1 July 1993 include (1) statement of work, (2) pre-testing needed or pre-testing results, (3) current practice (state of the art), (4) budget requirements (5) timing relative to drilling, (6) proposed vendors/suppliers, and (7) deliverables.

Table 1 summarizes the potential measurements to be made on the core, the priority, the questions each measurement will help answer and the person(s) responsible for furnishing material to UURI by 1 July 1993.

Table 1

POTENTIAL CORE MEASUREMENTS

MEASUREMENT	PRIORITY	QUESTIONS	RESPONSIBLE PARTY
1. Liquid saturation and heterogeneity	1	Reservoir liquid saturation and its variations. "Air" time, and core preservation requirements, methods.	Bonner - LLNL
2. Core preservation	1	Options, cost	Wright - UURI
3. Visual logging	1	Description, who does it, photos, video	Hulen - UURI
4. k, Ø, Pc @ room temp k, Ø, PC @ reservoir T, P kr @ reservoir T, P	1	Who does it, costs	Lippmann - LBL
5. Adsorption	1	Can it be done on whole core	Horne - Stanford
6. Electric logging of hole	2	Who does it, costs	Williams - USGS
7. Electric logging of core	2	Who would do it, costs	Kasameyer - LLNL
8. TPS survey of hole	2	Who would do it, costs	Smith - NCPA
9. Fluid samples from core	2	Who would do it, costs	Moore - UURI
10. Leachable salts from core	2	Who does it, costs	Fournier - USGS
11. Rock geochem	2	Who would do it, costs	Hulen - UURI
12. Petrography and fluid Inclusions	2	Write-up needed	Hulen - UURI
13. Downhole fluid samples	3	-	-
14. Drilling Plan	1	-	Stark - Unocal

4

4/7

Brian Bonner
26 May 93
5/7

APPENDIX I

Draft--Science Plan--The Geysers Corehole

General Objective--To understand the storage and transport of water in-situ

Rapid Core Recovery

Core Preservation

Objective--Screen suitable jacketing materials.

test several high temperature polymers (Viton and Kalrez) for durability as high temperature jackets for use at the corehole.

FOR A 'FEW' SAMPLES

Physical Chemistry of 'intrinsic' water storage
(Ramey / Horne - Stanford)

Drilling Simulation Experiments in the Laboratory

Objective--address the question of fluid movement during coring and core recovery

Run pre-corehole experiments to determine if saturation can be determined with this method. Focus on:

Fluid storage in fractures
Mud infiltration
Fluid loss

Saturate samples of NEGU-17 (or other suitable proxy) material at reservoir conditions to determine sensitivity of the CAT scan

CAT Scans of recovered (from lab and then field) core

FOR 'MANY' SAMPLES FROM THE COREHOLE

Jacket in the field
measure water content by weight loss; resaturate to determine the porosity
Do "Porosity and Permeability' on plugs

ADDITIONAL MEASUREMENTS ON RECOVERED CORE

Impedance Tomography of fluid movement in fractured core

Objective --observe fluid movement from matrix to fracture at the core scale

Other Relevant LLNL capabilities

Seismic properties- velocities and attenuation; now underway

Schatz model Q(f) for fractures

Transport properties

flow models/reactive flow

Nitao / Wang improved double porosity model?

Experimental validation / perm and closure measurements

Reactive flow code

Knapp code in place

Experimental validation / high pressure-temperature flow, profiling before and after

Geochemistry of fluids

modeling and laboratory

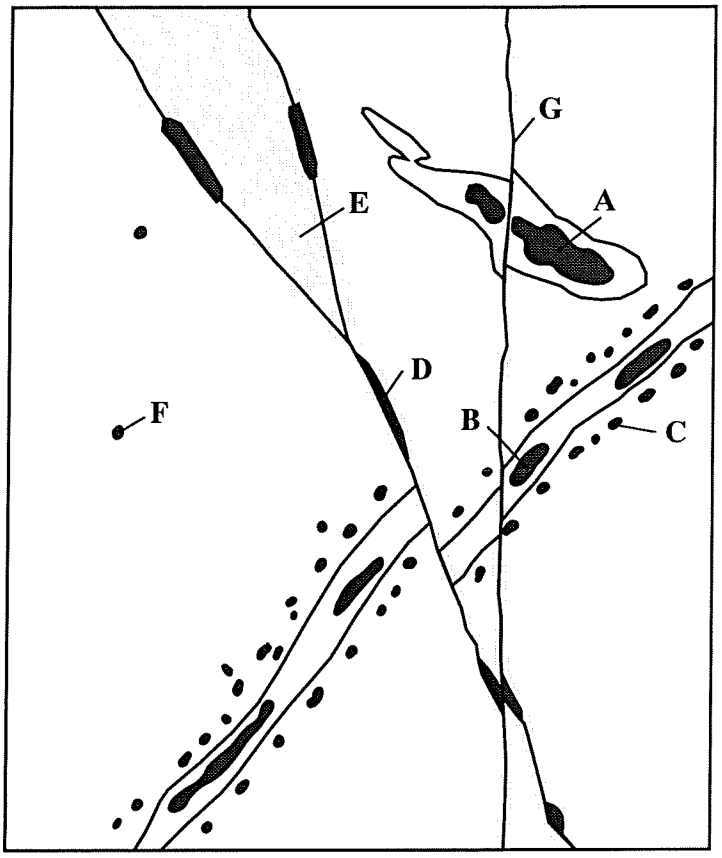

Figure 1 - Schematic diagram of "matrix" porosity in The Geysers normal graywacke reservoir. **A** is pore space created by dissolution of Franciscan calcite in discontinuous pods. **B** is pore space formed form dissolution of calcite in quartz + calcite veins. **C** are pores marginal to the quartz + calcite veins. **D** is porosity in small, partially sealed fractures, and **E** represents the porosity between and adjacent to these young fractures. **F** represents isolated pores. **G** are unmineralized fractures that are the youngest in the field. (Nielson et al., 1992; modified from Gunderson1990).

GEYSCORE.MS

Core Imaging and Data Archiving

Core, by its very nature, is difficult to handle and few people look at it in detail. Researchers often have to travel long distances to inspect the core, and hours of characterization are often required prior to sampling. When data is accumulated on the core, it is either not availabel or difficult to retrieve. It is our objective to make the core and scientific data available to companies and research organizations in a comprehensive and convenient to use format.

The core will be slabbed and then imaged at a resolution comparable to photography. These images will form the basis of a Geographic Information System data base. Additional data from researchers will be added to the data base as it becomes available. This will include the digital well logs, lithologic logging, fluid inclusion images and data, thin section images and data, alteration mineralogy, chemical analyses, radiometric dates, and drilling information.

This data base will be copied onto CD-ROM and made available to operating companies in The Geysers and research organizations. Thus it will be possible to easily inspect the core images and accumulated data base using a personal computer.

Imaging Logs

Imaging logs are proposed here to solve two principal problems: 1. to evaluate how representative a sample of the reservoir the core actually is, and 2. to determine the character and orientations of fractures intersected by drilling.

Companies have collected a number of cores from the Geysers reservoir. Core recovery is often poor, and the core retrieved is often broken into small pieces with milled ends. Since one would expect recovery to be poor within fractured areas, it is quite likely that the core provides an incomplete representation of the reservoir. Imaging of the borehole walls, using Schlumberger's Formation Microscanner (FMS) tool, will determine the character of the zones that are lost during the coring process. The FMS images rock based on constrasts in electrical resistivity. The principal difficulty in using the tool at The Geysers is that a fluid-filled hole is required for the tool to function.

Imaging tools are the only practical means for determining the orientations of fractures within the well. Core collected by conventional and wire-line means rotates within the barrel, and the collection of oriented core is tedious, prone to error, and has temperature limitations. Fracture orientation is of obvious

importance to companies for determining the most advantageous direction for wells to be deviated. It is also a significant factor in planning and evaluation of water injection to maintain the life of the reservoir.

It is proposed that the candidate well be filled with water and the open-hole portion of the well logged, using the FMS imaging technique, through the reservoir prior to initiating the coring program.

During or following the completion of the coring, additional imaging can be done using the slim-hole version of the FMS tool. This is provided that the hole can hold water and that the hole is sufficiently wide and straight to admit the logging tool.

Sulphur Bank 15 Drilling Review

Original Drilling Plan

- Set a packer and cement plug at 540'
- Install 8 3/8" Liner and New Wellhead
- Drill out cement and retrieve packer
- Set bottom 2000' of 7" liner
- Set top 2000' of 7" liner
- Core using 7" casing to support CHD 134 drill string

Problems and Solutions

- Packer moves downhole

  Multiple recovery attempts

- Severe hole sloughing at 638', and hole sloughing at 1134'

  Set cement plug from 776' to 663', and a second cement plug from 663' to 526'

- Hole sidetracks

  Drill 7 3/4" hole to 823' and begin CHD-134 coring

Final Completion

8 3/4' liner to 394'

7 3/4" hole to 823'

CHD-134 core hole to 1600'

4 1/2" liner to 1590'

Summary

Project near failure

Flexibility accomodates changing conditions

Adversity turns to opportunity

Nearly 800' of core recovered

Two pressurized cores retrieved

Well completed for injection

- A well behind city hall, used by the Modoc Lumber Company for makeup water to a boiler, increased in temperature by 5 °C, from 18 °C to 23 °C after the earthquakes.
- The Conger well field, near Link River, is used by the city as supply wells. After the earthquakes, these cold-water wells had a water-level increase of approximately 2.1 m.
- In late July and early August, wells in an area about 25 km southeast of Klamath Falls smelled and tasted "bad". In the same area, the Jim Moore well suddenly began producing 49 °C water, estimated at 15 °C before.
- On 20 September, between 4:00 p.m. and 5:00 p.m. and before the earthquakes, water changed at the Gordon Aires well, about 11 km south of the epicenter. The water was whitish-gray, with a tremendous amount of gas that had a strong hydrogen-sulfide odor. Others in the Keno area noticed similar changes in their wells. This area is southeast of the West Klamath Lake Fault Zone, along its structural trend.

Geysers Coring Project

— Marcelo Lippmann, Earth Sciences Division, Lawrence Berkeley Laboratory

The Geothermal Division of the U.S. Department of Energy (DOE), with support from *Unocal Geothermal Division* and other field operators at The Geysers, are planning the drilling of a deep core hole in this vapor-dominated geothermal system. The main objectives of the project are: (1) to obtain continuous core from the hydrothermally altered graywacke hosting the "normal" steam reservoir; (2) to measure in the laboratory and field the porosity, permeability, and other physical characteristics of these reservoir rocks; (3) to improve estimates of the nature, amount, and availability of liquid water reserves in the field; and (4) to investigate potential sources of chloride and non-condensable gases in the produced steam.

The preliminary plan calls for deepening an existing *Unocal* well in the Sulphur Bank area of The Geysers. Tentatively, an interval of up to 700 m might be cored continuously, starting at about 1,400 m depth, bottom of the present well. Initially, CHD-134 core (85-mm diameter) will be obtained.

A group of engineers and scientists from industry and DOE-supported organizations are finalizing the drilling and coring plans for this project, as well as a program of related studies. Scientists who might be interested in participating in the project, using their own funding, should contact Jeff Hulen, scientific coordinator of The Geysers Coring Project. His address is: University of Utah Research Institute, 391 Chipeta Way, Suite C, Salt Lake City, UT 84108-1295, U.S.A.; Tel.: 801-584-4446, Fax: 801-584-4453.

UPCOMING EVENTS

- **Symposium on New Developments in Geothermal Measurements in Boreholes**, Potsdam, Germany, 18–23 October 1993. Convenor: Eckhart Hurtig, GeoForschungs Zentrum Potsdam; Tel.: 49-331-310-347, Fax: 49-331-310-610.
- **11th IGA Board of Directors Meeting and Annual General Meeting**, Auckland, New Zealand, 8 and 9 November 1993. Contact: IGA Secretariat, LBL 50E, Rm. 143, One Cyclotron Road, Berkeley, CA 94720, U.S.A.; Tel.: 1-510-486-4584, Fax: 1-510-486-4889, e-mail: igasec@lbl.gov.
- **15th New Zealand Geothermal Workshop**, Auckland, New Zealand, 10–12 November 1993. Theme: *Long term use of geothermal resources: Problems and Solutions.* Manuscripts to be published in the Workshop Proceedings had to be received by 18 August 1993 at the Geothermal Institute, University of Auckland, Private Bag 92019, Auckland, New Zealand; Fax: 64-9-373-7346.
- **2nd Tianjin Geothermal Workshop**, Tianjin, China, 22–25 November 1993. Location: Tianjin Geothermal Research & Training Center, Tianjin University, China. Topics: *Geothermal geology, geophysics, geochemistry, resource assessment, reservoir engineering, monitoring systems, drilling technology, politics of geothermal development, international geothermal performance, dry rock research, and information exchange.* Proceedings will be published. Contact: Information Group, Tianjin Geothermal Research & Training Center, Tianjin, 300072, China.
- **26th General Assembly of the International Association of Seismology and Physics of the Earth's Interior (IASPEI)**, Wellington, New Zealand, 10–24 January 1994.

  IASPEI/IHFC Symposium: ***Geothermal Aspects of Lower Crustal Structure, Petrology and Rheology.*** Convenors: Vladimír Čermák, Geophysical Institute, Czech Acad. Sci., Praha 141-31, Czech Republic; Tel.: 42-2-76-4539, Fax: 42-2-761549. D.M. Fountain, Dept. of Geology and Geophysics, Univ. of Wyoming, Laramie, Wyoming, U.S.A., 82071; Tel.: 1-307-766-6299, Fax: 1-307-766-6679, e-mail: Fountain@uwyo.edu. Rick Allis, DSIR Geology and Geophysics, P.O. Box 30368, Lower Hutt, New Zealand; Tel.: 64-4-569-9059, Fax: 64-4-569-5016.

