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GEOLOGY OF THE SODA LAKE GEOTHERMAL AREA

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ABSTRACT

The Soda Lake geothermal area is located in the Carson Desert, west-central Nevada. Hot springs activity has occurred in the Soda Lake area in the past, resulting in surface deposits which have motivated present geothermal exploration. The geothermal anomaly is in Quaternary clastic sediments which are as much as 4600 feet thick. The sediments consist of interbedded deltaic, lacustrine, and alluvial sediments.

Quaternary basaltic igneous activity has produced cinder cones, phreatic explosions that formed the maar occupied by Soda Lake, and possible dikes.

Opal deposition and soil alteration are restricted to a small area two miles north of Soda Lake. The location of hot springs activity and the surface thermal anomaly may be partially controlled by north-northeast-trending faults.

INTRODUCTION

The Soda Lake geothermal area is located in the Carson Desert, in western Churchill County, west-central Nevada (Figure 1).

Thermal waters were first discovered in the Carson Desert in 1903 when a well drilled at the site of an extinct hot spring northeast of Soda Lake hit hot water at a depth of 60 feet (Garside and Schilling, 1979, p. 9). The mixture of steam and water produced by the well was used to furnish steam to a bathhouse until sometime after 1950. The U. S. Bureau of Reclamation and the U. S. Geological Survey drilled several temperature gradient holes over the Soda Lake anomaly during 1972 and 1973. These holes were drilled to a depth of about 33 m and temperature and thermal gradients were measured. Olmsted and others (1975) reported the results of this program. Chevron Resources Company became interested in the area in the early 1970s and has drilled several exploration holes in the Soda Lake area (Hill and others, 1979). Chevron encountered temperatures in excess of 365°F in exploratory holes (Hill and others, 1979).

The present study was undertaken as part of the Industry Coupled Case Studies Program of the Department of Energy, Division of Geothermal Energy. The objectives of this study are to present the geologic setting of the KGRA and the subsurface information available from the Chevron well cuttings.

GEOLOGIC SETTING

The rocks exposed within the Carson Desert consist of Quaternary to Recent, poorly consolidated sediments and minor basaltic volcanic rocks.

Figure 1. Index map of Churchill County, Nevada.

During the Quarternary the Carson Desert was filled with lacustrine sediments, alluvium, wind-blown sand, and in the southwest part by deltaic and fluvial deposits related to the Carson River. Morrison (1964) reported on the surficial deposits. The current study emphasizes the subsurface deposits within the basin.

Lake Lahontan and younger lake sediments cover most of the basin. Recent sand dunes, playa, and fluvial sediments have covered or reworked the lacustrine deposits in some areas. Morrison (1964) divided the Lake Lahontan deposits into several formations. The Sehoo and Wyemaha formation consists of lacustrine sand, silt and clay, and the Fallon formations consist of alluvial sand and silt (Figure 2). These formations could not be distinguished in drill cuttings from older Quaternary rocks penetrated in the drill holes.

Bouguer gravity studies (Wahl, 1965; Erwin and Berg, 1977) indicate that the depth of alluvial fill varies considerably across the Carson Desert. Wahl (1965) interpreted lows of 30 milligals amplitude within the Carson Sink (compared to gravity values along the western front of the Stillwater Range) to indicate about 10,000 feet of alluvium. A low of the same amplitude is located south of Fallon in the Carson Lake area. Between these two lows, gravity and geologic data indicate a bedrock ridge under thinner alluvial cover.

Soda Lake 44-5 and Carson Sink #1 (Figure 2), located in the southwest part of the Carson Desert, penetrated Quaternary sediments to a depth of 4600 feet.

Subsurface information in the Soda Lake area comes from six holes, Chevron's Soda Lake 44-5, 1-29, 63-33, 11-33, 36-78 and the Carson Sink #1 uranium exploration hole (Figure 2). Logs for the Chevron holes are in the Appendix. The sediments in the drill holes are poorly sorted lithic and arkosic sand, silt, tuffaceous mudstone, clay, and gravel. The coarser sediments are probably deltaic and alluvial fan deposits of the Carson River, whereas silt, mudstone, and clay interbeds are probably lacustrine and playa sediments.

IGNEOUS ACTIVITY

Igneous rocks in the Soda Lake area consist of basaltic cinder cones and dikes or flows.

Upsal Hogback, seven miles northeast of Soda Lake, is composed of overlapping basaltic tuff cones. Morrison (1964, p. 38) suggested that the cones were of Wyemaha age (30,000 to 45,000 years old). The basaltic tuff is olivine-rich, mostly sand to pebble-size, and was deposited subaerially (Morrison, 1964, p. 38).

