TEC-6

A THERMAL, GEOLOGICAL AND GEOCHEMICAL STUDY OF SELECTED GEOTHERMAL AREAS OF NEVADA AND EASTERN CALIFORNIA.

By

Frank Dellechaie

May 31, 1978.

AMAX Exploration, Inc.
4704 Harlan Street
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INTRODUCTION

The McCoy and Tuscarora Prospects were generated as a result of the 1977 geothermal reconnaissance. The greater part of Nevada and eastern California were explored in that program. Exploration consisted of non-thermal and thermal water collection, thermal gradient measurement and geological appraisal. This report attempts to discuss the great bulk of data gathered in 1977.

The criteria for selection of areas that are discussed is explained in the second chapter. A list of the omitted areas is recorded in chapter three. Springs and wells exhibiting high subsurface temperatures and interesting chemistry are discussed by geographic area in chapter four. Geology, geochemistry, land position and exploration drilling are treated there as consistently and briefly as possible. Holes or wells having high heat flow are treated in the fifth chapter.

This report will be used to assess various areas of Nevada during the 1978 program. A refined version of this report will be written at the end of the 1978 program.

CRITERIA FOR GEOCHEMICAL AND HEAT FLOW SELECTION

All of the Nevada and California geochemical data was sorted according to decreasing silica (quartz) and Na-K-Ca subsurface temperatures. Those samples having an alkali subsurface temperature in excess of 170°C and a corresponding silica subsurface temperature in excess of 120°C were selected. These samples exhibit reasonable correlation of subsurface temperatures and have the best chance of reflecting true subsurface conditions. Samples having greater discordance between geothermometers will be studied at some future date.

All heat flow data has been plotted. Those wells having above average uniform gradients, resulting in above average heat flow are discussed. Wells with above average, but compound, gradients will be reprobed and discussed at a future date.

AREAS OMITTED

The present AMAX data accumulation is far more extensive than the length of this report would indicate. Many well-known areas have not been discussed because of the following reasons: First, temperatures encountered either in exploratory drilling and/or by geochemical thermometry were below 170°C, i.e. Stillwater geothermal field, Second, the lack of natural surface leakage and heat flow data prevent a meaningful discussion, i.e. Humboldt House and San Emido Desert. Lastly, areas have been omitted that have little available land interspersed with highly priced, previously acquired federal land, i.e. Dixie Valley and Brady's Hot Spring. Table 1 is a listing of the areas not discussed.

Table 1. Hot springs (>37.5°C) and thermal areas not discussed in this report.

Name	County	State	Estimated Subsurface Temperature °C
Brady Hot Spring	Churchill	NV	200
San Emido Desert	Washoe	NV	?
Pinto Hot Spring	Humboldt	NV	?
Soda Lake	Churchill	NV	?
19 Hot Spring	Pershing	NV	169
Peterson Hot Spring	Modoc	CA	169
Palm Hot Spring	Inyo	CA	169
Hyder Hot Spring	Pershing	NV	167
Lee Hot Spring	Churchill	NV	166
Section 9 Hot Spring	Mono	CA	164
Hot Pot Hot Spring	Humboldt	NV	163
Alkali Hot Spring	Esmeralda	NV	163
Powley Creek Hot Spring	Modoc	CA	163
SE 36 Hot Spring	Pershing	NV	162
Needle Rocks Hot Spring	Washoe	NV	159
NW 10 Hot Spring	Washoe	NV	156
Black Rock Hot Spring	Humboldt	NV	155
Fly Ranch Geyser	Washoe	NV	150
NWNW 25 Hot Spring	Lander	NV	147
The Hot Springs	Humboldt	NV	146
Baltazor Hot Spring	Humboldt	NV	144

Table 1. (Continued)

Rawhide Hot Spring	Mineral	NV	138
Tecopa Hot Well	Inyo	CA	137
Double Hot Spring	Mineral	NV	134
Trego Hot Well	Pershing	NV	134
Stillwater Hot Well	Churchill	NV	132
SE 32 Hot Well	Plumas	CA	132
King Lear Hot Spring	Washoe	NV	131
Dyke Hot Spring	Humboldt	NV	130
Dixie Valley Hot Spring	Churchill	NV	129
Grovers Hot Spring	Alpine	CA	129
Leonards Hot Spring	Modoc	CA	129
Darrough Hot Spring	Nye	NV	122
Hobo Hot Spring	Lassen	CA	122
37 N 26 E Hot Spring	Humboldt	NV	116
Indian Valley Hot Spring	Plumas	CA	114
Winecup Hot Spring	Elko	NV	112
NE 2 Hot Well	Nye	NV	107
Horton Hot Spring	Modoc	CA	99
Bog Hot Spring	Humboldt	NV	98
Hicks Hot Spring	Nye	NV	98
Bruneau Hot Spring	Elko	NV	97
23 Hot Spring	Lander	NV	97
Amedee Hot Spring	Lassen	CA	97
SENE 33 Hot Well	Nye	NV	95
26 Hot Spring	Lander	NV	94
Mineral Hot Spring	Elko	NV	92
Marble Hot Well	Plumas	CA	91
Lower Ranch Hot Spring	Pershing	NV	89
NENE 4 Hot Spring	Humboldt	NV	86
Howard Hot Spring	Humboldt	NV	86
Diana's Punch Bowl	Nye	NV	84
Dick's Hot Well	Modoc	CA	83
Carson Hot Spring	Ormsby	NV	82
Brooks Hot Spring	Humboldt	NV	81
Wendel Hot Spring	Lassen	CA	81
Hobo Hot Spring	Douglas	NV	80
Peck Ranch Hot Spring	Elko	NV	79
Benton Hot Spring	Mono	CA	79
Nevada Hot Spring	Lyon	NV	79
Humboldt River Hot Spring	Elko	NV	78
Ruby Point Hot Spring	Elko	NV	77
NESE 18 Hot Spring	Nye	NV	76
Walley's Hot Spring	Douglas	NV	76
Walti Hot Spring	Eureka	NV	74
NE 2 Hot Spring	Nye	NV	73
Keough Hot Spring	Inyo	CA	72
McCoy Hot Spring	Pershing	NV	68
NWNE 22 Hot Spring	Nye	NV	66
Soldier Meadow Hot Spring	Humboldt	NV	60
Menlo Baths	Modoc	CA	60
Bruffy Ranch Hot Spring	Eureka	NV	57
Red Rock Hot Spring	Lassen	CA	54
Gambles Hole Hot Spring	Elko	NV	41
Bishop Creek Hot Spring	Elko	NV	41
State Prison Hot Spring	Ormsby	NV	41

AREAS OF GEOCHEMICAL AND HEAT FLOW INTEREST

NORTHEASTERN NEVADA

WHIRLWIND VALLEY

The Beowawe Hot Springs are in Township 31 North, Range 48 East, 17 kilometers southeast of Battle Mountain (Plate 1). A blowing Magma Well is visible in the background. The name was coined by early settlers who, looking from present-day Emmigant Pass, mistook

Plate 1. Beowawe Geyser, 88°C.

the geysers for whirlwinds. Several natural springs and geysers which no longer erupt issue out at the south margin of the valley. A profound east-west trending fault-set controls the thermal activity and the extensive silicious sinter terraces that can be seen for 20 kilometers. The fault separates unconsolidated valley deposits from late tertiary

basalt and andesite flows of the Malpais Rim. The tertiary volcanics are underlain by the Silurian-Ordovician carbonates of which the Valmy predominates. A minor mercury deposit is located 6 kilometers east of the geysers.

The thermal waters exhibit a basic pH and contain interesting concentrations of boron, lithium, ammonia and silica. The major ions occur as follows:

$HCO_3 > SO_4 > Cl$ Na > K > Ca > Mg

The levels of calcium and magnesium are low. Chemical geothermometry indicates temperatures in the range of 183 to 199°C (Table 2).

W-10738	
County	Eureka
Temp (C)	88.
Flow (GPM)	1.
pH	9.19
Cl	54.
F	16.
SO_4	120.
HCO_3	162.2
CO_3	88.
SiO_2	260.
Na	210.
K	14.
Ca	2.
Mg	.1
Li	1.2
Cu	0
B	1.3
MO	3.
NH_3	.51
TDS	932.3
$TSiO_2$	199.
TNa-K	141.
TNa-K-Ca	183.

Table 2. Analysis of Beowawe Geyser.

Thirteen holes ranging in depth from 72 to 1661 meters were drilled from 1959 to 1975. The companies were Magma Power, Vulcan Thermal Power and Sierra Pacific Power. Chevron drilled two holes in excess of 1500 meters in Sections 13 and 19 of Township 31 North, Range 47 East, during 1976. Temperatures were rumored to be 210°C.

Chevron has the commanding land position. Their land was acquired in 1974. Getty, G.R.I., Supron, Diablo Exploration, Delta Funds and American Thermal Resources also hold federal acreage. The bulk of the leases were taken in 1974.

BATTLE MOUNTAIN

Stony Point Hot Springs are in Section 6 of Township 32 North, Range 46 East, about 9 kilometers northeast of Battle Mountain. The springs flow from gravels and mud at the north bank of Rock Creek. The thermal water may be diluted significantly.

The thermal springs are controlled by a northeast trending fault-set that divides the Sheep Creek Range from the Boulder Valley. The Sheep Creek Range is capped by a veneer of late Tertiary basalts and andesites dated at 17 to 6 m.y. The volcanic capping lies on the siliceous lower Paleozoic assemblage, notably the Slaven Chert and the Valmy Formation which outcrop at the west margin of the range (Figure 1).

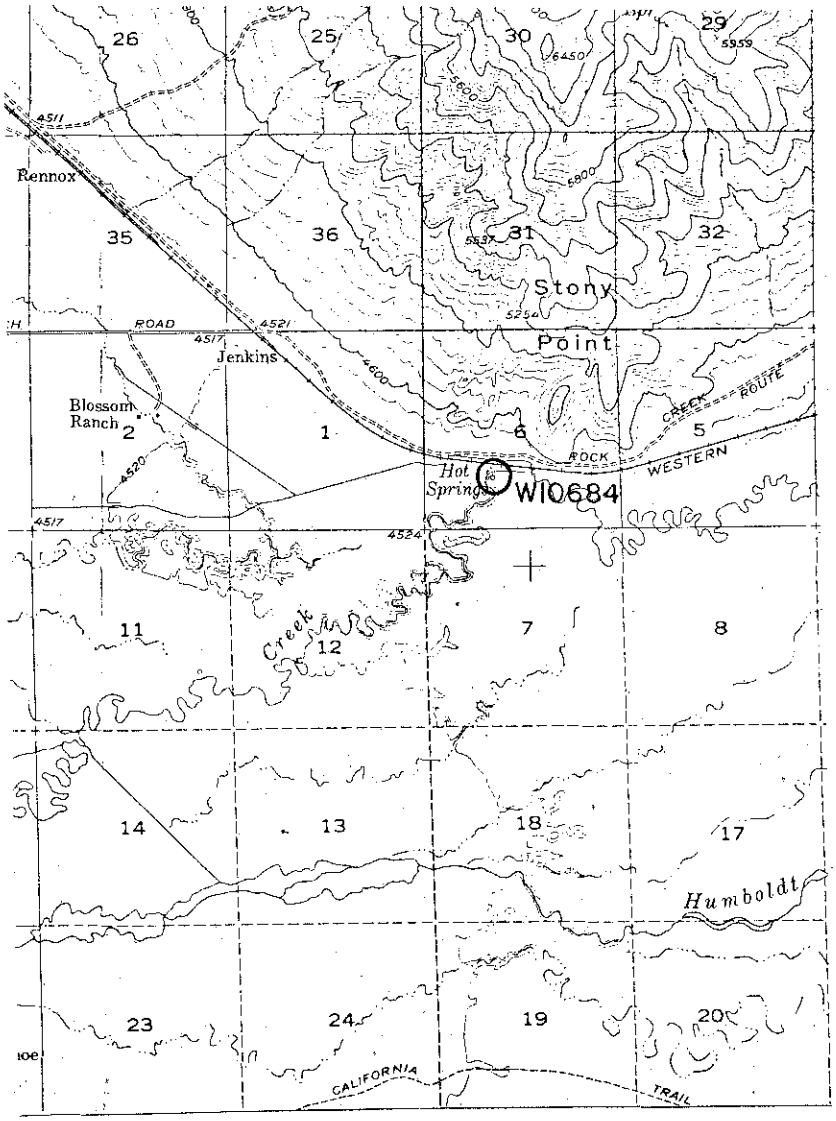

Figure 1. Location of Stony Point Hot Spring, 45°C.

The major ions of the thermal water are constituted as follows:

$HCO_3 > SO_4 > Cl$ Na > Ca > K > Mg.

The waters are enriched in boron, lithium and ammonia. Concentrations of calcium and magnesium are also high. The poor correlation with geothermometers may point to near surface mixing. Temperatures range from 130 to 180°C (Table 3).

Two drill holes of unknown origin, 12 kilometers south of the springs give heat flows of 3.5 and 4.3 H.F.U. Two oil tests 7 kilometers southwest of the spring might be probed.

Chevron has the commanding land position. Federal lands were applied for during February, March and September of 1976. Supron applied for federal land on May, 1977.

W-10684	
County	Lander
Temp (C)	45.
Flow (GPM)	10.
pH	6.7
Cl	44.
F	5.
SO_4	48.
HCO_3	556.
CO_3	0
SiO_2	88.
Na	250.
K	28.
Ca	37.
Mg	8.1
Li	.9
Cu	0
B	1.2
MO	2.
NH_3	.94
TDS	1069.1
$TSiO_2$	130.
TNa-K	197.
TNa-K-Ca	188.

Table 3. Chemical analysis of Stony Point Hot Springs.

CRESCENT VALLEY

Dewey Dan Hot Spring is in Section 10 of Township 28 North, Range 49 East, about 46 kilometers southeast of Carlin (Plate 2).

Plate 2. Dewey Dan Hot Spring, 82°C.

The spring issues out of a well marked range fault at the west margin of the Cortez Mountains. The Cortez Mountains consist of Jurassic quartz monzonite and a tuff sequence named the Pony Trail Group. Two minor mercury prospects are located within a mile of the spring. Cinnebar and realgar are clearly visible in portions of bleached and decomposed quartz monzonite. The waters deposit minor quantities of siliceous sinter.

The thermal waters have basic pH and have the major ions distributed as follows:

$HCO_3 > SO_4 > Cl$ Na > K > Ca > Mg.

The concentrations of silica, boron and lithium are very high while the calcium and magnesium are low. These waters are similar to those of Beowawe Geysers. Chemical geothermometry indicates subsurface temperatures ranging from 180°C to 218°C (Table 4).

Three holes of unknown origin were probed in the vicinity of the spring. Heat flows range from 4.3 to 20.5 H.F.U. (Figure 2).

W-10647	
County	Eureka
Temp (C)	82.
Flow (GPM)	10.
pH	8.41
Cl	82.
F	10.
SO_4	140.
HCO_3	544.
CO_3	12.
SiO_2	200.
Na	320.
K	44.
Ca	10.
Mg	1.3
Li	2.7
Cu	0
B	2.8
MO	2.
NH_3	.16
TDS	1371.0
$TSiO_2$	180.
TNa-K	224.
TNa-K-Ca	218.

Table 4. Analysis of Dewey Dan Hot Spring.

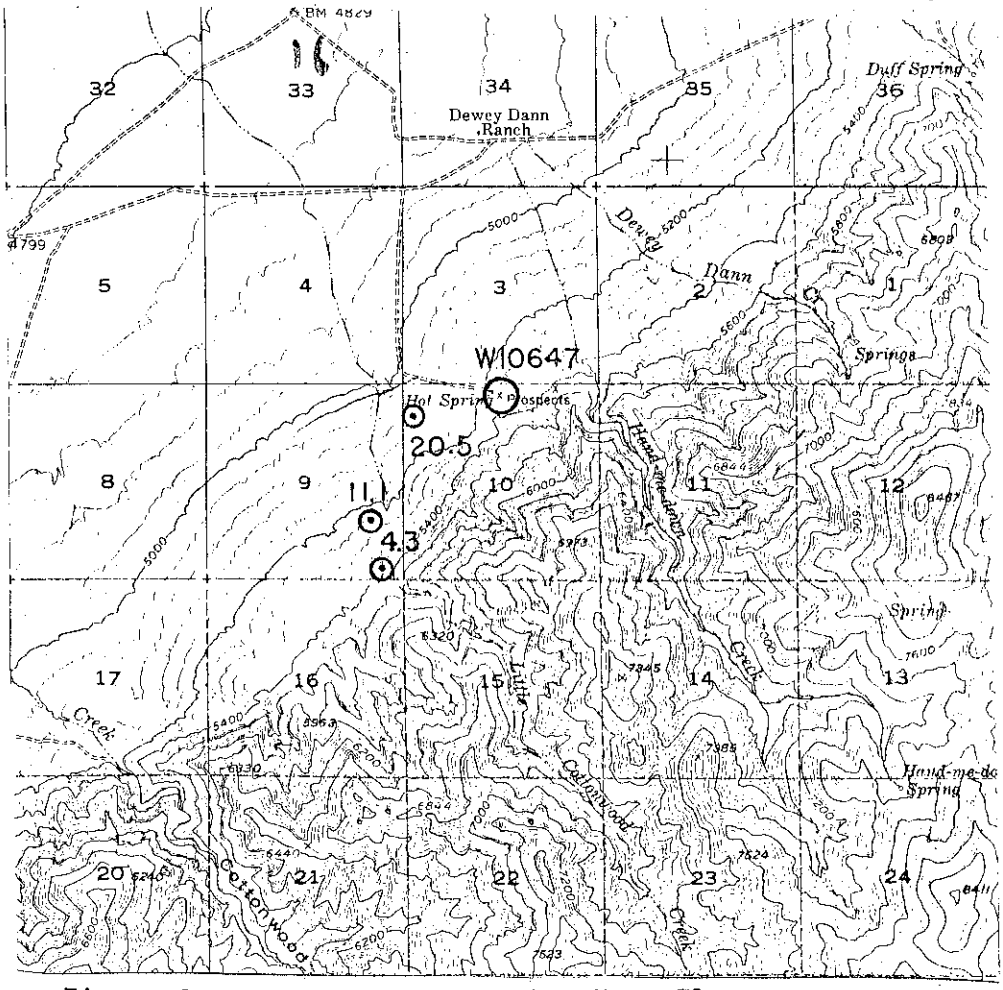

Figure 2. Location of Dewey Dan Heat Flow.