  IHFC Workshop: ***Heat Flow and Hydrothermal Circulation.*** Wednesday, 19 January 1994. Convenors: Ladislaus Rybach, Institute of Geophysics, ETH Hönggerberg, 8093 Zürich, Switzerland; Tel.: 41-1-377-2605, Fax: 41-1-371-2556. David S. Chapman, Dept. of Geology and Geophysics, Univ. of Utah, Salt Lake City, UT, U.S.A., 84112; Tel.: 1-801-581-6820, Fax: 1-801-581-7065. Valiya M. Hamza, Institute of Astronomy and Geophysics, University of Sao Paulo, C.P. 9638, 01050 Sao Paulo SP, Brazil; Fax: 55-11-815-4272.
- **19th Annual Workshop on Geothermal Reservoir Engineering—Stanford University**, Stanford, California, 18–20 January 1994. Contact: Jean Cook, Geothermal Program Manager, Petroleum Engineering Department, Green Building, Stanford, CA 94305-2220, U.S.A.; Tel.: 1-415-723-4745, Fax: 1-415-725-2099.

BILL SMITH
NCPA
(DATE?)

5. DEEP WELL CONTINUOUSLY CORED THROUGH THE GEYSERS RESERVOIR

Background-

In order to improve the ability to predict future reservoir performance at The Geysers, and the further changes that will occur in steam quality, far more complete determinations need to be made of specific reservoir parameters for the full vertical extent of the "typical" dry steam reservoir. And to the extent practical, these determinations need to be extended deeper into that reservoir section than present development exists, in order to determine if the underlying high temperature-high chloride-high NCG ("HTR") reservoir of the Northwest Geysers is also beneath the main part of the field.

Throughout The Geysers the dry steam reservoir typically begins at depths of from 3,000 to 5,000 ft, with production wells commonly extending downward through an interval thickness of 5,000 ft to an average total depth of about 9,000 ft. The produced steam comes from both fluid-filled fractures and from reservoir rock matrix, but their relative storage capacities still remain very uncertain because typical fracture investigative tools, such as down-hole televiewers, are inoperative in these wells incapable of being filled with water, and because the samples of reservoir rock normally obtained during drilling are completely disaggregated by the air drilling process. Some core samples have been obtained from within The Geysers reservoir section, but to date they collectively total only between 150 and 200 ft. These cores represented about 20 discontinuous intervals from as many scattered wells. Consequently, less than 4% of the reservoir interval has ever been core sampled, and little of that material now remains for examination.

Proposal-

A deep investigative well needs to be drilled in the Central Geysers region to acquire the information necessary to achieve improved forecasts of future reservoir performance. This well should be drilled to the top of the cap rock, which occurs at a depth of about 4500 ft, and then continuously cored through that cap rock and through the typical reservoir section to a depth of at least 9000 ft. Such a program will provide a continuous sampling of the total lithologic section present, from cap rock, through both the normal metagreywackes and progressively increased hornfelsic units, and then into the upper portions of the felsite intrusive. Continuing to a depth of 12,000 ft will characterize the reservoir section to the present limits of resource development, and deepening the well to 15,000 ft will reach the maximum suspected reservoir depth (based on seismicity data), while testing for the presence of a HTR in the area.

The wide range of specific scientific studies that can subsequently result only from having undertaken this proposed well program include a vertically continuous description of the following:

A. Reservoir physical properties: porosity, permeability, water saturation, density, velocity, and thermal conductivity.

B. Reservoir chemical properties: bulk, isotopic, fluid inclusion and pyrolysis-derived gas compositions of core materials, compositions of the various fluids recovered.

C. Mineralogical/hydrothermal variations, internal fluid saturations, leaching and solution history, and a description and dating of the felsite intrusion(s) that furnish the heat that sustains The Geysers.

D. Particular attention will focus on the distribution, orientation, relative age and hydrothermal histories of the reservoir fractures encountered.

E. In addition to simultaneously logging down-hole pressure/ temperature/flow rate (spinner) measurements, other logging tools can be utilized to the extent that their size and temperature limits permit.

Estimated Costs-

The proposed program to drill and set 4-1/2" casing to 4,500 ft and then continuously core a 4" diameter well through the Geyser reservoir to a minimum depth of 9000 ft is estimated to cost $1,395,000. As shown below, extending the well to a total depth of 12,000 ft to 15,000 ft is estimated to cost an additional $495,000 to $1,105,000.

	Proposed Well Depths		
	9,000'TD	12,000'TD	15,000'TD
Site Preparation	$41,000	$41,000	$41,000
Rig Costs @ $5100/day	510,000	760,000	1,020,000
Drilling Costs (bits,rentals,etc)	262,500	349,000	541,000
Cement, Mud, and Outside Services	432,500	567,000	701,000
Casing Costs	120,500	144,500	168,500
Valves, Wellhead, etc	28,500	28,500	28,500
Total Estimated Costs	$1,395,000	$1,890,000	$2,500,000

Anticipated Schedule Requirements-

The time needed to accomplish the basic elements of the proposed drilling/coring project can be summarized as follows:

Define Detailed Program, Site Selection, Negotiate Contracts, Prepare Location		120 days
Drill and core 4" hole to 9,000'	(115 days)	235 days
continue coring 3" hole to 12,000'	(35 days)	270 days
continue coring to 15,000'	(50 days)	320 days

ABBREVIATIONS AND ACRONYMS

Bbl.	barrel (42 gallons)
BHC	bore hole compensated
BOP	blow out preventer
BT&C	buttress threaded and coupled
CDL	compensated density log
Chl.	chlorides
circ.	circulate
Cmt.	cement
CN	compensated neutron log
compl.	completed
csg.	casing
cu. ft.	cubic feet
DC	drill collar
deg.	degrees
displ.	displace
DDNLL	dual detector neutron lifetime log
DP	drill pipe
drlg.	drilling
EUE	external upset end
°F	degrees Farenheit
FC	filter cake
GL	ground level
GR	gamma ray
hr.	hour
IEL	induction electric log
jts.	joints
KB	Kelly bushing
LASL	Los Alamos Scientific Laboratory
LCM	lost circulation material
LT&C	long threaded and coupled
max.	maximum
MI	move in
min.	minute
ml.	milliliter
MOR	move out rotary rig
MR	maximum reading
OD	outside diameter
POOH	pull out of hole
PPCo.	Phillips Petroleum Co.
ppm	parts per million
prep.	prepare
psi	pounds per square inch
psig	pounds per square inch guage
PV	plastic viscosity
RKB	Kelly bushing
rmd.	reamed
rpm	revolutions per minute
RUR	rig up rotary equipment
sec.	second
sd	sand
sx.	sacks
TD	total depth
temp.	temperature
thds.	threads
TV	true vertical depth
vis	viscosity
WL	water loss (mud filtrate)
WOC	waiting on cement (to set)
YP	yield point

from Pete Lysne; 11/93 orig. straw-person work statement

STATEMENT OF WORK

UNOCAL Geothermal

November 3, 1993
PR #AI-8115

CORING IN THE GEYSERS GEOTHERMAL FIELD

The Geothermal Research Department, Organization 6111, is supporting the Department of Energy/Geothermal Division in a diamond-coring operation to be conducted in The Geysers Geothermal Field located about 100 miles north of San Francisco. The Geysers field is in jeopardy since its pressure is declining at about 10% per year. This decline is due to a loss of working fluids (primarily water), and it is an issue of concern to the geothermal industry because The Geysers Field is one of the prime examples of geothermal development in the United States.

The DOE/GD has supported work in The Geysers for several decades, and recently Joint Industry/DOE Teams (Geysers working group) have been formulated to address the pressure-decline problem. These teams recognized that the pore structure of Geysers rocks may provide an untapped source of fluids. To study this possibility, pristine specimens of reservoir material are needed for laboratory analysis, and this material may be obtained by deepening an existing well using diamond coring techniques. The DOE/GD has placed $400K into the FY94 budget at Sandia to support coring operations.

The purpose of this purchase requisition is to enable the coring operations by allowing up to $400K to be spent by UNOCAL Geothermal, the operator of the existing well-of-interest. Day-to-day management of the coring will be under the directions of UNOCAL. Scientific direction for the project will come from the Joint Teams, and it will be transmitted to UNOCAL. Sandia will assist the Joint Teams in transmitting the scientific direction to UNOCAL as necessary.

The specific tasks to be undertaken by UNOCAL are:

1. Initiate diamond coring operations from the bottom of an existing hole, and continue until the funds allowed by Sandia are depleted. The coring operations should start at as large a diameter as possible commensurate with hole conditions and with the scientific goals determined by the Joint Teams that oversee the project. If hole conditions become difficult, or if scientific priorities indicate, the hole diameter may be decreased. In the eventuality that hole conditions become very difficult, operations may be ceased at any time by UNOCAL, Sandia and the Joint Teams in mutual consultation, before all allowed funds are spent. In any case, UNOCAL will have the final say regarding issues of safety and concerns by regulatory bodies.
2. Release recovered core to Sandia and to other institutions at the advice of the Joint Teams. The ultimate disposition of the core will be determined by the Joint Teams.
3. Provide information on operation costs, rate of hole advancement, and percent of core recovery to Sandia on a daily basis. These data will be used to allow a cost forecasting of the operation.
4. Provide a summary report on drilling conditions, problems encountered, solutions employed, and engineering practices and innovations used to complete the project.
5. Provide information on the drilling muds and other engineering data that may cause perturbations to the Science Plan developed by the Joint Teams.
6. Arrange for subcontracts pertinent to the coring operations. The main coring subcontractor is to be decided upon jointly with Sandia, but details of the subcontract remain the purview of UNOCAL.
7. Make provisions with the drilling subcontractor for normal on-site processing and preservation of the core. Input on processing and preservation will be provided by Sandia and the Joint Teams.
8. Submit subcontractor invoices to Sandia on a monthly basis for payment.
9. Limit the cost of the coring operations to $400K.

Well Name: Sulpher Bank---15 Core **Report:** 24 **Date:** 09/19/1994 **Page:** 2

Bits

Last Bit: Flow Rate: 40.0 gpm **Pressure:** 150.0 psi

No.	Bitsize in	Serial #	MF-Type	I	A	D	C	<------ Jet Sizes 32nd's						------>	TFA in2
5	5.500	L31623	LY S6					0	0	0	0	0	0	0	0.000

No.	Depth In ft	Depth Out ft	Drilled Distance ft	Hours	WOB Min/Max kip		RPM Min/Max rpm		I	O	D	L	B	G	O	R
5	825.0	1000.6	175.6	56.00	3.0	5.0	150	200								

Bottom Hole Assemblies

BHA # 3 CB-CBL-DP **Length:** 14.00 ft **Weight:** 0.0 kip

BHA # **Length:** ft **Weight:** kip

Torque/Drag

Drill Pipe

Check Depth	Torque On	Torque Off	<----- String Weight--> RTY	PU	SO	O.D.	G	S	Joints @ Location	Joints to Repair

Fuel on Hand: **Fuel Used:**

Daily Cost

Supv & Misc	0.00	Cement & Services	0.00
H2S/Noise Abatement	1265.00	Air Compressors	0.00
Location	0.00	Directional Services	0.00
Rig	7608.00	Fishing Tools & Svcs	0.00
Rig Move	0.00	Outside Labor & Svcs	750.00
Bits/Reamers	12330.00	Transportation	0.00
Well Control Parts	0.00	Casing & Accessories	0.00
Mud & Chemicals	1420.00	Production Equipment	0.00
Fuel	0.00	Tool/Equipment Maint	0.00
Equipment Rentals	80.00	Vacuum Trucking	0.00
		DAILY TOTAL	23453.00
		CUMULATIVE	455387.50
		AFE TOTAL	559000.00

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Geothermal Resources and Power Generation

Well Name: Sulpher Bank---15 Core **Report:** 23 **Date:** 09/18/1994 **Page:** 1

Sidetrack: 0 0 0 0 0
AFE Number: 342002
Supervisor: Tomas/Bundy
Rig Contractor: Tonto Drilling Co.
Rig Name: U 500 020-500

Hours Drilled: 0.00
Hours Tripped: 0.00
Hours Repair: 0.00
Hours Other: 24.00

Size in	Top ft	Bottom ft
20.000	0.0	28.0
10.750	0.0	499.0
8.625	-3.1	394.0
7.000	21.1	816.0

Rig Days: 23 **Hours:** 0 **Depth @ 2400 Hours:** 908.6 ft **TVD:** 908.6 ft
Drlg Days: 19 **Hours:** 2 **Footage:** 72.6 ft **ETD:** 908.6 ft

Current Formation: Graywacke
Accidents - LTA: N **OSHA:** N **Safety Meetings:**

24 Hour Comments

Cored 5.5" hole from 836' to 908.6' with 90 % mud returns.

Core #	Depth	Footage	% Recovery	Remarks/Formation
3	836 - 845.5	9.5	10' = 105 %	Graywacke
4	845.5 - 855.5	10	10.3 = 103 %	"
5	855.5 - 865.7	10.3	10.3 = 100 %	"
6	865.7 - 875.9	10.2	10.3 = 101 %	"
7	875.9 - 880.6	4.7	4.0 = 85 %	"
8	880.6 - 890.2	9.6	10.5 = 109 %	"
9	890.2 - 898.6	8.4	8.8 = 105 %	"
10	898.6 - 908.6	10.0	10.0 = 100 %	"

00:00 To 06:00 Comments

Cored 5.5" hole from 908.6 to 935' with 90 % mud returns.

