GL01104

DOE/ET/27100-1

INTERMEDIATE DEPTH GEOTHERMAL TEMPERATURE STUDY

Gradient Holes: 11-33 and 63-33, Soda Lake, NV

Final Report

Donald G. Hill

October, 1979

Work Performed Under Contract DE-AC08-78 ET 27100

Chevron Resources Company

225 Bush Street
San Francisco, California 94104

NV/SL/CRC-10

DOE/ET/27100-1
Distribution Category UC-66a

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For the Period 1 October 1978 - 30 April 1979

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San Francisco, California 94104

Prepared for the

U.S. Department of Energy
Division of Geothermal Energy
Under Contract DE-AC08-78 ET 27100

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ABSTRACT

During 1979, Chevron Resources Company drilled two 2000 ft. holes near Soda Lake in the Nevada Carson Sink area to obtain subsurface data for inclusion in the U.S. Department of Energy's Northern Basin and Range geothermal reservoir assessment program. Drilling information together with detailed lithologic, geophysical and temperature log data were compiled for each hole and is summarized in this report. Maximum stabilized temperatures of 297°F and 367°F were encountered at total depth in each of the holes respectively.

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INTRODUCTION

In January, 1979, Chevron Resources Company (Chevron) drilled two 2000 ft. intermediate depth temperature observation holes near Soda Lake, in Nevada's Carson Sink. Figure 1 shows the locations of these holes, designated Chevron-Soda Lake 11-33 and 63-33.

The purpose of these intermediate depth temperature holes was to further evaluate surface geothermal expressions and shallow (50-500 ft.) thermal anomalies observed by Chevron and the USGS. Appendices A and B, respectively, are the 11-33 and 63-33 drilling and completion reports. Each well was drilled to 400 ft. with a 9-7/8 inch bit, cased with 7 inch casing, drilled out to 2000 ft. with 6-1/4 inch bit, logged, and completed with water filled, closed 1-1/2 inch tubing. The holes were later logged for static temperature profiles. Lithologic discriptions for 11-33 and 63-33 drill cuttings are included in Appendices C and D, respectively. Table 1 summarizes the geophysical logging history of these holes. Copies of the geophysical logs are available through Rocky Mountain Well Log Service, Denver Colorado.

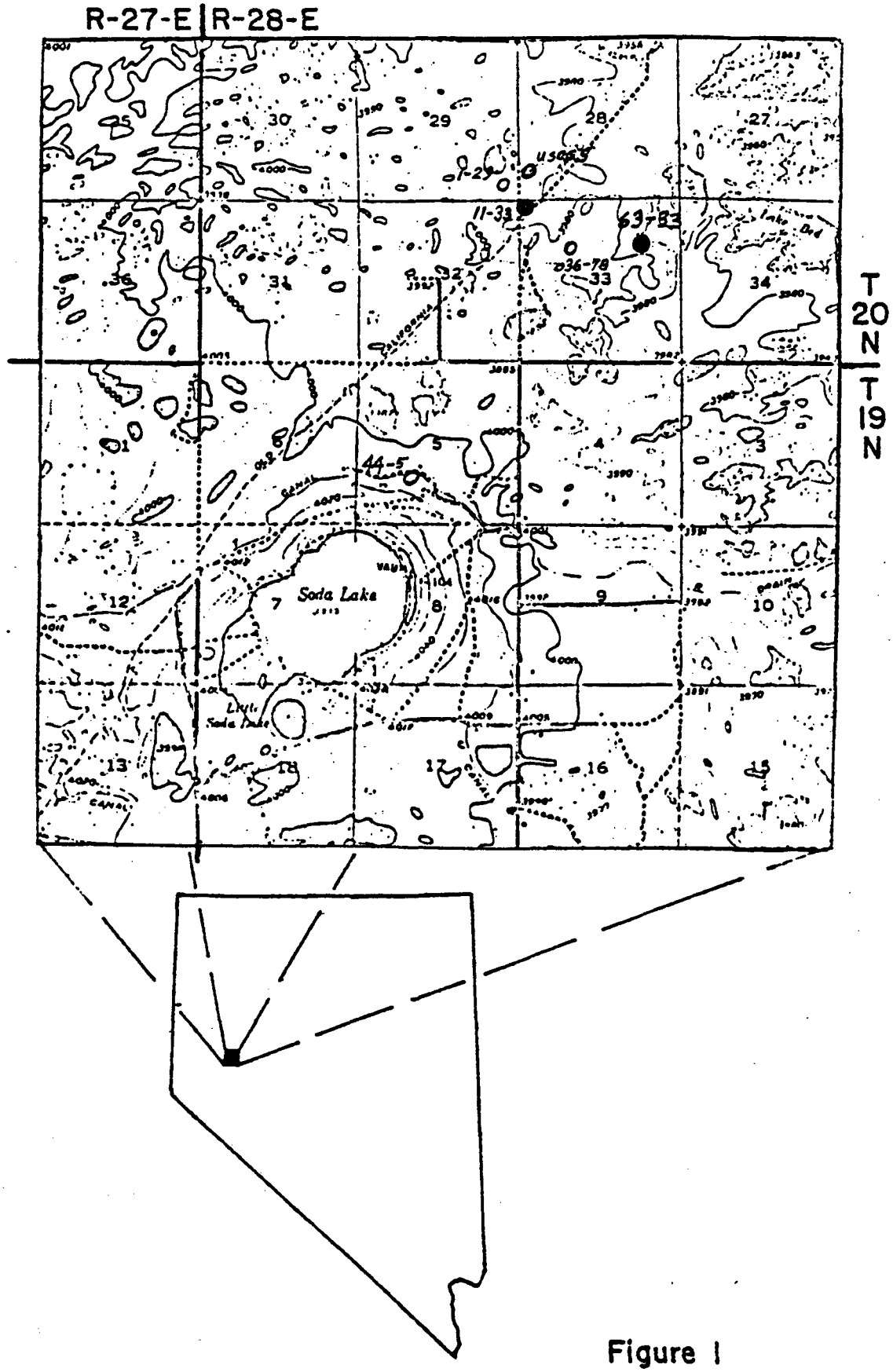

Figure 1

SODA LAKE, NEVADA

GEOTHERMAL TEMPERATURE HOLES

TABLE I

Chevron Soda Lake 2000 Foot Temperature Hole Logging History

Temperature Hole	Date	Contractor	Log Type	Interval Logged (Ft)
Soda Lake 11-33	1-10-79	Geothermal Services, Inc.	Gamma Ray	0-2015
"	"	" "	S. P.	398-2015
"	"	" "	Open-hole Temperature	100-2000
"	1-18-79	Agnew & Sweet	Static Temperature	20-1988
"	3- 8-79	" "	" "	20-1988
"	4-28-79	" "	" "	0-1988
Soda Lake 63-33	1-2-79	Minerals Survey Co.	Gamma Ray	0-1998
"	"	" "	S. P.	390-1998
"	"	" "	Single Point Resistance	390-1998
"	1-18-79	Agnew & Sweet	Static Temperature	160-1998
"	3-10-79	" "	" "	140-1998
"	4-28-79	" "	" "	0-1998

DISCUSSION

Site Selection

The Chevron-Soda Lake 11-33 and 63-33 intermediate depth temperature holes were drilled to further evaluate surface and near surface thermal anomalies. Hot springs were reported to have discharged in this area through the end of the 19th century. A shallow water well drilled by the U.S. Coast and Geodotic Survey, in 1903, in the SW 1/4 of Section 28, T20N, R28E encountered steam and hot water at 60 ft. (Garside and Schilling, 1979). The USGS (Olmstead, et al., 1975) and Chevron (Hill, et al., 1979) conducted shallow (100-500 feet deep) temperature surveys in the Soda Lake area in the mid-1970s. Both of these studies indicated a closed thermal high, in the vicinity of the USCGS well.*

Chevron (Hill, et al., 1979) also conducted a variety of geophysical surveys in the Soda Lake area aimed at defining the potential Soda Lake geothermal reservoir.* These studies outlined a graben trending NE from Soda Lake with the USCGS well on the NW flank.