Chevron has the commanding land position. The first applications were made in 1974, while others followed in 1975 and 1977. Diablo Exploration also holds acreage assigned from Chevron.

REESE RIVER VALLEY

Mound Warm Springs are in Section 7 of Township 28 North, Range 44 East, about 40 kilometers south of Battle Mountain (Plate 3). The waters issue out of a fault in the Ordovician Valmy Formation at the central-western margin of Shoshone Range (Figure 3). The central Shoshone

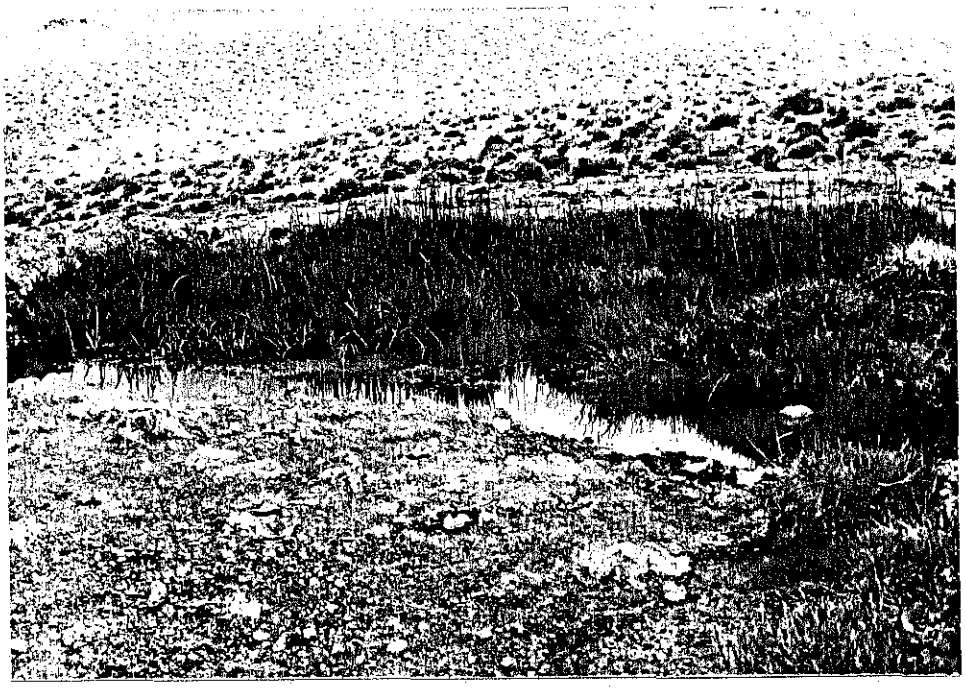

Plate 3. Mound Warm Spring, 35°C.

Mountains consist almost entirely of complexly faulted and thrusted Ordovician and Sulurian rocks of the eastern and western assemblage. The spring has deposited a travertine mound (96 percent calcium carbonate) with an approximate diameter of 150 meters.

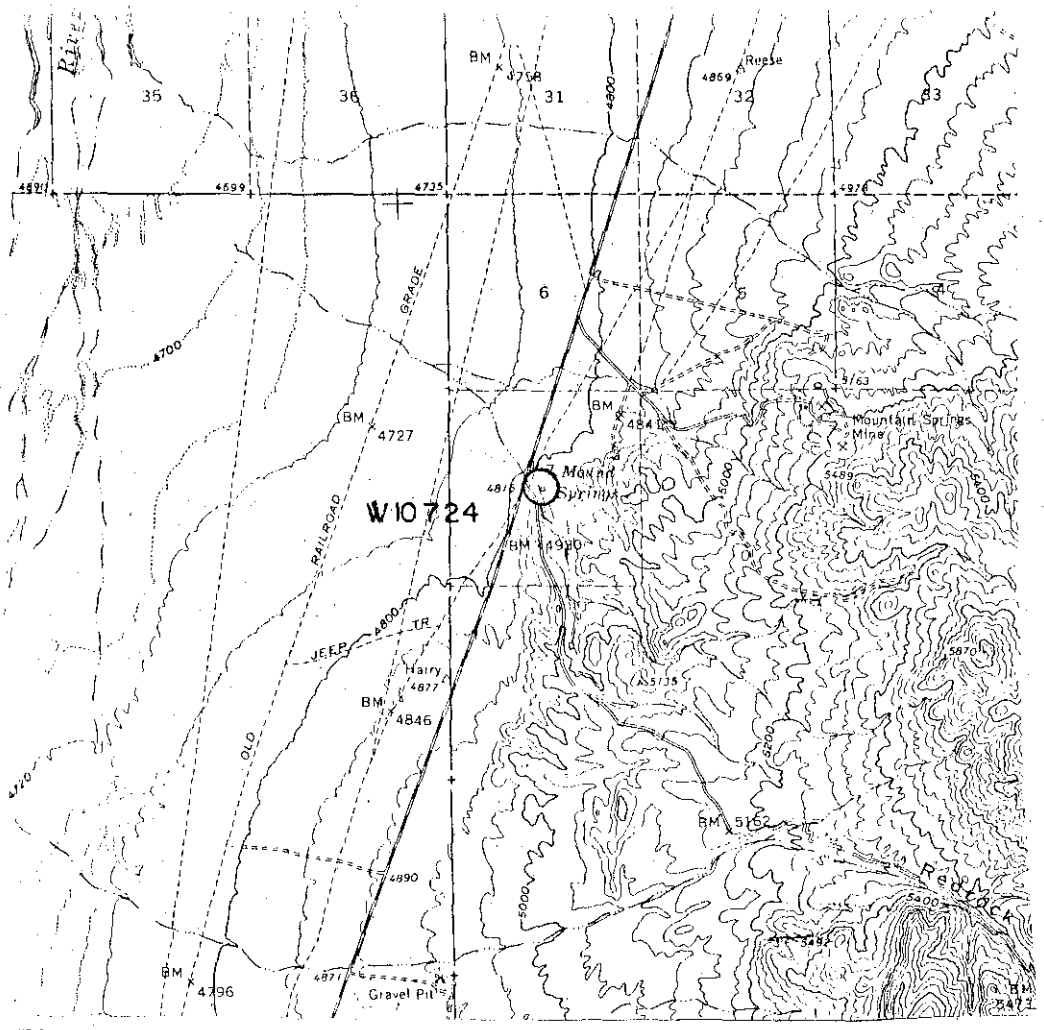

Figure 3. Location of Mound Warm Spring.

The waters have a neutral pH and have the following major ion constitution:

$HCO_3 > SO_4 > Cl$ Na > Ca > K > Mg

The water is dilute with respect to silica, ammonia, lithium, boron and is rich in calcium and magnesium. Subsurface temperatures have limited credibility. Temperatures range from 124 to 216°C. (Table 5).

W-10724	
County	Lander
Temp (C)	35.
Flow (GPM)	1.
pH	7.85
Cl	18.
F	3.
SO_4	100.
HCO_3	454.
CO_3	0
SiO_2	79.
Na	130.
K	33.
Ca	80.
Mg	23.
Li	.5
Cu	0
B	.4
MO	3.
NH_3	.21
TDS	924.1
$TSiO_2$	124.
TNa-K	326.
TNa-K-Ca	216.

Table 5. Analysis of Mound Warm Spring.

GRASS VALLEY

Hot Springs Point Hot Spring is in Section 16 of Township 24 North, Range 47 East, about 60 kilometers northwest of Austin. The springs issue out of playa deposits at the northwest margin of Grass Valley (Figure 4). An overthrust of the siliceous western assemblage over the carbonate eastern assemblages occurs 4.5 kilometers north of the spring. The springs may be associated with the overthrust.

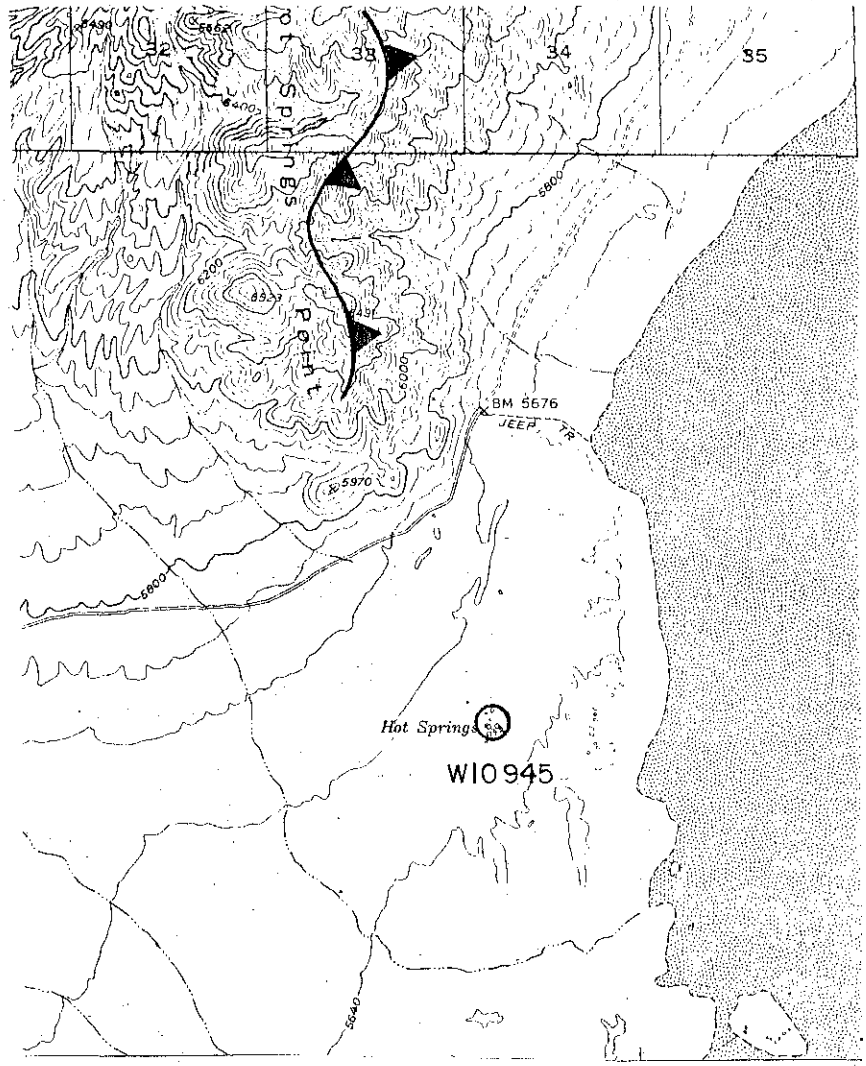

Figure 4. Location of Hot Springs Point Hot Spring, 57°C.

The thermal waters are the sodium bicarbonate variety, i.e.,

$HCO_3 > SO_4 > Cl$ Na > Ca > K > Mg

The waters are enriched in calcium and magnesium, a detriment to geothermometry. The waters are generally dilute. Subsurface temperatures range from 128 to 231°C (Table 6).

W-10945	
County	Lander
Temp (C)	57.
Flow (GPM)	2.
pH	7.18
Cl	31.
F	3.9
SO_4	54.
HCO_3	397.
CO_3	0
SiO_2	84.
Na	130.
K	40.
Ca	65.
Mg	12.
Li	.8
Cu	0
B	.7
MO	0
NH_3	1.0
TDS	819.4
$TSiO_2$	128.
TNa-K	368.
TNa-K-Ca	231.

Table 6. Analysis of Hot Springs Point Hot Spring.

ELKO

The Elko Hot Hole is in Section 21 of Township 34 North, Range 55 East, about 1.2 kilometers south of Elko (Plate 4). The springs flow from a travertine mound (94 percent $CaCO_3$) with a 0.3 kilometer diameter (Figure 5). A

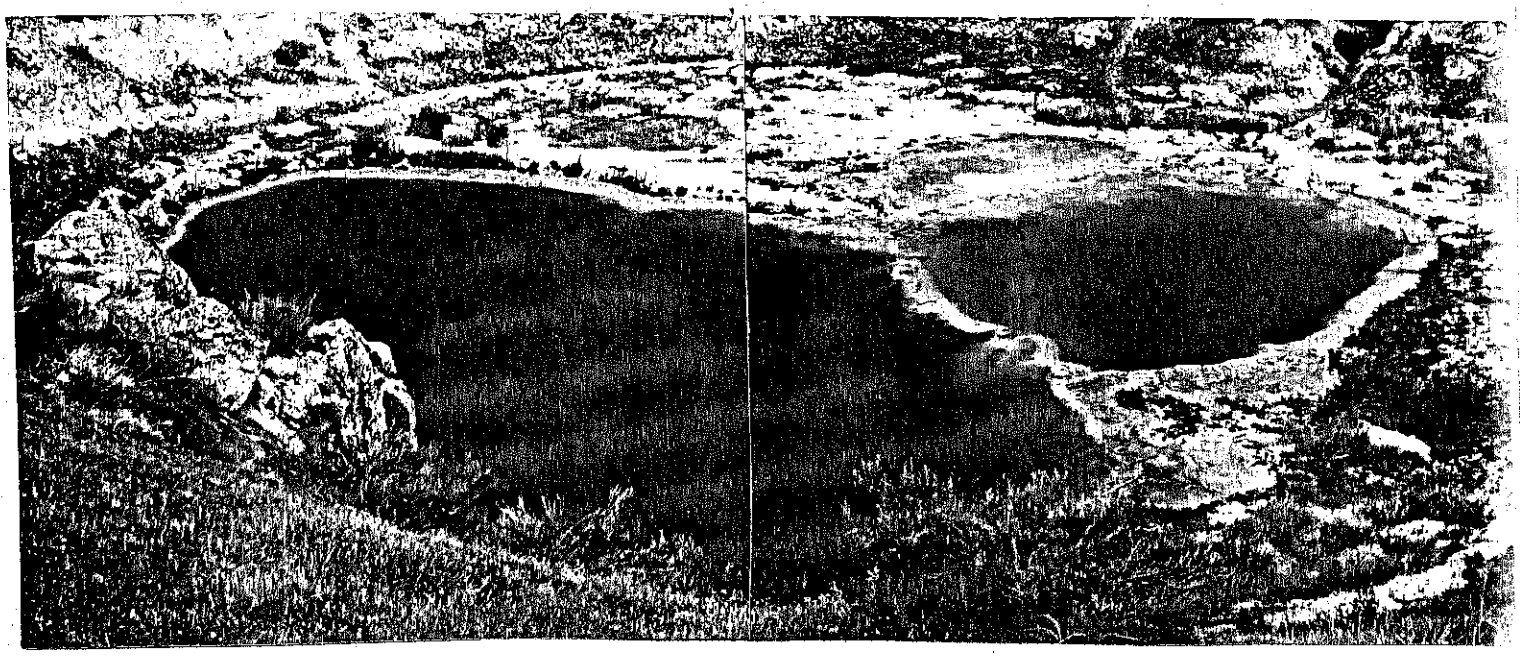

Plate 4. Elko Hot Hole, 55°C.

45°C spring of similar chemical character flows 0.6 kilometers south of the hot hole.

The springs are clearly controlled by a north trending fault that divides the Humboldt River Valley from the unnamed mountain range south of Elko. This range consists of shale and siltstone of Mississippian age overlain locally by late teritiary tuffaceous sediments. The area lacks profound alteration and youthful rocks, however, the size of the travertine mound is impressive.

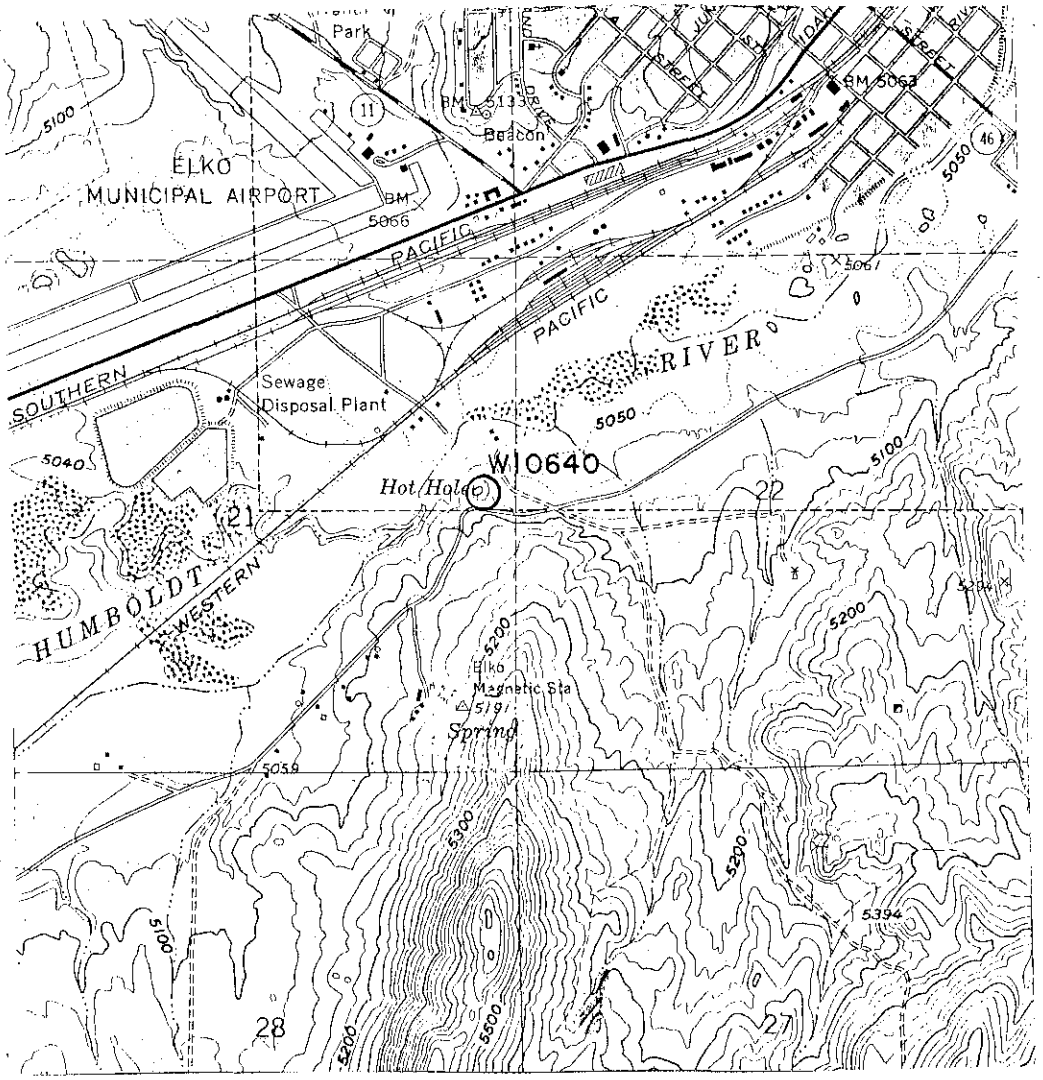

Figure 5. Location of Elko Hot Hole.