Core #	Depth	Footage	% Recovery	Remarks/Formation
11	908.6 - 918.3	9.7	10.2 = 105 %	Graywacke
12	918.3 - 928.3	10.0	10.0 = 100 %	Graywacke
13	928.3 - still on going			

Surveys

Planned Azimuth

MD	Angle	Azm	Tmp	TVD	V.Sect	<----- Closure -----> Distance	Azm	Total Coordinates (N/-S)	(E/-W)	DLS

Mud

Wt ppg	Vis sec	Water Loss APIWL/ Ck cc	32nd"	pH S	pH Fl	Cl- ppm	YP phsf	PV cp	Gel Strength 10 Sec.	10 Min. phsf	Sand %	Solid %	MBT lbm/bbl	Ca ppm	XLime lbm/bbl
8.40	32	20.00	0.0	9.20	0.00	1000	2.00	3.0	0.00	1.00	0.00	0.00	0.0	0	0.0

Temperatures: Flowline: 136.0 **Suction:** 0.0 **Max:** 0.0 deg_F **Cooling Tower:** N

Mud Pumps

Manufacturer	Model	Stk	Liner	SPM	Eff

Bits

Last Bit: Flow Rate: 0.0 gpm **Pressure:** 0.0 psi

No.	Bitsize in	Serial #	MF-Type	I	A	D	C	<------- Jet Sizes 32nd"	------>	TFA in2
5	5.500	L31623	LY S6					0 0 0 0 0 0 0 0		0.000

Well Name: Sulpher Bank---15 Core **Report:** 23 **Date:** 09/18/1994 **Page:** 2

No.	Depth In ft	Depth Out ft	Drilled Distance ft	Hours	WOB Min/Max kip	RPM Min/Max rpm	IODLBGOR
5	825.0	908.6	83.6	36.00	3.0 5.0	100 150	

Bottom Hole Assemblies

BHA # 3 CB-CBL-DP — Length: 14.00 ft, Weight: 0.0 kip

BHA # — Length: ft, Weight: kip

Torque/Drag

Check Depth	Torque On	Torque Off	<----- String Weight--> RTY	PU	SO

Drill Pipe

O.D.	G	S	Joints @ Location	Joints to Repair

Fuel on Hand: **Fuel Used:**

Daily Cost

Supv & Misc	0.00	Cement & Services	0.00
H2S/Noise Abatement	110.00	Air Compressors	0.00
Location	0.00	Directional Services	0.00
Rig	7407.00	Fishing Tools & Svcs	0.00
Rig Move	0.00	Outside Labor & Svcs	750.00
Bits/Reamers	0.00	Transportation	0.00
Well Control Parts	0.00	Casing & Accessories	0.00
Mud & Chemicals	984.00	Production Equipment	0.00
Fuel	0.00	Tool/Equipment Maint	0.00
Equipment Rentals	470.00	Vacuum Trucking	0.00
		DAILY TOTAL	9721.00
		CUMULATIVE	431934.50
		AFE TOTAL	559000.00

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Geothermal Resources and Power Generation

Well Name: Sulpher Bank---15 Core **Report:** 22 **Date:** 09/17/1994 **Page:** 1

Sidetrack: 0 0 0 0 0
AFE Number: 342002
Supervisor: Tomas/Bundy
Rig Contractor: Tonto Drilling Co.
Rig Name: U 500 020-500

Hours Drilled: 0.25
Hours Tripped: 4.25
Hours Repair: 0.00
Hours Other: 19.50

Size in	Top ft	Bottom ft
20.000	0.0	28.0
10.750	0.0	499.0
8.625	-3.1	394.0
7.000	21.1	816.0

Rig Days: 22 **Hours:** 0 **Depth @ 2400 Hours:** 836.0 ft **TVD:** 836.0 ft
Drlg Days: 18 **Hours:** 2 **Footage:** 13.0 ft **ETD:** 836.0 ft

Current Formation: Graywacke
Accidents - LTA: N **OSHA:** N **Safety Meetings:**

24 Hour Comments

Laid down 7" landing joint. Rigged down Bill casing tong equipment. RIH with 6" bit. Cleaned out 7' of fill. Drilled 2' of hole from 823' to 825'. POH. Prepare rig for coring. Made up wireline equipment. Clean mud tanks and mixed polymer mud. RIH with core barrel assembly. Cut core # 1 from 825' to 834'. Core recovered was 8.2',all of which was 100 % Graywacke. Cut core # 2 from 834' to 836' with full mud returns. Had 100% core recovery.

00:00 To 06:00 Comments

Cut core # 3 from 836' to 845.5' and core # 4 from 845.5' to 855.5' with full mud returns.

Surveys

Planned Azimuth

MD	Angle	Azm	Tmp	TVD	V.Sect	<---- Closure -----> Distance	Azm	Total Coordinates (N/-S)	(E/-W)	DLS

Mud

Wt ppg	Vis sec	Water Loss API WL / Ck cc	32nd"	pH S	pH FI	Cl- ppm	YP phsf	PV cp	Gel Strength 10 Sec.	10 Min. phsf	Sand %	Solid %	MBT lbm/bbl	Ca ppm	XLime lbm/bbl
8.40	33	20.00	0.0	9.30	0.00	1000	4.00	4.0	0.00	1.00	0.00	0.00	0.0	0	0.0

Temperatures: Flowline: 0.0 **Suction:** 0.0 **Max:** 0.0 deg_F **Cooling Tower:** N

Mud Pumps

Manufacturer	Model	Stk	Liner	SPM	Eff

Bits

Last Bit: Flow Rate: 0.0 gpm **Pressure:** 0.0 psi

No.	Bitsize in	Serial #	MF-Type	I	A	D	C	<------- Jet Sizes 32nd"	------>	TFA in2
5	5.500	L31623	LY S6					0 0	0 0 0 0 0 0	0.000

No.	Depth In ft	Depth Out ft	Drilled Distance ft	Hours	WOB Min/Max kip		RPM Min/Max rpm		I	O	D	L	B	G	O	R
5	825.0	836.0	11.0	12.00	3.0	3.0	100	150								

Bottom Hole Assemblies

BHA # 2 BIT-IBS-BS-XO-190.7DC **Length:** 199.00 ft **Weight:** 9.9 kip

BHA # **Length:** ft **Weight:** kip

Well Name: Sulpher Bank--15 Core Report: 22 Date: 09/17/1994 Page: 2

Torque/Drag **Drill Pipe**

Check Depth	Torque On	Torque Off	<---- String Weight--> RTY	PU	SO	O.D.	G	S	Joints @ Location	Joints to Repair

Fuel on Hand: **Fuel Used:**

Daily Cost

Supv & Misc	0.00	Cement & Services	0.00
H2S/Noise Abatement	110.00	Air Compressors	0.00
Location	0.00	Directional Services	0.00
Rig	6187.00	Fishing Tools & Svcs	0.00
Rig Move	0.00	Outside Labor & Svcs	1470.00
Bits/Reamers	2000.00	Transportation	0.00
Well Control Parts	0.00	Casing & Accessories	0.00
Mud & Chemicals	1316.00	Production Equipment	0.00
Fuel	2161.00	Tool/Equipment Maint	0.00
Equipment Rentals	480.00	Vacuum Trucking	1008.00
		DAILY TOTAL	14732.00
		CUMULATIVE	422213.50
		AFE TOTAL	559000.00

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Geothermal Resources and Power Generation

Well Name: Sulpher Bank---15 Core **Report:** 21 **Date:** 09/16/1994 **Page:** 1

Sidetrack: 0 0 0 0 0
AFE Number: 342002
Supervisor: Tomas/Bundy
Rig Contractor: Tonto Drilling Co.
Rig Name: U 500 020-500

Hours Drilled: 0.00
Hours Tripped: 0.00
Hours Repair: 0.00
Hours Other: 24.00

Size in	Top ft	Bottom ft
20.000	0.0	28.0
10.750	0.0	499.0
8.625	-3.1	394.0
7.000	21.1	816.0

Rig Days: 21 **Hours:** 0 **Depth @ 2400 Hours:** 823.0 ft **TVD:** 823.0 ft
Drlg Days: 17 **Hours:** 2 **Footage:** 0.0 ft **ETD:** 823.0 ft

Current Formation:

Accidents - LTA: N **OSHA:** N **Safety Meetings:**

24 Hour Comments

Made wiper trip to shoe and laid down excess CHD 134 rod on derrick. Ran back in hole. Worked on ledge at 633'. Continued RIH to 820'. Cleaned out 3' of fill on bottom. Made 2nd wiper trip. Encountered restriction at 730'. Reamed and washed to 750'. Continued RIH to bottom. Circulated. Made 3rd wiper tirp. No tight hole and no fill on bottom. POH. Laid down 4-3/4" drilling assembly. Rigged up to run 7" casing. Ran in 10 joints of 7" 23 #/ft, K-55, SFJ casing, 10 joints of 7" 20#/ft, CK-55, STC 8Rd casing, 2 cross overs and buttress pup joint. Net Length = 804.58'. Hole tight starting from 633' and had to circulate inside casing and worked pipe going down. Made up landing joint and ran casing to bottom. Had 7' of fill. Unable to wash fill by circulating inside casing. Laid out 1 pup joint. Released casing with shoe at 816', top of buttress casing collar is 2' below hanger spool.

00:00 To 06:00 Comments

Laid down landing joint. Rigged down Bill casing tong and accessories. RIH with 6" bit. Cleaned out 7' of fill. Drilled 2' of hole from 823' to 825'. POH.

Surveys

Planned Azimuth						<----- Closure ----->		Total Coordinates		
MD	Angle	Azm	Tmp	TVD	V.Sect	Distance	Azm	(N/-S)	(E/-W)	DLS

Mud

Wt	Vis	Water Loss API/WL / Ck	pH S	pH Fl	Cl-	YP	PV	Gel Strength 10 Sec. 10 Min.	Sand	Solid	MBT	Ca	XLime

Temperatures: Flowline: **Suction:** **Max:** **Cooling Tower:**

Mud Pumps

Manufacturer	Model	Stk	Liner	SPM	Eff

Bits

Last Bit: Flow Rate: **Pressure:**

No.	Bitsize	Serial #	MF-Type	I	A	D	C	<------- Jet Sizes	------>	TFA

No.	Depth In	Depth Out	Drilled Distance	Hours	WOB Min/Max	RPM Min/Max	I	O	D	L	B	G	O	R

Well Name: Sulpher Bank---15 Core Report: 21 Date: 09/16/1994 Page: 2

Bottom Hole Assemblies

BHA # Length:
Weight:

BHA # Length:
Weight:

Torque/Drag **Drill Pipe**

Check Depth	Torque On	Torque Off	<----- String Weight--> RTY	PU	SO	O.D.	G	S	Joints @ Location	Joints to Repair

Fuel on Hand: **Fuel Used:**

Daily Cost

Supv & Misc	0.00	Cement & Services	0.00
HZS/Noise Abatement	110.00	Air Compressors	0.00
Location	0.00	Directional Services	0.00
Rig	5967.00	Fishing Tools & Svcs	0.00
Rig Move	0.00	Outside Labor & Svcs	6491.00
Bits/Reamers	0.00	Transportation	0.00
Well Control Parts	0.00	Casing & Accessories	0.00
Mud & Chemicals	654.00	Production Equipment	0.00
Fuel	0.00	Tool/Equipment Maint	0.00
Equipment Rentals	1056.00	Vacuum Trucking	347.00
		DAILY TOTAL	14625.00
		CUMULATIVE	407481.50
		AFE TOTAL	559000.00

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Geothermal Resources and Power Generation

Well Name: Sulpher Bank---15 Core **Report:** 20 **Date:** 09/15/1994 **Page:** 1

Sidetrack: 0 0 0 0 0
AFE Number: 342002
Supervisor: Tomas/Bundy
Rig Contractor: Tonto Drilling Co.
Rig Name: U 500 020-500

Hours Drilled: 10.50
Hours Tripped: 2.00
Hours Repair: 0.00
Hours Other: 11.50

Size in	Top ft	Bottom ft
20.000	0.0	28.0
10.750	0.0	499.0
8.625	-3.1	394.0

Rig Days: 20 **Hours:** 0 **Depth @ 2400 Hours:** 823.0 ft **TVD:** 823.0 ft
Drlg Days: 16 **Hours:** 2 **Footage:** 33.0 ft **ETD:** 823.0 ft

Current Formation:

Accidents - LTA: N **OSHA:** N **Safety Meetings:**

24 Hour Comments

Continued drilling 7-3/4" sidetracked hole from 790' to 803' with full mud returns. Bit torqued up. POH. Changed bit. RIH with 7-3/4" drilling assembly. Encountered bridge/ledge at 633'. Reamed and washed hole to 650'. RIH to 661'. Reamed and washed to 671'. RIH to 750'. Reamed and washed hole to 803'. Drilled 7-3/4" hole to 823' with full mud returns. Circulated. Laid down excess CHD 134 rod in derrick while making wiper trip to shoe.

00:00 To 06:00 Comments

Made wiper trip to shoe and laid down excess CHD 134 rod on derrick. Ran back in hole. Worked on ledge at 633'. Continued RIH to 820'. Cleaned out 3' of fill on bottom. At 0600 hrs, making 2nd wiper trip.