Chevron and Phillips jointly drilled a deep test in the SE 1/4 of Section 29, T20N, R28E (Chevron-Phillips Soda Lake 1-29).* This well, drilled to a total depth of 4306 feet, bottomed in a coarse grained, altered diabase unit and yielded a stabilized bottom hole temperature of 342°F. Fluids recovered from flow tests of a permeable zone at 1000 feet yielded predominantly NaCl waters with total dissolved solids of 4000-6000 ppm. Geochemical base temperature determinations, (Na/K/Ca and SiO_2) on these fluids yielded estimated reservoir base temperatures in the range 385-435°F.

Chevron drilled a second deep test (Chevron-Soda Lake 44-5) in the NE 1/4 of Section 5, T19N, R28E.* This well was drilled to a vertical depth of 4883, encountered only minor volcanics, and yielded a stabilized bottom hole temperature of only 244°F.

Chevron drilled a 2000 foot intermediate depth temperature gradient hole (Chevron-Soda Lake 36-78) in the NW 1/4 of Section 33, T20N, R28E.* This hole encountered temperatures in excess of 340°F with a bottom hole conductive gradient of about 4°F/100 feet.

The temperature model that appeared from these results was a SE dipping thermal plume along the NW graben bounding faults, with surface expression near the USCGS and 1-29 wells (Hill, et al., 1979).

The current wells (Soda Lake 11-33 and 63-33) were drilled to evaluate this temperature model. Surveyed locations for these drill sites are shown in Figure 2.

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*The Department of Energy has purchased most of the Chevron Resources Company surface and subsurface Soda Lake data. This information is an open file with the University of Utah Research Institute, Earth Science Laboratory, Salt Lake City, Utah.

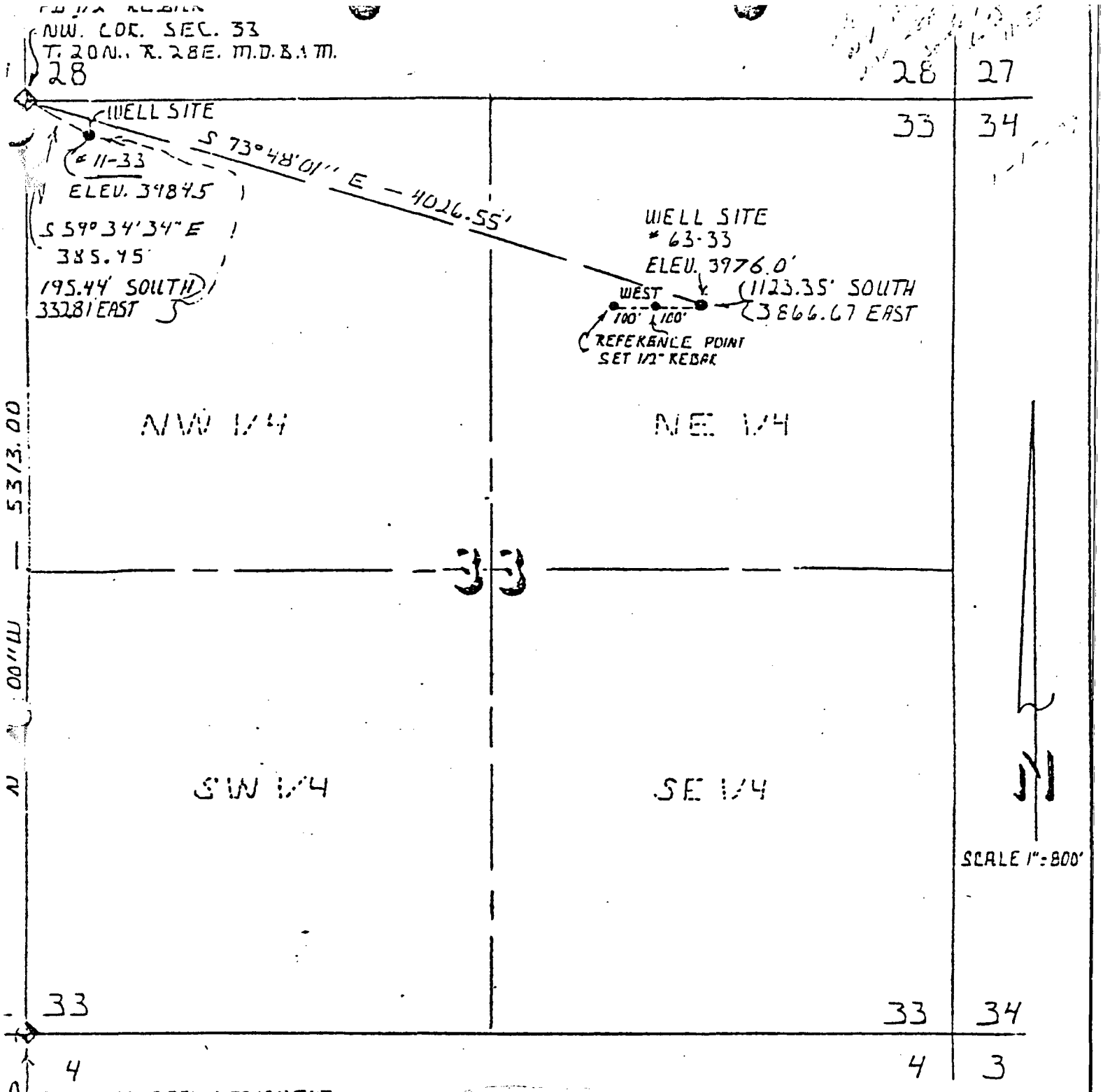

Figure 2

MAP

SHOWING LOCATION WELL #11-33 & 63-33
IN SEC. 33, T. 20N., R 28E., M.D.B. & M.
FOR CHEVRON RESOURCES CO.

DRAWN BY:
D.K. LUFT
DATE: JANUARY 17, 1979
SCALE: 1" = 800'

SURVEYED BY:
LOWELL D. EMERY R.L.S. 1251
P.O. BOX 84
FALLON, NEVADA

Drilling & Completion

Both (Soda Lake 11-33 and 63-33) intermediate depth temperature gradient holes were drilled and completed alike. Detailed drilling and completion reports for these wells are attached as Appendices A and B, respectively. Wooden Cellers, 6x6x6 feet were dug prior to moving the drilling rig. The hole was spudded in and air drilled to 10 feet with 12-1/4 inch bit. Surface conductor pipe (10/3/4 inch) was set and back filled with clay. The well was then drilled (with mud) to 400 feet, with a 9-7/8 inch bit. Surface casing (7 inch) was cemented to 400 feet and blowout preventers installed and tested at the surface. The well was then drilled to 2000 feet with a 6-1/4 inch bit. Samples were collected, from the mud returns, every 20 feet. At TD, open hole correlation logs (Gamma Ray, Single Point Resistance and S.P.) were run. Sealed tubing (1-1/2 inch) was hung to TD and the well completed with tubing-anulus valving. The sealed tubing was water filled to surface. Upon well completion, the drillsite was cleaned and returned to near original condition. Three repeat (cased hole) temperature surveys were run with Amerada-Hess type temperature logging tools.

