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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.

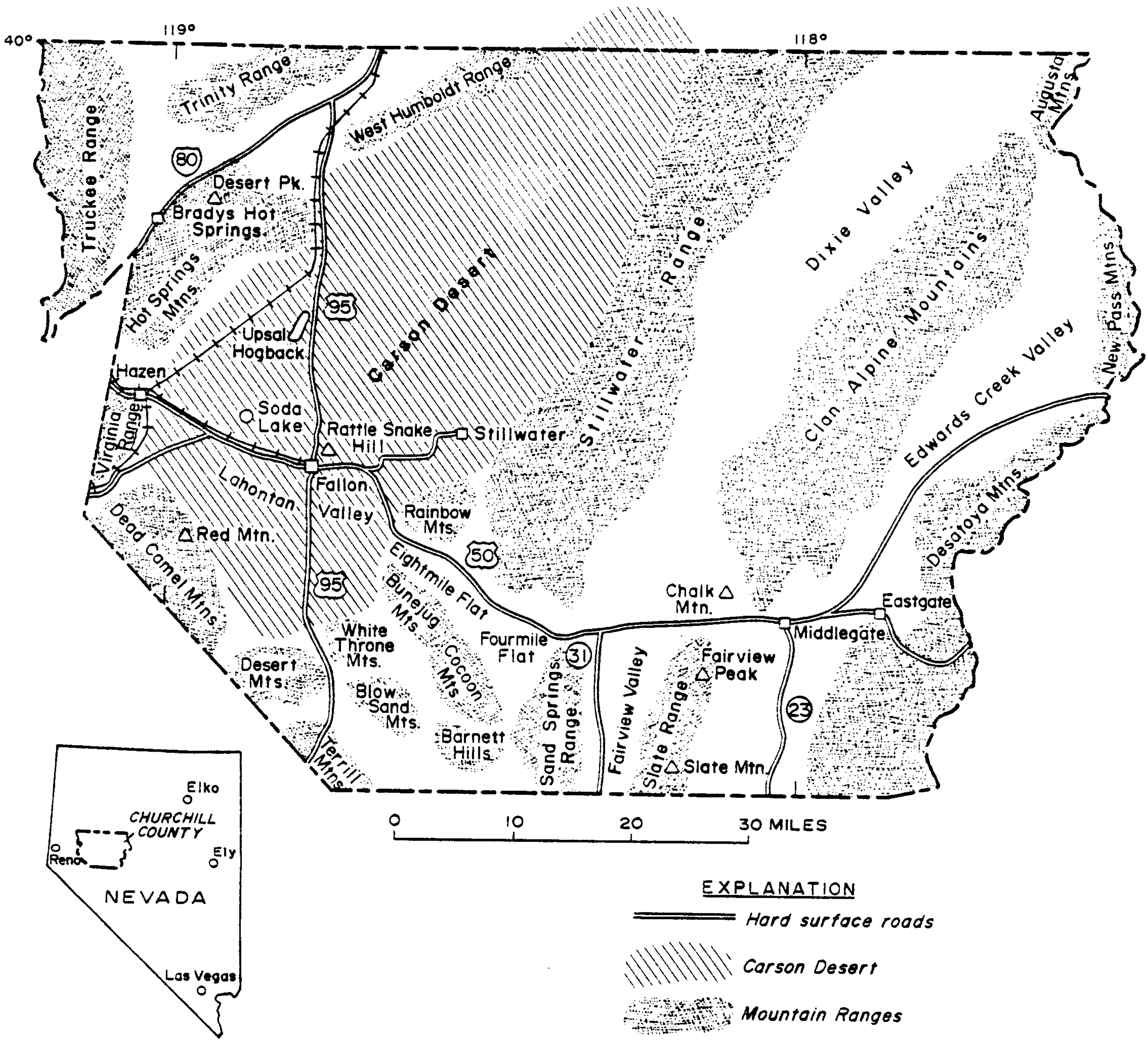

Figure 1. Index map of Churchill County, Nevada.

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.

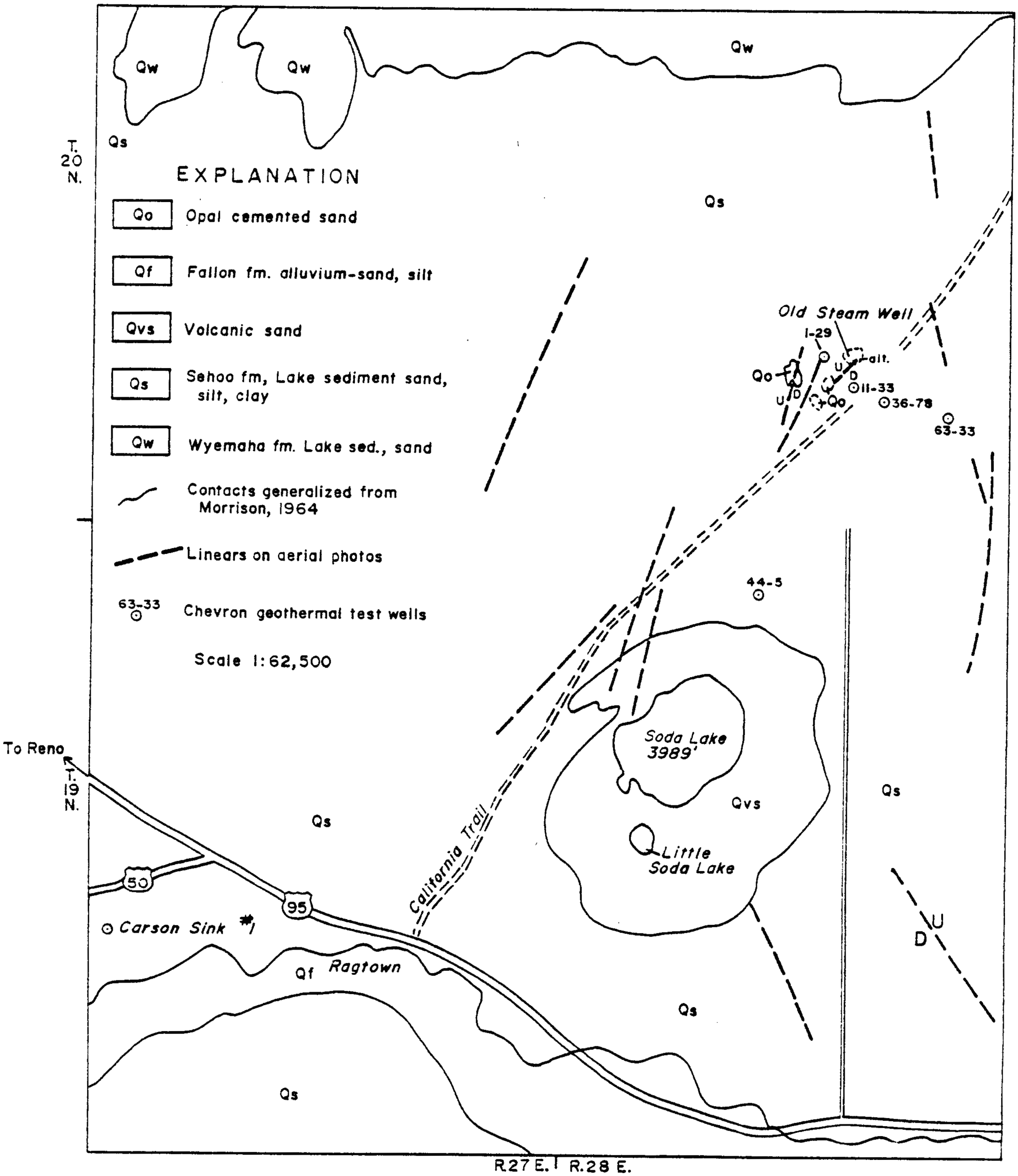

Figure 2. Geology of the Soda Lake area, Churchill Co., Nevada.