Soda and Little Soda Lakes occupy craters formed by multiple phreatic explosions and volcanic eruptions. The crater rim consists of volcanic sand, lapilli, and lacustrine deposits (Morrison, 1964, p. 71). The last eruption was subaerial and post-dated the last lake rise to that level.

A sample of basalt from Rattle Snake Hill, north of Fallon (Figure 1), yielded a whole-rock potassium-argon age of 1.05 ± 0.05 m.y. (Stan Evans, personal communication, 1979).

Subsurface basaltic rocks within the Quaternary alluvium were penetrated in Soda Lake 1-29, 11-33, and 63-33. The igneous rocks consist of non-porphyritic pyroxene basalt with trachytic texture. No evidence of vesicles or amygdaloids in the basalt was found in the cuttings, and the sediments in contact with the thick basalt intercept in Soda Lake 1-29 are altered above and below the basalt. This suggests that the basalt occurs as dikes rather than flows. The basalts in Soda Lake 63-33 and 11-33 are petrologically identical to the basalts in Soda Lake 1-29 and different from the basalt of the Pleistocene basalt flows penetrated in Soda Lake 44-5.

SUBSURFACE INFORMATION

Subsurface stratigraphic information in the Soda Lake area is based on interpretation of drill cuttings from six holes: Soda Lake 44-5, 1-29, 11-33, 56-33, and 36-78, drilled by Chevron (Earth Science Laboratory, 1979), and Carson Sink #1 (Horton, 1978). Lithology logs for Soda Lake 44-5, 1-29, 11-33, and 66-33 are included in the Appendix and a log summary is presented on Plate 1.

Soda Lake 44-5 and Carson Sink #1 each penetrated 4,600 feet of Quaternary sediments (Plate 1). Below these sediments is a sequence of thick, vesicular, olivine and augite basalt flows. These flows are interpreted to be the Pliocene to early Pleistocene Bunejug formation (Morrison, 1964, p. 14). The Carson Sink #1 hole penetrated over 3000 feet of basalt and andesite flows (Horton, 1978). Below the basalt flows is an altered, welded ash-flow tuff. Soda Lake 1-29 encountered a pyroxene gabbro below the sediments at a depth of 3940 feet.

Tuffs and tuffaceous sand and mudstone are predominant below a depth of 2400 feet. The basal eight hundred feet of Quaternary sediments are poorly sorted mudstone, sand, silt, and tuff. These are overlain by organic-rich, laminated mudstone which may represent the first lake event or a deltaic swamp. A channel gravel has replaced most of the mudstone unit in Soda Lake 44-5 (Plate 1). Above the organic-rich mudstone is 250 feet of sand and mudstone, which may also be lacustrine, overlain by 230 feet of mudstone, siltstone, and shale with organic carbon. In the next 2000 feet, between a depth of 3000 feet and 1000 feet, individual beds cannot be correlated. In general, sand and gravel predominate in the Carson Sink #1 hole and finer-grained sand to clay are present in the holes north of Soda Lake.

The basalt intercepts between 1300 and 2000 feet in Soda Lake 1-29, 11-33, and 63-33 are petrographically identical. These basalts are thought to be dikes and were discussed in the Igneous Activity section of this report. The basaltic crystal ash at 1520 feet in Soda Lake 44-5 has tabular plagioclase phenocryst and is distinct from basalt dikes.

A unit consisting of shale, mudstone, and fine sand occurs between a depth of 700 and 1000 feet in the four drill holes in which cuttings are available for this interval (Plate 1). These rocks probably formed in a deep lake environment. The Lake Lahontan formations probably account for only the upper 400 feet of sediments (Morrison, 1964).

SURFACE ALTERATION AND SINTER DEPOSITS

Hot springs deposits and alteration are restricted to several small areas

two miles north of Soda Lake (Figure 2). Here the soil has been altered to kaolinite, iron oxides, and hydroxides (Olmsted and others, 1975, p. 103). The alteration extends about two hundred feet to the section line road west of an abandoned steam well and approximately one hundred feet to the east where it is covered by a sand dune. Shallow hand-dug pits have exposed brightly colored alteration a few inches below the surface in the low area around the steam well.