Lithologic Logs

Appendices C and D, respectively, are the 11-33 and 63-33 lithologic logs prepared from cuttings sample descriptions. Both temperature holes penetrated Pleistocene Lake Lahonton and earlier sediments. Hole 11-33 encountered volcanics (predominently basalts) in the bottom forty (40) feet. Hole 63-33 encountered volcanics from 1790' to TD. Both holes exhibited various degrees of alteration throughout.

Geophysical Logs

Both holes were logged with Gamma Ray (ground level to TD) and SP and single point resistance (surface casing shoe to TD) for correlation. Table 1 is a tabulation of 11-33 and 63-33 geophysical logs.* Malfunction of the Chevron logging system forced the use of alternate logging contractors. The contractor used for 11-33 also had system problems and no usable single point resistance log was obtained for that hole. Both logging system problems (Chevron & Contractor) were due to conductor parting in the logging cable. This is a fairly common problem, accentuated by logging hot holes (≥350°F) at subfreezing surface temperatures.

Temperature Logs

Repeat static temperature profile logs (3) were obtained over a two-month period using Amerada-Hess type equipment. This yielded a bottom hole gradient of 0.3°F/100 feet and maximum temperature of 367.1°F for 11-33 and 6.65°F/100 feet and 297.0°F for 63-33. The final static temperature profiles are shown in Figures 3 and 4. Drilling mud temperatures are included with the lithologic descriptions of Appendices C and D. The logging contractor used for 11-33 also ran an open hole temperature profile.

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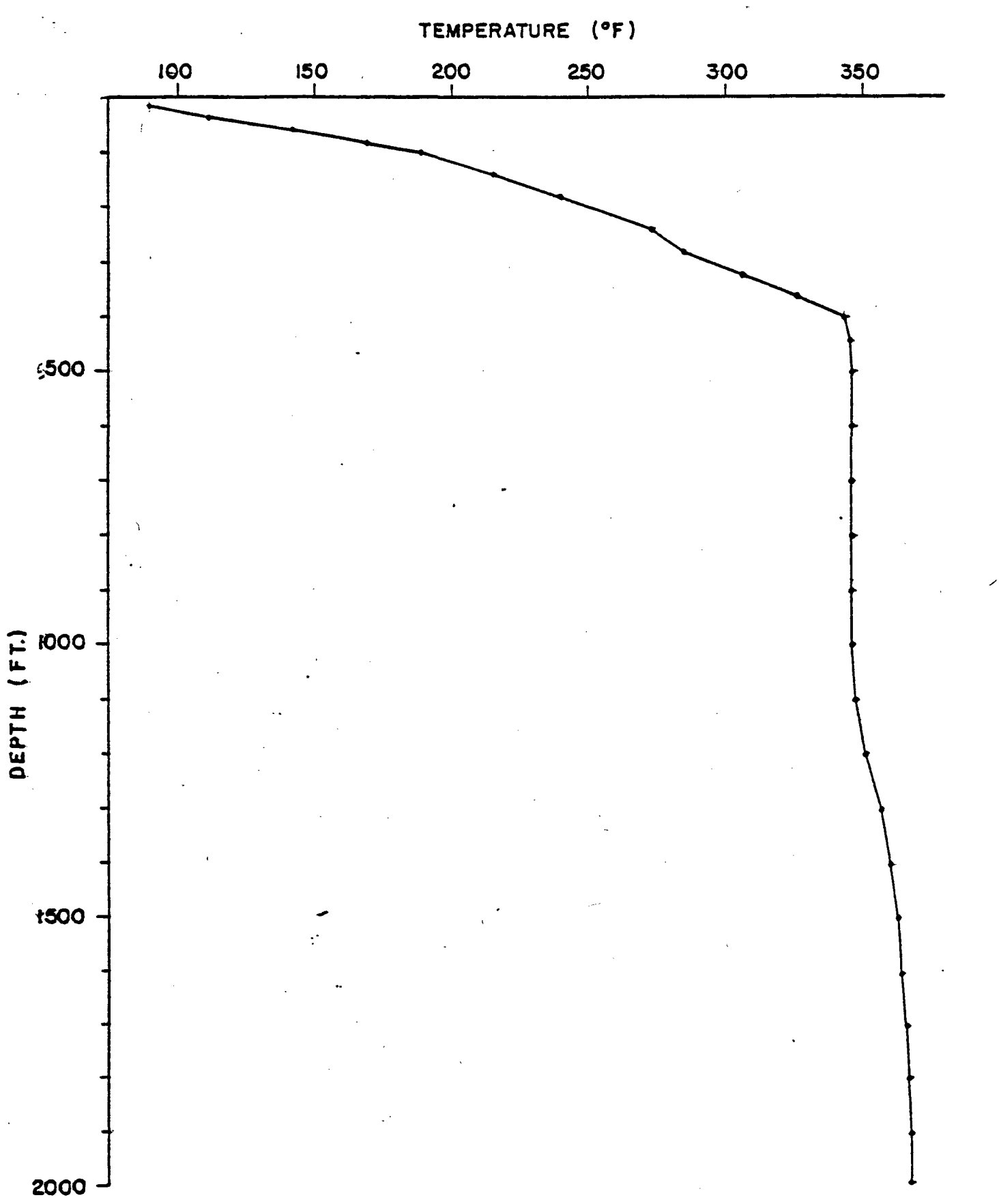
*Copies of these logs are available from Rocky Mountain Well Log Library, Petroleum Information, Denver, Colorado.