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 $\pm$ 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, 66-33, 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 x 10^6 cal/sec as a minimum from the Soda Lake thermal anomaly enclosed by the 20°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.

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APPENDIX

LITHOLOGIC LOGS

OF

CHEVRON RESOURCES COMPANY WELLS

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

GRAPHIC LOGS — Pg. 1

ALTERATION (1. weak, 2. mod., 3. strong): Pyrite, Red Clay, Chlor., Epidote, Hematite, Calcite, Gypsum

GRAPHIC GEOLOGY

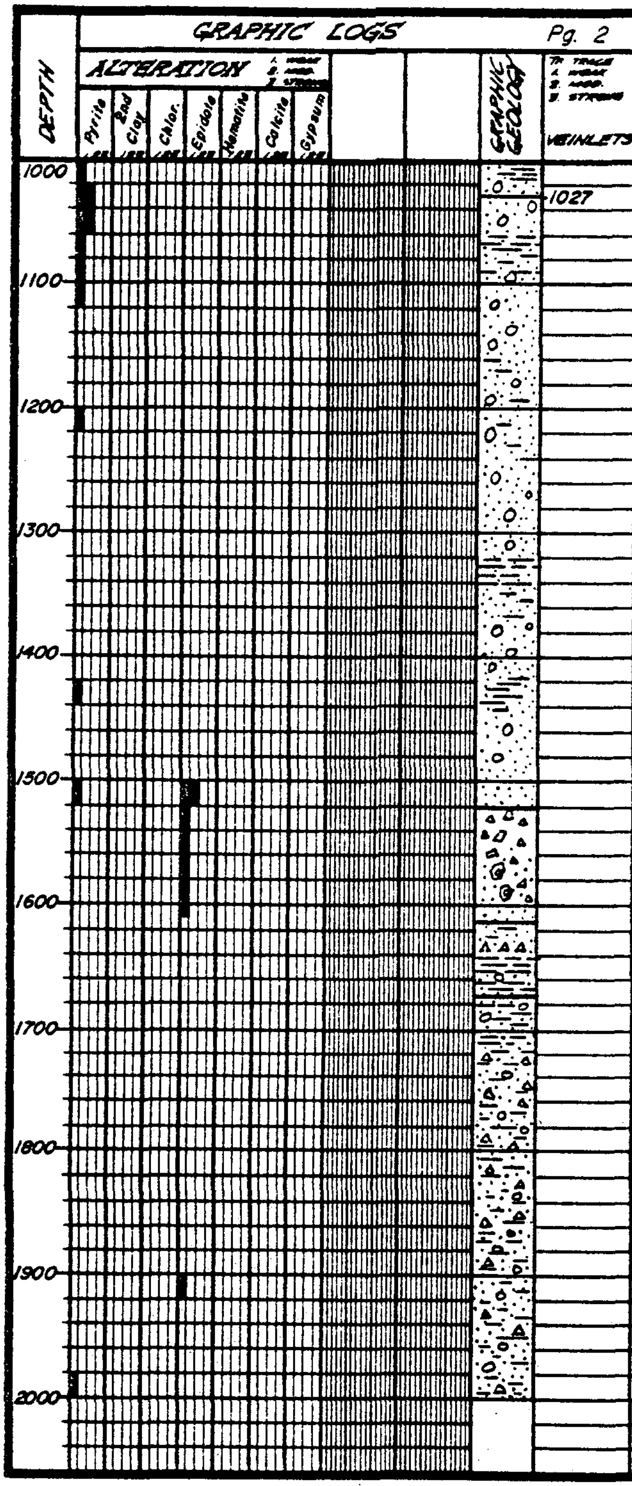
VEINLETS (Tr trace, 1. weak, 2. mod., 3. strong)

DEPTH	VEINLETS	DESCRIPTIONS
0		Sand - course to medium - & gravel, pebbles are tuff & lava, poorly sorted.
100		
200		
300		
310		Sand - medium to course, moderately sorted
		Gravel, pebbles of lava with sand & silt.
400		
460		No sample
500		
520		Sand - medium fine to very course, quartz rich, clean, well sorted.
		Gravel & sand - pebbles of volcanic, siltstone, poorly sorted, sub round lithic sand.
600		
		Siltstone bed - ? possibly at ≈ 700', well-sorted, with biotite flakes
700		
	737	
		Sand & mudstone - lava sandgrains with some pebbles
800		
		Clay, sand & gravel - clay is mont. rich - tuffaceous, water lain tuff is included. Pebbles are lava & quartzite - poor sorting.
900		
1000		
1027		Sand - very course to medium, with clay, siltstone, pebble gravel.
1060		

DRILL HOLE Soda Lake 44-5

LOCATION Center Sec. 5, T.19N., R.28E.

LOGGED BY Sibbett



DESCRIPTIONS

Sand-very course to medium with gravel, clay, silt,-poorly sorted.

Pebbles are volcanic rock, quartzite, and siltstone.

Thin section (1555')
Basalt lapilli, alt. vitric-basaltic tuff, lava flow fragments, mudstone &/or tuffaceous siltstone.

Epidote-could be detrital

Ash, basaltic, with phenocryst of euh. labradorite & amygdules. Also detrital grains of quartz, quartzite, & andesite-basalt lavas. Sand increases below 1580', epidote may be detrital.

Sand-very coarse & granules, & clay zones tuffaceous, most grains are vol., some quartz grains are glassy

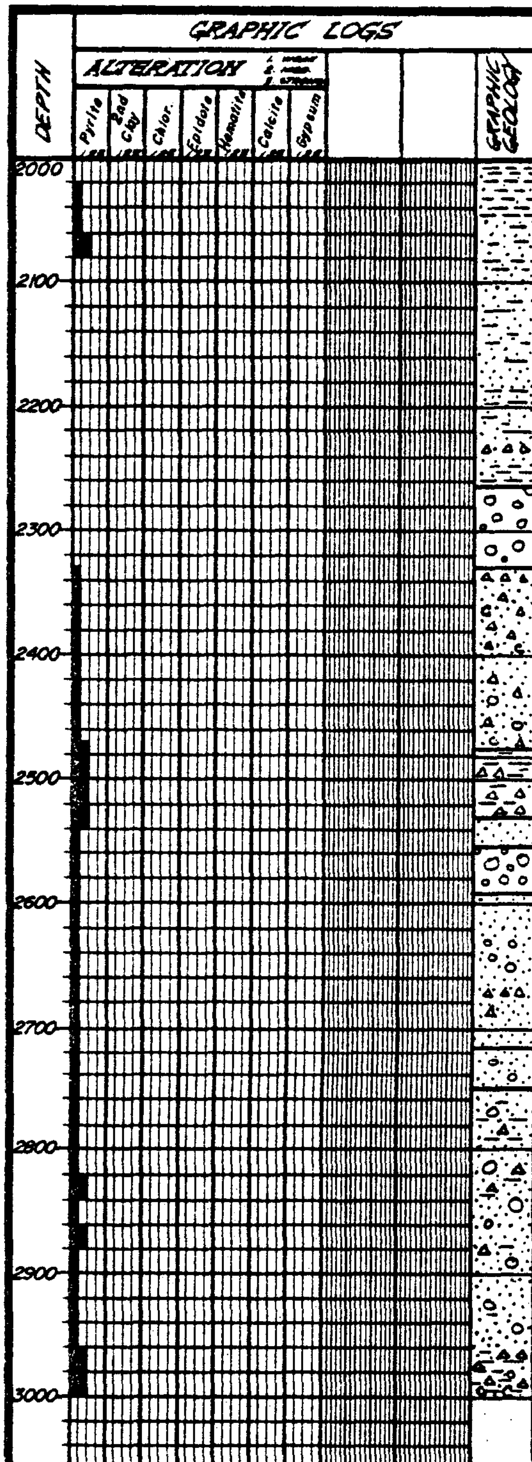
Tuffaceous clay dominant over sand (well setter's log calls this 'clay', the clay fraction could be washed out).