The hot springs deposits consist of small areas of opal-cemented sand in the SE 1/4 of section 29 and the NE 1/4 of section 32 (Figure 2). Opal replaced grass stems are abundant locally and opallized brush stems are also present, while opal-filled fractures were found at one location. The opal-cemented sand is deeply eroded and sand dunes have partly covered some outcrops. Alteration coloration was not evident in the sinter-cemented outcrops.

STRUCTURE

The dominant fault trend around the Carson Desert is northeast. Linears on aerial photographs of the Soda Lake area have a north-northeast trend (Figure 2), and several short linears were found near Soda Lake 1-29 and 11-33. One linear extends from opal-cemented sand to the altered area of the old steam well (Figure 2). This photo linear coincides with the thermal plume and a NE-SW-trending fault, defined from seismic reflection (Hill and others, 1979). The surface expression indicates relative movement down to the SE (Figure 2). Hill and others (1979) concluded that the fault dipped SE and formed the boundary of a NE-trending graben. Offset on the photo linears

appears to be a few feet at most. Some evidence for faulting was found in the cuttings in the form of gouge and slickenside surfaces on chips; locations of the possible fault intercepts are shown on Plate 1. There are no marker beds which could be used to demonstrate offset between holes. The sedimentary facies correlated between holes could be offset a few tens of feet.

HEAT FLOW AND TEMPERATURE

Olmsted and others (1975, p. 115) estimated a conductive heat discharge of 3.2×10^6 cal/sec as a minimum from the Soda Lake thermal anomaly enclosed by the 200°C isotherm at a depth of 30 m. Chemical analyses were made of several water samples from two intervals in Chevron's Soda Lake 1-29 test hole (Earth Science Laboratory, 1979). Calculated reservoir temperatures using the silica geothermometer averaged 183°C for both test intervals with a range of 176° to 192°C for 6 samples. The measured temperature in the lower interval, 1008-1531 feet deep, averaged 174°C. Hill and others (1979) estimated a reservoir temperature in excess of 400°F (190°C).

CONCLUSIONS

The Soda Lake thermal anomaly is located in thick Quaternary clastic sediments. In general the sediments are coarser to the southwest and finer to the north and northeast. The gravels found in Soda Lake 44-5 and Carson Sink #1 are probably channel deposits while the few clean sand zones may be beach deposits. There is a greater similarity between Carson Sink #1 and Soda Lake 44-5, which are five miles apart, than between Soda Lake 44-5 and Soda Lake 1-29, which are only 2 miles apart. This is probably because Carson Sink #1

and Soda Lake 44-5 are both in the delta-alluvial fan facies, but Soda Lake 1-29, 11-33, and 63-33 are in the lake-playa facies of deposition. The area of deltaic or lacustrine deposition shifted at times due to rise and fall of the basin lake, but the delta-alluvial fan generally extended from the southwest to just north of Soda Lake.

Soda Lake 1-29, 63-33, and 11-33 are in finer sediments than Soda Lake 44-5 and Carson Sink #1 to the south. Most of the cuttings from Soda Lake 1-29 are of silty and sandy mudstone derived from tuffaceous material. All of the tuffs intercepted have undergone fluvial transport.

The Quaternary sediments are 4600 feet thick and overlay basalt flow under Soda Lake and to the west. Two miles north of Soda Lake gabbro is overlain by the sediments.

ACKNOWLEDGEMENTS

I wish to credit Ed C. Bingler for the lithologic log of the Carson Sink #1 Borehole which was published in the Bendix report (Horton, 1978) and was used in this report. Helpful consultation on cuttings interpretation was provided by Jeff Hulen. Valuable guidance in the preparation of this report was given by Joe Moore, and the critical reviews of the manuscript by Joe Moore and Howard Ross are appreciated. The drafting was done by Dawnetta Bolaris and Connie Pixton and typing by Lucy Stout.