SODA LAKE, NEVADA
WELL NO. 11-33
Apr. 28, 1979

Fig. 3

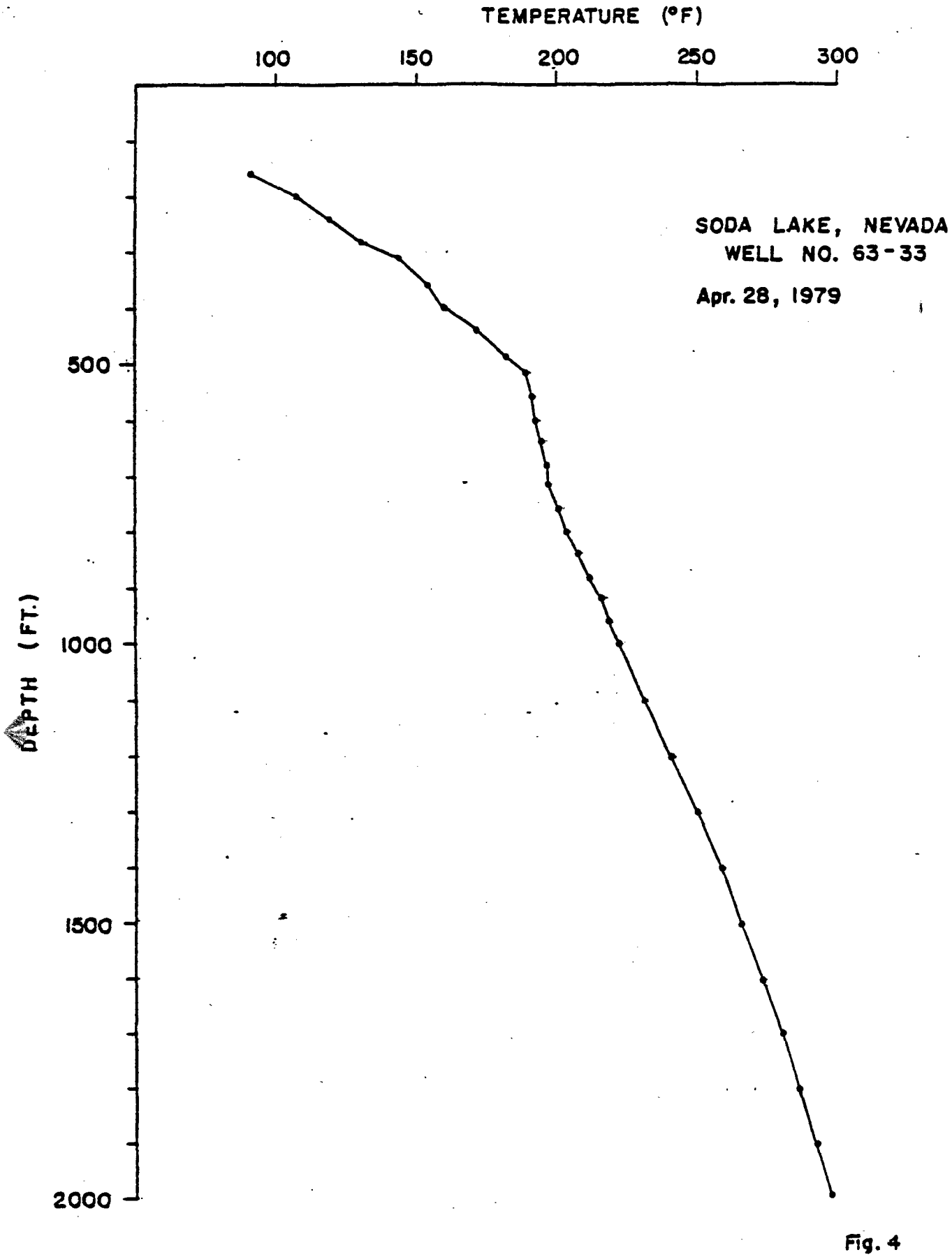

TEMPERATURE (°F)
100
150
200
250
300
SODA LAKE, NEVADA
WELL NO. 63-33
Apr. 28, 1979
500
1000
1500
2000
DEPTH (FT.)

Fig. 4

SUMMARY

Two 2,000 feet intermediate depth temperature observation holes were drilled near Soda Lake, Nevada. Detailed lithologic and temperature data were obtained, from these holes. Maximum stable temperatures of 297.0°F and 367.1°F were obtained at depths of 2,000 feet.

REFERENCES

GARSIDE, L. J. and SCHILLING, J. H., 1979, Thermal Waters of Nevada, Nevada Bureau of Mines and Geology.

HILL, D.G., LAYMAN, E.B., SWIFT, C. M., and YUNGUL, S. H., 1979, Soda Lake, Nevada, Thermal Anomaly, Geothermal Resources Council, Annual Meeting Transactions, v. 3.

OLMSTEAD, F. H., GLANCY, P. A., HARRILL, J. R., RUSH, F. E., AND VAN DENBURG, A. S., 1975, Preliminary Hydrogeologic Appraisal of Selected Hydrothermal Systems in Northern and Central Nevada, USGS Open File Report, 75-56.

APPENDIX A

11-33

Drilling and Completion Report

Completion Report
New Well PRO-31

Field Beowawe — Property:

Well No. Soda Lake 11-33 — Sec. 33 T. 20N R. 28E MD B.&M.

Location 195.44'S, 332.81'E of NW Corner Sec. 33, Churchill Co. Nevada

Elevation 3984.5' G.L. Derrick Floor — D.F. is _____ ' above ma

Data January 30, 1979

Chevron Resources Company

R. B. Murray/B. D. Garrett
(For Operations Manager, Producing Dept.)

Drilled By Geothermal Services Inc.

Date Commenced Drilling January 5, 1979 — Date Completed Drilling January 11, 1979

Date of Initial Production ----------

Production:					
Daily Average, 1st _____ Days	Gravity _____ °API	Pump _____
Oil _____ Bbls.	T.P. _____ PSI	Flowing _____
Water _____ Bbls.	C.P. _____ PSI	Gas Lift _____
Gas _____ Mcf.	Bean _____ /64"	

Summary

Total Depth: 2000'

Casing: 298' 7" x 23# K-55 8rnd LT & C CMTD at 395'

1991' 1 1/2" x 2.9# J-55 EUE tubing hung at 1984'

Logs: Gamma Ray, SP, resistance, temperature

Note: All measurements from ground level

DRILLING PROGRAM

Well No.: 11-33 Field: Soda Lake Unit
State: Nevada County: Churchill
Location: NW¼ of NW¼ of NW¼ Sec. 33, T20N, R28E, MDB&M

Discussion

Nearby Soda Lake 36-78 was drilled in March 1978 to a depth of 2000'.

No drilling problems were encountered and the hole was completed in 10 days with some time lost due to weather and mechanical repairs.

The entire section penetrated was sand and shale and no lost circulation was experienced.

Program

1. Prior to moving in drilling rig, Chevron will install wooden well cellar per attached sketch.
2. Move in rig.
3. Drill 12¼" hole to 10'±.
4. Install 10-3/4" conductor pipe and pack 10-3/4" x 12¼" annulus with clay to make fluid seal.
5. Drill 9-7/8" hole to 400'.
6. Run 7" casing to 400' equipped with float shoe on bottom and one 7" x 9-7/8 centralizer on the bottom two joints. Top casing collar to be at proper height to allow installation of blowout preventer.
7. Install cementing head and, using rig pump, cement 7" casing with 75 sacks of neat construction cement. Note this is 50% excessive.
8. While waiting on cement, install well head and BOPE consisting of Hydril GK and double ram preventer (blind and pipe rams). Test to 200 psi.
9. Drill 6¼" hole to 2000'. Take cuttings sample every 20'. Divide sample into three parts, bag and label.
10. At T.D run Chevron E-logs. (Resistance, S.P., Gamma, temperature.)
11. Run 1½' tubing (30' joints) to within 20' of T.D.
12. If well conditions warrant 1½", tubing will be hung from surface and well completed with tubing-annulus valving. If tubing is not hung, cement 1½" x 7" annulus from 400' to surface and proceed with steps 13, 14 etc. to complete well.

13. Remove BOP and well head. Welded ¼" plate on top of 1½" x 7" annulus.

14. Install 1½" gate valve on top of tubing with bull plug and locking chain. Plug to be approximately 1' below ground level.