The thermal waters are saturated with calcium carbonate and contain more than minor concentrations of lithium, boron and ammonia. The major ions are distributed as follows:

$HCO_3 > SO_4 > Cl$ Na > Ca > K > Mg.

The geothermometry of the thermal waters may be exaggerated due to the calcium saturation. Temperatures range from 115 to 229°C (Table 7).

W-10640	
County	Elko
Temp (C)	55.
Flow (GPM)	10.
pH	7.32
Cl	14.
F	2.
SO_4	80.
HCO_3	430.
CO_3	0
SiO_2	66.
Na	120.
K	37.
Ca	70.
Mg	13.
Li	.4
Cu	0
B	.7
MO	0
NH_3	1.15
TDS	834.2
$TSiO_2$	115.
TNa-K	368.
TNa-K-Ca	229.

Table 7. Chemical analysis of the Elko Hot Hole water.

MARY'S RIVER

The Mary's River Hot Springs are in Sections 11 and 14 of Township 38 North, Range 59 East, about 40 kilometers northwest of Wells (Plate 5).

Plate 5. Mary's River Hot Springs

The springs deposit neither carbonate nor silica. The thermal waters are somehow associated with a nearby outcrop of the Eastern Carbonate Assemblage (Paleozoic) seen in figure 6 as Twin Buttes. The remaining rocks in the area are late tertiary tuffaceous sediments.

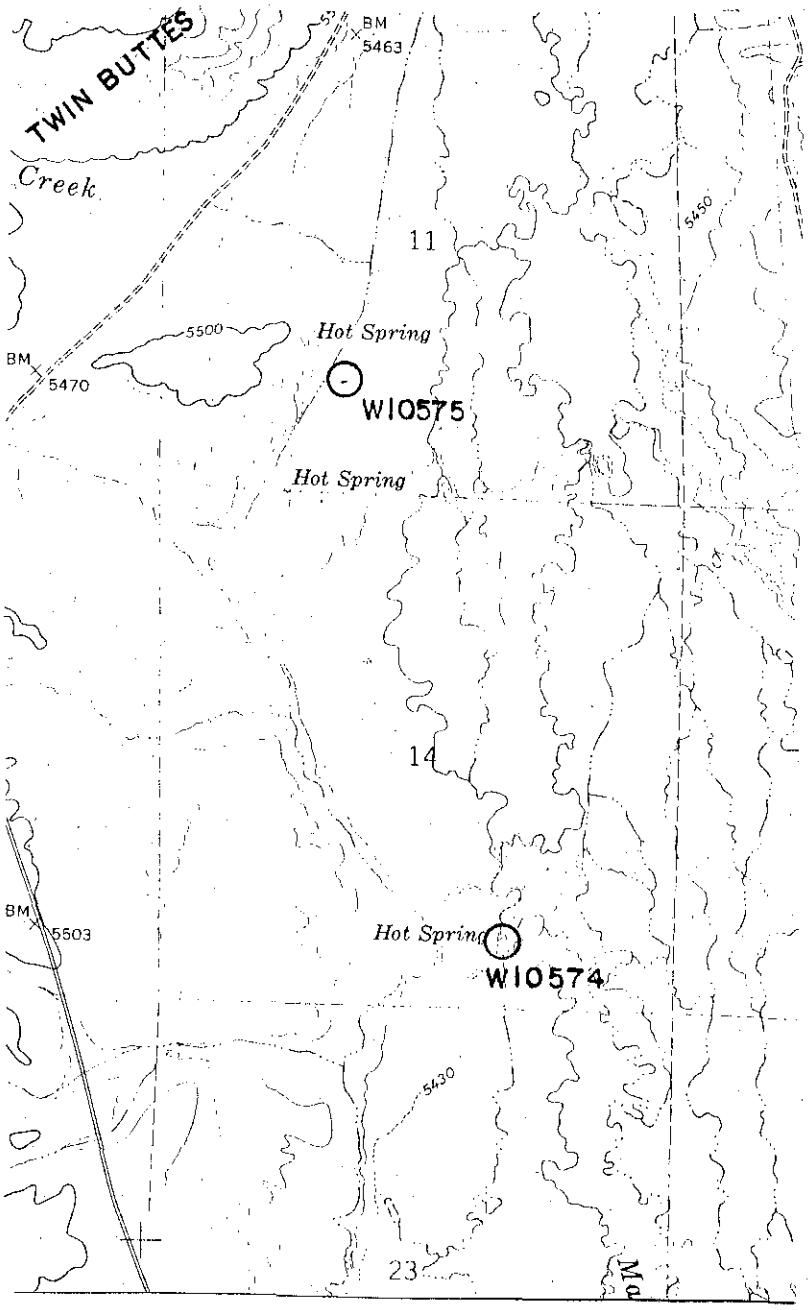

Figure 6. Location of the Mary's River Hot Springs.

The major ions of the thermal waters are distributed as follows:

$HCO_3 > Cl > SO_4$ Na > K > Ca > Mg

The waters are very high in fluoride (22 mg/l) and are depleted in lithium, boron and ammonia. Geothermometry should be reliable owing to the low calcium content. Temperatures range from 161 to 197°C (Table 8).

W-10574	
County	Elko
Temp (C)	38.
Flow (GPM)	5.
pH	8.15
Cl	29.
F	22.
SO_4	5.
HCO_3	988.
CO_3	0
SiO_2	150.
Na	500.
K	34.
Ca	3.
Mg	.4
Li	0
Cu	0
B	0
MO	15.
NH_3	.2
TDS	1741.7
$TSiO_2$	161.
TNa-K	143.
TNa-K-Ca	197.

Table 8. Analysis of Mary's River Hot Springs.

RUBY VALLEY

The Sulphur Hot Springs are in the north Ruby Valley in Section 11 of Township 31 North, Range 59 East. The springs flow from a sinter mound (99 percent SiO_2) above a southeastward sloping alluvial apron (Plate 6). The sinter mound has a diameter of about 450 meters.

Plate 6. Sulphur Hot Springs, 97°C.

A major normal fault forms the contact between the unconsolidated rocks of the valley and the metamorphosed Cambrian to Ordovician carbonates of the Ruby Mountains. No tertiary or younger rocks are exposed in the area.

Thermal waters have a basic pH and are constituted as follows:

$HCO_3 > SO_4 > Cl$ Na > K > Ca > Mg.

Waters are saturated with silica and contain low concentrations of calcium and magnesium, a qualitative indication of high subsurface temperature. The low concentrations of chloride, lithium and boron indicate equilibration in a metamorphic reservoir. Subsurface temperatures correlate well in the vacinity of 175°C.(Table 9).

W-10558	
County	Elko
Temp (C)	97.
Flow (GPM)	10.
pH	9.
Cl	26.
F	17.
SO_4	35.
HCO_3	153.4
CO_3	53.6
SiO_2	220.
Na	130.
K	8.1
Ca	1.
Mg	0.1
Li	.6
Cu	0
B	.3
MO	0
NH_3	0
TDS	645.0
$TSiO_2$	174.
TNa-K	134.
TNa-K-Ca	177.

Table 9. Analysis of Sulphur Hot Spring.

Data from ten 30-meter U.S.G.S. holes (Figure 7) show an ill-defined circular anomaly of relatively small proportions. The holes were drilled in 1973.

Union Oil and Thermex have the commanding land position in the area. Leases were applied for in 1974 and 1976.

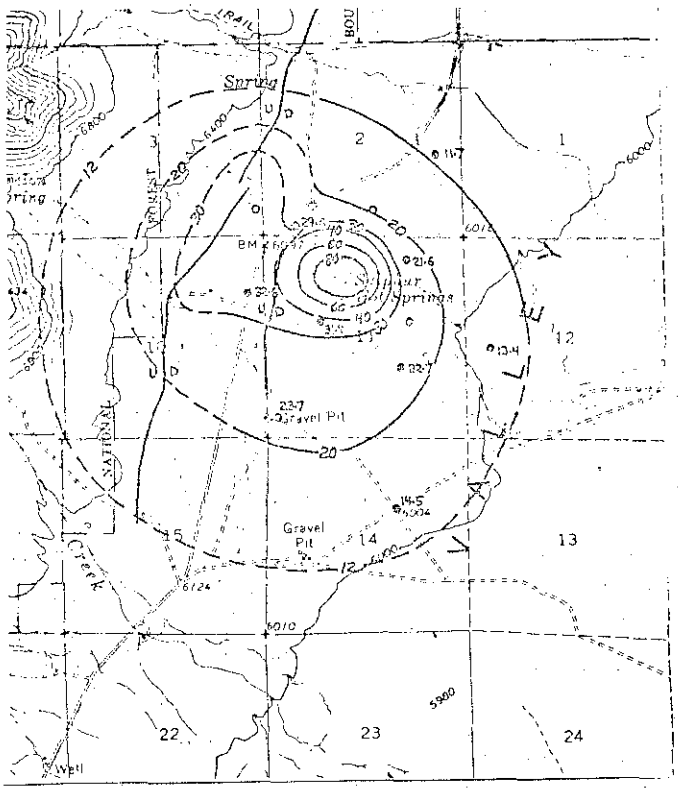

Figure 7. Location of Sulphur Hot Springs temperature at 30 meters (Olmsted et al, 1975).

BRUNEAU RIVER

The Bruneau River Warm Springs are in Section 6 of Township 42 North, Range 58 East, about 60 kilometers northwest of Wells (Plate 7).

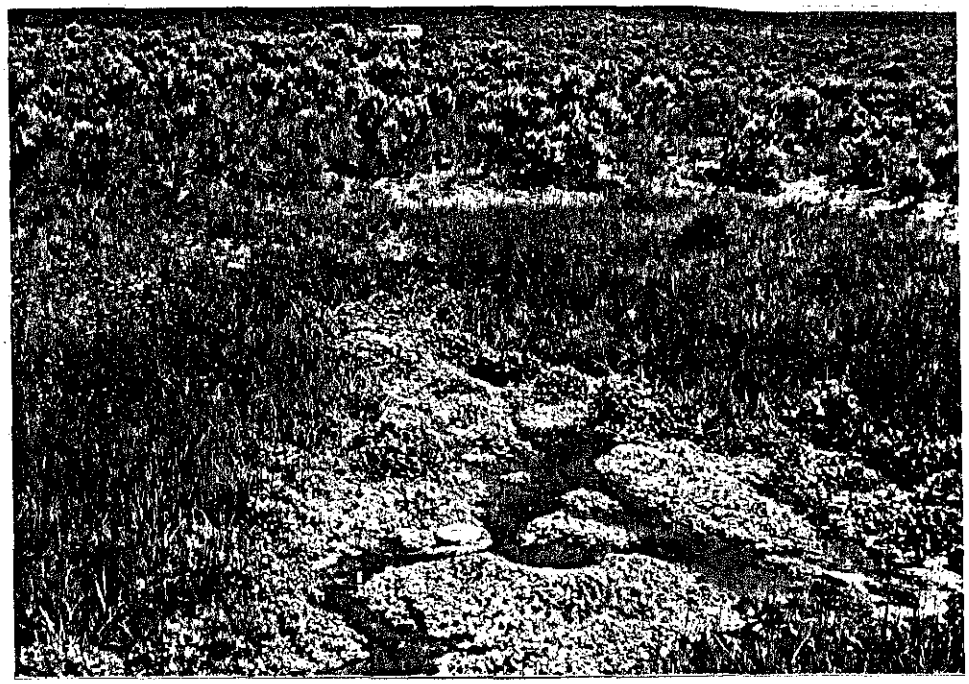

Plate 7. Bruneau River Warm Spring, 27°C.

The thermal feature is controlled by a northwest trending fault that in part controls the course of the Bruneau River (Figure 8). No rocks other than tertiary lake sediments are exposed locally.

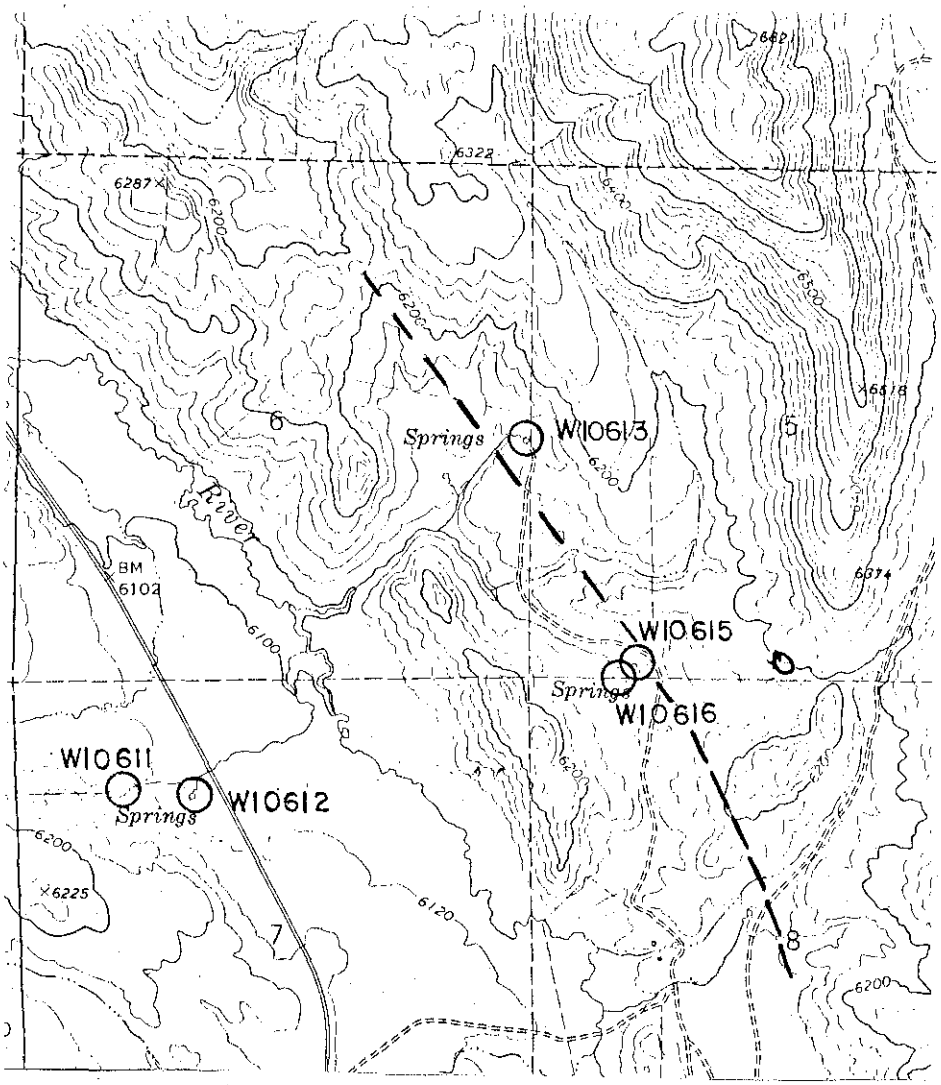

Figure 8. Location of the Bruneau River Warm Springs.

The thermal waters have a basic pH. Major ions are distributed as follows:

$HCO_3 > SO_4 > Cl$ Na > K > Ca > Mg.

The waters are generally very dilute. The geochemical thermometers have tenuous significance because of the dilute nature of the water. Temperatures range from 125 to 225°C (Table 10).

W-10613	
County	Elko
Temp (C)	27.
Flow (GPM)	40.
pH	8.05
Cl	3.6
F	2.
SO_4	8.
HCO_3	74.6
CO_3	0
SiO_2	81.
Na	27.
K	8.6
Ca	6.
Mg	.5
Li	0
Cu	0
B	0
MO	2.
NH_3	0
TDS	240.3
$TSiO_2$	126.
TNa-K	376.
TNa-K-Ca	225.

Table 10. Analysis of the Bruneau River Warm Spring.

WELLS

The unnamed hot springs 5 kilometers northwest of Wells are in Section 17 of Township 38 North, Range 62 East (Plate 8). The thermal water flows from a travertine mound (94 percent $CaCO_3$) with the largest dimension of 150 meters (Figure 9).