Poorly sorted &/or interbedded tuffaceous clay or mud, sand, gravel.

DRILL HOLE Soda Lake 44-5
LOCATION

LOGGED BY Sibbett

Pg. 3



Veinlets	DESCRIPTIONS
	Mudstone & sand, tuffaceous.
2172	Sand is dominant with minor mudstone.
2236	Tuffaceous clay more abundant
	Fossil claim shells
	Gravel, pebbles-granules. Pebbles are quartzite, vol. intrusive, tuff, fairly clean & sorted.
	Tuff or ash-basaltic with sand or
2237-	lava grains.
2473	Organic carbon grains - wood.
2473	
	Tuffaceous clay - rhyolitic ?
	Sand, medium to coarse, 1/2 quartz - 1/2 vol., well sorted
	Gravel, pebbles of vol., sand matrix.
	Sand, medium to fine. Some pebbles & tuff, quartz rich & vol. grains.
	Sand, coarse to medium, some pebbles, carbon-lignite.
	Sand with interbedded & mixed tuffaceous clay, pebbles, carbon present as grains.
	Zone—20% carbon, more clay 2970-2985

DRILL HOLE Soda Lake 44-5

LOCATION

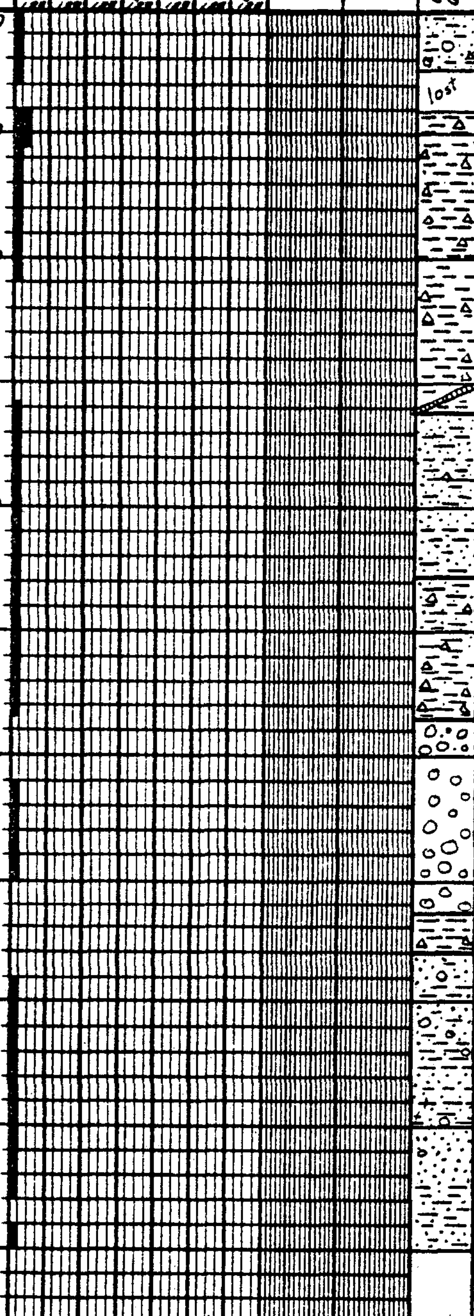
LOGGED BY Sibbett

GRAPHIC LOGS

ALTERATION: 1. weak, 2. mod., 3. strong — Pyrite, Arg Clay, Chlor., Epidote, Hematite, Calcite, Gypsum

GRAPHIC GEOLOGY

VEINLETS: Tr. trace, 1. weak, 2. mod., 3. strong



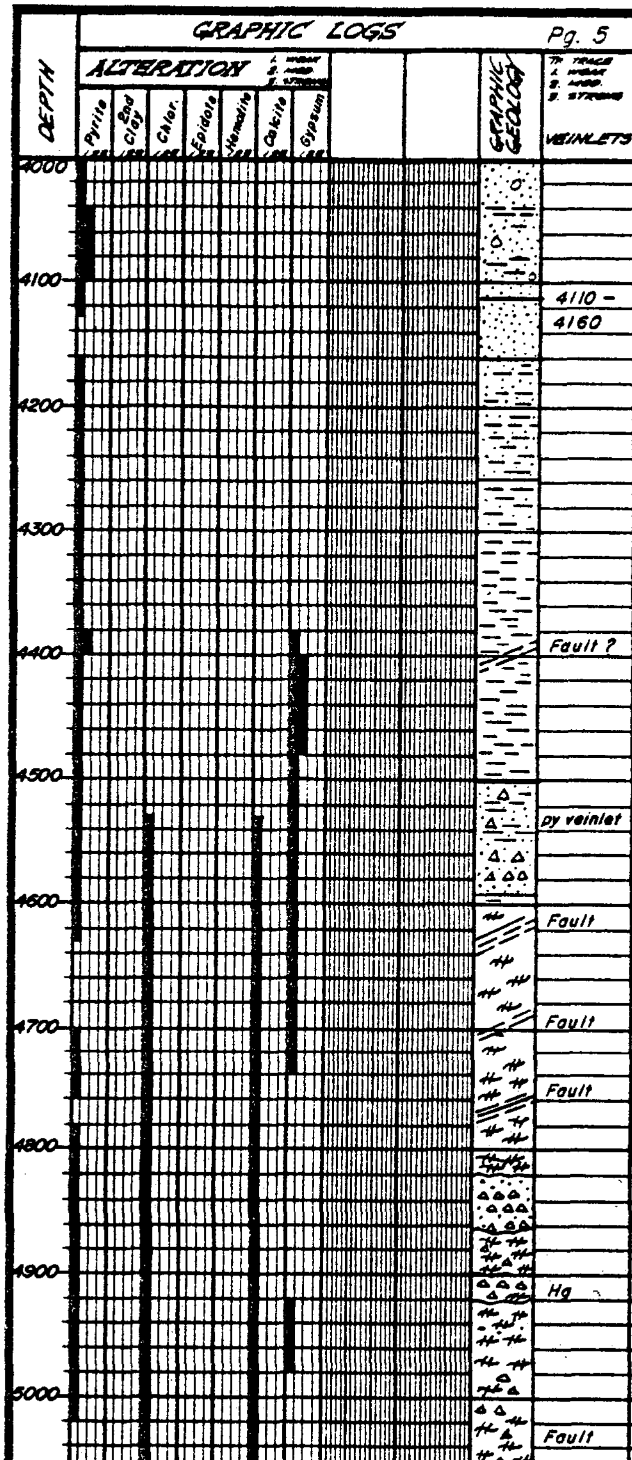
DEPTH	VEINLETS	DESCRIPTIONS
3000		Sand with clay (tuffaceous) & carbon continued
		No sample.
3100		Mudstone (tuffaceous) & shale, minor quartz sand.
	3177 - 3205	10-20% lignite
3200	3205 - 3236	10% lignite
3300	Py vein	
		Sand 2/3, medium to coarse, quartz rich. Mudstone - clay 1/3, tuffaceous.
3400		
		Tuffaceous mudstone & shale with minor sand.
3500		
3600		Gravel, granule to pebbles - pebbles of lava, tuff, obsidian & quartzite.
3700		Tuffaceous mudstone & clay, minor sand.
		Sand, medium to coarse, quartz & lithic minor mudstone & pebbles.
3800		Claystone zone.
3900		Arkosic zone.
4000		