Surveys

Planned Azimuth

MD	Angle	Azm	Tmp	TVD	V.Sect	<---- Closure ----> Distance	Azm	Total Coordinates (N/-S)	(E/-W)	DLS

Mud

Wt ppg	Vis sec	Water Loss API/WL / Ck cc	32nd"	pH S	pH Fl	Cl- ppm	YP phsf	PV cp	Gel Strength 10 Sec.	10 Min. phsf	Sand %	Solid %	MBT lbm/bbl	Ca ppm	XLime lbm/bbl
8.69	46	30.00	3.0	10.20	0.00	700	26.00	6.0	17.00	24.00	1.00	0.00	15.0	280	0.0

Temperatures: Flowline: 128.0 **Suction:** 0.0 **Max:** 0.0 deg_F **Cooling Tower:** N

Mud Pumps

Manufacturer	Model	Stk	Liner	SPM	Eff

Bits

Last Bit: Flow Rate: 0.0 gpm **Pressure:** 0.0 psi

No.	Bitsize in	Serial #	MF-Type	I	A	D	C	<------ Jet Sizes 32nd"	------>	TFA in2
4	7.750	E8208	SM DTJ					3 32	0 0 0 0 0 0	2.356

No.	Depth In ft	Depth Out ft	Drilled Distance ft	Hours	WOB Min/Max kip		RPM Min/Max rpm		I	O	D	L	B	G	O	R
4	526.0	790.0	264.0	0.00	3.0	6.0	70	80	5	5	WT	A	8	2	CT	HR

Well Name: Sulpher Bank---15 Core Report: 20 Date: 09/15/1994 Page: 2

Bottom Hole Assemblies

BHA # 2	BIT-IBS-BS-XO-190.7DC	Length:	199.00 ft
		Weight:	9.9 kip
BHA #		Length:	ft
		Weight:	kip

Torque/Drag **Drill Pipe**

Check Depth	Torque On	Torque Off	<---- String Weight--> RTY	PU	SO	O.D.	G	S	Joints @ Location	Joints to Repair

Fuel on Hand: **Fuel Used:**

Daily Cost

Supv & Misc	0.00	Cement & Services	0.00
H2S/Noise Abatement	110.00	Air Compressors	0.00
Location	0.00	Directional Services	0.00
Rig	6000.00	Fishing Tools & Svcs	0.00
Rig Move	0.00	Outside Labor & Svcs	912.00
Bits/Reamers	0.00	Transportation	0.00
Well Control Parts	0.00	Casing & Accessories	0.00
Mud & Chemicals	215.00	Production Equipment	0.00
Fuel	0.00	Tool/Equipment Maint	0.00
Equipment Rentals	1556.00	Vacuum Trucking	284.00

DAILY TOTAL	9077.00
CUMULATIVE	392856.50
AFE TOTAL	559000.00

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Geothermal Resources and Power Generation

Well Name: Sulpher Bank---15 Core **Report:** 26 **Date:** 09/21/1994 **Page:** 1

Sidetrack: 0 0 0 0 0
AFE Number: 342002
Supervisor: Tomas/Bundy
Rig Contractor: Tonto Drilling Co.
Rig Name: U 500 020-500

Hours Drilled: 0.00
Hours Tripped: 0.00
Hours Repair: 0.00
Hours Other: 24.00

Size in	Top ft	Bottom ft
20.000	0.0	28.0
10.750	0.0	499.0
8.625	-3.1	394.0
7.000	21.1	816.0

Rig Days: 26 **Hours:** 0 **Depth @ 2400 Hours:** 1125.0 ft **TVD:** 1125.0 ft
Drlg Days: 22 **Hours:** 2 **Footage:** 69.0 ft **ETD:** 1125.0 ft

Current Formation: Graywacke

Accidents - LTA: N **OSHA:** N **Safety Meetings:**

24 Hour Comments

Continued cutting core with 5-1/2" core bit from 1056' to 1125' with 80% returns. Ran deviation survey at 1094' = 7 deg. S 40 W, BHT = 268 deg. F.

Core #	Depth	Footage	% Recovery	Remarks
28	1056.4 - 1064.4	8.0	8.0' = 100 %	Graywacke
29	1064.4 - 1069.6	5.2	5.2 = 100 %	"
30	1069.6 - 1077.6	8.0	8.0 = 100 %	"
31	1077.6 - 1084.0	6.4	6.3 = 99 %	"
32	1084.0 - 1094.0	10.0	10.3 = 103 %	"
33	1094.0 - 1099.0	5.0	5.0 = 100 %	"
34	1099.0 - 1109.0	10.0	10.0 = 100 %	"
35	1109.0 - 1115.0	6.0	6.0 = 100 %	"
36	1115.0 - 1125.0	10.0	10.0 = 100 %	"

00:00 To 06:00 Comments

Continued cutting core with 5-1/2" core bit from 1125' to 1154' with 80% mud returns. ROP = 4'/hr, Flowline Temp. = 156 deg. F.

Core #	Depth	Footage	% Recovery	Remarks
37	1125 - 1134	9.0	100%	Graywacke
38	1134 - 1144	10.0	100%	"
39	1144 - 1154	10.0	(in the process of retrieving core)	

Surveys

Planned Azimuth

MD	Angle	Azm	Tmp	TVD	V.Sect	<----- Closure -----> Distance	Azm	Total Coordinates (N/-S)	(E/-W)	DLS

Mud

Wt ppg	Vis sec	Water Loss API WL / Ck cc	32nd"	pH S	pH Fl	Cl- ppm	YP phsf	PV cp	Gel Strength 10 Sec. phsf	10 Min. phsf	Sand %	Solid %	MBT lbm/bbl	Ca ppm	XLime lbm/bbl
8.40	32	24.00	0.0	0.00	8.50	1200	2.00	3.0	0.00	0.00	0.00	1.00	0.0	160	0.0

Temperatures: Flowline: 156.0 **Suction:** 0.0 **Max:** 156.0 deg_F **Cooling Tower:** N

Mud Pumps

Manufacturer	Model	Stk	Liner	SPM	Eff

Bits

Last Bit: Flow Rate: 40.0 gpm **Pressure:** 100.0 psi

No.	Bitsize in	Serial #	MF-Type	I	A	D	C	<------- Jet Sizes 32nd"	------>	TFA in2
6	5.500	L31622	LY S6					0 0 0 0 0 0 0 0		0.000

Well Name: Sulpher Bank---15 Core **Report:** 26 **Date:** 09/21/1994 **Page:** 2

No.	Depth In ft	Depth Out ft	Drilled Distance ft	Hours	WOB Min/Max kip	RPM Min/Max rpm	I O D L B G O R
6	1006.9	1125.0	118.1	38.75	3.0 5.0	150 200	

Bottom Hole Assemblies

BHA # 3 CB-CBL-DP **Length:** 14.00 ft **Weight:** 0.0 kip

BHA # **Length:** ft **Weight:** kip

Torque/Drag **Drill Pipe**

Check Depth	Torque On	Torque Off	<---- String Weight--> RTY	PU	SO	O.D.	G	S	Joints @ Location	Joints to Repair

Fuel on Hand: **Fuel Used:**

Daily Cost

Supv & Misc	0.00	Cement & Services	0.00
H2S/Noise Abatement	165.00	Air Compressors	0.00
Location	0.00	Directional Services	0.00
Rig	7347.00	Fishing Tools & Svcs	0.00
Rig Move	0.00	Outside Labor & Svcs	750.00
Bits/Reamers	0.00	Transportation	0.00
Well Control Parts	0.00	Casing & Accessories	0.00
Mud & Chemicals	1081.00	Production Equipment	0.00
Fuel	0.00	Tool/Equipment Maint	0.00
Equipment Rentals	80.00	Vacuum Trucking	0.00
		DAILY TOTAL	9423.00
		CUMULATIVE	474763.50
		AFE TOTAL	559000.00

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Geothermal Resources and Power Generation

Well Name: Sulpher Bank---15 Core **Report:** 25 **Date:** 09/20/1994 **Page:** 1

Sidetrack: 0 0 0 0 0
AFE Number: 342002
Supervisor: Tomas/Bundy
Rig Contractor: Tonto Drilling Co.
Rig Name: U 500 020-500

Hours Drilled: 0.00
Hours Tripped: 3.25
Hours Repair: 0.00
Hours Other: 20.75

Size in	Top ft	Bottom ft
20.000	0.0	28.0
10.750	0.0	499.0
8.625	-3.1	394.0
7.000	21.1	816.0

Rig Days: 25 **Hours:** 0 **Depth @ 2400 Hours:** 1056.0 ft **TVD:** 1056.0 ft
Drlg Days: 21 **Hours:** 2 **Footage:** 55.4 ft **ETD:** 1056.0 ft

Current Formation: Graywacke
Accidents - LTA: N **OSHA:** N **Safety Meetings:** Proper core handling

24 Hour Comments

Continued cutting core with 5-1/2" core bit from 1000.6 to 1006.9 with 90 % mud returns. Rate of penetration slowed down to .3 feet per hour. POH to check bit. Bit was worn out. Made up new 5-1/2" core bit. RIH. Cleaned out 6" of fill on bottom. Continued cutting core from 1006' to 1052' with 90% returns. Encountered TLC at 1052' but regained circulation back after 4 minutes. Continued cutting core from 1052' to 1056' with 80% returns.

Core #	Depth	Footage	% Recovery	Remarks/Formation
21	1000.6'-1006.6'	6.0'	6' = 100%	Graywacke
22	1006.6'-1006.9	.3'	.3 = 100 %	Graywacke
23	1006.9 -1016.6	9.8	9.6 = 98 %	"
24	1016.6 -1026.2	9.6	9.6 = 100 %	"
25	1026.2- 1036.4	10.2	10.3 = 101 %	"
26	1036.4- 1046.4	10.0	10.0 = 100 %	"
27	1046.4- 1056.4	10.0	10.2 = 102 %	"

00:00 To 06:00 Comments

Continued cutting core with 5-1/2" core bit from 1056' to 1078' with 80% returns. ROP = 3.6'/hr, Flowline Temp. = 148 deg. F.

Core #	Depth	Footage	% Recovery	Remarks
28	1056.4 - 1064.4	8.0	8.0' = 100 %	Graywacke
29	1064.4 - 1069.6	5.2	5.2 = 100 %	"

Surveys

Planned Azimuth

MD	Angle	Azm	Tmp	TVD	V.Sect	<----- Closure -----> Distance	Azm	Total Coordinates (N/-S)	(E/-W)	DLS

Mud

Wt ppg	Vis sec	Water Loss API WL / Ck cc	32nd"	pH S	pH Fl	Cl- ppm	YP phsf	PV cp	Gel Strength 10 Sec.	10 Min. phsf	Sand %	Solid %	MBT lbm/bbl	Ca ppm	XLime lbm/bbl
8.40	33	20.00	0.0	8.60	8.60	1100	2.00	4.0	0.00	0.00	0.00	1.00	0.0	80	0.0

Temperatures: Flowline: 143.0 **Suction:** 0.0 **Max:** 152.0 deg_F **Cooling Tower:** N

Mud Pumps

Manufacturer	Model	Stk	Liner	SPM	Eff

Bits

Last Bit: Flow Rate: 40.0 gpm **Pressure:** 100.0 psi

No.	Bitsize in	Serial #	MF-Type	I	A	D	C	<------- Jet Sizes 32nd"	------>	TFA in2
5	5.500	L31623	LY S6					0 0 0 0 0 0 0 0		0.000
6	5.500	L31622	LY S6					0 0 0 0 0 0 0 0		0.000

Well Name: Sulpher Bank---15 Core **Report:** 25 **Date:** 09/20/1994 **Page:** 2

No.	Depth In ft	Depth Out ft	Drilled Distance ft	Hours	WOB Min/Max kip		RPM Min/Max rpm		I	O	D	L	B	G	O	R
5	825.0	1006.9	181.9	58.00	3.0	5.0	150	200	6	5	SS	A	5	I	NO	PR
6	1006.9	1056.0	49.1	17.75	3.0	5.0	150	200								

Bottom Hole Assemblies

BHA # 3 CB-CBL-DP **Length:** 14.00 ft **Weight:** 0.0 kip

BHA # **Length:** ft **Weight:** kip

Torque/Drag

Check Depth	Torque On	Torque Off	<---- String Weight--> RTY	PU	SO

Drill Pipe

O.D.	G	S	Joints @ Location	Joints to Repair

Fuel on Hand: **Fuel Used:**

Daily Cost

Supv & Misc	0.00	Cement & Services	0.00
H2S/Noise Abatement	165.00	Air Compressors	0.00
Location	0.00	Directional Services	0.00
Rig	7075.00	Fishing Tools & Svcs	0.00
Rig Move	0.00	Outside Labor & Svcs	926.00
Bits/Reamers	0.00	Transportation	0.00
Well Control Parts	0.00	Casing & Accessories	0.00
Mud & Chemicals	1360.00	Production Equipment	0.00
Fuel	0.00	Tool/Equipment Maint	0.00
Equipment Rentals	80.00	Vacuum Trucking	347.00

DAILY TOTAL	9953.00
CUMULATIVE	465340.50
AFE TOTAL	559000.00

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Geothermal Resources and Power Generation

Well Name: Sulpher Bank---15 Core **Report:** 24 **Date:** 09/19/1994 **Page:** 1

Sidetrack: 0 0 0 0 0
AFE Number: 342002
Supervisor: Tomas/Bundy
Rig Contractor: Tonto Drilling Co.
Rig Name: U 500 020-500

Hours Drilled: 0.00
Hours Tripped: 0.00
Hours Repair: 0.00
Hours Other: 24.00

Size in	Top ft	Bottom ft
20.000	0.0	28.0
10.750	0.0	499.0
8.625	-3.1	394.0
7.000	21.1	816.0

Rig Days: 24 **Hours:** 0 **Depth @ 2400 Hours:** 1000.6 ft **TVD:** 1000.6 ft
Drlg Days: 20 **Hours:** 2 **Footage:** 92.0 ft **ETD:** 1000.6 ft

Current Formation: Graywacke
Accidents - LTA: N **OSHA:** N **Safety Meetings:**

24 Hour Comments

Continued cutting core with 5-1/2" core bit from 908.6 to 1000.6' with 90 % mud returns.

Core #	Depth	Footage	% Recovery	Remarks/Formation
11	908.6 - 918.3	9.7	10.2 = 105 %	From 908' to 931', had
12	918.3 - 928.3	10.0	10.0 = 100 %	60% Graywacke and 40 %
13	928.3 - 938.0	9.7	10.0 = 103 %"	Argillite, from 931' to
14	938.0 - 948.0	10.0	10.3 = 103 %	934' is 80% Graywackwe
15	948.0 - 957.7	9.2	10.0 = 108 %	with 20% black carbona-
16	957.7 - 965.7	8.0	8.1 = 101 %	ceous shale, from 934'
17	965.7 - 975.6	9.9	10.3 = 103 %	to 1000.6' had 75% Gray
18	975.6 - 985.6	10.0	10.3 = 103 %	wacke and 25% Argillite
19	985.6 - 990.6	5.0	5.0 = 100 %	
20	990.6 - 1000.6	10.0	10.0 = 100 %	

Note: Pumping rate while coring is 40 gallon per minute.

00:00 To 06:00 Comments

Continued cutting core with 5-1/2" core bit from 1000.6 to 1006.9 with 90 % mud returns. Rate of Penetration slowed down to .3 feet per hour. POH to check bit. Bit was worn out. Made up new 5-1/2" core bit. RIH. Cleaned out 6" of fill on bottom.