BIBLIOGRAPHY

- Axelrod, D. I., 1956, Mio-Pliocene Floras from west-central Nevada: Geol. Sci., v. 33.
- Bingler, E. C., 1978, Abandonment of the name Hartford Hill Rhyolite Tuff and adoption of new formation names for Middle Tertiary Ash-Flow Tuffs in the Carson City-Silver City Area, Nevada: U. S. Geol. Survey Bull. 1457-D, 19 p.
- Bonham, Harold F., 1969, Geology and mineral deposits of Washoe and Storey Counties, Nevada: Nev. Bur. Mines, Bull. 70, 140 p.
- Earth Science Laboratory, 1979, Chevron Resources Company data for Soda Lake: Salt Lake City, Open-file release, March, 1979, CRC 8-9.
- Erwin, J. W., and Berg, J. C., 1977, Bouguer gravity map of Nevada, Reno Sheet: Nev. Bur. Mines, Geol. Map 58.
- Garside, L. J., and Schilling, J. H., 1979, Thermal waters of Nevada: Nev. Bur. of Mines, Bull. 91, 163 p.
- Garside, L. J., 1974, Geothermal exploration and development in Nevada through 1973: Nev. Bur. of Mines, Rept. 21, 12 p.
- Hill, D. G., Layman, E. B., Swift, C. M., and Yungul, S. H., 1979, Soda Lake, Nevada, thermal anomaly: Geoth. Res. Council, Transactions, v. 3, p. 305-308.
- Horton, Robert C., 1978, Lithologic log and interpretation of instrument logs, NURE Project, Carson Sink, Nevada, Bore Hole: Bendix Field Eng. Corp., GJBX - 53(78), 36 p.
- Langenheim, R. L. Jr., and Larson E. R., 1973, Correlation of Great Basin Stratigraphic units: Nev. Bur. of Mines, Bull. 72, 36 p.
- Mariner, R. H., Rapp, J. B., Willey, L. M., and Presser, T. S., 1974, The chemical composition and estimated minimum thermal reservoir temperatures of the principal hot springs of northern and central Nevada: U. S. Geol. Survey, Open-File Report 74-1066, 32 p.
- Moore, James G., 1969, Geology and mineral deposits of Lyon, Douglas, and Ormsby Counties, Nevada: Nev. Bur. Mines, Bull. 75, 45 p.
- Morrison, R. B., 1964, Lake Lahontan: Geology of Southern Carson Desert, Nevada: U. S. Geol. Survey, Prof. Paper 401.
- Nielson, R. L., 1964, Right-lateral strike-slip faulting in the Walker Lane, west-central Nevada: Geol. Soc. of Am. Bull., v. 76, p. 1301-1308.

- Olmsted, F. H., 1977, Use of temperature surveys at a depth of 1 meter in geothermal exploration in Nevada: U. S. Geol. Survey, Prof. P. 1044-B, 25 p.
- Olmsted, F. H., Glaney, P. A., Harrill, J. R., Rush, F. E., and Van Denburgh, A. S., 1975, Preliminary hydrogeologic appraisal of selected hydrothermal systems in northern and central Nevada: U. S. Geol. Survey, Open-File Rept. 75-56, 267 p.
- Page, B. M., 1965, Preliminary geologic map of a part of the Stillwater Range, Churchill County, Nevada: Nev. Bur. Mines, Geol. Map 28.
- Riehle, J. R., McKee, E. H., and Speed, R. C., 1972, A Tertiary volcanic center, west-central Nevada: Geol. Soc. Am. Bull., v. 83, p. 1383-1396.
- Rush, F. E., 1972, Hydrologic reconnaissance of Big and Little Soda Lakes, Churchill County, Nevada: Nevada State, Dept. Cons. and Nat. Res., Div. Water Res., Rept. 11.
- Silberman, M. L., and McKee, E. H., 1972, A summary of radiometric age determinations on Tertiary volcanic rocks from Nevada and eastern California: Part II, Western Nevada: Isochron/West, no. 4, Aug.
- Speed, R. C., 1975, Carbonate breccia (rauhwacke) nappes of the Carson Sink region, Nevada: Geol. Soc. America Bull., v. 86, p. 473-486.
- Stanley, W. D., Wahl, R. R., and Rosenbaum, J. G., 1976, A magneto-telluric study of Stillwater-Soda Lake, Nevada geothermal area: U. S. Geol. Survey, Open-File Report 76-80, 38 p.
- Swanberg, C. A., and Alexander, S., 1979, Use of water quality file WATSTORE in geothermal exploration: An example from the Imperial Valley, California: Geol., v. 7, p. 108-111.
- Trexler, D. T., Bell, E. J., and Roguemore, G. R., 1978, Evaluation of lineament analysis as an exploration technique for geothermal energy, western and central Nevada: Nev. Bur. Min., DOE Contract EY-76-5-08-0671, 78 p.
- Vanderburg, W. O., 1940, Reconnaissance of mining districts in Churchill County, Nevada: U. S., Bur. Mines, Inf. Circ. 7093.
- Wahl, Ronald R., 1965, An interpretation of gravity data from the Carson Sink area, Nevada: Stanford Univ., Dept. of Geophysics, unpub. report, 38 p.
- Willden, R., and Speed, R. C., 1974, Geology and mineral deposits of Churchill County Nevada: Nev. Bur. Min., Bull. 83.
- Zohdy, A. A., and Bisdorf, R. J., 1977, Delineating a basaltic aquifer with Schlumberger soundings near Fallon, Nevada: Geophysics, v. 42, no. 7, p. 1550.