DRILL HOLE Soda Lake 44-5

LOCATION

LOGGED BY Sibbett

GRAPHIC LOGS Pg. 5



DEPTH	VEINLETS (Tr. TRACE, 1. WEAK, 2. MOD., 3. STRONG)	DESCRIPTIONS
4000		Arkose & tuffaceous mudstone, few pebbles, poorly sorted.
4100	4110 – 4160	Sand, medium, arkosic & lithic.
4200		Arkose, & mudstone or clay interbedded, gray to very light gray mudstone, tuffaceous grades to mudstone at 4260'.
4300		Mudstone, tuffaceous, medium gray & light olive gray interbedded. The medium gray has light & dark gray lamina 0.1 mm thick. Argillaceous siltstone in minor amounts is also present. Mudstone contains calcite.
4400	Fault ?	
4500	py veinlet	Coarse sand, tuff & mudstone. (thin sec. 4534) grades into pure tuff, basalt flow frag. & tuff, calcite amydules. (thin sec. 4568)
4600	Fault	Lava flow, alt. basalt & basalt.
4700	Fault	
	Fault	
4800		Basalt lava flow, alt. olivine, vesicles (See core description). Lava flow, ash flows & sand interbedded.
4900	Hg	Trace cinnabar ? (thin sec. 4905)
		Basalt to andesite - upper Andesine Augite, alt. to bio. (thin sec. 4936)
		Porphyritic, plag. hornblende - alt. palagonite, celladonite, chlorite.
5000	Fault	Lava & tuff only
		T.D. 5069'

DRILL HOLE Soda Lake 44-5

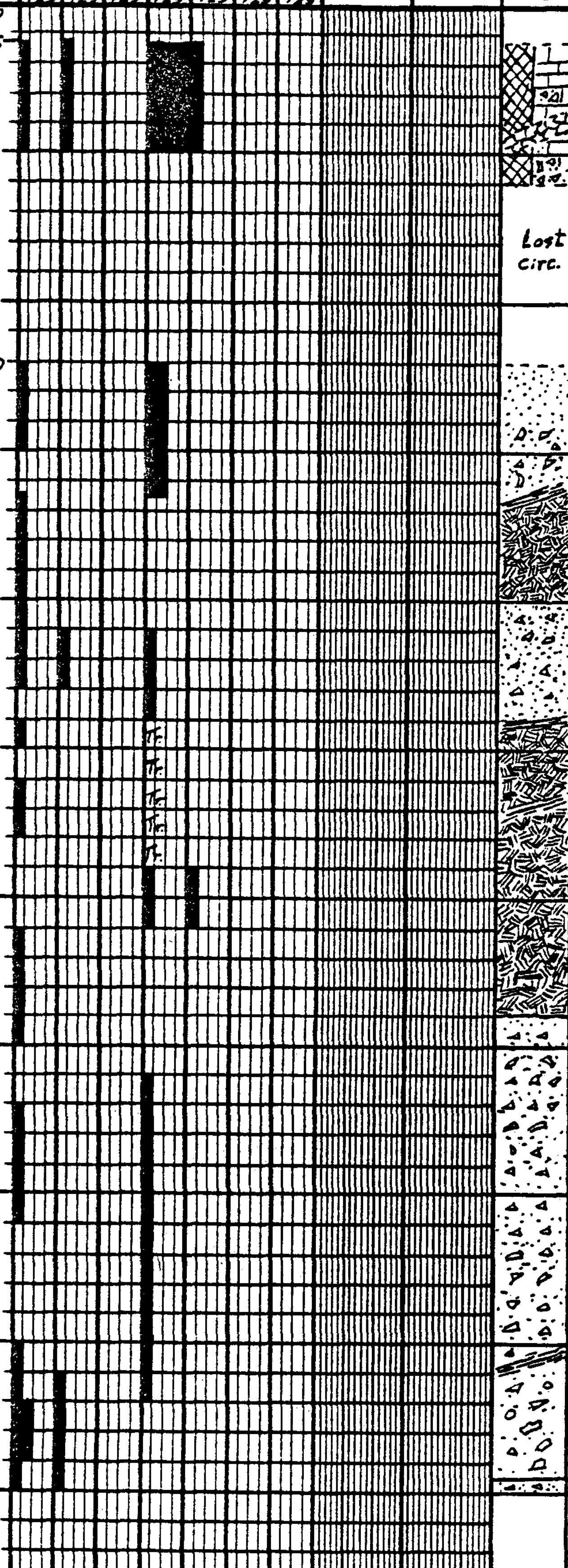
LOCATION

LOGGED BY Sibbett

p. 1

GRAPHIC LOGS

ALTERATION (1. weak, 2. mod., 3. strong): pyrite, chlor., hem., calcite, gypsum, 2nd clay — GRAPHIC GEOLOGY — VEINLETS & Type (Tr trace, 1. weak, 2. mod., 3. strong) — DESCRIPTIONS



DEPTH	VEINLETS & Type	DESCRIPTIONS
1,000		(no cuttings above 1025')
1,025		1025-1120 Secondary calcite, vugy, some lar. calcite x'ls, pyrite, anhydrite
	3	Some mafic pumice grains with gypsum in ves. (poss. calcite repl. gyps.)
1,100		drilling cement also present
1240		1240-1330 Sand, qtz rich, tuffaceous,
	Tr. qtz & py.	calcite cement, li. frag., poss. 2nd. qtz, chert, tr. lignite.
1300		1290-1330 has white tuff component.
	fault	slicken sides and fault gouge
		1330-1400 Basaltic dike or flow, dk-gy
	Tr. qtz	bk, aphanitic, in th. sec. plag.-pyrox.
1400		glass, opaques, hyp., trachytic text.
		1400-1480 Sand, tuffaceous, qtz
	Tr. qtz	med-f., mod. sort.
	cal & py	detrital ep.? large rounded grains
	Tr. qtz	
	fault cont	1480-1680 Basaltic dike or flow
1500		aphanitic, dk-gy-bk, no pheno.
	1-2 qtz & calc.	Thinsec: trachytic text., ave. 0.1 mm xls., few 0.3 mm plag. laths, glass
		matrix, anh. hypersthene, opaques
1600		~0.02 mm, apatite rods, basalt comp
		some calcite alt.
		contact picked from drilling rate
1700	1 py.	1680-1910 Tuff, siliceous, v. li gy.
	Tr.-1 py. qtz	to pinkish gy, pumice, bio. speck
		glass shards, variable text.
		non-welded.
1800	Tr. qtz-py	color changes to li. gy-grn & li. gy. pk at 1815'
1900	Tr. qtz	fault gouge at 1910
	Tr. cal-py	1910-1990 Dacite tuff (poss. flow)
		grn-gy, irregular vugs with
		chlor., possible lithic frag.
2000		