Core #	Depth	Footage	% Recovery	Remarks/Formation
21	1000.6'-1006.6'	6'	100%	Graywacke
22	1006.6'-1006.9	.3'	100%	Graywacke

Surveys

Planned Azimuth

MD	Angle	Azm	Tmp	TVD	V.Sect	<----- Closure -----> Distance	Azm	Total Coordinates (N/-S)	(E/-W)	DLS

Mud

Wt ppg	Vis sec	Water Loss API WL / Ck cc	32nd"	pH S	pH Fl	Cl- ppm	YP phsf	PV cp	Gel Strength 10 Sec.	10 Min. phsf	Sand %	Solid %	MBT lbm/bbl	Ca ppm	XLime lbm/bbl
8.40	32	25.00	0.0	8.80	0.00	1000	2.00	3.0	0.00	0.00	0.00	1.00	0.0	80	0.0

Temperatures: Flowline: 152.0 **Suction:** 0.0 **Max:** 0.0 deg_F **Cooling Tower:** N

Mud Pumps

Manufacturer	Model	Stk	Liner	SPM	Eff

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Unocal Energy Resources

Geothermal Resources and Power Generation

UNOCAL 76

Well Name: Sulpher Bank--15 Core **Report:** 19 **Date:** 09/14/1994 **Page:** 1

Sidetrack: 0 0 0 0 0
AFE Number: 342002
Supervisor: Tomas/Bundy
Rig Contractor: Tonto Drilling Co.
Rig Name: U 500 020-500

Hours Drilled: 17.00
Hours Tripped: 0.00
Hours Repair: 0.00
Hours Other: 7.00

Size in	Top ft	Bottom ft
20.000	0.0	28.0
10.750	0.0	499.0
8.625	-3.1	394.0

Rig Days: 19 **Hours:** 0 **Depth @ 2400 Hours:** 790.0 ft **TVD:** 790.0 ft
Drlg Days: 15 **Hours:** 2 **Footage:** -3345.0 ft **ETD:** 790.0 ft

Current Formation:

Accidents - LTAN OSHA: N **Safety Meetings:**

24 Hour Comments

Drilled out cement from 533' to 691' with full mud returns. Continued cleaning out and started seeing formation cuttings at 710'. Drilled ahead and had 99% rock cuttings coming over shale shaker starting from 759' to 790'. Had full mud returns to surface while cleaning out cement and formation.

00:00 To 06:00 Comments

Continued drilling 7-3/4" hole from 790' to 803' with full mud returns. Bit torqued up. POH. RIH with 7-3/4" drilling assembly.

Surveys

Planned Azimuth

MD	Angle	Azm	Tmp	TVD	V.Sect	<-- Closure --> Distance	Azm	Total Coordinates (N/-S)	(E/-W)	DLS

Mud

Wt ppg	Vis sec	Water Loss API WL / Ck cc	32nd"	pH S	pH Fl	Cl- ppm	YP phsf	PV cp	Gel Strength 10 Sec.	10 Min. phsf	Sand %	Solid %	MBT lbm/bbl	Ca ppm	XLime lbm/bbl
8.69	48	30.00	3.0	0.00	0.00	700	30.00	5.0	18.00	19.00	1.00	0.00	19.0	360	0.0

Temperatures: Flowline: 146.0 Suction: 0.0 Max: 0.0 deg_F Cooling Tower: N

Mud Pumps

Manufacturer	Model	Stk	Liner	SPM	Eff

Bits

Last Bit: Flow Rate: 0.0 gpm Pressure: 0.0 psi

No.	Bitsize in	Serial #	MF-Type	I	A	D	C	<-- Jet Sizes 32nd" -->						TFA in2
4	7.750	E8208	SM DTJ					3	32	0	0	0	0	2.356

No.	Depth In ft	Depth Out ft	Drilled Distance ft	Hours	WOB Min/Max kip		RPM Min/Max rpm		I	O	D	L	B	G	O	R
4	526.0	790.0	264.0	0.00	4.0	6.0	70	80								

Bottom Hole Assemblies

BHA # 1 BIT-IBS-BS-XO-190.7DC **Length:** 199.00 ft **Weight:** 9.9 kip

BHA # **Length:** **Weight:**

Well Name: Sulpher Bank---15 Core Report: 19 Date: 09/14/1994 Page: 2

Torque/Drag **Drill Pipe**

Check Depth	Torque On	Torque Off	<— String Weight—> RTY	PU	SO	O.D.	G	S	Joints @ Location	Joints to Repair

Fuel on Hand: **Fuel Used:**

Daily Cost

Supv & Misc	0.00	Cement & Services	0.00
H2S/Noise Abatement	110.00	Air Compressors	0.00
Location	0.00	Directional Services	0.00
Rig	5967.00	Fishing Tools & Svcs	0.00
Rig Move	0.00	Outside Labor & Svcs	2102.00
Bits/Reamers	0.00	Transportation	0.00
Well Control Parts	0.00	Casing & Accessories	0.00
Mud & Chemicals	830.00	Production Equipment	0.00
Fuel	0.00	Tool/Equipment Maint	0.00
Equipment Rentals	4265.00	Vacuum Trucking	221.00
		DAILY TOTAL	13495.00
		CUMULATIVE	398198.50
		AFE TOTAL	559000.00

UNOCAL 76

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UNOCAL 76

Well Name: Sulpher Bank---15 Core **Report:** 18 **Date:** 09/13/1994 **Page:** 1

Sidetrack: 0 0 0 0 0
AFE Number: 342002
Supervisor: Tomas/Bundy
Rig Contractor: Tonto Drilling Co.
Rig Name: U 500 020-500

Hours Drilled: 0.00
Hours Tripped: 7.00
Hours Repair: 0.00
Hours Other: 17.00

Size in	Top ft	Bottom ft
20.000	0.0	28.0
10.750	0.0	499.0
8.625	-3.1	394.0

Rig Days: 18 **Hours:** 0 **Depth @ 2400 Hours:** 4135.0 ft **TVD:** 4135.0 ft
Drlg Days: 14 **Hours:** 2 **Footage:** 0.0 ft **ETD:** 4135.0 ft

Current Formation: Cement

Accidents - LTA: N **OSHA:** N **Safety Meetings:**

24 Hour Comments

POH. RIH with 5" CHD 134 rod to 772'. Circulated. Rigged up Haliburton. Pumped 20 barrels water. Mixed and pumped 400 CF of cement slurry consisting of Class G Cement with 40% Silica Flour, 4% Gel, and 0.5% CFR-3. Displaced cement with 6 bbls of fresh water. Had good mud returns to surface while cementing and displacing. CIP at 0400 hrs. POH. WOC 3 hours. RIH with cementing string and located TOC at 660'. Circulated while preparing for next cement job. Howco mixed and pumped 291 CF cement slurry consisting of Class G cement with 40% Silica Flour, 4% Gel, and 0.5% CFR-3. Had cement returns to surface. Pulled back to 480' and circulated out cement inside casing. POH. Made up 7-3/4" drilling assembly. WOC 5 hours. RIH. Located top of soft cement at 526'. WOC for 2 hours. Cleaned out cement from 526' to 533' with full mud returns at 2400 hrs.

00:00 To 06:00 Comments

Continued drilling out cement from 533' to 691' with full mud returns.

Surveys

Planned Azimuth

MD	Angle	Azm	Tmp	TVD	V.Sect	<----- Closure -----> Distance	Azm	Total Coordinates (N/-S)	(E/-W)	DLS

Mud

Wt ppg	Vis sec	Water Loss API WL / Ck cc	32nd"	pH S	pH FI	Cl- ppm	YP phsf	PV cp	Gel Strength 10 Sec.	10 Min. phsf	Sand %	Solid %	MBT lbm/bbl	Ca ppm	XLime lbm/bbl
8.69	40	30.00	4.0	12.40	0.00	800	8.00	4.0	11.00	14.00	0.00	2.50	12.0	320	0.0

Temperatures: Flowline: 100.0 **Suction:** 0.0 **Max:** 0.0 deg_F **Cooling Tower:** N

Mud Pumps

Manufacturer	Model	Stk	Liner	SPM	Eff

Bits

Last Bit: Flow Rate: 0.0 gpm **Pressure:** 0.0 psi

No.	Bitsize in	Serial #	MF-Type	I	A	D	C	<------- Jet Sizes 32nd"	------>	TFA in2
3	7.750		SE					3 32	0 0 0 0 0 0	2.356

No.	Depth In ft	Depth Out ft	Drilled Distance ft	Hours	WOB Min/Max kip		RPM Min/Max rpm		I	O	D	L	B	G	O	R
3	671.0	2580.0	0.0	0.00	5.0	5.0	40	50	2	3	SS	H	4	1	NO	HP

Well Name: Sulpher Bank---15 Core **Report:** 18 **Date:** 09/13/1994 **Page:** 2

Bottom Hole Assemblies

BHA # 1	BIT-IBS-BS-XO-190.7DC	**Length:**	199.00 ft
		Weight:	9.9 kip
BHA #		**Length:**	
		Weight:	

Torque/Drag **Drill Pipe**

Check Depth	Torque On	Torque Off	<----- String Weight--> RTY	PU	SO	O.D.	G	S	Joints @ Location	Joints to Repair

Fuel on Hand: **Fuel Used:**

Daily Cost

Supv & Misc	0.00	Cement & Services	21866.00
H2S/Noise Abatement	110.00	Air Compressors	0.00
Location	0.00	Directional Services	0.00
Rig	5967.00	Fishing Tools & Svcs	0.00
Rig Move	0.00	Outside Labor & Svcs	1108.00
Bits/Reamers	0.00	Transportation	0.00
Well Control Parts	0.00	Casing & Accessories	0.00
Mud & Chemicals	313.00	Production Equipment	0.00
Fuel	0.00	Tool/Equipment Maint	0.00
Equipment Rentals	884.00	Vacuum Trucking	945.00
		DAILY TOTAL	31193.00
		CUMULATIVE	384703.50
		AFE TOTAL	559000.00

Report #17 9/12/94

Continued cleaning out bridge from 1120' to 1148' with 80% returns. Hole sloughing. Had tight hole and 10' of fill. Large amounts of cuttings were coming over the shaker. POH to shoe. Changed slush pump liners and valve seat. Changed worn out stripper rubber on rotating head. Cleaned ~~out~~ mud tanks and mixed new mud. RIH with 7-3/4" cleanout assembly. Encountered bridge at 665'. Cleaned out bridge to 775'. POH. Made wiper trip to 10 3/4" shoe. RIH to 775'. No tight hole and no fill.

Report #15. 9/10/94

Continued POH to 10-3/4" shoe. Hole pulling tight all the way to 573. Built up mud volume with cotton seed LCM in mud pits. RIH with same 7-3/4" cleanout assembly. Encountered bridge at 730'. Cleaned out bridge to 770'. RIH to 1165'. Cleaned out bridge to 1225' with PLC of 50 BPH. RIH to 1465'. Cleaned out bridge to 1475'. RIH to 1694'. Cleaned out bridge blind with mud to 1734'. RIH to 1871. Reamed and washed 8-3/4" hole blind with mud to 2344.

Report #16 9/11/94

Continued reaming 8-3/4" hole blind with mud from 2344' to 2580'. Centrifugal pump used for mixing mud broke down. Running low on mud. POH. Hole tight at 2520'. Circulated and worked pipe. POH. Hole tight from 858' to 720'. Continued POH. Checked bit. Bit still ok. RIH to 394'. Built up mud volume. Continued RIH with 7-3/4" cleanout assembly. Encountered bridge at 716'. Cleaned out bridge to 848' with partial circulation loss of 70 BPH. POH to 690' to checks if hole will stay open. Ran back to 850'. RIH to 1120'. Added extra pump to gun system.

Sept. 14 09/09 —

Cont. cleaning out 9 7/8" hole fr. 1225' to 1670' w PLC of 25 BPH. Encl. TLC @ 1670'. Reamed and washed 9 7/8" hole blind to top of 8 3/4" hole at 1790 ft. Cont. cleaning out 8 3/4" hole blind w/mud to 2200'. Hole sloughed — hole tight — worked pipe.

Rpt. 13

RIH to 10¾" shoe. Cleaned mud tanks & mixed new mud w/ cottonseed ~~hulls~~ LCM. RIH w/ 7⅞" cleanout assembly. Enc. bridge at 671'. Cleaned out bridge to 710' w/ partial loss. circ. of 20 BPH. Hole sloughing. Spent 6 hr. reaming and circ. hole clean at this spot. Cleaned out bridge to 720'. TLC. Circ and worked pipe RIH by stands to 1143'. Cleaned out bridge fr. 1143 to 1220 w/ partial LC of ½ BPH. Spent 2 hr. cleaning out hole fr. 1200 to 1220' due to sloughing problem. Cleaned out bridge to 1225'. Enc. TLC, Circ. and worked pipe, regaining partial returns as of 2400 hrs.

(11) 09/06/94

Cont. clng. out bridge to 661'. Reg. full returns. Built up mud vol. & cleaned out bridge w/ polymer mud to 680'. Cleaned out bridge fr. 680' to 710' w/ intermittent returns. Having 5' of fill. Had to re-ream hole and slugged hole as necessary. Built up gel/lime mud in mud pits. Cleaned out bridge from 710 to 747'. Enc. TLC @ 748' but regained circulation back after 5 minutes. Cont. cleaning out ~~hole~~ bridge w/ mud from 748 to 1439'. Enc. TLC at 1439' Hole getting tight. Worked pipe free.