15. Release rig.

16. Remove cellar, clean and fill pits, cleanup location.

17. Run temperature survey 30 days after completion.

18. Fill 1½" tubing with neat cement from 30' to surface, remove valve, and install 1½" pipe cap to abandon well.

O/S B. D. Garrett Date 11-15-78
B. D. Garrett

O/S M. A. Lane Date 11-15-78
M. A. Lane

APPROVED
SUBJECT TO THE ATTACHED CONDITIONS

SODA LAKE 11-33

Jan. 5, 79 — Air drilled 12 1/4" and set 10 3/4" conductor pipe at 17'. Spudded in with 9 7/8" and drilled ahead to 345'. Pooh to check bit. RIH. Drill ahead 9 7/8" to 350'. Twisted off drill pipe. Pooh. RIH with overshot and engaged fish. Pooh with bit and stab.

Jan. 6, 79 — Drilled ahead 9 7/8" to 402'. Conditioned mud for casing Ran 20 jts. (398') 7" x 23# K-55-8rnd. R-1, LT &C casing with B&W float shoe and centralizers. Cemented casing with 160 sx ready mix cement at 395'. Partial to no cement returns bumped plug at 800 PSI. Installed Class II-B BOPE.

Casing Detail

20 jts (398.08') 7" x 23# K-55 8rnd seamless LT & C casing of unknown mfg with B&W float shoe cemented at 395'.

Jan. 7, 79 — Drilled out rubber plug at 150' and cleaned out cement to 360'. Tested BOPE and casing at 200 PSI. Cleaned out cement 360' to 395. Drill ahead 6 1/4" to 1140'.

Jan. 8, 79 — Drill ahead 6 1/4" to 1560'. Pooh to change bit trip line started to part.

Jan. 9, 79 — Installed new trip line. Drilled ahead 6 1/4" to 2000'. Conditioned mud for logging. Rigged up G/S logging equipment and ran gamma, resistance SP.

Jan. 10, 79 — Ran temp. survey 2000' - surface in 100' stations. Conditioned mud pooh and layed down drill pipe. Ran 60 jts (1991') 1 1/2" x 2.9# eue tubing. Ran 140' 1" line pipe in 1 1/2" x 7" annulus and flushed out with water.

Tubing Detail

60 jts (1990.51') 1 1/2" x 2.9# J-55 Eue tubing hung at 1984'

Jan. 11, 79 — Cemented 1 1/2" tubing at 1984' in annulus thru 1" pipe hung at 140' with 50 sx ready mix cement with good returns to surface. Added 10sx cement to return to surface. Removed BOPE. Cut off tubing head. Rigged down and out. Rig Released.

Jan. 12, 79	Installed 1 1/2" valve on tubing and bull plugged, chained and locked 1' below ground. Welded metal plate on 7" casing. Filled cellar.

APPENDIX B

63-33

Drilling and Completion Report

Completion Rep
New Well PRO-

Property: Soda Lake

Well No. 63-33 (Proj x 20401) Sec. 33 T. 20N R. 28E MD 8

Location 1123.35'S, 3866.67'E From NW Cor. Sec. 33.
Churchill County, NV.

Elevation 3976.0 G.L. Derrick Floor D.F. is _____ above

Date 1-16-79

Chevron Resources Company

BDG

B. D. Garrett/R. B. Murray
(For Operations Manager, Producing Dept.)

Drilled By Geothermal Services, Inc.

Date Commenced Drilling 12-28-78 Date Completed Drilling 1-4-78

Date of Initial Production ----

Production:					
Daily Average, 1st _____ Days	Gravity _____ °API	Pump _____
Oil _____ Bbls.	T.P. _____ PSI	Flowing _____
Water _____ Bbls.	C.P. _____ PSI	Gas Lift _____
Gas _____ Mcf.	Bean _____ /64"	

Summary

Total depth: 2000'

Casing : 17' 10-3/4" conductor cemented at 17'
: 393' 7" x 23# casing cemented at 393'
: ~1990' 1½" EUE J-55 tubing

Logs : E-Log, Resistance, SP

Note: All measurements from ground level.

PRO-31B (CD-10
Printed in U.S.A.

DRILLING PROGRAM

Well No.: 63-33 Field: Soda Lake Unit
State: Nevada County: Churchill
Location: NE¼ of SW¼ of NE¼, Sec. 33, T20N, R28E, MDB&M

Discussion

Nearby Soda Lake 36-78 was drilled in March 1978 to a depth of 2000'.

No drilling problems were encountered and the hole was completed in 10 days with some time lost due to weather and mechanical repairs.

The entire section penetrated was sand and shale and no lost circulation was experienced.

Program

1. Prior to moving in drilling rig, install wooden well cellar per attached sketch.
2. Move in rig.
3. Drill 12¼" hole to 10'±.
4. Install 10-3/4" conductor pipe and pack 10-3/4" x 12¼" annulus with clay to make fluid seal.
5. Drill 9-7/8" hole to 400'.
6. Run 7" casing to 400' equipped with float shoe on bottom and one 7" x 9-7/8 centralizer on the bottom two joints. Top casing collar to be at proper height to allow installation of blowout preventer.
7. Install cementing head and, using rig pump, cement 7" casing with 75 sacks of nea construction cement. Note this is 50% extra.
8. While waiting on cement, install well head and BOPE consisting of Hydrill GK and double ram preventer (blind and pipe rams). Test to 200 psi.
9. Drill 6¼" hole to 2000'. Take cuttings sample every 20'. Divide sample into three parts, bag and label.
10. At T.D. run Chevron E-Logs. (Resistance, S.P., Gamma, Temperature.)
11. Run 1½" tubing (30' joints) to within 20' of T.D.

APPROVED
SUBJECT TO THE ATTACHED CONDITIONS

13. Remove BOP and well head. Welded ¼" plate on top of 1½" x 7" annulus.

14. Install 1½" gate valve on top of tubing with bull plug and locking chain. Plug to be approximately 1' below ground level.

15. Release rig.

16. Remove cellar, clean and fill pits, cleanup location.

17. Run temperature survey 30 days after completion.

18. Fill 1½" tubing with neat cement from 30' to surface, remove valve, and install 1½" pipe cap to abandon well.

O/S B. D. Garrett Date 11-15-78
B. D. Garrett

O/S M. A. Lane Date 11-15-78
M. A. Lane

APPROVED
~~APPROVED~~
SUBJECT TO THE ATTACHED CONDITIONS

Dec. 28 Spudded in and drilled to set 17' 10-5/8" conductor pipe. Drilled ahead 9-7/8" to 120'.

Dec. 29 Drilled ahead 9-7/8" to 393'. Circulated to condition hole. POOH. Ran 20 jts (392') 7" x 23 lb casing.

Casing Detail

392.30' (20 jts) 7" x 23# LT & C 8rnS casing of unk. mfg. wi 1.00' shoe. Total 393.20'.

Cemented casing with 125 sx neat cement. Bumped plug on shoe at 400 psi, with returns to surface. Welded on tubing head, installed Class 2B B.O.P.E.

Dec. 30 Finished installing BOPE and tested to 400 psi RIH, drilled out cement, plug and shoe 388' to 393'. Drilled ahead 6¼" to 1000'.

Dec. 31 Drilled ahead 6¼" to 1780'.

Jan. 1 Drilled ahead 6¼" to 1940'.

Jan. 2 Drilled ahead 6¼" to 2000'. Circulated hole clean. Ran E-logs.