DRILL HOLE Soda Lake 1-29

LOCATION SE¼ Sec. 29, T. 20 N., R. 28 E., Nevada

LOGGED BY Sibbett

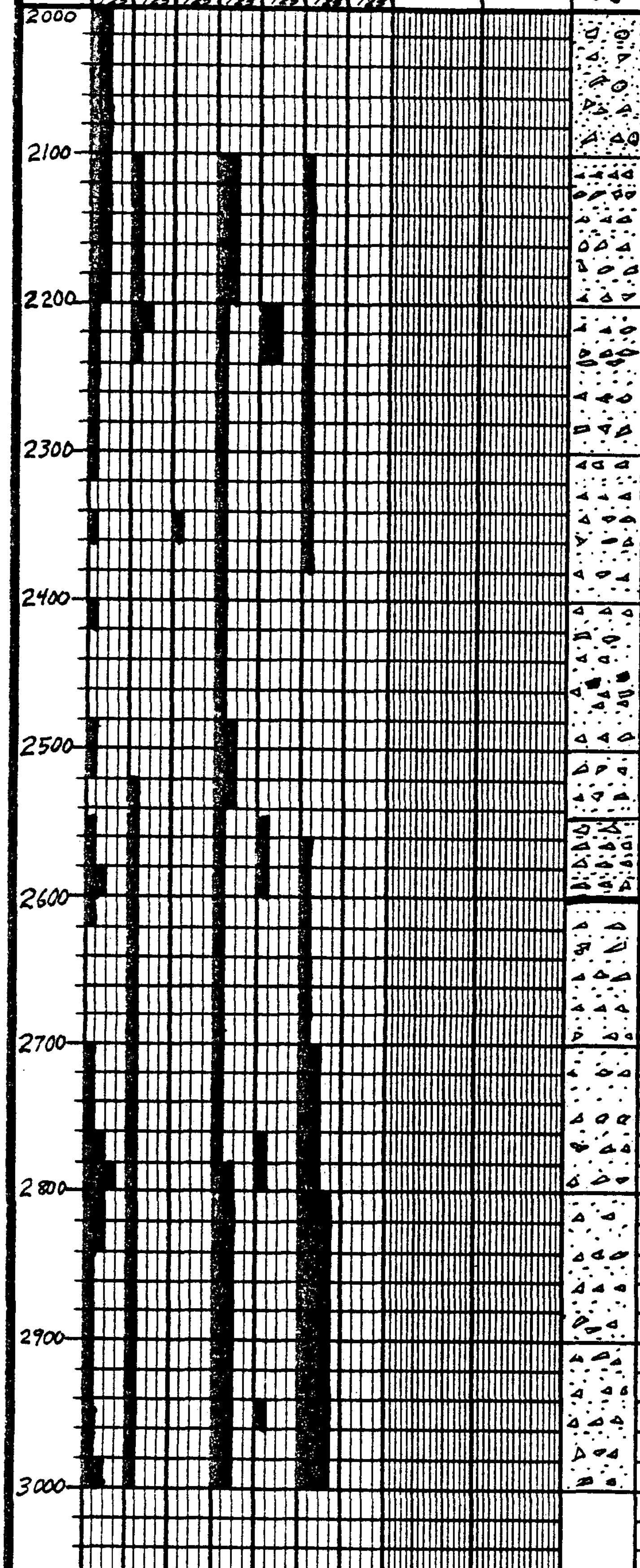
GRAPHIC LOGS

ALTERATION (1. weak, 2. mod., 3. strong): pyrite, chlor., hem., 2nd calcite, gypsum, 2nd clay — 123

GRAPHIC GEOLOGY

VEINLETS (Tr. trace, 1. weak, 2. mod., 3. strong) — Type

DESCRIPTIONS

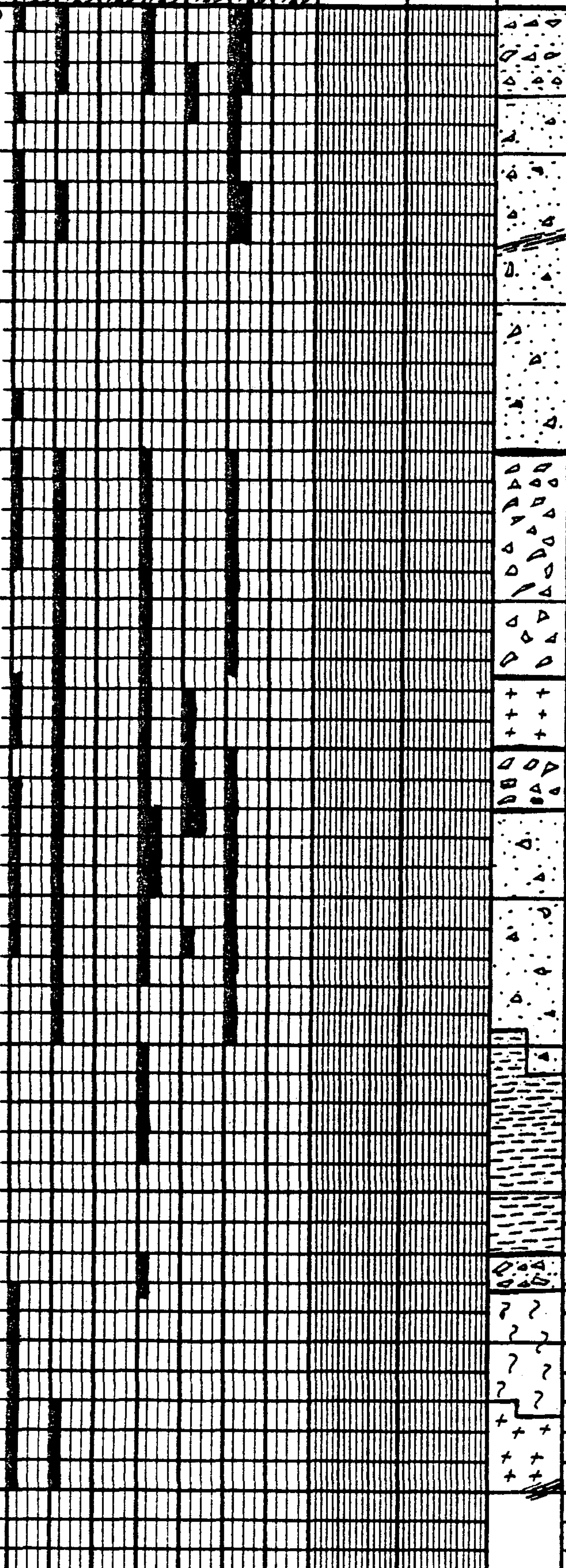


Depth	Veinlets	Descriptions
2000		1990-2100' lithic tuff or tuffaceous
	Tr.-1 qtz-py	sand, with lithic & qtz grains
		med.-fine grained.
2100	1 py	
	1 py	2100-2545' vitric tuff, non-welded
	1 py	li. gy. bio specks
	2 py	Some alt. to clay
		variable text. & color
2200		
2300		
2400		
		lignite grains - 2440
2500		Color change to more white tuff
		with sand grains at 2480'
		2545-2600 Tuffaceous mudstone
	1 qtz-py	
2600	1	greenish gray
	Tr.	2600-3060 vitric tuff, alt. to clay
		calcite and chlor.
		Chlorite grains, with a few lithic
		frag.
2700		abundant clay mont. & kaolinite
		May have other carbonates in
		addition to calcite.
	1 to 2	py + gyp. veins
2800	2	py + qtz veins & calcite
	2 cal+py	
	1	
2900	1	Tr. chalcopyrite at 2900'
	1	
	1	
	1	
3000	1 qtz+py	

DRILL HOLE Soda Lake 1-29

LOCATION SE¼ Sec. 29, T.20N., R.28E., Nevada

LOGGED BY Sibbett

DEPTH	GRAPHIC LOGS: ALTERATION (1. weak 2. mod. 3. strong) — pyrite, chlor., hem., 2nd calcite, gypsum, 2nd clay; GRAPHIC GEOLOGY	VEINLETS type (Tr. trace 1. weak 2. mod. 3. strong)	DESCRIPTIONS
3000			2600-3060' (cont.) alt vitric tuff non-welded, poss. water lain or airfall
			3060-3300 Sand, tuffaceous, vitric, lithic grains, lignite, kaolinite, li-gy. to v. li-gy.
3100			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.
		Tr. cal + py	
3400			peppered with sulfide grains
		Tr. cal+py	3450-3500 Basalt, similar to 1480-1680', dike or flow, dk-gy, aphanitic minior alt. Thin sec.: trachytic text
3500			3500-3540 vitric-crystal tuff <1mm 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
3600			
3700			3690-3840 Mudstone, even text. med. gy 3690-3780 dk-gy 3780-3840 & fine carbon
			Thin laminae of med & dk-gy in 3780-3840' part.
3800			3840-3865 Crystal tuff & vitric tuff possibly detrital, gy-grn
3900			3865-3940 silicified tuff & mudst. detrital grains? li-gy
		1 qtz-py	with bio. specks, few dk-gy frag.
		2 qtz	3940-3950 transition zone
4000			3950-4306 pyroxene gabbro, alt. dk-grnish-gy, xls of labradorite, augite, opaques magnetite