(12) 09/07/94

POH to 10 3/4" shoe. Had tight spot fr. 1310' to 1231'. RIH. Enc. bridge at 711'. Cleaned out bridge to 1284' w/ 50% returns. Circ. Pipe got stuck while making connection. Worked pipe free. Circ. to condition mud & clean hole. Cleaned out bridge to 1295'. Enc. TLC POH. Had tight hole from 1100 to 700'. Changed bit. Making up 7 3/4" cleanout assembly as of 2400 hr

REPORT 10 — SEPTEMBER 5, 1994 — MONDAY, LABOR DAY

CLOSED BLIND RAM, MADE UP 7¼" O.D. SOCKET DRESSED TO 3" SLIP SHORT CATCH. CHECKED PRESSURE GAUGE ON CHOKELINE BEFORE OPENING WELL. WELL HAD 30 P.S.I. EVEN WHILE CONTINUOUSLY PUMPING WATER DOWN ANNULUS AT 2 BPM. WELL WAS ON VACUUM AFTER PUMPING CONDENSATE WATER FOR 3 HR. RIH W/FISHING ASSEMBLY LOC. TOP OF PACKER AT 623'. CIRC. TRIED TO GET HOLD OF PACKER W/O SUCCESS. P.O.H. RIH W/PACKER-RETRIEVING TOOL DOWN TO (628') HAD SUDDEN INCREASE IN PUMP PRESSURE AND HAD GAINED ADDITIONAL STRING WT. P.O.H. RECOVERED & LAID DOWN PACKER. MADE UP 7¾" CLEAN-OUT ASSEMBLY. RIH & ENCOUNTERED BRIDGE AT (628'). CLEANED OUT BRIDGE W/WATER TO 651'. UNABLE TO MAKE ROD CONNECT. HAD 8-10 FT OF FILL. RE-REAMED HOLE & PUMPED 20 ~~BBL~~ BARREL MUD SWEEP.

REPORT 9 — SEPTEMBER 4, 1994 — SUNDAY

CIRCULATED OUT SAND FILL TO TOP OF BAKER INFLATABLE PACKER RETRIEVING TOOL TO 477 FT. CIRC. TRIED TO GET AHOLD OF PACKER W/O SUCCESS. PACKER SLIPPING DOWNHOLE. CHASED PACKER TO 517 FT. TRIED AGAIN TO GET AHOLD OF PACKER W/O SUCCESS. POH. FABRICATED 7" LIP GUIDE FOR BAKER RETRIEVING TOOL. RIH TO 620 FT. CIRC. WORKED RETRIEVING TOOL W/O SUCCESS. RAN BACK W/ SAME FISHINGS TOOL TO 620 FT. PUMPED 168 CF HI-VIS PILL. WORKED TOOL DOWN TO 623 FT. TRIED TO GET HOLD OF FISH SEVERAL TIMES W/O SUCCESS. P.O.H. CHECKED FISHING TOOL & FOUND TIP OF LIP GUIDE A LITTLE BENT IN.

Calculation Record

UNOCAL 76

PREPARED BY	CHECKED BY	DATE	PAGE
			OF

SUBJECT: SB-15-D (RPT. 8) | W.O./A.F.E. NO.:

SAT. SEPT. 3 DAILY REPORT (TRANSCRIBED FROM CRT)

WELDED 8⅝" CSNG. HEAD. PRESSURE-TESTED CASING-HEAD WELD TO 500 PSI (OK). INSTALLED A- 10" DONUT-400 DONUT HANGER SPOOL & A 10" WKM MASTER VALVE. NIPPLE UP BOP. INSTALLED ROTATING HEAD & FLOWLINE. HOOKED UP CHOKELINE & KILL LINE PRESSURE-TESTED BLIND RAM & CHOKELINE TO 500 PSI (OK). RIH W/ 7¾" BIT. LOC. T.O.C. INSIDE 8⅝" CASING AT 341 FT. CLEANED OUT TO 370'. CIRCULATED. PRESSURE-TESTED PIPE RAM & ANNULAR RAM TO 500 P.S.I (OK). CLEANED OUT CEMENT TO 372 FT. P.O.H. PICKED UP ADDITIONAL 2 JOINTS TO 468 FT. AS OF 2400 HRS.

UNOCAL 76

Unocal Energy Resources

Geothermal Resources and Power Generation

UNOCAL 76

Well Name: Sulpher Bank---15 Core **Report:** 7 **Date:** 09/02/1994 **Page:** 1

Sidetrack: 0 0 0 0 0
AFE Number: 342002
Supervisor: Tomas/Bundy
Rig Contractor: Tonto Drilling Co.
Rig Name: U 5000

Hours Drilled: 0.00
Hours Tripped: 1.00
Hours Repair: 0.00
Hours Other: 23.00

Size in	Top ft	Bottom ft
20.000	0.0	28.0
10.750	0.0	499.0
8.625	-3.1	394.0

Rig Days: 7 **Hours:** 0 **Depth @ 2400 Hours:** 4135.0 ft **TVD:** 4135.0 ft
Drlg Days: 3 **Hours:** 2 **Footage:** 0.0 ft **ETD:** 4135.0 ft

Current Formation:

Accidents - LTA: N **OSHA:** N **Safety Meetings:**

24 Hour Comments

Continued POH. Pressure tested casing to 200 psi for 10 minutes,(Ok). Rigged up Bill Casing Tong equipment. Ran 10 joints of 8-5/8", 36#, K-55, Buttress casing with special clearance couplings. Net Length = 397.11'. Landed 8-5/8" shoe at 394', and 8-5/8" flapper float insert at 353'. Circulated to cool well prior to cement casing. Cemented 8-5/8" casing with 124 CF cement slurry consisting of Class G Cement with 40% Silica Flour, 3% Gel and 1% CFR-3. Displaced cement with 118 CF water. CIP at 0535 hrs. Had good cement returns to surface while displacing cement. WOC 12 hrs. Slacked off and cut 8-5/8" casing. Laid down BOP and 10" master valve. Cut 10-3/4" casing and laid down 10-3/4" casing head. Made final cut on 8-5/8" casing at 2400 hrs.

00:00 To 06:00 Comments

Installed 8-5/8" casing head. Pressure tested casing head weld to 500 psi, (OK). Installed 10"-400 donut hanger spool and 10" WKM master valve. Nippled up BOPE. At 0600 hrs, tightening bolts on wellhead and BOPE flange connections.

Surveys

Planned Azimuth MD	Angle	Azm	Tmp	TVD	V.Sect	<----- Closure -----> Distance	Azm	Total Coordinates (N/-S)	(E/-W)	DLS

Mud

Wt	Vis	Water Loss API WL / Ck	pH S	pH Fl	Cl-	YP	PV	Gel Strength 10 Sec. 10 Min.	Sand	Solid	MBT	Ca	XLime

Temperatures: Flowline: **Suction:** **Max:** **Cooling Tower:**

Mud Pumps

Manufacturer	Model	Stk	Liner	SPM	Eff

Bits

Last Bit: Flow Rate: **Pressure:**

No.	Bitsize	Serial #	MF-Type	I	A	D	C	<------- Jet Sizes ------>	TFA

No.	Depth In	Depth Out	Drilled Distance	Hours	WOB Min/Max	RPM Min/Max	I	O	D	L	B	G	O	R

Well Name: Sulpher Bank---15 Core **Report:** 7 **Date:** 09/02/1994 **Page:** 2

Bottom Hole Assemblies

BHA #	Length:
	Weight:
BHA #	Length:
	Weight:

Torque/Drag **Drill Pipe**

Check Depth	Torque On	Torque Off	<----- String Weight--> RTY	PU	SO	O.D.	G	S	Joints @ Location	Joints to Repair

Fuel on Hand: **Fuel Used:**

Daily Cost

Supv & Misc	0.00	Cement & Services	10783.00
H2S/Noise Abatement	110.00	Air Compressors	0.00
Location	0.00	Directional Services	0.00
Rig	5967.00	Fishing Tools & Svcs	0.00
Rig Move	0.00	Outside Labor & Svcs	828.00
Bits/Reamers	0.00	Transportation	300.00
Well Control Parts	0.00	Casing & Accessories	6329.00
Mud & Chemicals	0.00	Production Equipment	0.00
Fuel	0.00	Tool/Equipment Maint	0.00
Equipment Rentals	1312.00	Vacuum Trucking	0.00
		DAILY TOTAL	25629.00
		CUMULATIVE	206677.00
		AFE TOTAL	559000.00

Calculation Record

UNOCAL 76

PREPARED BY	CHECKED BY	DATE	PAGE
			OF

SUBJECT	W.O/A.F.E. NO.
SB-15-D	

SEPT. 1 DAILY REPT

REPT. 6 —— TRANSCRIBED

CONT. WOC FOR 7½ hr. RIH & tagged @ 462'. Circ. Set OEDP @ 452 ft. SPOTTED 30 lin. ft. of cmt. plug. CIP @ 1015 hr. POH. PICKED UP 7 Joints 8⅝" casing and stood back in derrick while WOC. RIH to 250ft while WOC. WOC total of 12 hr. RIH w/9⅞" bit. Loc. TOC @ 395'. Circ. POH as of 2400 hrs

UNOCAL 76

Unocal Energy Resources

Geothermal Resources and Power Generation

UNOCAL 76

Well Name: Sulpher Bank--15 Core **Report:** 5 **Date:** 08/31/1994 **Page:** 1

Sidetrack: 0 0 0 0 0
AFE Number: 342002
Supervisor: Walters/Bundy/Tomas
Rig Contractor: Tonto Drilling Co.
Rig Name: U 5000

Hours Drilled: 0.00
Hours Tripped: 19.50
Hours Repair: 0.00
Hours Other: 4.50

Size in	Top ft	Bottom ft
20.000	0.0	28.0
10.750	0.0	499.0

Rig Days: 5 **Hours:** 0 **Depth @ 2400 Hours:** 4135.0 ft **TVD:** 4135.0 ft
Drlg Days: 1 **Hours:** 2 **Footage:** 0.0 ft **ETD:** 4135.0 ft

Current Formation:

Accidents - LTA: N **OSHA:** N **Safety Meetings:** Held BOP and H2S meeting

24 Hour Comments

Killed well at 1.6 BPM. Made up 9-7/8" drilling assembly. RIH to 515' with no obstruction. Continuously pumped water in annulus at 2 BPM while tripping out of hole. RIH with 7" Baker inflatable packer (P.I.P) and set at 491' with top of plug at 477'. Set OEDP at 451'. Dropped 10 sacks of screened sand down hole through OEDP. Waited on sand to settle. Ran back OEDP located top of sand at 473'. POH. Dropped additional 6 sacks of sand down 10-3/4" casing. RIH with CHD coring rods. Located top of sand fill at 458'. Cleaned out sand to 468'. Placed 15 linear feet of cement on top of sand fill. CIP at 1900 hrs. POH. Ran in hole with 9-7/8" bit to 250 while WOC. Continue WOC at 2400 hrs.

00:00 To 06:00 Comments

Continue WOC for a total of 7-1/2 hrs. Ran in hole and tagged at 466'. POH. At 0600 hrs, continue POH to run 8-5/8" casing.

Surveys

Planned Azimuth

MD	Angle	Azm	Tmp	TVD	V.Sect	<----- Closure -----> Distance	Azm	Total Coordinates (N/-S)	(E/-W)	DLS

Mud

Wt	Vis	Water Loss API WL / Ck	pH S	pH FI	Cl-	YP	PV	Gel Strength 10 Sec. 10 Min.	Sand	Solid	MBT	Ca	XLime

Temperatures: Flowline: **Suction:** **Max:** **Cooling Tower:**

Mud Pumps

Manufacturer	Model	Stk	Liner	SPM	Eff

Bits

Last Bit: Flow Rate: 0.0 gpm **Pressure:** 0.0 psi

No.	Bitsize in	Serial #	MF-Type	I	A	D	C	<------- Jet Sizes 32nd'	------>	TFA in2
1	9.880	570682	SE M44N	2	1	4		0 0	0 0 0 0 0 0	0.000

No.	Depth In ft	Depth Out ft	Drilled Distance ft	Hours	WOB Min/Max kip		RPM Min/Max rpm		I	O	D	L	B	G	O	R
1	515.0	515.0	0.0	0.00	0.0	0.0	0	0	1	1	NO	A	1	I	NO	TD

Well Name: Sulpher Bank---15 Core **Report:** 5 **Date:** 08/31/1994 **Page:** 2

Bottom Hole Assemblies

BHA #	Length:
	Weight:
BHA #	Length:
	Weight:

Torque/Drag **Drill Pipe**

Check Depth	Torque On	Torque Off	<----- String Weight--> RTY	PU	SO	O.D.	G	S	Joints @ Location	Joints to Repair

Fuel on Hand: **Fuel Used:**

Daily Cost

Supv & Misc	572.00	Cement & Services	4524.00
H2S/Noise Abatement	860.00	Air Compressors	0.00
Location	6016.00	Directional Services	0.00
Rig	9884.00	Fishing Tools & Svcs	0.00
Rig Move	0.00	Outside Labor & Svcs	374.00
Bits/Reamers	0.00	Transportation	304.00
Well Control Parts	0.00	Casing & Accessories	9035.00
Mud & Chemicals	0.00	Production Equipment	0.00
Fuel	0.00	Tool/Equipment Maint	0.00
Equipment Rentals	2026.00	Vacuum Trucking	0.00
		DAILY TOTAL	33595.00
		CUMULATIVE	158654.00
		AFE TOTAL	559000.00

UNOCAL 76 **Unocal Energy Resources** UNOCAL 76

Geothermal Resources and Power Generation

Well Name: Sulpher Bank--15 Core **Report:** 4 **Date:** 08/30/1994 **Page:** 1

Sidetrack: 0 0 0 0 0
AFE Number: 342002
Supervisor: Walters/Bundy/Tomas
Rig Contractor: Tonto Drilling Co.
Rig Name: U 5000

Hours Drilled: 0.00
Hours Tripped: 0.00
Hours Repair: 0.00
Hours Other: 24.00

Size in	Top ft	Bottom ft
20.000	0.0	28.0
10.750	0.0	499.0

Rig Days: 4 **Hours:** 0 **Depth @ 2400 Hours:** 4135.0 ft **TVD:** 4135.0 ft
Drlg Days: 0 **Hours:** 0 **Footage:** 0.0 ft **ETD:** 4135.0 ft

Current Formation:

Accidents - LTAN OSHA: N **Safety Meetings:**

24 Hour Comments

Rig up 100% complete. Rig on day rate at 22:00 Hrs on 08/30/94. Installed rotating head, hooked up flowline, choke line and manifold. Functioned tested BOPE,(OK). Opened 3" wing valve. WHP = 130 PSI. Killed well using condensate water. Started killing well at a rate of .4 BPM. Staged to 1.5 BPM at 2400 hrs.