Plate 8. Unnamed hot spring north of Wells, 49°C.

The springs are controlled by a range front fault at the west margin of the Snake Range. The Snake Range consists of the Paleozoic Eastern (carbonate) assemblage, notably Ordovician and Silurian limestones and dolomites. These Paleozoic rocks are overlain by late tertiary tuffaceous sediments in certain areas.

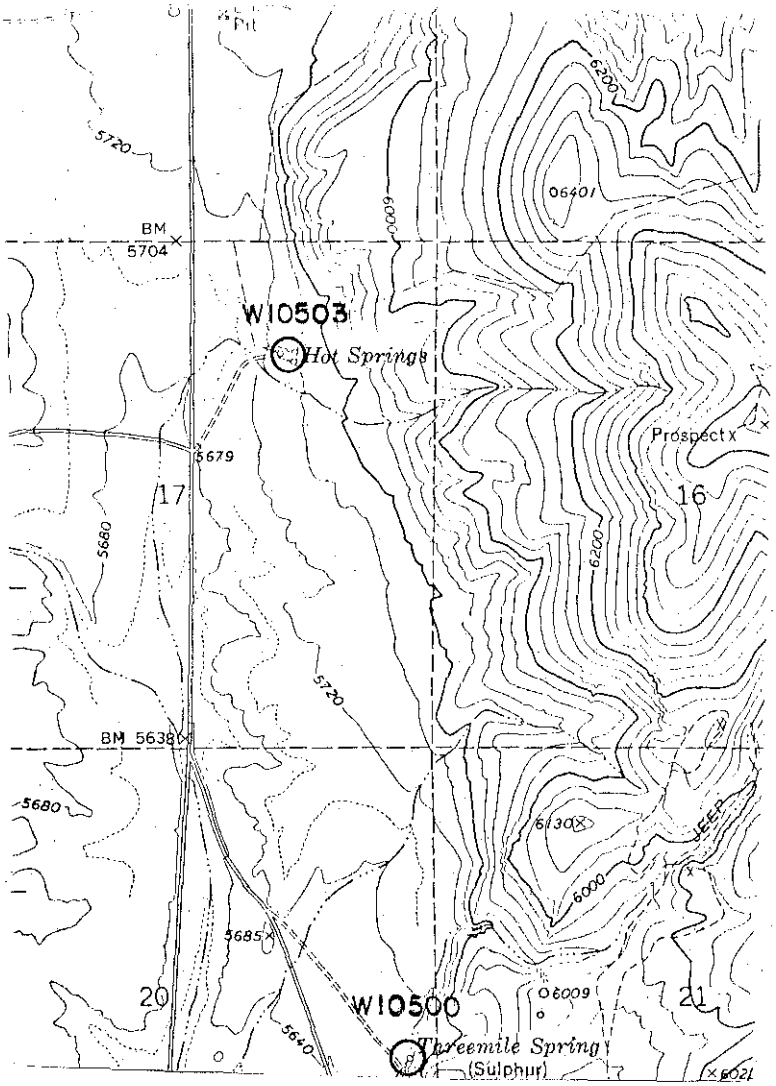

Figure 9. Location of unnamed hot springs north of Wells.

The major ions of the thermal waters are distributed thusly:

$HCO_3 \simeq SO_4 \simeq Cl$ Na > Ca > Mg > K.

The waters are saturated with calcium carbonate. The geochemical temperatures are tenuous and range from 143 to 174°C (Table 11).

W-10503	
County	Elko
Temp (C)	49.
Flow (GPM)	10.
pH	6.64
Cl	26.
F	5.8
SO_4	25.
HCO_3	977.
CO_3	0
SiO_2	94.
Na	310.
K	29.
Ca	90.
Mg	31.
Li	.9
Cu	0
B	.9
MO	0
NH_3	.54
TDS	1496.1
$TSiO_2$	143.
TNa-K	174.
TNa-K-Ca	174.

Table 11. Analysis of the unnamed hot springs north of Wells.

AREAS OF GEOCHEMICAL AND HEAT FLOW INTEREST

NORTHWESTERN NEVADA

GERLACH

Great Boiling Hot Springs are at the south end of the Granite Range in the southern Black Rock Desert. The largest group of springs occurs 1.4 kilometers northwest of Gerlach. The springs issue out of unconsolidated lacustrine and alluvial deposits near a well-defined north trending range front fault (Plate 9). The Granite Range consists of granodiorite and diorite of Cretaceous age (Figure 10). Both unconsolidated deposits and the granodiorite

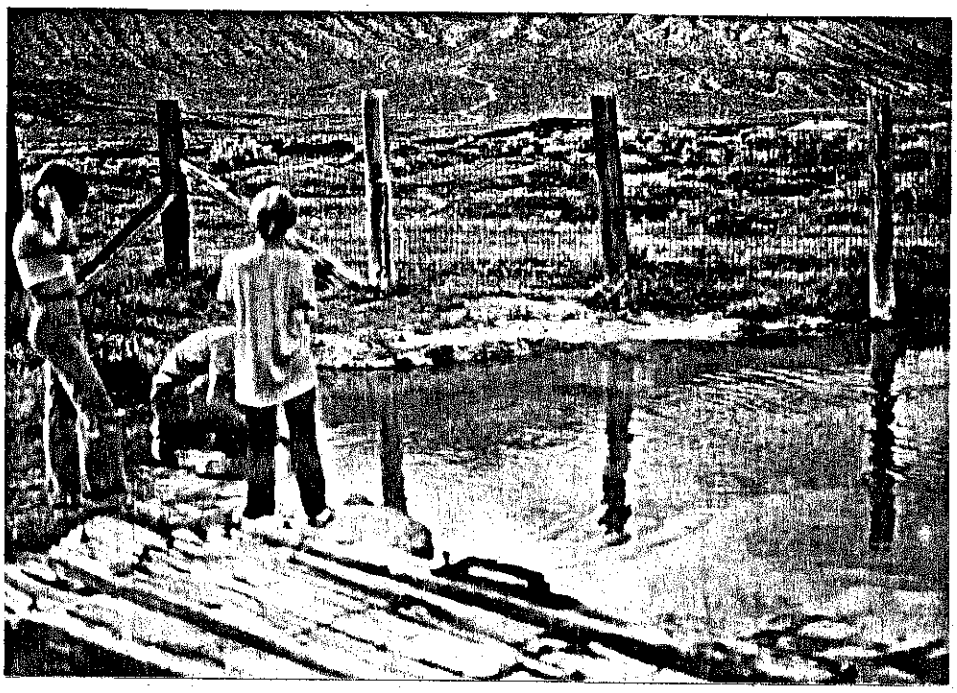

Plate 9. Great Boiling Hot Spring, 92°C.

are altered to clay along the range front fault so that neither can be distinguished. The springs deposit minor amounts of travertine.

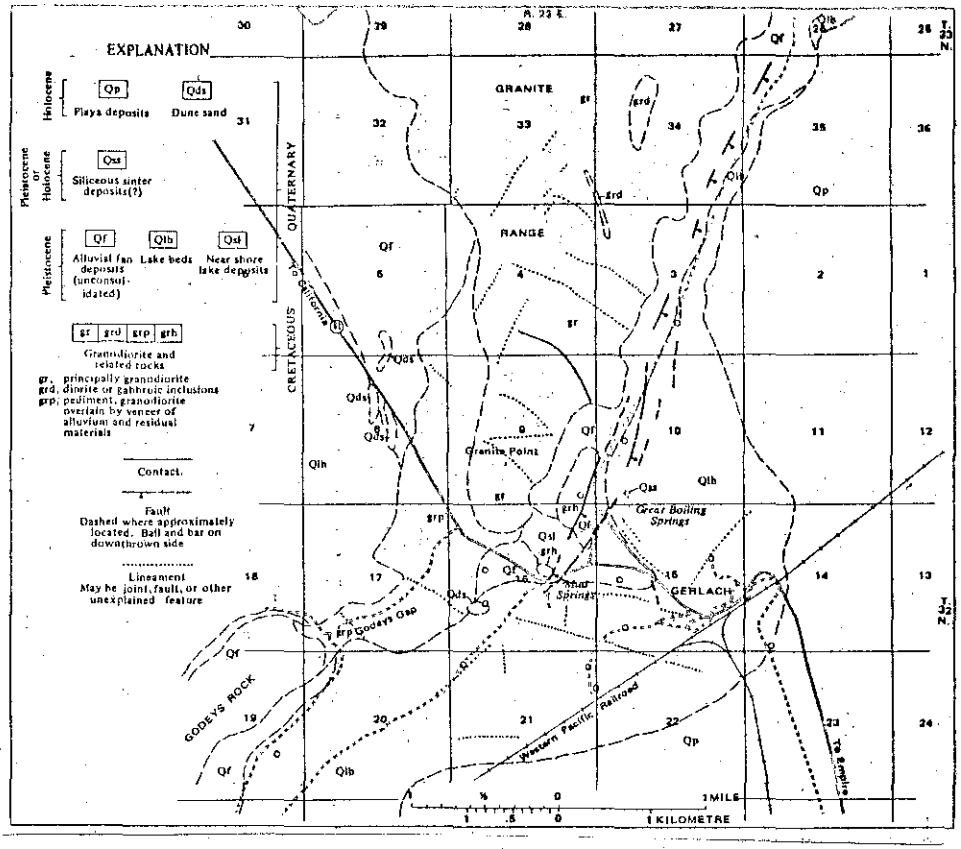

Figure 10. Geology of the Gerlach Area (Olmsted et al, 1975)

The thermal waters exhibit neutral pH and are constituted as follows (Table 12):

$Cl > SO_4 > HCO_3$ Na > K > Ca > Mg.

The waters are old relative to the bicarbonate waters of the state. The waters are similar to the waters of Steamboat Springs and Roosevelt Hot Springs, Utah. They contain high concentrations of boron, lithium and ammonia. The waters are slightly saturated with calcium carbonate. Subsurface temperatures range from 177 to 192°C.

Data from thirteen 30 to 50 meter U.S.G.S. holes is shown in figure 11. The anomaly is elongated to the north and south. The elongation is directly related to the local fault system.

W-11241	
County	Pershing
Temp (C)	92.
Flow (GPM)	500.
pH	7.48
Cl	2100.
F	4.6
SO_4	380.
HCO_3	84.
CO_3	0
SiO_2	190.
Na	1600.
K	120.
Ca	95.
Mg	1.5
Li	.17
Cu	0
B	6.8
MO	10.
NH_3	.9
TDS	4593.0
$TSiO_2$	179.
TNa-K	152.
TNa-K-Ca	192.

Table 12. Analysis of Great Boiling Hot Spring.

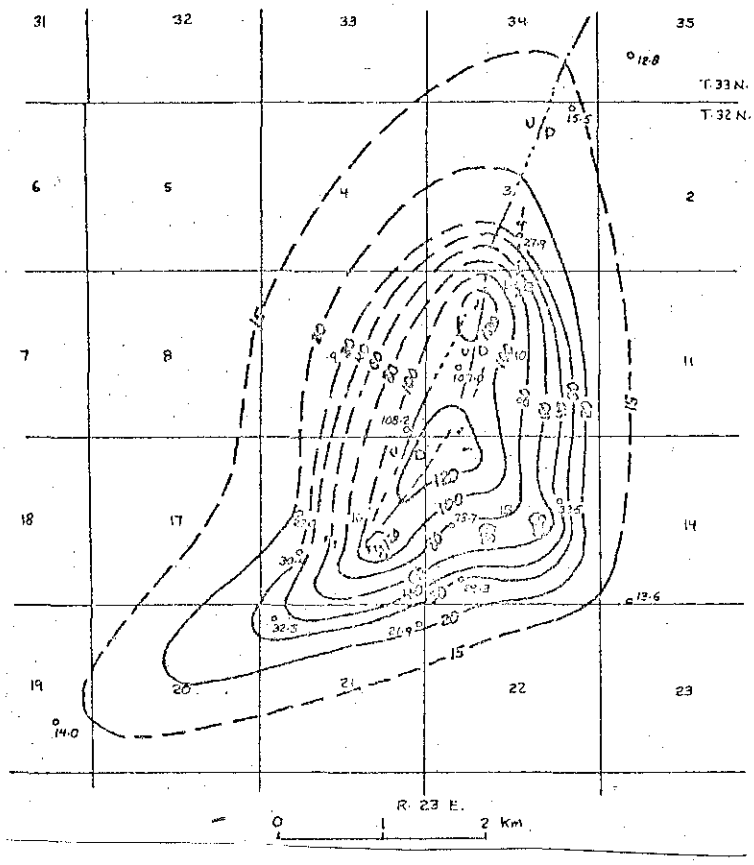

Figure 11. Location of Gerlach 30 meter temperatures with faults (Olmsted et al, 1975).

Supron is the major land holder. Applications were made on November, 1975. Sunoco is in second place even though they were first to apply in 1974. Leases are also held by Kirk Greene, Calvert and Hunt.

GRIDLEY LAKE

Gridley Lake Hot Spring is about 20 kilometers southwest of Denio in Section 1 of Township 44 North, Range 27 East (Figure 12). The springs issue from Tertiary lake sediments. Oligocene to Miocene welded

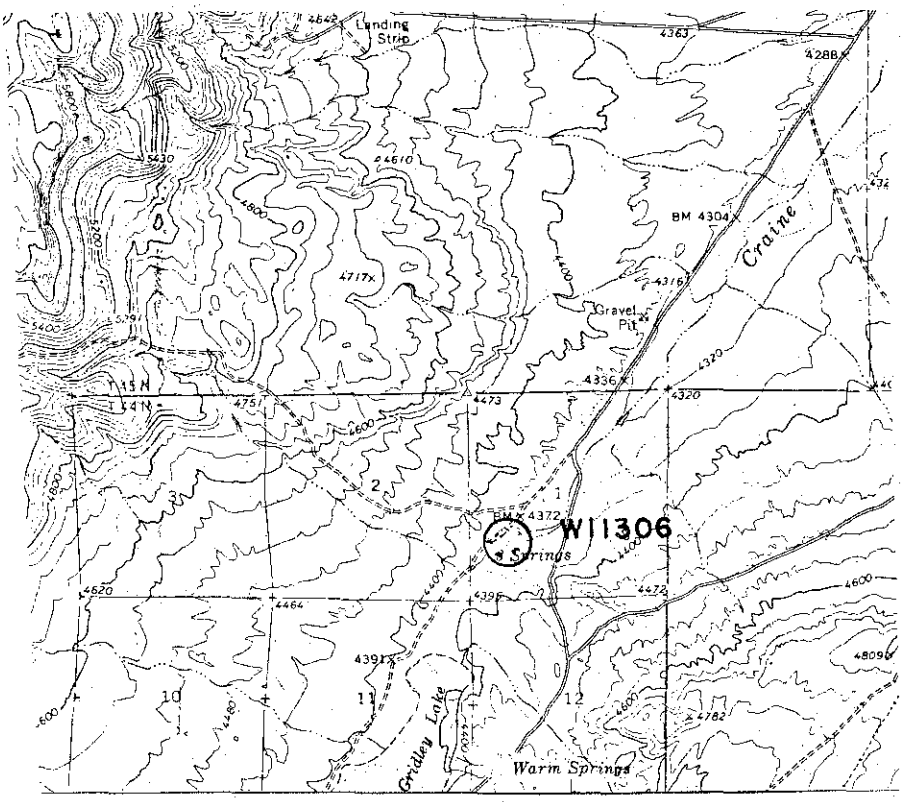

Figure 12. Location of Gridley Lake Hot Spring.

and non-welded acid tuffs of unknown origin are exposed nearby. No evident structure is seen to control the spring.

The water is very low in dissolved solids. The major ions are arranged thusly:

$HCO_3 > SO_4 > Cl$ Na > K > Ca > Mg.

Subsurface geothermometers have little credibility. Temperatures range from 114 to 205°C (Table 13).

The area has been leased by E.P.C., U.S.G.S. and T.R.I. Leases were all applied for in 1977.

W-11306	
County	Humboldt
Temp (C)	40.
Flow (GPM)	30.
pH	7.95
Cl	10.
F	.7
SO_4	15.
HCO_3	59.6
CO_3	0
SiO_2	64.
Na	34.
K	6.1
Ca	2.
Mg	0
Li	0
Cu	0
B	.2
MO	8.
NH_3	0
TDS	199.6
$TSiO_2$	114.
TNa-K	264.
TNa-K-Ca	205.

Table 13. Analysis of Gridley Lake Hot Spring.

BLACK ROCK DESERT

Sulfur Warm Spring is about 60 kilometers northeast of Gerlach in Township 35 North, Range 29 East (Plate 10). The springs issue from unconsolidated deposits on the west flank of the Kamma Mountains (Figure 13).

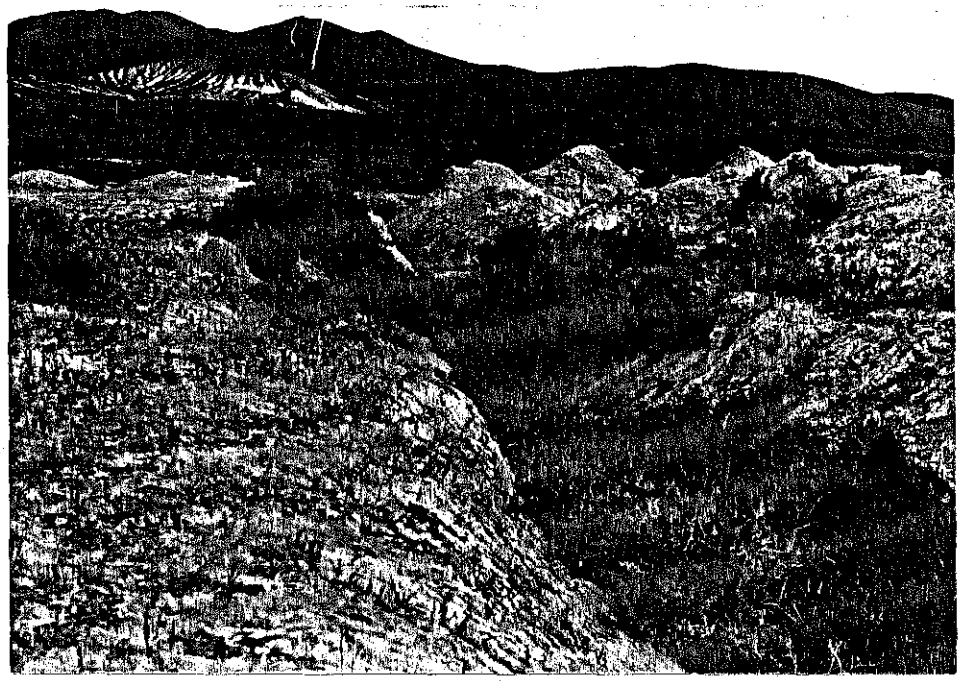

Plate 10. Sulfur Warm Spring, 25°C.