APPENDIX

LITHOLOGIC LOGS

OF

CHEVRON RESOURCES COMPANY WELLS

Soda Lake 44-5
Soda Lake 1-29
Soda Lake 11-33
Soda Lake 63-33

DRILL HOLE Soda Lake 44-5
 LOCATION Center Sec. 5, T.19N., R.28E.

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DRILL HOLE Soda Lake 44-5
LOCATION

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DRILL HOLE Soda Lake 44-5
 LOCATION _____

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DRILL HOLE Soda Lake 44-5
LOCATION _____

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DRILL HOLE Soda Lake 44-5
LOCATION

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p. I

DRILL HOLE Soda Lake 1-29
LOCATION SE $\frac{1}{4}$ Sec. 29, T.20N., R.28E., Nevada

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DEPTH	GRAPHIC LOGS										GRAPHIC GEOLOGY	TR. TRACE 1. WEAK 2. MOD. 3. STRONG	VEINLETS Type	DESCRIPTIONS
	ALTERATION													
	pyrite	chlor.	hem.	2nd Calcite	gypsum	2nd clay								
									1. WEAK 2. MOD. 3. STRONG					
3000													2600-3060' (cont.) alt vitric tuff non-welded, poss. water lain or airfall	
3100													3060-3300 Sand, tuffaceous, vitric, lithic grains, lignite, kaolinite, li-gy. to v. li-gy. Zone 3120-3160' vitric tuff, alt. gy-grn Fault gouge Sand grains are sub-well round	
3200													detrital	
3300													3300-3450 Vitric tuff, alt li-gy. with some grn-gy grains Slight to non-welded.	
3400													Tr. calt py peppered with sulfide grains	
3500													3450-3500 Basalt, similar to 1480- 1620', dike or flow, dk-gy, aphanitic minor alt. Thin sec.: trachytic text	
3600													3500-3540 vitric-crystal tuff 41mm feld. phen. alt. to cal+mic+clay 3540-3590 Sand, tuffaceous, grn-gy med. grain, sub-well round sand grains of tuff, pumice, xls, lithic, with a tuff matrix. montm. and poss. other clays	
3700													3690-3840 Mudstone, even text. med. gy 3690-3780 dk-gy 3780-3840 & fine carbon	
3800													Thin laminae of med & dk-gy in 3780-3840' part.	
3900													3840-3865 Crystal tuff & vitric tuff possibly detrital, gy-grn 3865-3940 silicified tuff & mudst. detrital grains? li-gy 1 qtz-py with bio. specks, few dk-gy frag. 1 qtz	
4000													3940-3950 transition zone 3950-4306 pyroxene gabbro, alt. dk-grn-ish-gy, xls of labradorite, augite, opaques magnetite	

DRILL HOLE Soda Lake 1-29
LOCATION SE 1/4 Sec. 29, T. 20N., R. 28E., Nevada

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DESCRIPTIONS

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DEPTH	GRAPHIC LOGS							P. I	VEINLETS	DESCRIPTIONS	
	ALTERATION							GRAPHIC GEOLOGY			TR. TRACE 1. WEAK 2. MOD. 3. STRONG
	Pyrite	Znd Clay	Chlor	Hem	Cal	Gyp					
400									Tr. qtz-py.	0-400 no cutting	
									400-480	Arkose, med. to fine gr. calcite & clay matrix, V.li. grayish-green; grains ang.-subround, mod. sort.	
										~ 40% tuff, rhy. ? bio. phen. opaques minor silica cementing, of arkose	
500									480-660	Arkose, lithic med.-coarse, to fine kaollinite matrix, white with bio.	
										~ 25% tuff, light gray non-weld.	
										Sand grains are mod. rounded qtz., chalcedony, feldspar, lavas & mudstone grains.	
600								Lost	Tr.-qtz.-py.		
										620-660 ~ 30% tuff & lithic clast	
									660-740	Graywacke, f. gr., clay & cal. matrix 680-VC-M, clay matrix, 30% tuff sub-ang. to mod-round.	
700								Lost			
									740-780	Granules, & graywacke, white kaoline matrix, minor chlor, 1/4 tuff., 1/4 C.Ss tuffis V.li. gray	
800									780-800	Mudstone, tuffaceous & siltstone	
									800-1180	Graywacke, med. to fine, kaoline matrix few granules & mudstone clast lithic sand grains of tuff, lava, qtzf, 840-860 tuffaceous mudstone unit. Tuff is 1/2 of sample 860-880	
										About 30% mudst. 920-980	
900								Lost		V.li. gy, with bio. specks.	
									Tr. py.	py, fine grain, some in Ss & tuff also Ss. frag. with py. matrix.	
1000									Tr. - calc.		
										Some calcite matrix cement. Most the sand grains are tuff & lava, now alt/weathered to clay + mica V.pale grn color in part of the grains & matrix is probably sericite & clays	
										epidote grain, probably detrital.	
1100											
										1180'-Trace organic carbon.	
									1180-1220	Lithic Arkose, fine-m., li. gray, angular, few graywacke & tuffaceous clasts.	
1200									1220-1280	Lithic, qtz. sand, med. to coarse, cleaner & more qtz. than above, angular to subangular. 1260-1280 1/3 graywacke	
								Lost		Graywacke, med. clay matrix abundant tuff or alt feldspar ? grains.	
1300								Lost			
								Lost			
										Calcite cemented lithic grains, round grain mostly tuffaceous - clay matrix.	
1400											