00:00 To 06:00 Comments

Killed well at 1.6 BPM. Made up 9-7/8" drilling assembly. RIH to 400' as of 0600 hrs with no obstruction encountered. Continuously pumped water in the annulus at 2 BPM to keep the well dead while running in the hole.

Surveys

Planned Azimuth

MD	Angle	Azm	Tmp	TVD	V.Sect	<-- Closure --> Distance	Azm	Total Coordinates (N/-S)	(E/-W)	DLS

Mud

Wt	Vis	Water Loss API/WL / Ck	pH S	pH Fl	Cl-	YP	PV	Gel Strength 10 Sec. 10 Min.	Sand	Solid	MBT	Ca	XLime

Temperatures: Flowline: Suction: Max: Cooling Tower:

Mud Pumps

Manufacturer	Model	Stk	Liner	SPM	Eff

Bits

Last Bit: Flow Rate: Pressure:

No.	Bitsize	Serial #	MF-Type	I	A	D	C	<-- Jet Sizes -->	TFA

No.	Depth In	Depth Out	Drilled Distance	Hours	WOB Min/Max	RPM Min/Max	I	O	D	L	B	G	O	R

Bottom Hole Assemblies

BHA # Length:
Weight:

BHA # Length:
Weight:

Well Name: Sulpher Bank---15 Core Report: 4 Date: 08/30/1994 Page: 2

Torque/Drag **Drill Pipe**

Check Depth	Torque On	Torque Off	<— String Weight—> RTY	PU	SO	O.D.	G	S	Joints @ Location	Joints to Repair

Fuel on Hand: **Fuel Used:**

Daily Cost

Supv & Misc	1824.00	Cement & Services	0.00
H2S/Noise Abatement	0.00	Air Compressors	0.00
Location	0.00	Directional Services	0.00
Rig	840.00	Fishing Tools & Svcs	0.00
Rig Move	66418.00	Outside Labor & Svcs	2939.00
Bits/Reamers	3480.00	Transportation	4472.00
Well Control Parts	650.00	Casing & Accessories	0.00
Mud & Chemicals	0.00	Production Equipment	200.00
Fuel	0.00	Tool/Equipment Maint	0.00
Equipment Rentals	2486.00	Vacuum Trucking	0.00
		DAILY TOTAL	83309.00
		CUMULATIVE	125059.00
		AFE TOTAL	559000.00

UNOCAL 76

Unocal Energy Resources

UNOCAL 76

Geothermal Resources and Power Generation

Well Name: Sulpher Bank---15 Core **Report:** 3 **Date:** 08/29/1994 **Page:** 1

Sidetrack: 0 0 0 0 0
AFE Number: 342002
Supervisor: Walters/Bundy
Rig Contractor: Tonto Drilling Co.
Rig Name: U 5000

Hours Drilled: 0.00
Hours Tripped: 0.00
Hours Repair: 0.00
Hours Other: 24.00

Size in	Top ft	Bottom ft
20.000	0.0	28.0
10.750	0.0	499.0

Rig Days: 3 **Hours:** 0 **Depth @ 2400 Hours:** 4135.0 ft **TVD:** 4135.0 ft
Drlg Days: 0 **Hours:** 0 **Footage:** 0.0 ft **ETD:** 4135.0 ft

Current Formation:

Accidents - LTA: N **OSHA:** N **Safety Meetings:**

24 Hour Comments

Rigged up Tonto U 5000 core rig. Rig up is 95% complete. Finished water lines at rig. Installed BOE. Working on choke and kill lines. Hauled 8-5/8" casing to location. Six living trailers set.

00:00 To 06:00 Comments

No activity. Daylight rig up.

Surveys

Planned Azimuth MD	Angle	Azm	Tmp	TVD	V.Sect	<----- Closure -----> Distance	Azm	Total Coordinates (N/-S)	(E/-W)	DLS

Mud

Wt	Vis	Water Loss API WL / Ck	pH S	pH Fl	Cl-	YP	PV	Gel Strength 10 Sec. 10 Min.	Sand	Solid	MBT	Ca	XLime

Temperatures: Flowline: Suction: Max: Cooling Tower:

Mud Pumps

Manufacturer	Model	Stk	Liner	SPM	Eff

Bits

Last Bit: Flow Rate: Pressure:

No.	Bitsize	Serial #	ME-Type	I	A	D	C	<------ Jet Sizes ------>	TFA

No.	Depth In	Depth Out	Drilled Distance	Hours	WOB Min/Max	RPM Min/Max	I	O	D	L	B	G	O	R

Bottom Hole Assemblies

BHA # Length: Weight:

BHA # Length: Weight:

Well Name: Sulpher Bank---15 Core **Report:** 3 **Date:** 08/29/1994 **Page:** 2

Torque/Drag **Drill Pipe**

Check Depth	Torque On	Torque Off	<---- String Weight--> RTY	PU	SO	O.D.	G	S	Joints @ Location	Joints to Repair

Fuel on Hand: **Fuel Used:**

Daily Cost

Supv & Misc	500.00	Cement & Services	0.00
H2S/Noise Abatement	0.00	Air Compressors	0.00
Location	0.00	Directional Services	0.00
Rig	750.00	Fishing Tools & Svcs	0.00
Rig Move	0.00	Outside Labor & Svcs	0.00
Bits/Reamers	0.00	Transportation	500.00
Well Control Parts	0.00	Casing & Accessories	0.00
Mud & Chemicals	0.00	Production Equipment	0.00
Fuel	0.00	Tool/Equipment Maint	0.00
Equipment Rentals	0.00	Vacuum Trucking	0.00
		DAILY TOTAL	1750.00
		CUMULATIVE	41750.00
		AFE TOTAL	559000.00

UNOCAL 76 **Unocal Energy Resour s** UNOCAL 76

Geothermal Resources and Power Generation

Well Name: Sulpher Bank---15 Core **Report:** 2 **Date:** 08/28/1994 **Page:** 1

Sidetrack: 0 0 0 0 0
AFE Number: 342002
Supervisor: Walters/Bundy
Rig Contractor: Tonto Drilling Co.
Rig Name: U 5000

Hours Drilled: 0.00
Hours Tripped: 0.00
Hours Repair: 0.00
Hours Other: 24.00

Size in	Top ft	Bottom ft
20.000	0.0	28.0
10.750	0.0	499.0

Rig Days: 2 **Hours:** 0 **Depth @ 2400 Hours:** 4135.0 ft **TVD:** 4135.0 ft
Drlg Days: 0 **Hours:** 0 **Footage:** 0.0 ft **ETD:** 4135.0 ft

Current Formation:

Accidents - LTA: N **OSHA:** N **Safety Meetings:**

24 Hour Comments

Rigging up core rig. 70% rigged up. Completed building pony bases at 1245 hrs. Set in sub-bases. Mounted and raised mast. Set in mud pits.

00:00 To 06:00 Comments

No activity. Rigging up, daylights only.

Surveys

Planned Azimuth

MD	Angle	Azm	Tmp	TVD	V.Sect	<---- Closure ----> Distance	Azm	Total Coordinates (N/-S)	(E/-W)	DLS

Mud

Wt	Vis	Water Loss API/WL / Ck	pH S	pH Fl	Cl-	YP	PV	Gel Strength 10 Sec. 10 Min.	Sand	Solid	MBT	Ca	XLime

Temperatures: Flowline: Suction: Max: Cooling Tower:

Mud Pumps

Manufacturer	Model	Stk	Liner	SPM	Eff

Bits

Last Bit: Flow Rate: Pressure:

No.	Bitsize	Serial #	MF-Type	I	A	D	C	<------ Jet Sizes ------>	TFA

No.	Depth In	Depth Out	Drilled Distance	Hours	WOB Min/Max	RPM Min/Max	I	O	D	L	B	G	O	R

Bottom Hole Assemblies

BHA # Length:
Weight:

BHA # Length:
Weight:

Torque/Drag **Drill Pipe**

Check Depth	Torque On	Torque Off	<---- String Weight--> RTY	PU	SO	O.D.	G	S	Joints @ Location	Joints to Repair

Well Name: Sulpher Bank--15 Core **Report:** 2 **Date:** 08/28/1994 **Page:** 2

Fuel on Hand: **Fuel Used:**

Daily Cost

Supv & Misc	0.00	Cement & Services	0.00
H2S/Noise Abatement	0.00	Air Compressors	0.00
Location	5000.00	Directional Services	0.00
Rig	0.00	Fishing Tools & Svcs	0.00
Rig Move	0.00	Outside Labor & Svcs	0.00
Bits/Reamers	0.00	Transportation	0.00
Well Control Parts	0.00	Casing & Accessories	0.00
Mud & Chemicals	0.00	Production Equipment	35000.00
Fuel	0.00	Tool/Equipment Maint	0.00
Equipment Rentals	0.00	Vacuum Trucking	0.00
		DAILY TOTAL	40000.00
		CUMULATIVE	40000.00
		AFE TOTAL	559000.00

Well Name: Sulpher Bank--15 Core **Report:** 1 **Date:** 08/27/1994 **Page:** 1

Sidetrack: 0 0 0 0 0
AFE Number: 342002
Supervisor: Walters/Bundy
Rig Contractor: Tonto Drilling Co.
Rig Name: U 5000

Hours Drilled: 0.00
Hours Tripped: 0.00
Hours Repair: 0.00
Hours Other: 24.00

Size in	Top ft	Bottom ft
20.000	0.0	28.0
10.750	0.0	499.0

Rig Days: 1 **Hours:** 0 **Depth @ 2400 Hours:** 4135.0 ft **TVD:** 4135.0 ft
Drlg Days: 0 **Hours:** 0 **Footage:** 0.0 ft **ETD:** 4135.0 ft

Current Formation:

Accidents - LTA: N **OSHA:** N **Safety Meetings:** Contractor orientation 8-26-94

24 Hour Comments

Moved in Tonto U-5000 core rig. Rigging up.
Held general safety orientation for all contractors, scientists and other interested parties Fri 8/26/94 at 0900 hrs at Unocal lunchroom.

00:00 To 06:00 Comments

No activity. On daylights rigging up core rig.

Surveys

Planned Azimuth

MD	Angle	Azm	Tmp	TVD	V.Sect	<----- Closure -----> Distance	Azm	Total Coordinates (N/-S)	(E/-W)	DLS

Mud

Wt	Vis	Water Loss API WL / Ck	pH S	pH Fl	Cl-	YP	PV	Gel Strength 10 Sec. 10 Min.	Sand	Solid	MBT	Ca	XLime

Temperatures: Flowline: Suction: Max: Cooling Tower:

Mud Pumps

Manufacturer	Model	Stk	Liner	SPM	Eff

Bits

Last Bit: Flow Rate: Pressure:

No.	Bitsize	Serial #	MF-Type	I	A	D	C	<----- Jet Sizes ----->	TFA

No.	Depth In	Depth Out	Drilled Distance	Hours	WOB Min/Max	RPM Min/Max	I	O	D	L	B	G	O	R

Bottom Hole Assemblies

BHA # Length:
Weight:

BHA # Length:
Weight:

Well Name: Sulpher Bank---15 Core **Report:** 1 **Date:** 08/27/1994 **Page:** 2

Torque/Drag **Drill Pipe**

Check Depth	Torque On	Torque Off	<-- String Weight--> RTY	PU	SO	O.D.	G	S	Joints @ Location	Joints to Repair

Fuel on Hand: **Fuel Used:**

Daily Cost

Supv & Misc	0.00	Cement & Services	0.00
H2S/Noise Abatement	0.00	Air Compressors	0.00
Location	0.00	Directional Services	0.00
Rig	0.00	Fishing Tools & Svcs	0.00
Rig Move	0.00	Outside Labor & Svcs	0.00
Bits/Reamers	0.00	Transportation	0.00
Well Control Parts	0.00	Casing & Accessories	0.00
Mud & Chemicals	0.00	Production Equipment	0.00
Fuel	0.00	Tool/Equipment Maint	0.00
Equipment Rentals	0.00	Vacuum Trucking	0.00

DAILY TOTAL	0.00
CUMULATIVE	0.00
AFE TOTAL	559000.00

Sandia National Laboratories

SF 6432-UNB(12-88)

Purchasing Organization 10232
P. O. Box 5800
Albuquerque, NM 87185-5800

DOCUMENT NUMBER AI-8115

Document Date AUG 12 1994

This is a Contract on a Cost Sharing basis between Sandia and the Contractor noted below.

CONTRACTOR:
UNOCAL CORPORATION
ATTENTION: BRIAN KOENIG
3576 UNOCAL PLACE
SANTA ROSA, CA 95403

This Contract includes the terms on this Signature Page and:
1. Section I bearing the above document date
2. Section II SF 6432-CR (06-91) and no other terms except as expressly agreed to in writing.

Financial Rating:

Prop: V
Class: U Priority: Nonrated Insp: X
Case Sub Cls: 1651010 346

Buyer: Green Org: 10232 Ph: 4-0765
Analyst:
Requester: A. R. Sattler Org: 06111 Ph: 4-1019
Deliver To: Org: Bldg: Room:
Recvng Rpt: 10232

```
103 #1 - AI-8115  *  *     *      N     U* U* *           400000 * U02362
103 #2 - *    *  *  NA NA * * * PO CS *            *           *      *
103 #3 -  0  1 *  *  *   0  1 *  *  *  NS * 0 N 3204 *          *
103 #4 - *      083195 * * *
103 #5 - *         *       *  * * *            *      * * * * *
103 #6 - *         *      *     *      *
```

Purchasing Approvals: SCR JJ TL_____ Dept_____ PPO_____ Dir_____

MS1033 REQ I

SP

SECTION I

CLAUSE 0 - MODIFICATIONS TO SECTION II.