The Kamma Mountains consist of Jurrasic - Triassic sediments that are covered by late Tertiary rhyolite flows and Tertiary lake sediments. Major sulfur deposition is visible in Quaternary alluvial deposits west of the spring.

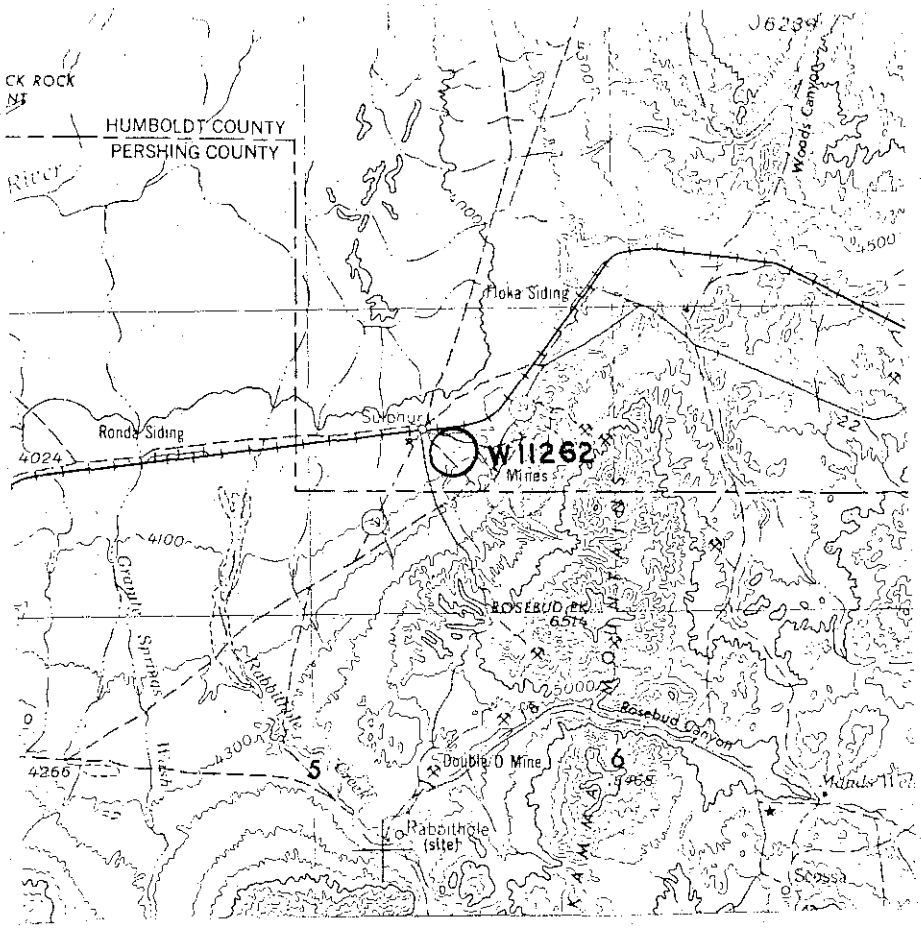

Figure 13. Location of Sulfur Warm Spring.

The thermal waters contain 1932 mg/l of dissolved solids (Table 14). Major ions are distributed as follows:

$HCO_3 > SO_4 > Cl$ Na > Ca > K > Mg.

Levels of boron, lithium and ammonia are high. Subsurface thermometers may be affected by the high calcium concentrations. Subsurface temperatures range from 126 to 181°C.

Union, Hunt and Alta Energy are lessors of federal lands. Leases were taken as early as March, 1974.

W-11262	
County	Washoe
Temp (C)	25.
Flow (GPM)	15.
pH	6.89
Cl	130.
F	6.8
SO_4	270.
HCO_3	830.6
CO_3	0
SiO_2	81.
Na	510.
K	41.
Ca	45.
Mg	7.5
Li	1.9
Cu	0
B	5.0
MO	2.
NH_3	1.53
TDS.	1932.3
$TSiO_2$	126.
TNa-K	160.
TNa-K-Ca	181.

Table 14. Analysis of Sulfur Warm Spring.

WINNEMUCCA LAKE

The Manure Canyon Warm Spring is about 50 kilometers south of Gerlach in Section 3 of Township 26 North, Range 23 East (Plate 11). The waters issue from tertiary andesites and basalts on the west flank of the Lake Range (Figure 14). The structural control of the springs is not obvious.

Plate 11. Manure Canyon Warm Spring, 25°C.

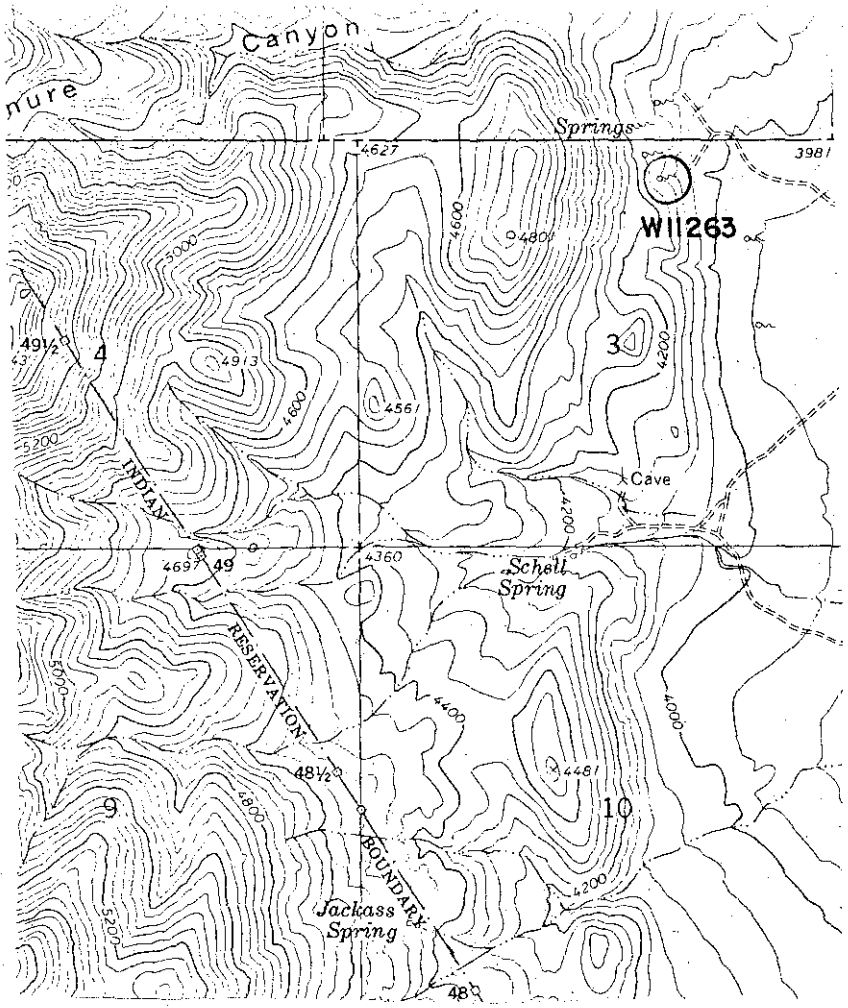

Figure 14. Location of the Manure Canyon Warm Spring.

The waters are low in dissolved solids (Table 15). The major ions are constituted thusly:

$HCO_3 > SO_4 = Cl$ Na > K > Ca > Mg.

The geochemical thermometers may be greatly exaggerated. Subsurface temperatures range from 117 to 201°C.

W-11263	
County	Washoe
Temp (C)	25.
Flow (GPM)	10.
pH	8.6
Cl	14.
F	.4
SO_4	15.
HCO_3	83.6
CO_3	6.4
SiO_2	68.
Na	49.
K	7.2
Ca	2.
Mg	.8
Li	0
Cu	0
B	.2
MO	4.
NH_3	0
TDS	250.6
$TSiO_2$	117.
TNa-K	234.
TNa-K-Ca	201.

Table 15. Analysis of Manure Canyon Warm Spring.

SMOKE CREEK DESERT

The Bonham Ranch Warm Well is about 33 kilometers southwest of Gerlach in Section 6 of Township 28 North, Range 20 East (Plate 12). The well was drilled in unconsolidated deposits at the southwest corner of the Smoke Creek Desert (Figure 15). No local structure is evident. The nearest rocks are Tertiary basalts.

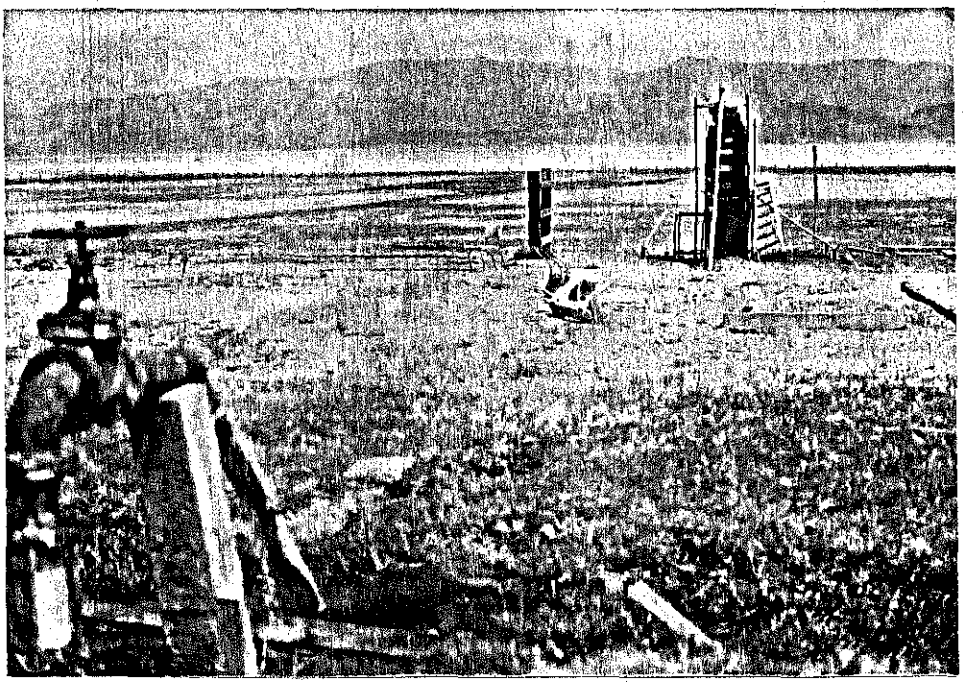

Plate 12. Bonham Ranch Warm Well, 31°C.

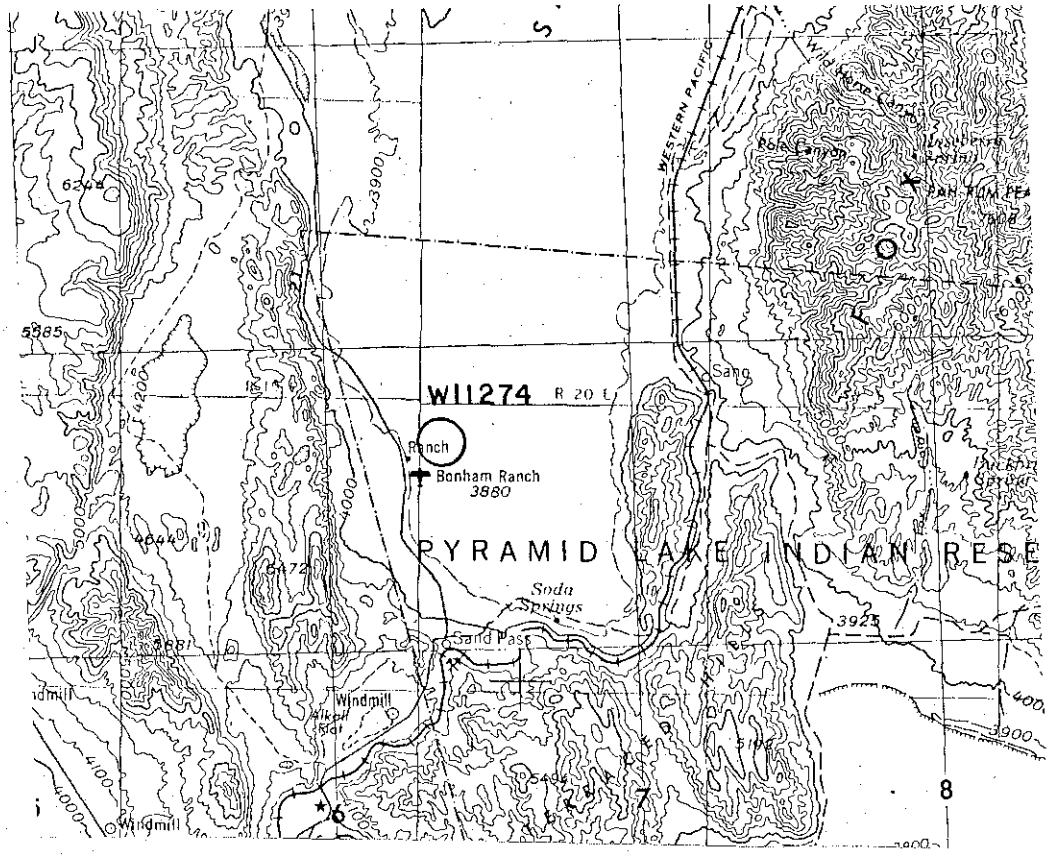

Figure 15. Location of the Bonham Ranch Warm Well.

The waters contain a high concentration of dissolved solids (Table 16). The major ions are distributed as follows:

$Cl > SO_4 > HCO_3$ $Na > K > Ca > Mg$.

The concentrations of lithium, boron and ammonia are encouraging. Silica concentrations are low. Subsurface temperatures range from 132 to 174°C.

W-11274	
County	Washoe
Temp (C)	31.
Flow (GPM)	75.
pH	8.4
Cl	840.
F	2.4
SO_4	480.
HCO_3	117.2
CO_3	4.8
SiO_2	91.
Na	790.
K	47.
Ca	39.
Mg	1.6
Li	.2
Cu	0
B	4.5
MO	20.
NH_3	.9
TDS	2538.6
$TSiO_2$	132.
TNa-K	130.
TNa-K-Ca	174.

Table 16. Analysis of the Bonham Ranch Warm Well.

ROSE CREEK

An unnamed warm spring is 20 kilometers southwest of Winnemucca in Section 28 of Township 35 North, Range 36 East (Figure 16).

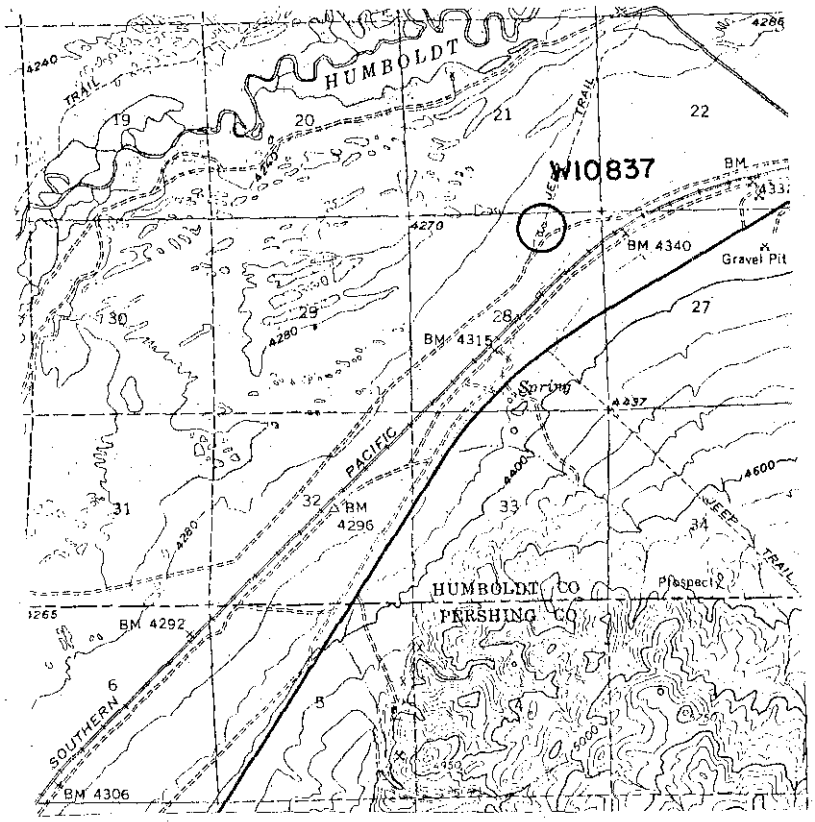

Figure 16. Location of unnamed Warm Spring near Rose Creek.