DRILL HOLE Soda Lake 1-29

LOCATION SE¼ Sec. 29, T.20N., R.28E., Nevada

LOGGED BY Sibbett

GRAPHIC LOGS

ALTERATION (1. WEAK 2. MOD 3. STRONG): Pyrite, chlor., hem., 2nd Calcite, Gypsum, 2nd clay

GRAPHIC GEOLOGY

VEINLETS (Tr. TRACE 1. WEAK 2. MOD. 3. STRONG)

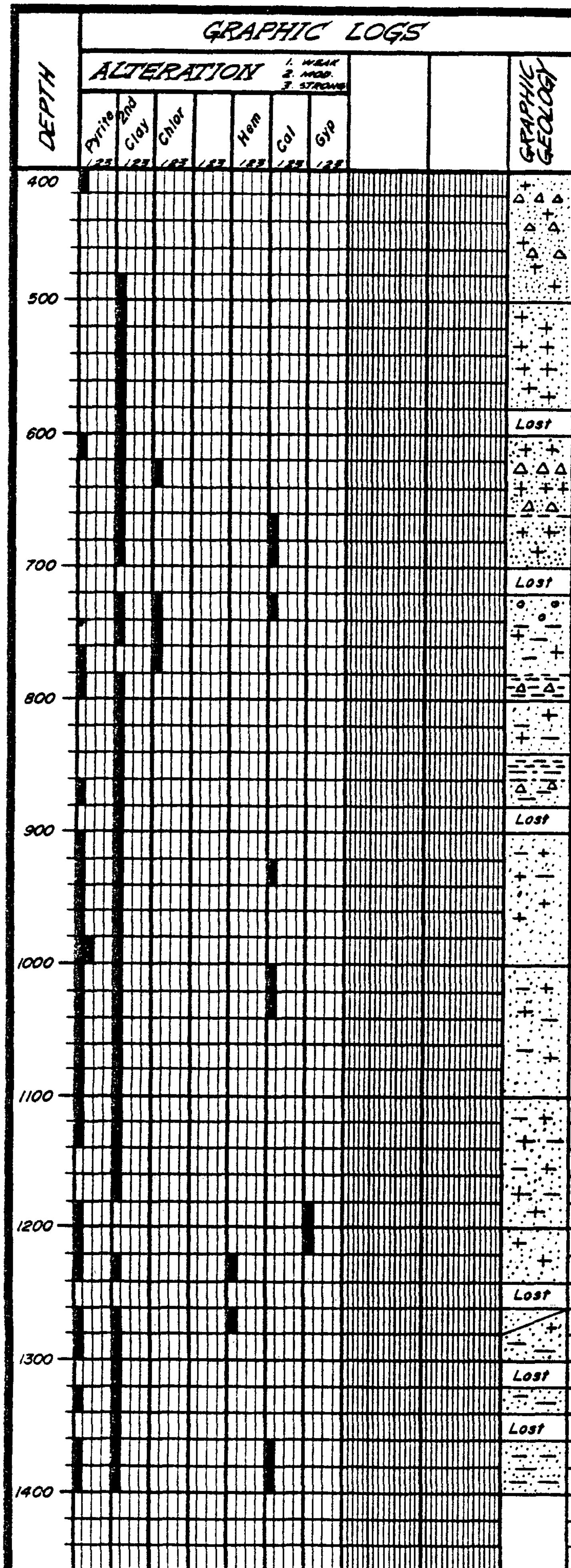
DESCRIPTIONS

DEPTH	VEINLETS	DESCRIPTIONS
4000	slickens	fine phaneritic text.
		Mod. alt. (thin section made)
		sphene, epidote
	fault gouge	
4100		
	f. gouge	secondary albite ?
4200		
	fault gouge	
4300		

DRILL HOLE Soda Lake 1-29

LOCATION SE¼ Sec. 29, T.20N., R.28E., Nevada

LOGGED BY Sibbett



P. 1

VEINLETS (Tr. TRACE, 1. WEAK, 2. MOD., 3. STRONG)	DESCRIPTIONS
	0-400 no cutting
Tr. qtz.-py.	Arkose, med. to fine gr. calcite & clay matrix,
400-480	V.li. grayish-green; grains ang.-sub round, mod. sort.
	~40% tuff, rhy.? bio. phen. opaques minor
	silica cementing, of arkose
480-660	Arkose, lithic med.-coarse, to fine kaolinite
	matrix, white with bio.
	~25% tuff, light gray non-weld.
	Sand grains are mod. rounded qtz.,
	chalcedony, feldspar, lavas & mudstone grains.
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.
740-780	Granules, & graywacke, white kaoline matrix,
	minor chlor, 1/4 tuff., 1/4 C.Ss tuff is V.li. gray
780-800	Mudstone, tuffaceous & siltstone
800-1180	Graywacke, med. to fine, kaoline matrix few
	granules & mudstone clast lithic sand grains of
	tuff, lava, qtzt, 840-860 tuffaceous
	mudstone unit. Tuff is 1/3 of sample 860-880
	About 30% mudst. 920-980
	V.li. gy, with bio. specks.
Tr. py.	py, fine grain, some in Ss & tuff also Ss.
	frag. with py. matrix.
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.
	1180'-Trace organic carbon.
1180-1220	Lithic Arkose, fine-m., li. gray, angular,
	few graywacke & tuffaceous clasts.
1220-1280	Lithic, qtz. sand, med. to coarse, cleaner
	& more qtz. than above, angular to
	subangular. 1260-1280 1/3 graywacke
1280-1560	Graywacke, med. clay matrix abundant tuff
	or alt feldspar? grains.
	Calcite cemented lithic grains, round grain
	mostly tuffaceous - clay matrix.

DRILL HOLE Soda Lake 11-33

LOCATION Sec. 33, T. 20 N., R. 28 E.