Jan. 3 Continued logging. Ran Mineral Services Co. GR 0-1000; Resistance and SP 393-2000'. RIH to 2000'. POOH and lay down drill pipe. Attempt to blow hole dry with air. Well produced water. Ran 1½" tubing - hit bridge at 470'. POOH, lay down tubing. RIH and clean out bridges every 60-100' to TD.

Jan. 4 Run 60 jts 1½" EVE J-55 tubing to TD, pick up 10' (approx. 15' above ground.).
Ran 140' of 1" pipe in 1½" x 7" annulus. Cemented with 50 sx neat cement mixed with 6 gal water/sk. Had initial mud returns, lost returns, regained returns. No cement returns to surface. Ran 1" pipe in annulus - located cement at 110'. Removed B.O.P.E., rig down and out.

Jan. 11 Filled 1½ x 7" annulus w/cement. Welded ¼" plate on top of 1½ x 7" annulus, filled cellar w/dirt. Location graded and cleaned up.

Appendix C

11 - 33

Sample description

Lithologic Log

Memorandum

San Francisco, CA
March 15, 1979

PETROGRAPHIC REPORT
CHEVRON "SODA LAKE" #11-33
SEC. 33, T11N, R28E, MDB&M
NEVADA
BY: E. W. CHRISTENSEN

MR. J. M. KEHOE:
CHEVRON RESOURCES

D/S 460': Most of the chips are a very fine-grained lithology, probably ash, with few to numerous pyrite crystals. A few of these fragments appear partially altered; several contain clay and silt. Also present are silicified sandstone, sandy tuff(?) and tuffaceous lithic-feldspathic sandstone.

D/S 1000': There are a few fragments similar to 160' but most are zeolitized fine and medium-grained angular to sub-round fairly well-sorted lithic-feldspathic sandstones. Volcanic grains and feldspars are the most abundant grains and many are rimmed by a greenish clay. The degree of zeolitization ranges between pore-filling and pore-filling plus extensive grain replacement.

D/S 1560': Several lithologies are represented in the cuttings:

1. altered vesicular/amygdaloidal basalt
2. carbonate-cemented basaltic sandstone
3. altered pyritic tuff/ash
4. microcrystalline limestone(?)
5. altered lithic sandstone, clay alteration
6. zeolitized lithic-feldspathic sandstone
7. zeolitized tuff
8. lithic-feldspathic(?) sandstone extensively replaced by carbonate

Presence of hornblende in some of the sandstones suggests that the volcanic rock fragments could be andesitic.

D/S 1960': Altered fine-grained, often flow-lineated basaltic rock fragments are the dominant lithology. Alteration products include chlorite and sericite(?), leucoxene and carbonate. Zeolite could not be conclusively identified but might be present also. Veins were scarce and largely carbonate with minor chlorite(?).

D/S 1980': Similar to 1960', quartz followed by chlorite in a couple veins.

D/S 2000': Similar to 1980'.

Volcanic rocks in the interval 1960'-2000' are called basaltic mainly on the plagioclase, sodic labradorite; the mafic minerals are all altered.

EWC:gda

CHEVRON RESOURCES COMPANY

LITHOLOGIC WELL LOG

PROSPECT: Soda Lake
STATE: Nevada
SECTION: 33
TOWNSHIP: 20 N
RANGE: 28 E
WELL NO.: 11-33

DEPTH	LITHOLOGY	COMMENTS
420'	Fine grained sandstone - highly silicified, secondary silica, pyrite minor micas, siltstone, Fe alteration	
*460'	Fine grained sandstone - highly silicified, Euhedral Qtz. crystals, mica - chlorite rich clay stone (argillic alteration), minor HCL reaction	
480'	Siltstone - Mudstone - mica - chlorite rich - minor pyrite, fine grained sandstone, HCL reaction	
560'	Fine grained sandstone - highly silicified, secondary silica, pyrite rich, mica rich, no HCL reaction, Fe reaction	Mud Temp 100°F In 120°F Out
580'	Fine grained sandstone and siltstone moderately silicified mica & pyrite rich, No HCL reaction	Mud Temp 100°F In 125°F Out
620'	Fine to medium grained sandstone, highly silicified, mica rich, abundant Fe alteration, secondary Qtz., chlorite alteration	Mud Temp 116°F In 126°F Out
640'	Fine grained sandstone, highly silicified, mica & pyrite rich, abundant Fe, chlorite, and argillic alteration	Mud Temp 125°F In 136°F Out
660'	Same as above with minor siltstone	Mud Temp 116°F In 130°F Out
680'	Same as above with minor Fe, chlorite & argillic alteration	Mud Temp 125°F In 133°F Out
700'	Same as above and minor euhederal Qtz.	Mud Temp 125°F In 140°F Out
740'	Same as above and minor volcanic rock fragments	Mud Temp 130°F In 140°F Out
760'	Same as above	Mud Temp 130°F In 148°F Out

CHEVRON RESOURCES COMPANY

LITHOLOGIC WELL LOG

PROSPECT: Soda Lake
STATE: Nevada
SECTION: 33
TOWNSHIP: 20 N
RANGE: 28 E
WELL NO.: 11-33

DEPTH	LITHOLOGY	COMMENTS		
780'	Same as above with abundant argillic alteration	Mud Temp	130°F 150°F	In Out
800'	Predominately siltstone - mudstone and minor sandstone as described above	Mud Temp	130°F 142°F	In Out
820'	Same as above	Mud Temp	130°F 160°F	In Out
840'	Fine - medium sandstone - poorly silicified with mica, pyrite feldspars, Fe alteration, argillic alteration, chlorite, secondary silica	Mud Temp	131°F 150°F	In Out
860'	Same as above - minor pyrite, mudstone, abundant argillic alteration	Mud Temp	130°F 143°F	In Out
880'	Same as above with volcanic rock fragments, minor pyrite, abundant mica	Mud Temp	135°F 150°F	In Out
920'	Same as above	Mud Temp	130+° 160°F	In Out
940'	Same as above	Mud Temp	130°F 160°F	In Out
960'	Same as above	Mud Temp	130°F 160°F	In Out
980'	Same as above - abundant pyrite	Mud Temp	130+° 162°F	In Out
*1000	Same as above	Mud Temp	130°F 161°F	In Out
1020	Same as above - minor pyrite, mudstone abundant - mica, argillic alteration, secondary silica	Mud Temp	130+° 160°F	In Out
1040	Same as above - abundant pyrite mica argillic alteration - minor mudstone, chlorite alteration	Mud Temp	130°F 160°F	In Out

CHEVRON RESOURCES COMPANY

LITHOLOGIC WELL LOG

PROSPECT: Soda Lake
STATE: Nevada
SECTION: 33
TOWNSHIP: 20 N
RANGE: 28 E
WELL NO.: 11-33