The spring is controlled by a north trending fault at the northwest side of the East Range. The East Range consists almost entirely of Jurassic sediments of the Auld Lang Syne Group. The spring flows from unconsolidated sediments of the Humboldt River.

The waters are high in dissolved solids (Table 17) and have a neutral pH. Major ions are distributed thusly:

HCO_3 > Cl > SO_4 Na > Ca > K > Mg.

The waters are rich in boron, lithium and ammonia. Subsurface geochemical temperatures range from 126 to 185°C.

W-10837	
County	Humboldt
Temp (C)	19.
Flow (GPM)	5.
pH	6.38
Cl	240.
F	6.2
SO_4	76.
HCO_3	1368.
CO_3	0
SiO_2	81.
Na	540.
K	52.
Ca	100.
Mg	25.
Li	2.2
Cu	0
B	8.5
MO	4.
NH_3	1.2
TDS	2504.1
$TSiO_2$	126.
TNa-K	179.
TNa-K-Ca	185.

Table 17. Analysis of SE 28 Warm Spring.

GOLCONDA

The Golconda Hot Springs are 20 kilometers east of Winnemucca in Sections 29 and 32 of Township 36 North, Range 40 East (Plate 13). The spring flows from unconsolidated Quarternary sediments near the

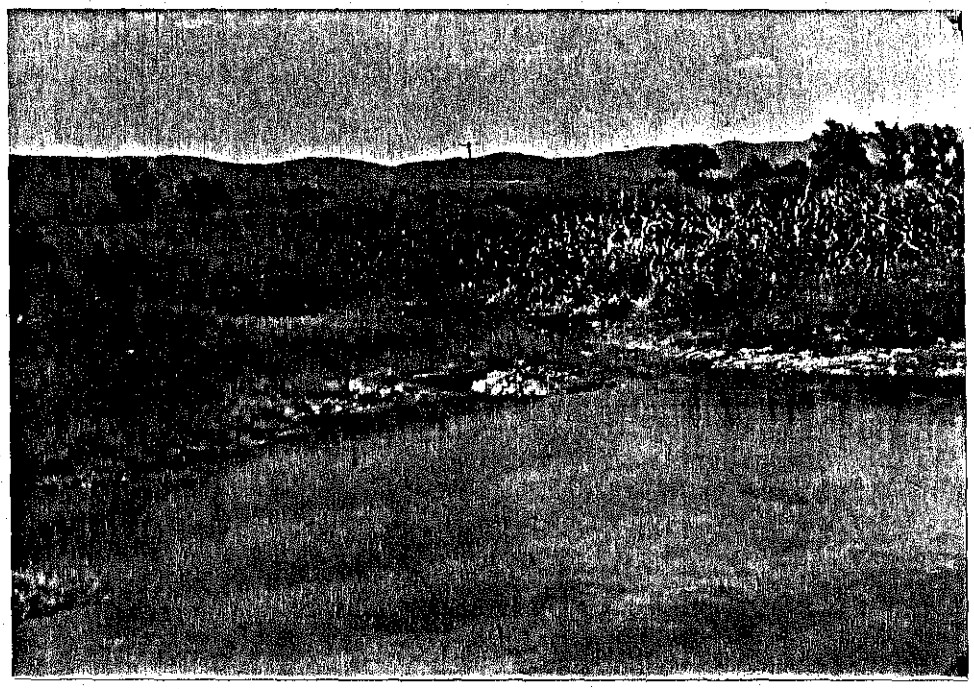

Plate 13. Golconda Hot Spring, 77°C.

Humboldt River (Figure 17). No structure is evident locally. Tertiary andesites and basalts that veneer the Osgood Mountains to the northeast are the youngest rocks in the area.

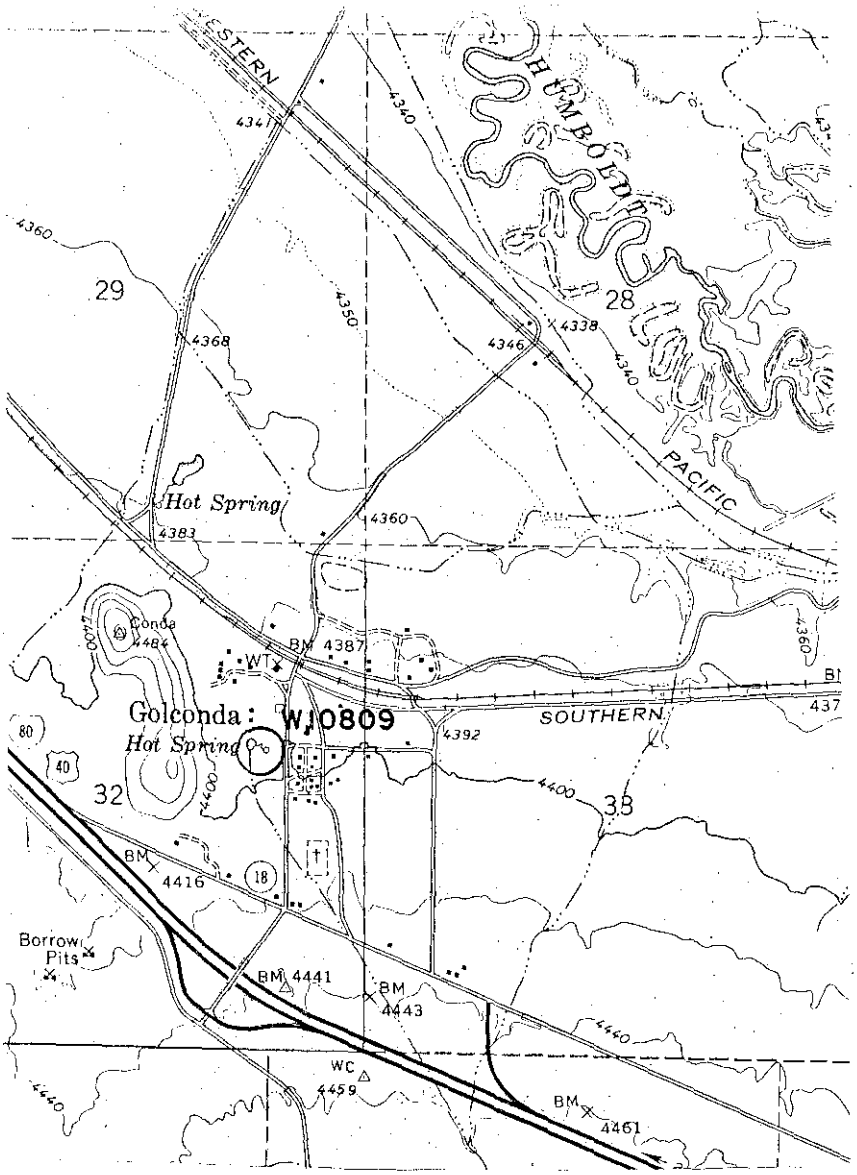

Figure 17. Location of Golconda Hot Spring.

The thermal waters exhibit neutral pH and have the following major ion distribution:

$HCO_3 > SO_4 > Cl$ Na > Ca > K > Mg.

The waters have little silica and high calcium (Table 18). Geothermometers have low reliability. Subsurface temperatures range from 114 to 196°C.

Union Oil has explored in the area. The nature of the work and results are not known.

W-10809	
County	Humboldt
Temp (C)	77.
Flow (GPM)	3.
pH	7.35
Cl	19.
F	1.8
SO_4	60.
HCO_3	362.8
CO_3	0
SiO_2	64.
Na	130.
K	21.
Ca	38.
Mg	7.1
Li	.4
Cu	0
B	1.6
MO	0
NH_3	.269
TDS	706.
$TSiO_2$	114.
TNa-K	248.
TNa-K-Ca	196.

Table 18. Analysis of the Golconda Hot Spring.

PUMPERNICKEL VALLEY

The Hot Springs Ranch Hot Springs are in Sections 4 and 5 of Township 33 North, Range 40 East, about 30 kilometers southeast of Winnemucca (Plate 14). The several natural springs are controlled by a profound northeast trending fault that divides the Sonoma

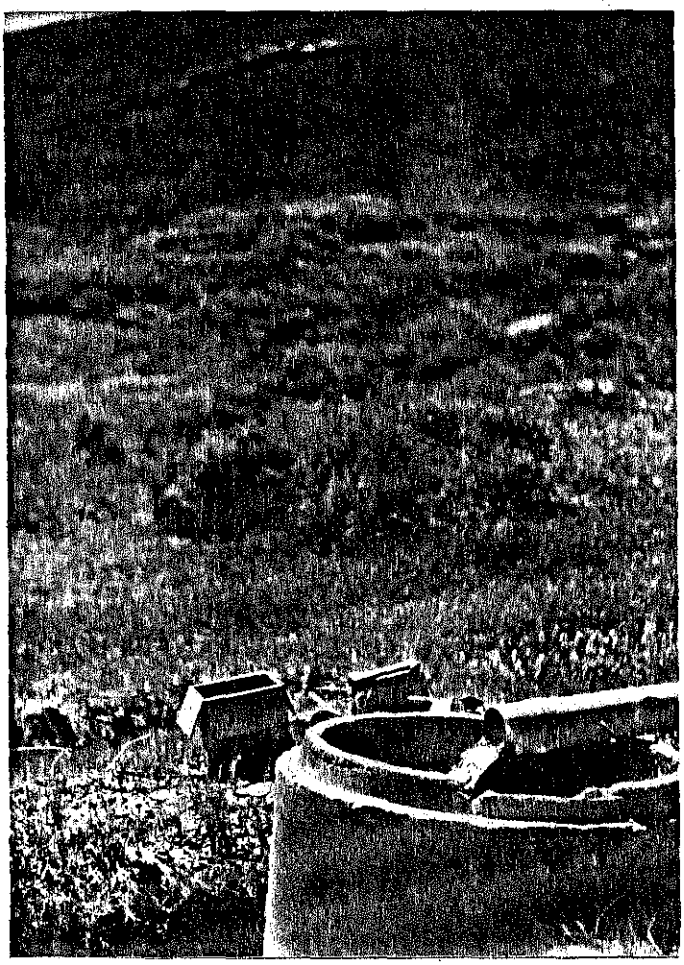

Plate 14. Hot Springs Ranch Hot Springs, 78°C.

Range to the west from the Pumpernickel Valley to the east (Figure 18). The Sonoma Range consists of Paleozoic shales and carbonates which were intruded by Cretaceous granites. The waters have deposited a limited quantity of 99 percent siliceous sinter.

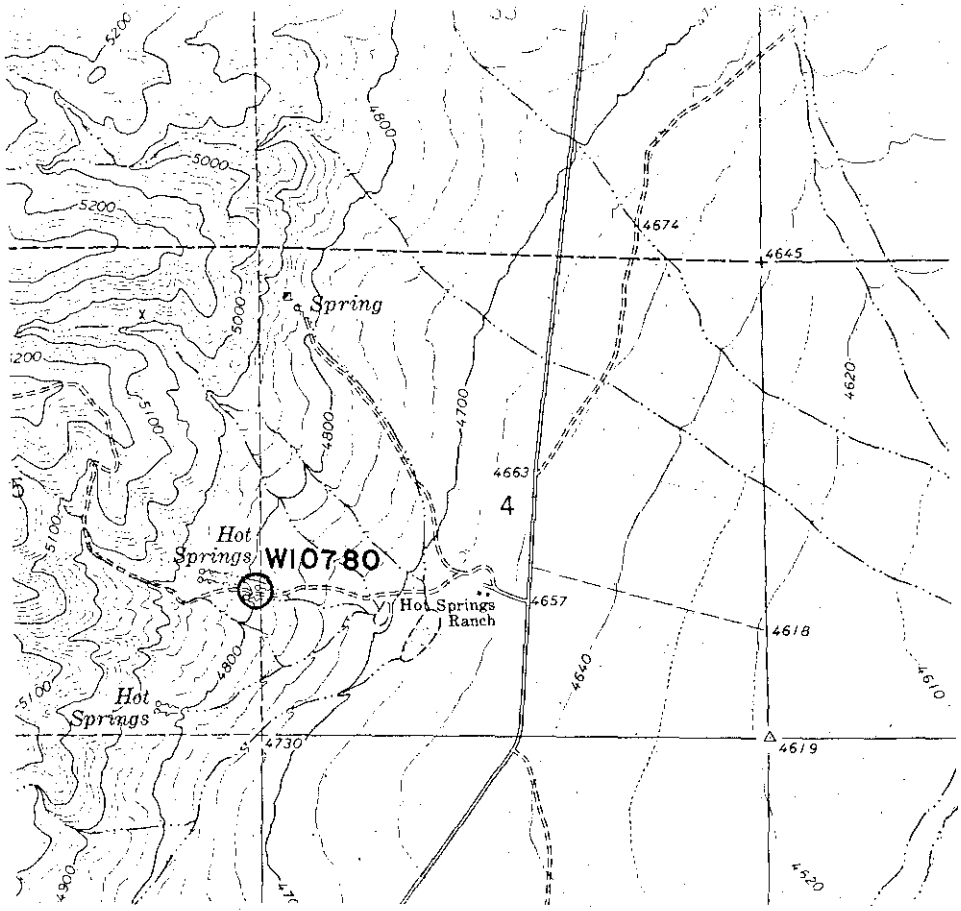

Figure 18. Location of the Hot Springs Ranch Hot Springs.

The waters have a basic pH and have the following major ion distribution:

$HCO_3 > SO_4 > Cl$ Na > K > Ca > Mg.

The waters contain generous amounts of boron and lithium, little calcium and magnesium. The waters may have been heated in the Mesozoic Granite. Subsurface temperatures range from 157 to 187°C (Table 19).

Magma Power drilled the Tipton No. 1 to a depth of 936 meters in 1974. Temperatures were rumored to be 130°C.

W-10780	
County	Humboldt
Temp (C)	78.
Flow (GPM)	200.
pH	8.91
Cl	37.
F	10.
SO_4	140.
HCO_3	297.2
CO_3	67.6
SiO_2	140.
Na	230.
K	20.
Ca	8.
Mg	.8
Li	1.5
Cu	0
B	2.5
MO	2.
NH_3	0
TDS	956.6
$TSiO_2$	157.
TNa-K	168.
TNa-K-Ca	187.

Table 19. Analysis of Hot Springs Ranch Hot Springs.

Supron leased federal land in October 1975 and April 1976. Magma has dropped the fee acreage on which they drilled.

GRASS VALLEY

Leach Hot Springs are in Grass Valley about 45 kilometers south of Winnemucca. The springs are at the base of a fault escarpment near the east side of the valley in Section 36 of Township 32 North, Range 38 East (Plate 15). The faults are normal with downthrown sides toward the west. The main spring fault is visible south of the springs as cracks in alluvium. Rocks of the Sonoma Range to the east are the Permian-Pennsylvanian Pumpernickel and Havallah Formation, the Koipato Group and the China Mountain Formation (Tatlock, 1969). These rocks are overlain by Tertiary sediments and Pliocene to recent gravels. The springs deposit an opaline sinter.

Plate 15. Leach Hot Spring, 91°C.

Thermal waters have a basic pH and major ions occur as follows:

$HCO_3 > SO_4 > Cl$ Na > K > Ca > Mg.

The waters are saturated with silica and contain small amounts of calcium and magnesium, a qualitative indication of high subsurface temperature. Low concentrations of boron, lithium and chloride are indicative of equilibration in an igneous metamorphic reservoir. The subsurface temperatures show poor correlation and range from 168 to 191°C (Table 20).

Data from eleven U.S.G.S. test holes drilled in 1973 are shown in figure 19. The resulting anomaly is eliptical and extends lengthwise for two kilometers.

W-10831	
County	Pershing
Temp (C)	91.
Flow (GPM)	1200.
pH	9.5
Cl	32.
F	9.
SO_4	50.
HCO_3	148.6
CO_3	186.
SiO_2	200.
Na	180.
K	13.
Ca	1.
Mg	0
Li	1.0
Cu	0
B	.9
MO	0
NH_3	.38
TDS	821.9
$TSiO_2$	168.
TNa-K	149.
TNa-K-Ca	191.

Table 20. Analysis of Leach Hot Spring.

Aminoil is the largest lease holder. Lease applications were made in 1976 and 1977. Leases are also held under the names of Sidney Glen, G. M. Booth and William Bucklin.

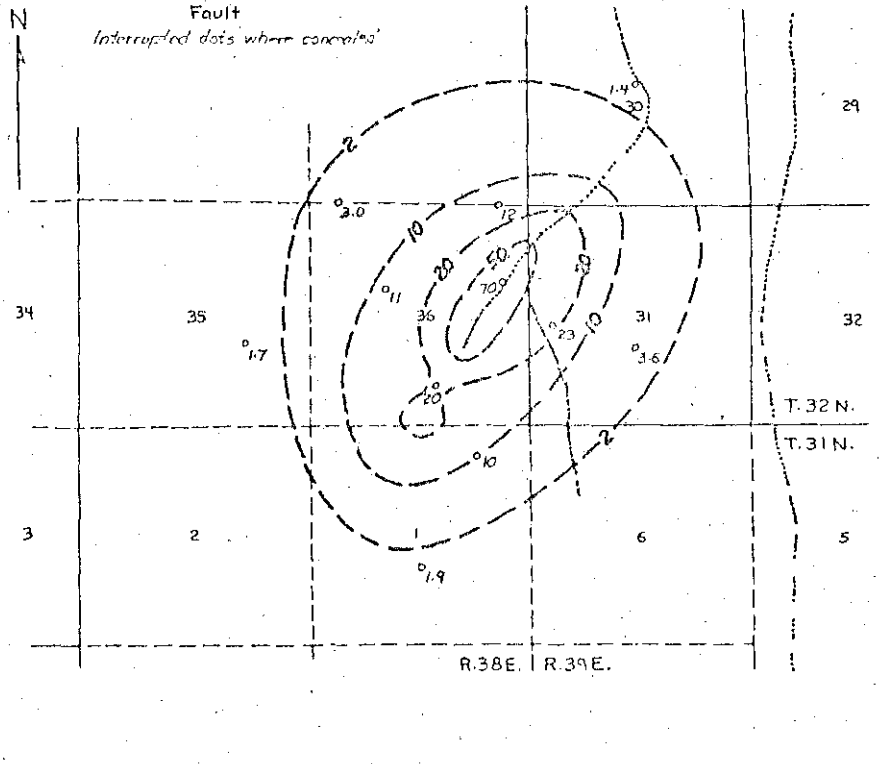

Figure 19. Location of Leach Hot Springs heat flow with faults (Olmsted et al,

BUFFALO VALLEY HOT SPRING

Buffalo Valley Hot Springs (Plate 16) are in Section 23 of Township 29 North, Range 41 East, 47 kilometers southwest of Battle Mountain. The oldest rock in the area is the Tertiary Fish Creek Mountain Tuff. Vents cutting the Fish Creek Tuff have erupted basaltic cinders and flows 3 m.y. old at the west margin of the valley. The volcanic vents are aligned along a major normal fault. The springs issue out of playa deposits and deposit travertine.