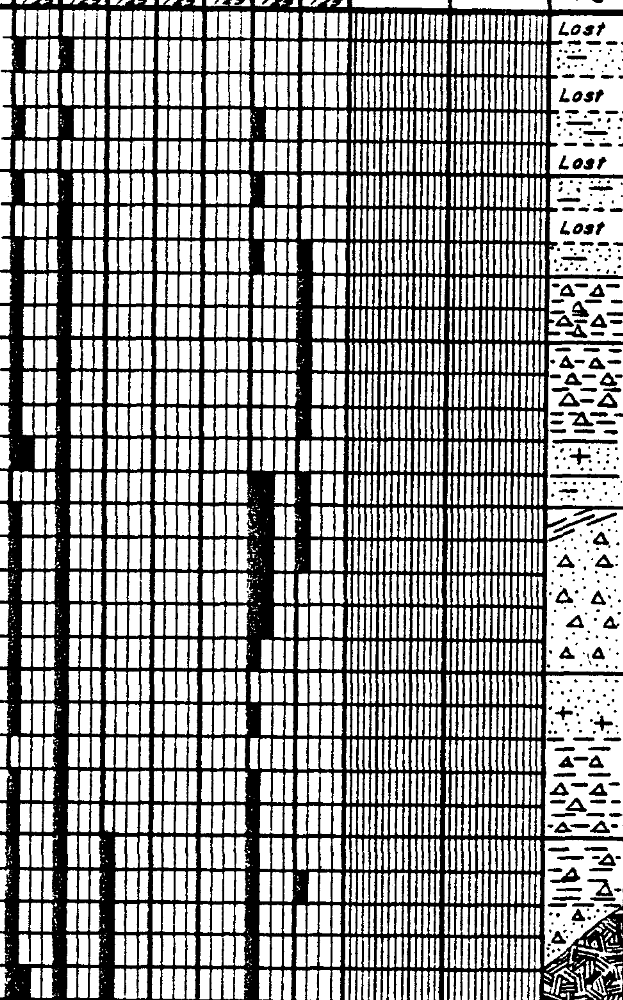
LOGGED BY Sibbett

GRAPHIC LOGS P. 2

ALTERATION: 1. WEAK 2. MOD. 3. STRONG — Pyrite, 2nd Clay, Chlor, Hem, Cal, Gyp

GRAPHIC GEOLOGY

VEINLETS: Tr. TRACE 1. WEAK 2. MOD. 3. STRONG



DEPTH	GRAPHIC GEOLOGY	VEINLETS	DESCRIPTIONS
1400	Lost		Gray wacke - continuing from 1280
			hem. stain due to drilling steel.
	Lost		
		Tr. py	Organic carbon, bivalve shells.
1500	Lost		
			Sericite and kaolin, minor cal. cem.
	Lost		
		Tr. cal.	Tuff content increased -
		1560-1660	Tuffaceous sed. sand ?
1600			V. li, gray tuff, matrix mostly
			tuff - clay ?, some calcite & gypsum
			matrix, fine-med. grains.
		1660-1680	Lithic arkose, tuffaceous, med.-fine grd.
1700		1680-1820	Gray wacke, tuffaceous, cal. in matrix.
		Fault	
			1720-1740 fine ground zone ?
			≈ half of matrix is calcite,
			qtz sand grains ≈ 20% below 1760.
1800			
		1820-1840	Lithic-arkose, med. to fine, tuffaceous
		1840-1940	Tuffaceous sed. v.li. gray and med. gray.,
			1860-1880 fine ground zone.
1900			
			1900-1940 increased qtz sand grains.
		1940-1980	Basaltic-andesite, plag-taths.
			Matrix bio. & chlor., calcite, clay ?
2000		1980-2000	Basaltic-andesite, plag. laths are 0.2mm
T.D.			long - few ½ mm in Trachytic,
			li. gray to li. bluish gray, even color.
			Thinsection 2000'
			est. 30% plag. laths, euh
			normal zone in larger xls.
			20% bio. alt to chlor.
			10 % hem.
			5-7% obaques.
			A few pyroxene grains
			minor clay.