1. Clause A10 - Definitions are modified by:

   Delete: Contract No. DE-AC04-76DP00789
   Add: Contract No. DE-AC04-94AL85000

2. Clause R11 - Patent Royalties Due AT&T is deleted in its entirety.

3. Clause A52 or D42 - Titled Patent Indemnity is replaced in its entirety as follows:

PATENT INDEMNITY

(a) The Contractor shall indemnify Sandia and the Government and their officers, agents, and employees against liability, including costs, for infringement of any United States patent (except a patent issued upon an application that is now or may hereafter be withheld from issue pursuant to a Secrecy Order under 35 U.S.C. 181) arising out of the manufacture or delivery of supplies, the performance of services, or the construction, alteration, modification or repair of real property (hereinafter referred to as "construction work") under this contract, or out of the use or disposal by or for the account of Sandia or the Government of such supplies or construction work, but only to the extent that the manufacture or delivery of supplies, the performance of services, or construction work are those that normally are or have been sold or offered for sale by any supplier to the public in the commercial open market or that are the same as such supplies or services with relatively minor modifications.

(b) This indemnity shall not apply unless the Contractor shall have been informed as soon as practicable by Sandia or the Government of the suit or action alleging such infringement and shall have been given the opportunity as is afforded by applicable laws, rules, or regulations to participate in its defense. Further, this indemnity shall not apply to (1) an infringement resulting from compliance with specific written instructions of the SCR directing a change in the supplies to be delivered or in the materials or equipment to be used, or directing a manner of performance of the contract not normally used by the Contractor, (2) an infringement resulting from addition to or change in supplies or components furnished or construction work performed that was made subsequent to delivery or performance, or (3) a claimed infringement that is unreasonably settled without the consent of the Contractor, unless required by a final decree of a court of competent jurisdiction.

CLAUSE 1 - STATEMENT OF WORK

CORING IN THE GEYSERS GEOTHERMAL FIELD

The Geothermal Research Department, Organization 6111, is supporting the Department of Energy/Geothermal Division in a diamond-coring operation to be conducted in the Geysers Geothermal Field located about 100 miles north of San Francisco. The Geysers field pressure is declining at about 10% per year. This decline is due to a loss of working fluids (primarily water), and it is an issue of concern to the geothermal industry because The Geysers Field is one of the prime examples of geothermal development in the United States.

The DOE/GD has supported work in the Geysers for several decades, and recently Joint Industry/DOE Teams (Geysers Working Group) have been formulated to address the pressure-decline problem. These teams recognized that the pore structure of Geysers rocks may provide important clues to reservoir behavior. To study this possibility, carefully collected and preserved specimens of reservoir material are needed for laboratory analysis, and this material may be obtained by deepening an existing well using diamond coring techniques.

Day-to-day management of the coring will be under the directions of UNOCAL. Scientific direction for the project will come from the Joint Teams, and it will be transmitted to UNOCAL. Sandia will assist the Joint Teams in transmitting the scientific direction to UNOCAL as necessary.

The specific tasks to be undertaken by UNOCAL are:

1. Initiate diamond coring operations from the bottom of an existing hole, and continue until the funds allowed by Sandia are depleted. The coring operations should start at as large a diameter as possible commensurate with hole conditions and with the scientific goals determined by the Joint Teams that oversee the project. If hole conditions become difficult, or if scientific priorities indicate, the hole diameter may be decreased. In the eventuality that hole conditions become very difficult, operations may be ceased at any time by UNOCAL, Sandia and the Joint Teams in mutual consultation, before all allowed funds are spent. In any case, UNOCAL will have the final say regarding issues of safety and concerns by regulatory bodies.

2. Sandia requests that the recovered core be delivered to:

   UURI
   Research Park
   Earth Science Department
   Attn: Jeffrey Hulen
   391 Chipeta Way, Ste C
   Salt Lake City, Utah 84108

   UNOCOL may retain any portion of the core agreed to by the Sandia Delegated Representative (SDR).

3. Provide information on operation costs, rate of hole advancement and percent of core recovery to Sandia on a daily basis. These data will be used to allow a cost forecasting of the operation.

4. Provide a summary report on drilling conditions, problems encountered, solutions employed, and engineering practices and innovations used to complete the project.

5. Provide information on the drilling muds and other engineering data as requested that may cause perturbations to the Science Plan developed by the Joint Teams.

6. Arrange for subcontracts pertinent to the coring operations. The main coring subcontractor is to be decided upon jointly with Sandia, but details of the subcontract remain the purview of UNOCAL.

7. UNOCAL will make any necessary arrangements for processing and preservation of the core. These arrangements will be made in consultation with the Joint Teams who will provide a site specific Core Protocol.

CLAUSE 2 - SUBCONTRACTS

Subcontracting effort, identified below, is authorized under this contract.

Subcontractor name:	Description of effort to be furnished:
Tonto Drilling Services, Inc. Salt Lake City, UT	Wireline coring
M-I Drilling Fluids Company Healdsburg, CA	Drilling fluids
Epoch Well Logging, Inc. Bakersfield, CA	Core logging/handling

See Section II Standard Terms and Conditions for Time and Material or Labor Hours Contracts, Clause A35 Subcontracts.

CLAUSE 3 - PERIOD OF PERFORMANCE

The term of this contract shall be from May 1, 1994 through a period of one year.

CLAUSE 4 - PRECONTRACT COSTS - 212-KPC (12-92)

Costs and/or commitments incurred subsequent to May 1, 1994 in the performance of the scope of work of this contract and charged to the Contractor's job number 342002 will be allowable to the extent that these costs would have been allowable if incurred after the date of this contract; and provided that these costs and/or commitments do not exceed $200,000.00 prior to the date of this definitive contract.

CLAUSE 5 - CEILING PRICE

The ceiling price for this contract is $400,000.00

Sandia shall not be obligated to make any additional payments and the Contractor shall not be obligated to furnish further services, when cumulative billings under this contract total the above amount, or a lesser amount as indicated in the "Limitation of Obligation" Clause, if such an clause appears in this contract.

Contractor shall give written notification to Sandia's Contracting Representative, when billings total 75% of the ceiling price.

CLAUSE 6 - LIMITATION OF OBLIGATION - NON-FIXED PRICE CONTRACTS - 220-KLM (05-92)

Funding for the performance of this contract is authorized in accordance with the schedule given herein, until this contract clause is amended. Contractor shall not incur costs and/or make commitments for expenditures allowable under this contract in excess of the amount shown for the period ending at the date listed. When no date is stated, the funding limitation remains in full force and effect until this contract clause is amended, or until expiration of the contract. The limitation of obligation amount shown on each line is cumulative through the indicated time period(s).

CLAUSE 7 - ESTIMATE OF COST STATUS - 249-CH (05-92)

Contractor shall furnish to the SCR:

(a) With the quotation, an estimate of the percentage of cost which will be incurred each month from start to finish of the proposed contract.

(b) After award of contract, a Contractor's Monthly Cost Status Report in a form prescribed or agreed to by the SCR to reach the SCR not later than the 15th of each month following the report period or at such other time as requested by the SCR during contract.

CLAUSE 8 - ALLOWABLE CHARGES

Labor

Cost of drilling for core per linear foot (Include all costs - equipment, manpower, G&A, etc. Provide a cost breakout for each cost element included in this proposal.)	$333.33
Fixed Fee	0.00

1) $9,000 total cost per day for drilling operations

2) Penetration rate equals 75 ft./day

3) $145,000 (of the $400,000) available for wireline coring

4) Total penetration is 12000 ft.

The calculations are:

$145,000/$9,000/day - approximately 16 days

16 days x 75 ft./day = 1,200 ft.

$400,000/1200 ft. = $333.33/linear foot

Sandia will Cost Share this contract. The Sandia share will be $400,000.00. In the event all funds are not used, a portion of the funding will be returned to Sandia. In the event that the project exceeds the $400,000.00, Sandia will not be liable for any additional costs. The Cost Share breakout is shown on Attachment 1 - Summary of Shared Costs.

CLAUSE 9 - SANDIA NORMAL WORK HOURS AND HOLIDAYS

Sandia, Albuquerque normal work hours are:

8:00 AM to 4:30 PM, Monday through Friday.

Due to Sandia's observance of the below listed holidays, no work will be available at Sandia for the Contractor's employees under this contract on those days (except on an emergency basis as discussed in Clause I, Statement of Work:

1. Memorial Day
2. Independence Day
3. Labor Day
4. Thanksgiving Day
5. The six working days comprising the Christmas/New Year holiday season
6. Energy Conservation Day; date varies

Normally, when a holiday falls on Saturday, the preceding Friday is observed as the holiday; if the holiday falls on Sunday, the following Monday is observed as the holiday.

CLAUSE 10 - BILLING

Contractor's billing shall be submitted only once each month and shall include:

- Contract number
- Hours worked by labor category and by person(s) populating that category(ies)
- Listing of all purchased supplies/materials with quantities and prices of same
- Travel expenses with a detailed cost breakdown by trip by person showing dates and times of day that travel occurred, air fare, car rental, lodging, meals, etc.

CLAUSE 11 - DELEGATION OF AUTHORITY - 404-KDA (06-91)

The following Sandia personnel are hereby authorized to act as official representatives of Sandia for the specific purpose(s) shown.

Delegated representatives shall exercise no supervision over the Contractor's employees.

DELEGATE(S)	PHONE	ORG. NO.	PURPOSE(S)
Allan Sattler	505 844-1019	6111 MS 1033	At any time during the term of this Contract, the Sandia Delegated Representative (SDR) may assign work within the scope of this Contract's Statement of Work, authorize travel, approve invoices, approve time records and inspect/accept work in process or completed. The SDR serves as the technical liaison.

NOTE: The Sandia Contracting Representative (SCR) is the only person who can legally obligate Sandia for the expenditure of funds, change scope and/or level of effort and/or terms and conditions, negotiate, and sign documents legally binding Sandia. COMMITMENT, OBLIGATIONS OR PROMISES, IMPLIED OR EXPRESSED, BY SANDIA PERSONNEL OTHER THAN THE SCR DO NOT BIND SANDIA IN ANY MANNER.

CLAUSE 12 - TERMINATION OF DEFINED BENEFIT PENSION PLANS - 228-BP (02-92)

In the event this contract or any amendment, thereto, required Current Cost or Pricing Data to be submitted, the Contractor shall promptly notify the Sandia Contracting Representative (SCR) in writing when it

determines that it will terminate a defined benefit pension plan or otherwise recapture such pension fund assets. If pension fund assets revert to the Contractor or are constructively received by it under a termination or otherwise, the Contractor shall make a refund or give a credit to Sandia or the Government for its equitable share. The Contractor shall include the substance of this clause in all subcontracts under this contract, which are subject to Current Cost or Pricing Data.

CLAUSE 13 - INCORPORATION OF SUPPLEMENTAL TERMS AND CONDITIONS - 840-SX

The following Clause(s) contained in the Supplemental Terms and Conditions, SF 6432-STD (10-92), are hereby incorporated into this contract.

Clause No.	Title
206-CX	Cost Accounting Standards Notices and Clauses for National Defense Contracts
301-RN	Patent and Technical Data Provision
412-SC	Service Contract Act of 1965, as Amended
614-CP	Contractor/Subcontractor Personnel List
826-OS	Organizational Conflicts of Interest - Special

CLAUSE 14 - MODIFICATIONS TO SUPPLEMENTAL TERMS AND CONDITIONS

CLAUSE 301-RN - PATENT AND TECHNICAL DATA PROVISIONS, Section VII (g) Protection of Limited Rights Data and Restricted Computer Software has been changed to read as follows:

(1) When data other than that listed in subparagraphs (b)(1)(i), (ii), and (iii) above are specified to be delivered under this contract and qualify as either limited rights data or restricted computer software, if the Contractor desires to continue protection of such data, the Contractor shall withhold such data and not furnish them to Sandia or the Government under this contract. As a condition to this withholding, the Contractor shall identify the data being withheld and furnish form, fit, and function data in lieu thereof. Limited rights data that are formatted as a computer data base for delivery to Sandia or the Government is to be treated as limited rights data and not restricted computer software.

(2) [Reserved.]

(3) [Reserved.]

DOCUMENTS INCORPORATED BY REFERENCE, IN CONTRACTOR'S POSSESSION:

Monthly Cost Status Report - SF 6432-CS

Supplemental Terms and Conditions, SF 6432-STD (10-92)

Attachment 1 - Summary of Shared Costs, 2 pages

	Sandia/DOE		Unocal
Location (site) work			
Prepare a level surface for rig	$10,000		
Mobilization/Demobilization	$127,000		
Casing			
7" (w/ special clearance couplings)	$25,000		$25,000
8 5/8" (w/ special clearance couplings)	$5,000		$5,000
Cement + Packers	$7,500		$7,500
7" wellhead (w/valves and hanger)	$7,500		$7,500
3 Days rig time to prepare well for coring	$15,000		$15,000
Bits			
Rotary and diamond coring	$17,000		
Drilling Fluids	$22,000		$10,000
Rerun 7" casing for injector			
7" Perforated Casing			$7,500
Cement + Plugs			$5,000
1 Rig Day time to prepare well for injection			$15,000
Geologic Service Co.	$17,000		
20 days including supplies and trailer			
Wireline Coring			
16 Days: includes rig day rate, footage charge, and support equipment rental	$145,000		
Core shipping			
(Geysers to Salt Lake City)	$2,000		
Drilling Supervision			
For coring only (25 days)		*	$15,000
Field Support			
mechanical, electrical, equipment, etc.		*	$15,000

Lost Generation Revenue			
30 days @ 18 MWe/day		*	$12,300
General and Administrative			
Logistics, accounting, reporting, etc.			
100 person-days		*	$50,000
Total	$400,000		$189,800

* These figures represent in-kind costs borne by Unocal to permit additional core recovery