DRILL HOLE Soda Lake 11-33
LOCATION Sec. 33, T. 20 N., R. 28 E.

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DRILL HOLE Soda Lake 11-33

LOCATION

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GRAPHIC LOGS										P. 1	DESCRIPTIONS T. S. → Thin section for indicated interval. 20 ft. sample interval 0- 400' no cuttings
DEPTH	ALTERATION							GRAPHIC GEOLOGY	7" TRACE 1. WEAK 2. MOD. 3. STRONG		
	Py. inf.	2nd Clay	Chlor.	Celad.	Ser.	Cal.	Gyp.				
	1/25	1/25	1/25	1/25	1/25	1/25	1/25				
400										400-420	Sand, lithic-qtzose, med.-c grain sub. round- few lithic pebbles
										420-440	Sand, v. c. & granules
										440-480	Sand, c-qtzose & 15% lithic plus peb. in 460-480'.
500										480-490	Granules, lithic-tuff, & v. f. sand.
										490-600	Sand, v. f. with few lithic granules some med. grains in 520-540 & 560-580'.
600										600-640	Lithic Arkose, c., 1/2 lithic 1/3 fine grains.
T.S. →										640-700	Lithic Sand, v. f. to m., 1/2 coarse grains in 660-680', few c. grains 680-700 arkosic, subangular.
700										700-720	Lithic Arkose, v. c. to granules, ~40% lithic
										720-740	Lithic Arkose, v. f., with ~15% c. v. c. lithic grains.
										740-780	Tuff, bio-opaque specks few lithic sand grains, tuff prob. waterlain.
										780-820	Sand, v. f. qtzose, few lithic granules and c. sand grains, few bio. grains.
800										820-840	Silt & clay, mont., few lithic grains.
										840-920	Sand, v. f.-f., few c. lithic grains few tuff granules 880-920'
900										920-940	Sand, v. c. to granules, lithic, rounded, euh-py. cubes partially cementing.
										940-1010	Graywacke, v. f., lithic with ~1/3 v. c. grains with some py cement.
											960-980' qtz sand zone
1000										1010-1060	Lithic Arkose, v. f., few tuff & lava granules py. cubes & massive cementing.
										1060-1220	Graywacke, fine, tuff & lava granules, qtzose, ~15% lithic.
											1120-1220., v. f. to f. with lithic granular.
1200											1200-1220, 1/2 pebbles of tuff & lava.
										1220-1260	Sand, arkosic, v. f., few c. lithic. frg. few grains contain celadonite.
										1260-1280	Sand, arkosic, f., few lithic granuals.
T.S. →										1280-1340	Lithic Arkose, fine to med. grains few tuff granules 1300-1320'.
1300											
										1340-1360	Sand, lithic, v. c. to granular
										1360-1380	Arkose, m.-f., & v. coarse bival. shell at 1370' lithic-tuff grains.
1400										1380-1540	Graywacke, fine-med. grained, chal. cement with chlorite in final interst. pores.

DRILL HOLE Soda Lake 63-33
LOCATION NE 1/4 Sec. 33, T. 20N., R. 28 E.

LOGGED BY Sibbett

DRILL HOLE Soda Lake 63-33
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PLATE I
SODA LAKE WELL LOG CORRELATION
CHURCHILL CO., NEVADA