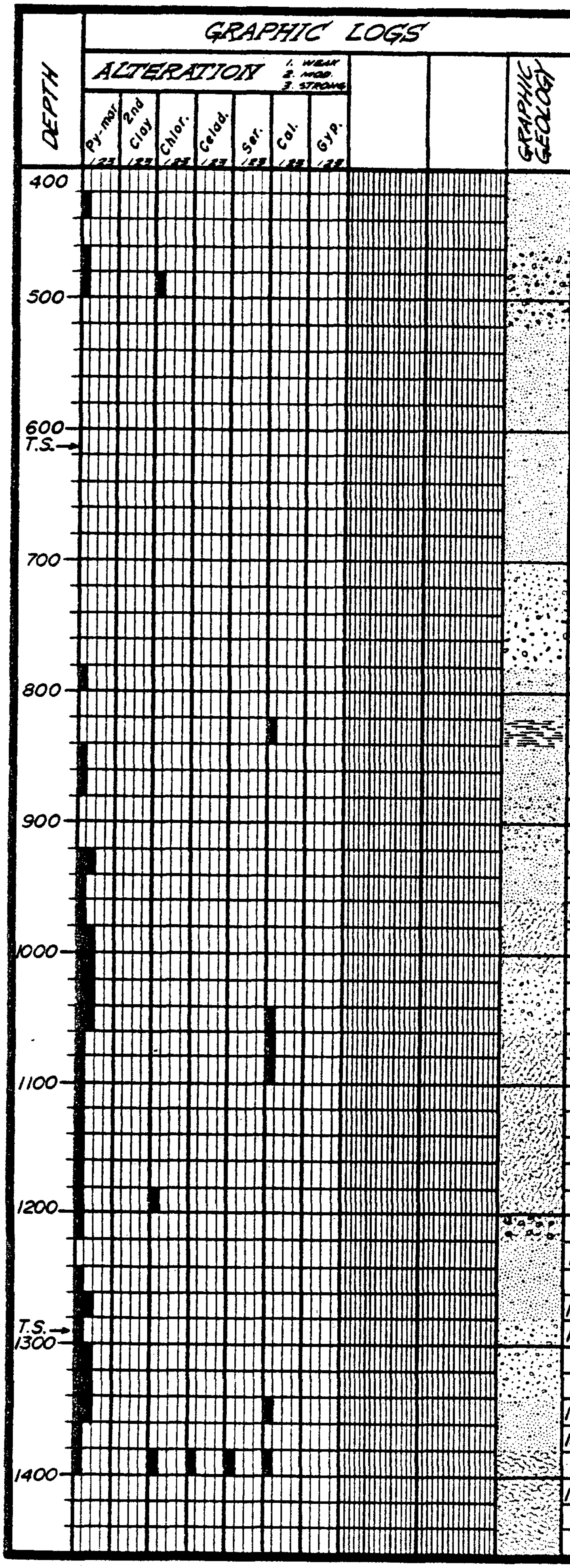
DRILL HOLE Soda Lake 11-33

LOCATION

LOGGED BY Sibbett

GRAPHIC LOGS

P. 1



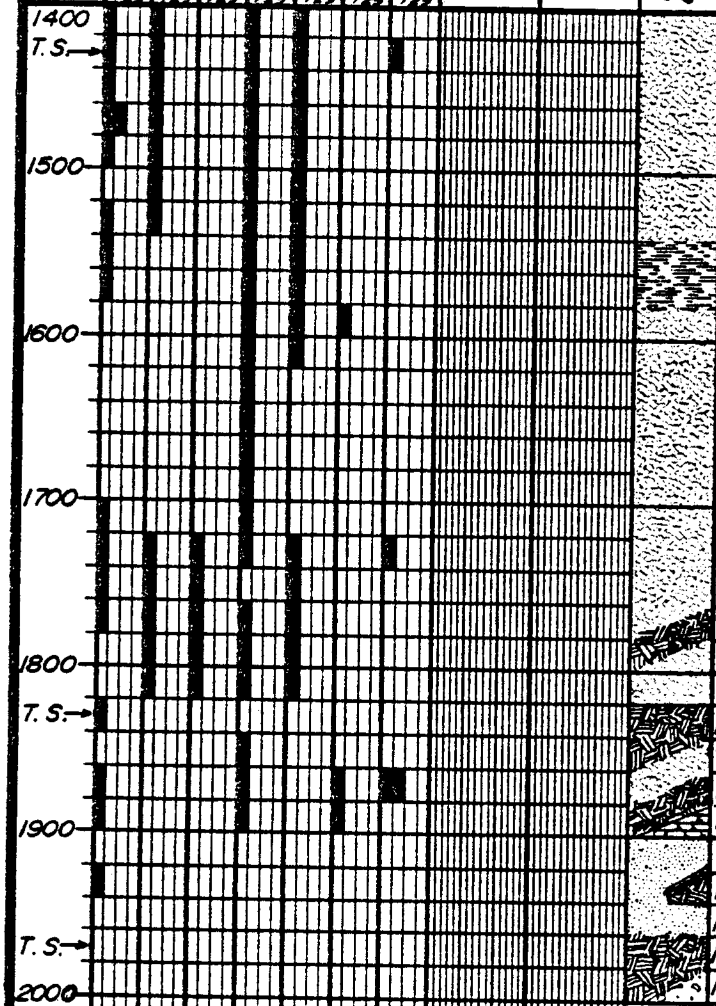
DESCRIPTIONS

T. S. → Thin section for indicated interval.
20 ft. sample interval
0- 400' no cuttings

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'.
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'.
600-640	Lithic Arkose, c., 1/2 lithic 1/3 fine grains.
640-700	Lithic Sand, v. f. to m., 1/2 coarse grains in 660-680', few c. grains 680-700 arkosic, subangular.
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.
820-840	Silt & clay, mont., few lithic grains.
840-920	Sand, v. f.- f., few c. lithic grains few tuff granules 880 - 920'
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
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. 1200-1220, 1/2 pebbles of tuff & lava.
1220-1260	Sand, arkosic, v. f., few c. lithig. frg. few grains contain celadonite.
1260-1280	Sand, arkosic, f., few lithic granuals.
1280-1340	Lithic Arkose, fine to med. grains few tuff granules 1300-1320'.
1340-1360	Sand, lithic, v. c. to granular
1360-1380	Arkose, m.-f., & v. coarse bival. shell at 1370' lithic-tuff grains.
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. 20 N., R. 28 E.
LOGGED BY Sibbett

DEPTH	GRAPHIC LOGS		DESCRIPTIONS
	ALTERATION (1. WEAK 2. MOD. 3. STRONG): Py-mar, 2nd Clay, Chlor., Celad., Ser., Cal., Gyp. — GRAPHIC GEOLOGY	Tr. TRACE 1. WEAK 2. MOD. 3. STRONG	



1380-1540	Graywacke, m.-f. grd. (continued)
	lithic clast of lava & tuff.
	1460-1480 few tuff. frag.
	1480-1560 small bival. shells
	1500-1520 secondary qtz., calcite cement.
1540-1580	Silt st. & v.f. Ss, few granules bival shell, arkosic, to graywacke.
1580-1820	Graywacke, fine grd. tuffaceous
	Trace cinnabar 1580-1600
	1620-1700 fine ground sample.
	Celadonite? in matrix 1580-1620
	~1/3 c. grain zones-1660-1720
	1700- celadonite in matrix
	1720-1740 coarse drill chips
1760-1800	1/2 basaltic-andesite, trachytic text.
	Olive black color, 1/2 mm plag laths.
	1800-1820 fine ground graywacke?
1820-1840	Basalt-Andesite, olive black with
Tr. py qtz	1/2 mm plag. laths, 10% tuff-frag,
1840-1880	1/2 basalt, 1/2 graywacke, c
1880-1900	alt & fresh basalt, xl tuff frag. & micrite.
1900-1920	Sand, v.f. lithic-arkose-slicken sides
1920-1940	Graywacke, m. grain. ~1/4 basalt frag.
1940-1960	lithic-arkose, v. f. grain-few bas. frag.
1960-2000	Basalt, olive-black, ~1/3 tuff. grains
Tr. py qtz	in 1980-2000' sample, basalt is fresh chips, without weathering, chill, vesicles or oxidation which might indicate a flow.

DRILL HOLE Soda Lake 63-33

LOCATION NE 1/4 Sec. 33, T. 20N., R. 28 E.

LOGGED BY Sibbett

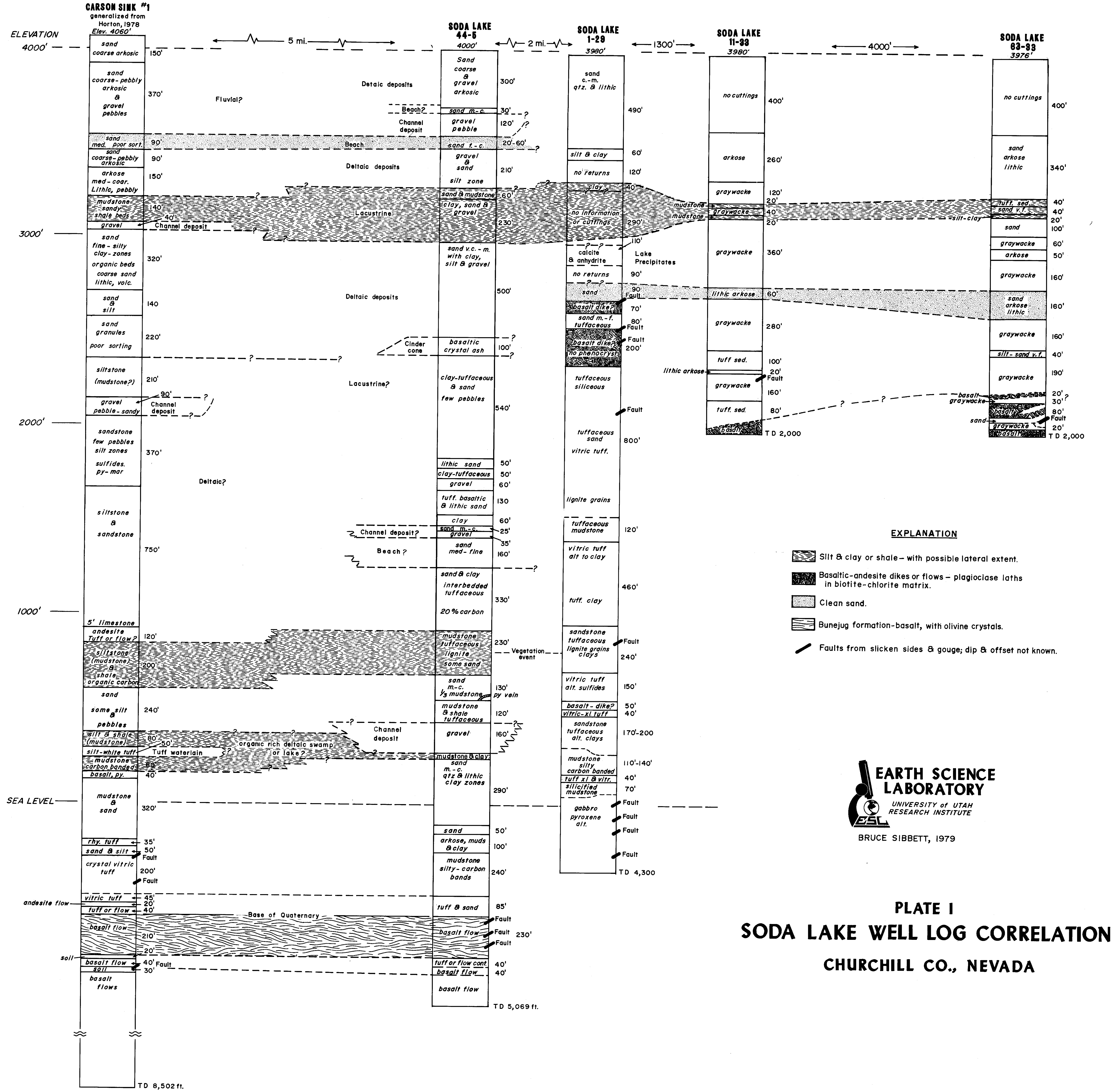


PLATE I
SODA LAKE WELL LOG CORRELATION
CHURCHILL CO., NEVADA