DEPTH	LITHOLOGY	COMMENTS		
1060'	Same as above - minor pyrite	Mud Temp	130°F	In
			164°F	Out
1080'	Same as above	Mud Temp	130°F	In
			170°F	Out
1100'	Same as above	Mud Temp	100°F	In
			172°F	Out
1120'	Same as above	Mud Temp	130°F	In
			171°F	Out
1140'	Fine - medium grained sandstone - poorly cemented argillic alteration matrix secondary silica, abundant micas, feldspars, minor pyrite mudstone, volcanic rock fragments, Fe alteration	Mud Temp	100°F	In
			170°F	Out
1160'	Same as above with very little pyrite	Mud Temp	130°F	In
			180°F	Out
1180'	Same as above with minor pyrite, moderately cementes, minor argillic alteration	Mud Temp	130°F	In
			180°F	Out
1200'	Same as above with minor pyrite & gypsum	Mud Temp	130°F	In
			172°F	Out
1220'	Same as above with very little pyrite & gypsum	Mud Temp	130°F	In
			176°F	Out
1240'	Same as above with minor pyrite, & moderate Fe alteration cementation	Mud Temp	95°F	In
			124°F	Out
1280'	Same as above	Mud Temp	90°F	In
			132°F	Out
1300'	Fine - very fine grained sandstone - poorly cemented, argillic alteration, minor mica, feldspar, secondary silica, very little pyrite, Fe alteration, volcanic rock fragments	Mud Temp	95°F	In
			126°F	Out
1340'	Same as above with small amount of blue-green clay (polygorskite)	Mud Temp	109°F	In
			128°F	Out

CHEVRON RESOURCES COMPANY

LITHOLOGIC WELL LOG

PROSPECT: Soda Lake
STATE: Nevada
SECTION: 33
TOWNSHIP: 20 N
RANGE: 28 E
WELL NO.: 11-33

DEPTH	LITHOLOGY	COMMENTS		
1380'	Same as above	Mud Temp	NA	
1400'	Same as above without polygorskite, little pyrite	Mud Temp	115°F 140°F	In Out
1440'	Same as above with abundant pyrite, Fe alteration	Mud Temp	124°F 150°F	In Out
1480'	Same as above with minor pyrite & Fe alteration	Mud Temp	130°F 155°F	In Out
1520'	Same as above	Mud Temp	130°F 159°F	In Out
*1560'	Same as above with minor pyrite, gypsum moderate volcanic rock fragments, little secondary silica	Mud Temp	130°F 162°F	In Out
1660'	Same as above			
1680'	Same as above with moderate secondary silica			
1700'	Same as above with minor mudstone, very little pyrite & Fe alteration			
1720'	Same as above			
1740'	Same as above with minor Fe alteration, very little mudstone			
1760'	Same as above	Mud Temp	142°F 167°F	In Out
1780'	Same as above with minor pyrite	Mud Temp	140°F 164°F	In Out
1800'	Same as above with very little gypsum, mica, pyrite, mudstone	Mud Temp	140°F 164°F	In Out
1820'	Same as above with minor Fe alteration	Mud Temp	150°F 170°F	In Out

CHEVRON RESOURCES COMPANY

LITHOLOGIC WELL LOG

PROSPECT: Soda Lake
STATE: Nevada
SECTION: 33
TOWNSHIP: 20 N
RANGE: 28 E
WELL NO.: 11-33

DEPTH	LITHOLOGY	COMMENTS		
1840'	Same as above with moderate claystone	Mud Temp	150°F 172°F	In Out
1860'	Same as above	Mud Temp	150°F 172°F	In Out
1880'	Same as above with moderate claystone, minor pyrite, reaction to HCL, Fe alteration, argillic alteration	Mud Temp	153°F 175°F	In Out
1900'	Fine - very fine sandstone predominantly Qtz., feldspars, lithic rock fragments, volcanic rock fragments & secondary silica - minor pyrite, mica, gypsum, Fe alteration, argillic alteration. Mudstone ≈ 30% of sample	Mud Temp	150°F 176°F	In Out
1920'	Same as above with 20% mudstone	Mud Temp	153°F 178°F	In Out
1940'	Same as above with 20% mudstone	Mud Temp	152°F 177°F	In Out
*1960	75% volcanic fragments - with amphiboles, rock is altered & possibly metamorphosed, amphiboles orientated in foliation type pattern, 25% fine sandstone & mudstone with secondary Quartz & chalcedony, pyrite, Fe alteration, mica, gypsum, argillic alteration	Mud Temp	153°F 180°F	In Out
*1980	Same as above	Mud Temp	153°F 180°F	In Out
*2000	85% volcanics, 15% sandstone as above			

* Indicates samples which will have petrologic identification completed

APPENDIX D

63-33

Sample Description

Lithologic Log

Memorandum

San Francisco, CA
March 15, 1979

PETROGRAPHIC REPORT
CHEVRON "SODA LAKE" #63-33
SEC. 33, T20N, R28E, MDB&M
NEVADA
BY: E. W. CHRISTENSEN

MR. M. J. KEHOE:
CHEVRON RESOURCES

D/S 440': Lithologies present include:

1. granitic rock grains-pebbles
2. welded tuff(?)
3. very fine to coarse, poorly sorted, feldspathic sandstone with rare granite and schist grains. Grains have clay coating but the sand is porous.
4. coarse siltstone, composition similar to #3
5. microcrystalline limestone
6. tuffaceous(?) siltstone and silty clay(?)
7. andesite-basalt

D/S 1000': Predominantly partially altered ash(?), with some andesite(?), volcanic sandstone, granite and petrified wood fragments.

D/S 1400': Mainly lithic to lithic-feldspathic sandstones containing numerous basalt-andesite grains. A few fragments are cemented by chlorite; most are zeolitic. Zeolite replacement is extensive in some fragments. Chlorite followed zeolite filling pores in some of the chips. The zeolite is probably laumontite, possibly neulandite.

D/S 1460': In addition to zeolitic volcanic sandstones there are carbonate rock fragments with ostracod shells. A few zeolitic sandstones contain late stage carbonate.

D/S 1600': Volcanic-sandstones similar to 1400' but zeolitization is more extensive.

D/S 1660': Zeolitized, volcanic sandstones, ostracodal limestones and ash with ostracod shells are the principal lithologies. Altered tuff-ash is rare; the alteration may be to zeolite.

D/S 1700': Volcanic sandstones in this sample do not appear to be as severely zeolitized as previous samples; a few are carbonate-cemented. Vesicular basalt fragments are rare; plagioclase crystals are fairly fresh but mafic minerals are altered.

D/S 1780': Basalt is the most abundant lithology with ash(?) and shale-claystone(?) next in abundance. Plagioclase looks zeolitic in some fragments. Iron-oxide and quartz occur in some severly altered basalt fragments.

D/S 1800': Several lithologies are present:

1. granite grains-pebbles
2. altered andesite
3. altered basalt
4. altered ash with carbonate replacement
5. volcanic sandstone with pores partially filled with zeolite
6. zeolitized volcanic sandstone

D/S 1880': Mainly partially altered basalt fragments, some containing carbonate and chlorite in veins and spots. Several fragments appear zeolitic. Shale-claystone fragments are rare. A single silicified volcanic(?)fragment was seen.

D/S 1940': Mainly volcanic fragments, partially altered. Many of these may be andesitic in composition based mainly on texture and presence of hypersthene; the groundmass of these fragments is more glassy.

D/S 2000': Andesite fragments; feldspar, hypersthene and opaque crystals are scattered in a glassy groundmass stained to varying degrees by iron-oxide. Fractures containing opaline silica(?) and quartz are present but rare.