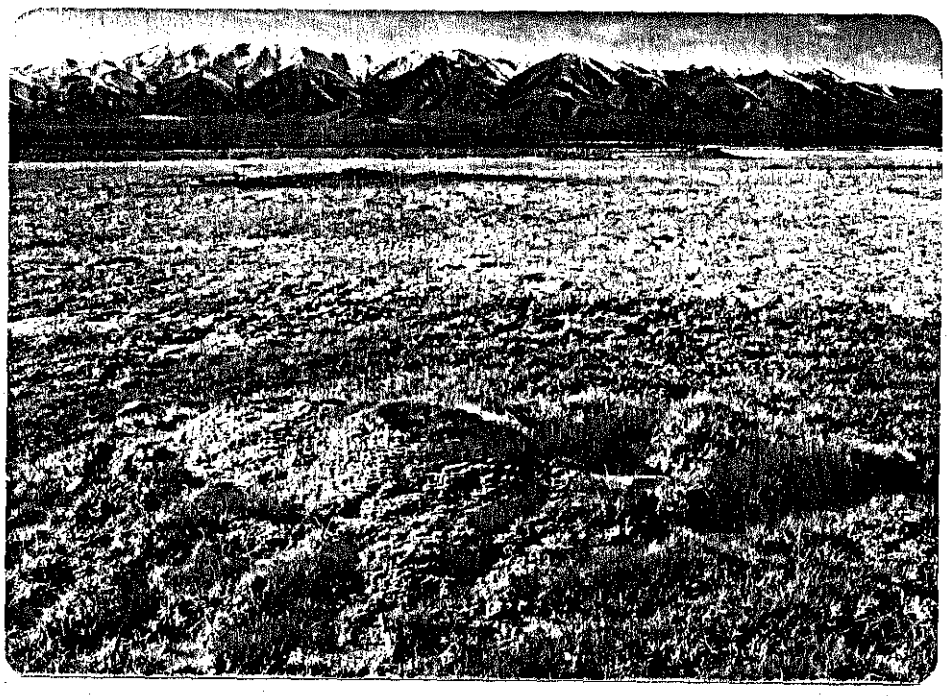

Plate 16. Buffalo Valley Hot Spring

The thermal waters have a neutral pH and the major ions occur as:

$HCO_3 > SO_4 > Cl$ Na > Ca > K > Mg

The waters are saturated with calcium carbonate and contain high concentrations of magnesium and low concentrations of silica. The geothermometers show poor correlation and temperatures range from 137 to 185°C. Geothermometry at Buffalo Valley has low credibility owing to the calcium saturation (Table 21).

Data from nine U.S.G.S. drill holes shown in figure 20 depicts a circular four kilometer heat flow anomaly.

Mobil is the only lease holder. Applications were made in January of 1974.

W-10726	
County	Lander
Temp (C)	54.
Flow (GPM)	1.
pH	7.4
Cl	26.
F	4.7
SO_4	100.
HCO_3	695.4
CO_3	0
SiO_2	100.
Na	310.
K	33.
Ca	60.
Mg	5.5
Li	.9
Cu	0
B	1.8
MO	0
NH_3	1.10
TDS	1338.4
$TSiO_2$	137.
TNa-K	191.
TNa-K-Ca	185.

Table 21. Analysis of Buffalo Valley Hot Spring.

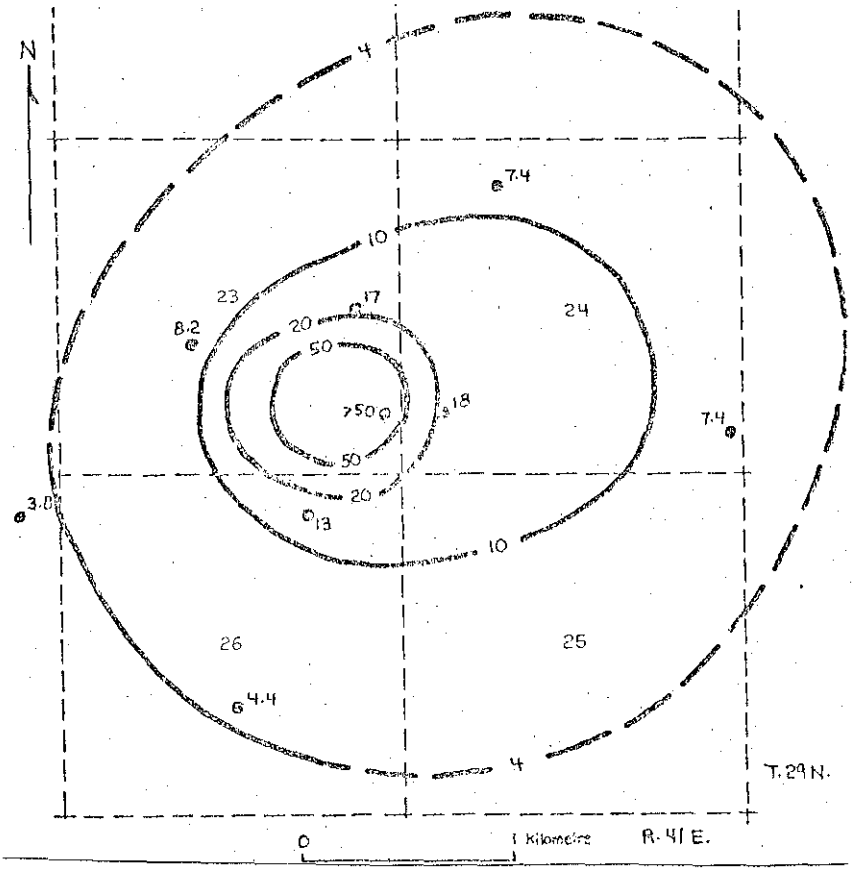

Figure 20. Location of Buffalo Valley Heat flow (Olmsted et al, 1975).

JERSEY VALLEY

The Jersey Valley Hot Spring is 85 kilometers southeast of Winnemucca in Section 29 of Township 27 North, Range 40 East (Plate 17).

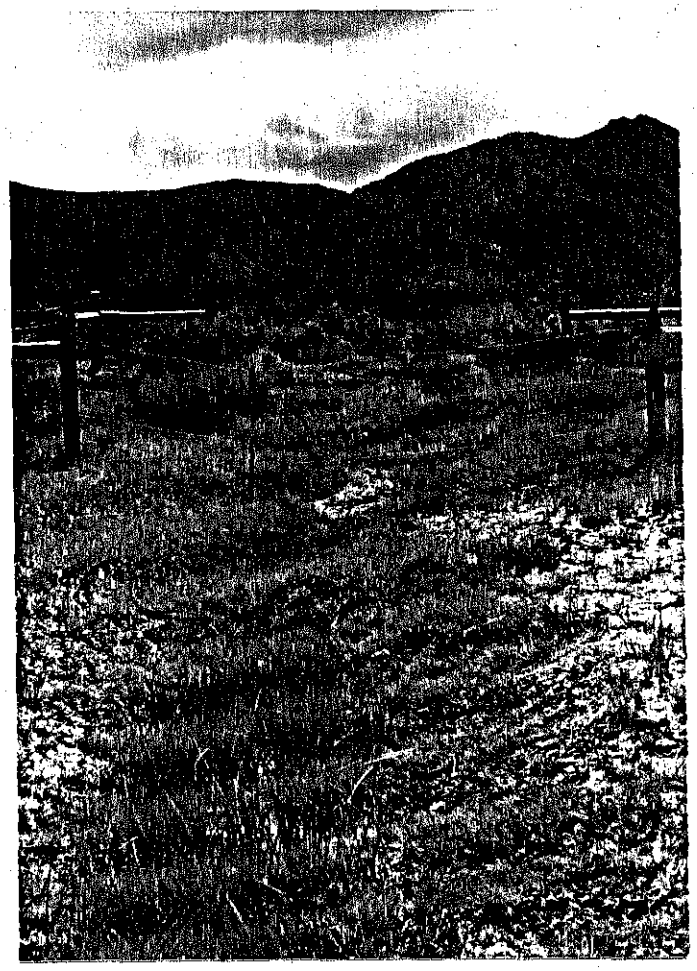

Plate 17. Jersey Valley Hot Spring, 42.5°C.

The spring flows from unconsolidated deposits at the west flank of the Fish Creek Mountains. No structure is immediately visible, however, extensions of the northeast trending range front fault intersect the spring (Figure 21). The Fish Creek Mountains consist of Permian sediments overlain by Tertiary welded tuffs of unknown origin. The springs have deposited silicious sinter in the past.

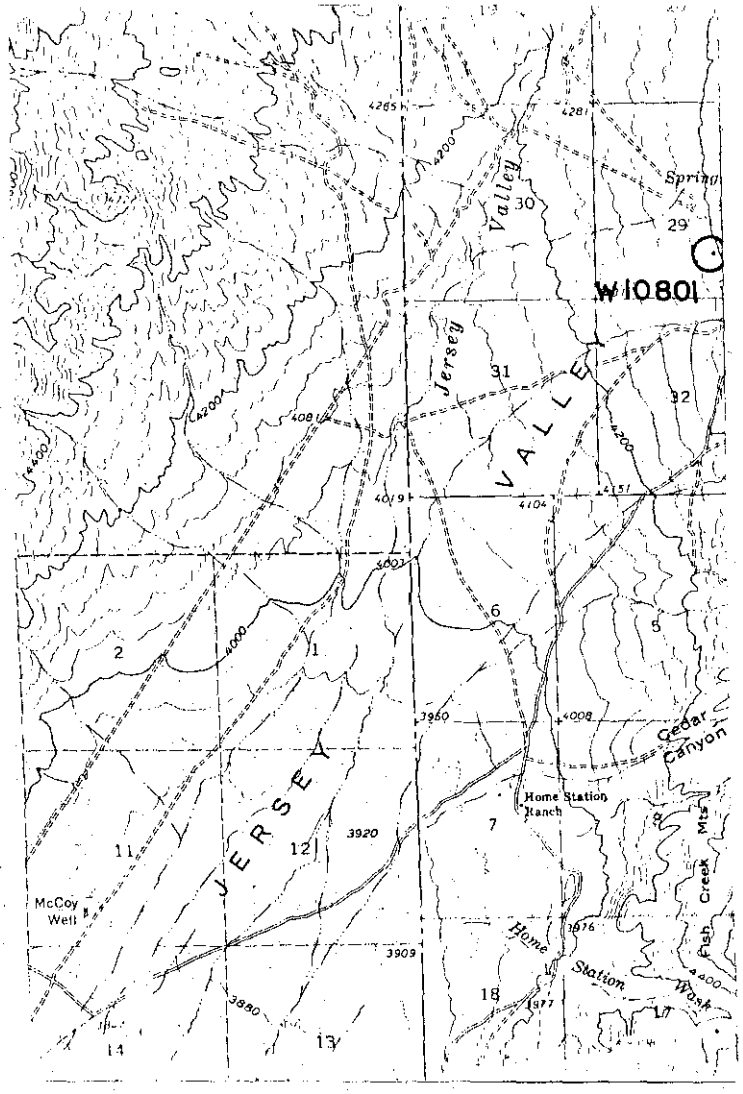

Figure 21 Location of Jersey Valley Hot Spring.

The water has a basic pH and exhibits low dissolved solids (Table 22). Major ions are distributed as follows:

$HCO_3 > SO_4 > Cl$ Na > Ca > K > Mg.

The waters contain interesting levels of boron and lithium. Subsurface geochemical temperatures range from 152 to 181°C.

Supron holds the only leases in the area. Applications were made in October 1975.

W-10801	
County	Pershing
Temp (C)	42.5
Flow (GPM)	1.
pH	7.49
Cl	37.
F	8.
SO_4	110.
HCO_3	193.6
CO_3	0
SiO_2	130.
Na	170.
K	18.
Ca	27.
Mg	3.3
Li	1.3
Cu	0
B	1.5
MO	2.
NH_3	0
TDS	701.7
$TSiO_2$	152.
TNa-K	190.
TNa-K-Ca	181.

Table 22. Analysis of Jersey Valley Hot Spring.

BUENA VISTA VALLEY

Kyle Hot Springs are in Section 1 of Township 29 North, Range 26 East, 62 kilometers southwest of Winnemucca (Plate 18). The springs issue out

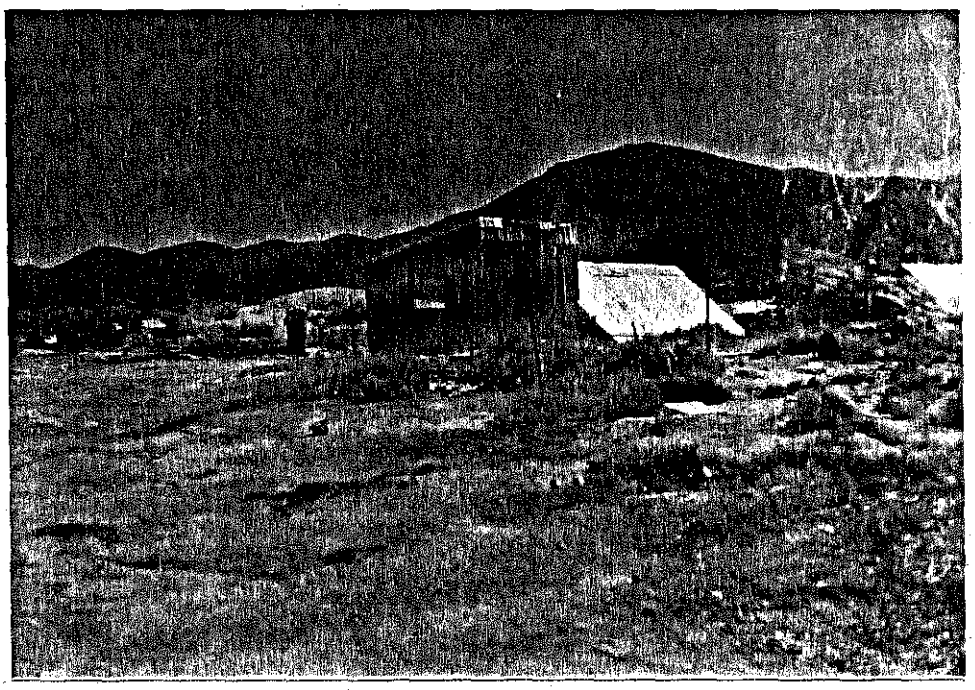

Plate 18. Kyle Hot Springs, 80°C.

of well-defined range-front faults that separate the Buena Vista Valley from the East Range (Figure 22). The East Range consists of Paleozoic sediments, Mesozoic and Tertiary granites and basalts. The springs flow from unconsolidated Quaternary deposits. The springs deposit a pure travertine (3 percent SiO_2).

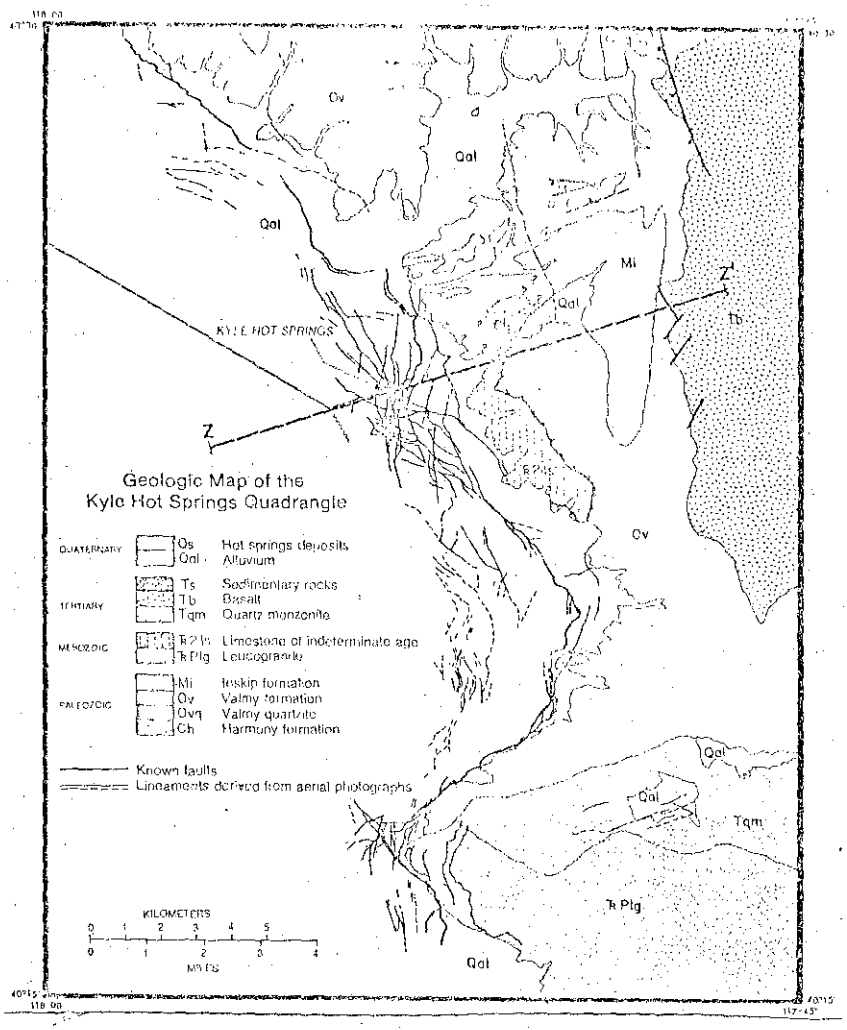

Figure 22. Geologic map of the Buena Vista Quad (Goldstein et al 1976).