EWC:gda

CHEVRON RESOURCES COMPANY

PROSPECT Soda Lake

LITHOLOGIC WELL LOG

SECTION 33
TOWNSHIP 20N
WELL No. 63-33 RANGE 28E

	DEPTH	LITHOLOGY	COMMENTS	
	420'	fine to Medium Sand - Predominately Quartz. Minor lithic fragments, Feldspar, mica very little pyrite		
			Mud Temp.	
*	440'	fine to Medium Sandstone - Predom. Quartz, Abundant Pyrite, mica, lithic fragments, Secondary silica, minor chlorite & argillic alteration poorly cemented.	In 48°	Out 50°F
	460'	fine to Medium Sand - Predom. Quartz Moderate feldspar, lithic fragments minor mica & argillic alteration	48°F	52°F
	480'	Same as above w/minor pyrite	49°F	52°F
	500'	Same as above w/poorly cemented sandstone and very little pyrite	50°	56°
	520'	Same as above w/minor chlorite	50°	58°
	540'	Same as above w/out pyrite	52°	59°
	560'	Same as above w/minor mudstone	54°	60°
	580'	Same as above	56°	60°
	600'	Same as above w/secondary silica	58°	62°
	620'	Same as above	59°	64°
	640'	Same as above w/very little secondary silica	59°	64°
	660'	Same as above w/minor secondary silica and argillic alteration	59°	66°
	680'	Same as above	60°	67°
	700'	Same as above	60°	70°
	720'	fine to Medium Sandstone - poorly cemented predominately Quartz; abundant lithic fragments; minor, feldspar mica, chlorite, argillic alteration secondary silica; very little pyrite	60°	68°

CHEVRON RESOURCES COMPANY

PROSPECT Soda Lake

LITHOLOGIC WELL LOG

SECTION 33
TOWNSHIP 20N
WELL No. 63-33 RANGE 28E

DEPTH	LITHOLOGY	COMMENTS
740'	Same as.above w/no pyrite	In 65° Out 70°
760'	Same as above w/lithic fragments up to pea gravel size w/very little pyroxenes	65° 70°
780'	Predominately mudstone w/moderate lithic fragments, minor poorly cemented fine sandstone; very little mica, pyrite secondary silica	65° 72°
800'	Same as above	68° 78°
820'	fine to Medium Sandstone - poorly cemented predominately Quartz; abundant lithic fragments; minor feldspars, mica secondary silica	58° 72°
840'	Predominately mudstone w/moderate fine to medium sandstone, lithic fragments, minor secondary silica, pyrite	60° 75°
860'	Same as above	62° 78°
880'	fine to Medium Sandstone - poorly cemented predominately Quartz; moderate lithic fragments, feldspars, amphiboles, micas; minor pyrite chlorite, argillic alteration, mudstone	66° 78°
900'	Same as above	68° 78°
920'	Same as above	68° 80°
940'	Same as above w/moderate pyrite	68° 82°
960'	Same as above w/minor pyrite	68° 82°
980'	Same as above w/moderate pyrite	68° 85°
* 1000'	Same as above w/minor secondary silica	68° 89°
1020'	Same as above	68° 95°
1040'	Same as above	75° 85°
1060'	Same as above w/abundant pyrite	
1080'	Same as above	75° 91°

CHEVRON RESOURCES COMPANY

PROSPECT Soda Lake

LITHOLOGIC WELL LOG

SECTION 33
TOWNSHIP 20N
WELL No. 63-33 RANGE 28E

DEPTH	LITHOLOGY	COMMENTS Mud Temp
1100'	Same as above w/moderate pyrite	In 82° Out 96°
1120'	Same as above w/moderate secondary silica; minor pyrite	69° 91°
1140'	Same as above	79° 91°
1160'	Same as above w/minor secondary silica and pyrite	80° 94°
1180'	Same as above w/moderate pyrite	81° 100°
1200'	Same as above w/minor pyrite	81° 100°
1220'	Same as above	70° 98°
1240'	Same as above	69° 96°
1260'	Same as above	74° 96°
1280'	Same as above	79° 98°
1300'	Same as above w/finer sand	80° - 100°
1320'	Same as above w/moderate pyrite minor polygorskite	80° - 102°
1340'	Same as above no polygorskite	79° - 103°
1360'	fine to Medium Sandstone poorly cemented predominately Quartz; abundant lithic fragments, feldspars; moderate amphiboles, mica, pyrite; minor Chlorite argillic alteration, mudstone	80° 104°
1380'	Same as above w/very little polygorskite	82° 106°
* 1400'	fine to Medium Sandstone moderately cemented predominately Quartz; abundant lithic fragment, feldspar; moderate amphiboles minor chlorite, mica, mudstone, no pyrite. Highly altered and silicified green overall color	84° 108° Rock is possibly a water lain tuff unit have thin sectioned
1420'	Same as above	
1440'	Same as above	88° 112°

CHEVRON RESOURCES COMPANY

PROSPECT Soda Lake

LITHOLOGIC WELL LOG

SECTION 33
TOWNSHIP 20N
WELL No. 63-33 RANGE 28E

	DEPTH	LITHOLOGY	COMMENTS Mud Temp.	
*	1460'	Same as above w/minor pyrite	In 87°	Out 114°
	1480'	Same as above	86°	115°
	1500'	Same as above w/moderate pyrite argillic alteration	87°	116°
	1520'	Same as above	86°	117°
	1540'	Same as above w/very little pyrite	95°	117°
	1560'	Same as above		
	1580'	Same as above		
*	1600'	Same as above	74°	114°
	1620'	Same as above	76	11°
	1640'	Same as above w/minor pyrite, secondary silica		
*	1660'	fine to Medium Volcanic sediments (?) tuff, highly silicified and altered moderate secondary silica, lithic fragments; minor mudstone, pyrite tan color overall	74°	124°
	1680'	Same as above	74°	123°
*	1700'	fine to Medium Sandstone predominately Quartz; abundant lithic fragments, volcanic fragments; minor mica, pyrite, argillic alteration		
	1720'	Medium to coarse sand predominately Quartz; abundant lithic fragments, volcanic fragments; minor pyrite, argillic alteration, secondary alteration	100°	122°
	1740'	Medium to coarse sand predominately volcanic fragments; abundant Quartz, lithic fragments; moderate pyrite, argillic alteration secondary silica		
	1760'	Same as above		

CHEVRON RESOURCES COMPANY

PROSPECT Soda Lake

LITHOLOGIC WELL LOG

SECTION 33
TOWNSHIP 20N
RANGE 28E

WELL No. 63-33

	DEPTH	LITHOLOGY	COMMENTS
			Mud Temp.
*	1780'	Highly altered volcanic rocks abundant secondary silica moderate pyrite	
*	1800'	Volcanic rock crystaline, glassy moderate secondary silica, pyrite black color overall - Rhyolitic	
	18[illegible]'	Same as above	
	1840'	Same as above	In 80° Out 119°
	1860'	Same as above w/abundant Quartz	
*	1880'	fine to Medium volcanic fragment sands predominately - rhyolitic to tuffaceous volcanic fragments Moderate - Secondary silica, euhederal quartz crystals, gypsum; minor pyrite, micas, argillic alteration	
	1900'	Same as above w/majority of volcanic fragments - vitric basalt (?)	110° 125°
	1920'	Same as above	110° 126°
*	1940'	Same as above w/abundant Quartz	91° 124°
	1960'	Same as above	
	1980'	Black vitric basalt w/minor Quartz, pyrite	
*	2000'	Same as above	

* Sample for thin Section