The waters exhibit neutral pH and the major ions occur as:

$Cl > HCO_3 > SO_4$ $Na > Ca > K > Mg$.

The waters are rich in boron, lithium and ammonia (Table 23). The credibility of the geothermometers is lessened by the saturation with calcium carbonate.

Four 100-meter holes were drilled by the U.S.G.S. Heat flow measurements are shown in figure 23.

W-10811	
County	Pershing
Temp (C)	80.
Flow (GPM)	2.
pH	6.68
Cl	760.
F	5.9
SO_4	80.
HCO_3	467.4
CO_3	0
SiO_2	160.
Na	520.
K	78.
Ca	110.
Mg	21.
Li	3.4
Cu	0
B	3.0
MO	
NH_3	.9
TDS	2209.6
$TSiO_2$	165.
TNa-K	236.
TNa-K-Ca	209.

Table 23. Analysis of Kyle Hot Springs.

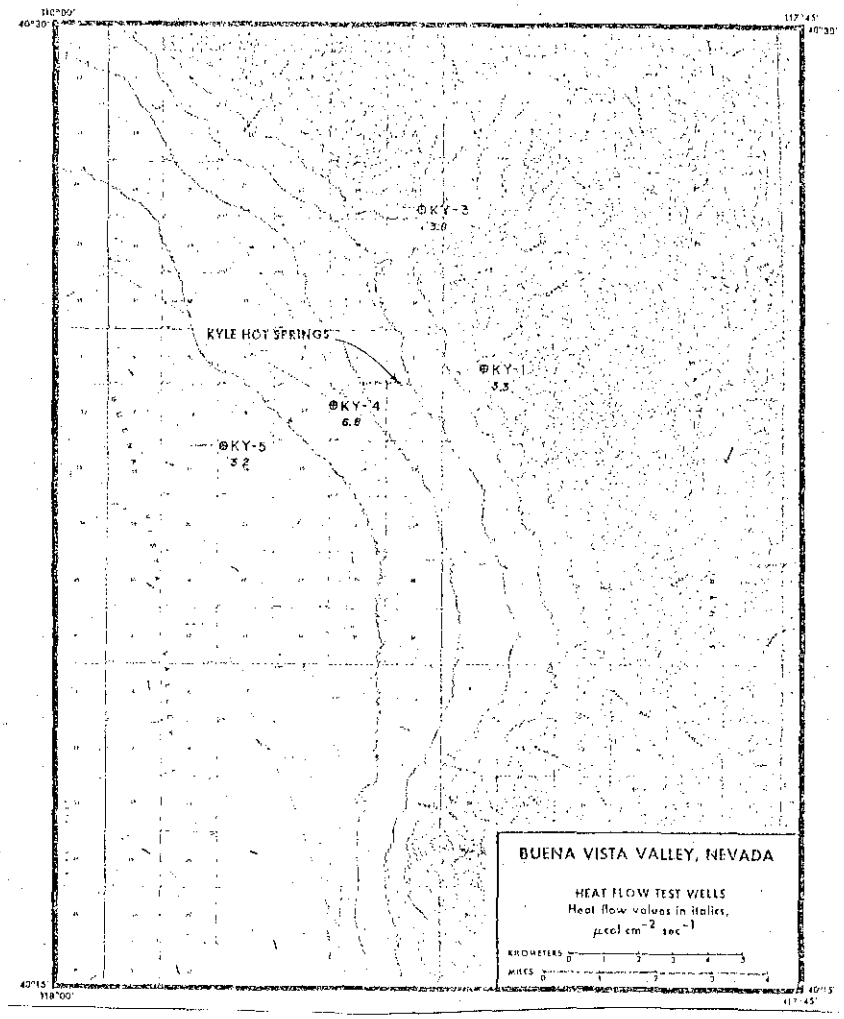

Figure 23. Location of Heat flow at Kyle Hot Springs.

AREAS OF GEOCHEMICAL AND HEAT FLOW INTEREST

SOUTHWESTERN NEVADA

RENO

Steamboat Hot Springs are in the southeast quarter of Township 18 North, Range 20 East, 18 kilometers south of Reno (Plate 19).

Plate 19. Steamboat Hot Springs, 91°C.

Pre-tertiary metamorphic and granitic rocks form the basement in the area. Middle and late Tertiary volcanic rocks are abundant in the surrounding area. The Pleistocene Lousetown andesite , the Steamboat Rhyolite and the Pleistocene mud-volcano breccia are the most youthful rocks.

The most numerous faults in the area strike nearly north. These faults displace pre-Lake Lahontan alluvium and middle Pleistocene siliceous

sinter. The large siliceous sinter terraces (Plate 19) are controlled structurally by a north-trending fault system. Lead, tungsten, silver or mercury mineralization is associated with certain faults.

The thermal waters have a neutral pH and contain high concentrations of boron, lithium and silica. The concentrations of calcium and magnesium are low. The major ions are distributed as follows:

$Cl > HCO_3 > SO_4$ $Na > K > Ca > Mg$.

Results from chemical geothermometry should be very reliable. Subsurface temperatures range from 190 to 210°C (Table 24).

W-11236	
County	Storey
Temp (C)	91.
Flow (GPM)	15.
pH	7.4
Cl	850.
F	2.1
SO_4	120.
HCO_3	310.
CO_3	0
SiO_2	290.
Na	650.
K	64.
Ca	12.
Mg	.5
Li	8.1
Cu	0
B	50.
MO	
NH_3	.13
TDS	2356.8
$TSiO_2$	190.
TNa-K	182.
TNa-K-Ca	210.

Table 24. Analysis of Steamboat Hot Springs.

Nevada Thermal Power Company (Magma) drilled six holes in the area between 1954 and 1961. The holes range from 159 to 588 meters. Phillips has recently completed a deep test in the southwest quarter of Section 4 of Township 18 North, Range 20 East. Wells drilled in the past have been plagued by scaling and limited permeability. The land situation is generally complicated.

Phillips, Gulf, Hunt, Pacific Energy and William Hendrey have taken federal geothermal applications. Leasing took place from 1974 to 1975.

HAZEN

The Hazen (Patua) Hot Spring is about 9 kilometers northwest of Hazen in Section 18 of Township 20 North, Range 26 East (Figure 24).

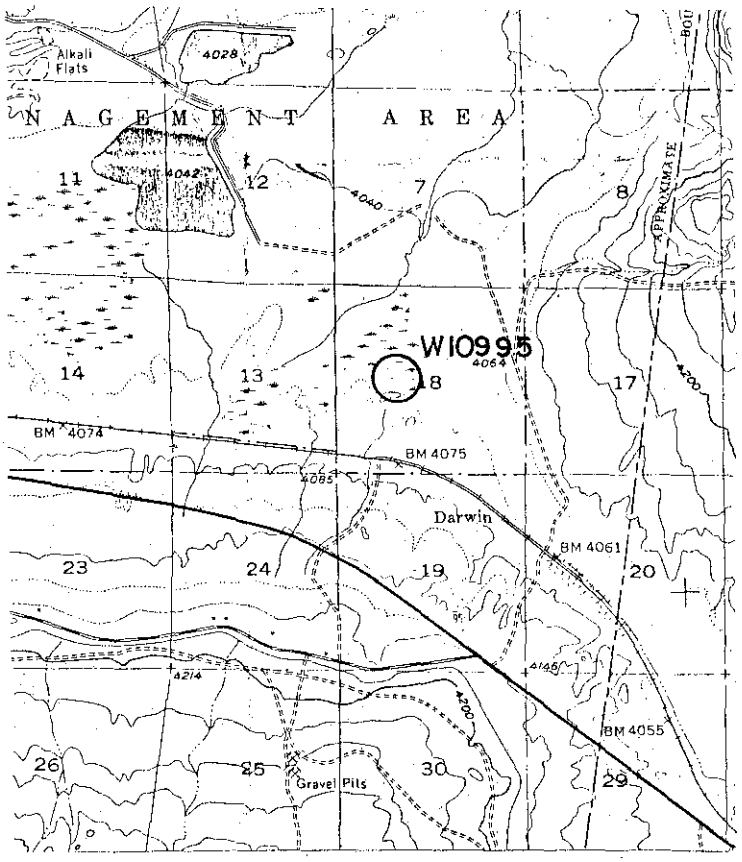

Figure 24. Location of Hazen Hot Spring, 92°C.

The natural hot spring rises at the south end of the Hot Springs Range in unconsolidated Lake Lahontan sediments. The Hot Springs Range is composed of late Miocene and early Pliocene basalts, andesites and lake sediments.

The spring water issues out at 92°C. The water is the sodium chloride variety as seen below:

$Cl > SO_4 > HCO_3$ Na > Ca > K > Mg.

Boron, lithium and ammonia are present at high levels (Table 25). Geothermometers may be adversely affected by the high calcium contents. Subsurface temperatures range from 165 to 194°C.

Magma Power drilled three holes in 1962 to depths between 95 and 228 meters. Fluid temperatures were approximately 130°C.

Union Oil, Geo Products Corporation and Supron are the major federal land lessors. Acreage was taken as early as 1974.

W-10995	
County	Lyon
Temp (C)	92.
Flow (GPM)	500.
pH	7.19
Cl	780.
F	5.
SO_4	380.
HCO_3	71.4
CO_3	0
SiO_2	190.
Na	580.
K	59.
Ca	60.
Mg	.8
Li	1.8
Cu	0
B	5.2
MO	10.
NH_3	.82
TDS	2144.0
$TSiO_2$	165.
TNa-K	186.
TNa-K-Ca	194.

Table 25. Analysis of Hazen Hot Spring.

DESERT PEAK

Desert Peak Warm Spring is 3 kilometers south of Brady's Hot Spring in Section 35 of Township 22 North, Range 26 East (Plate 20). The water

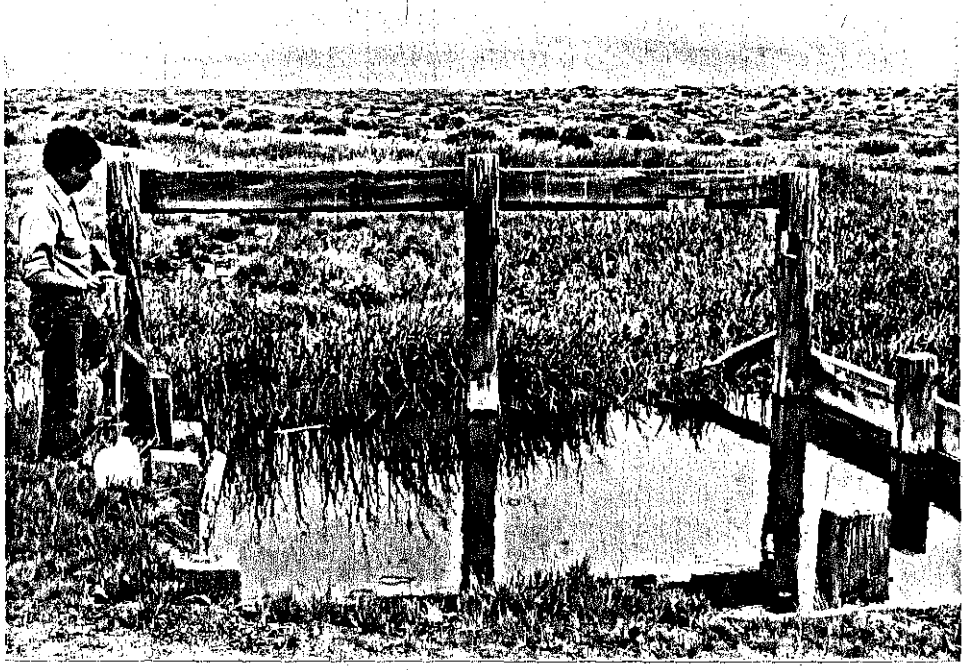

Plate 20. Desert Peak Warm Spring, 18°C.

rises at the north end of the Hot Springs Range which was discussed with Hazen Hot Spring (Figure 25).

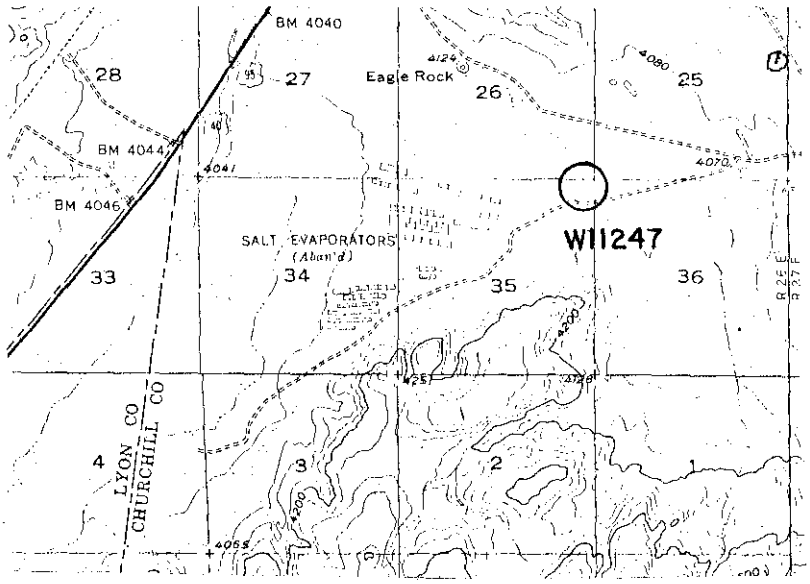

Figure 25. Location of Desert Peak Warm Spring.

The water is the sodium chloride variety:

$Cl > HCO_3 > SO_4$ Na > K > Ca > Mg.

The water is high in boron, lithium, ammonia and dissolved solids. The concentrations of calcium and magnesium are relatively low (Table 26). Subsurface temperatures range from 137 to 221°C. Phillips Petroleum indicates this water is very similar to the effluent of production wells of the Desert Peak discovery except for silica which is lost by precipitation.

Phillips has the most federal acreage leased in 1974. G.R.I., Thermal Power, Supron and W. O. Darley also hold federal leases.

W-11247	
County	Churchill
Temp (C)	18.
Flow (GPM)	5.
pH	7.71
Cl	3700.
F	2.6
SO_4	90.
HCO_3	172.
CO_3	0
SiO_2	100.
Na	1900.
K	160.
Ca	15.
Mg	12.
Li	2.9
Cu	0
B	18.
MO	10.
NH_3	.95
TDS	6183.4
$TSiO_2$	137.
TNa-K	160.
TNa-K-Ca	221.

Table 26. Analysis of Desert Peak Warm Spring.

LOVELOCK

The Colado Hot Well is 12 kilometers northeast of Lovelock in Section 33 of Township 27 North, Range 32 East (Figure 26). The well

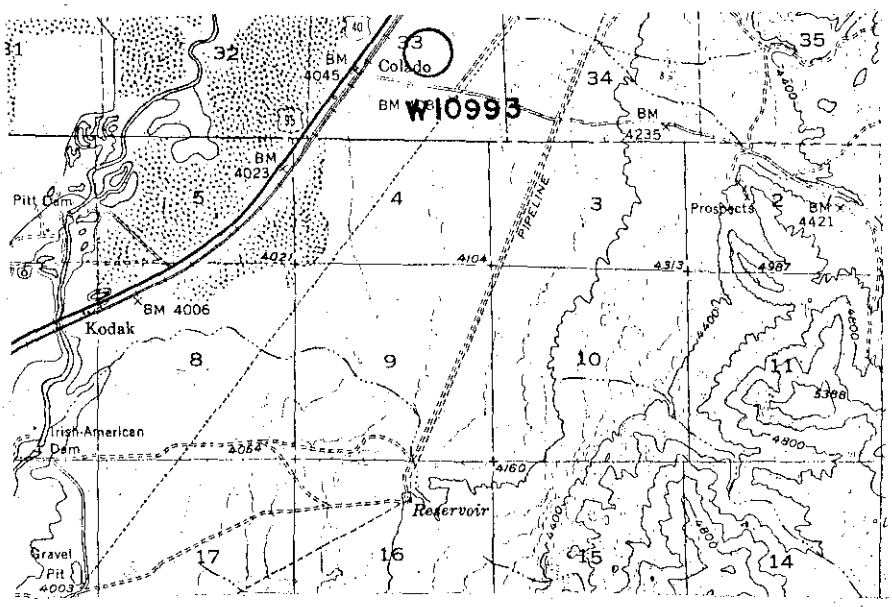

Figure 26. Location of the Colado Hot Well, 54°C.

was drilled by a mineral concern for processing water. The depth is unknown.

The well is located at the mouth of Coal Canyon, on the west flank of the Humboldt Range. The range is composed of Jurassic and Triassic sediments and basic intrusives which are covered with Miocene ash-fall tuffs and rhyolite flows. No geologic structure is evident in the vicinity of the well.

The thermal water is rich in dissolved solids (Table 27). They have neutral pH and have major ions arranged thusly:

$Cl > HCO_3 > SO_4$ Na > Ca > K > Mg.

Boron, ammonia and lithium are found in high concentrations. The waters contain much calcium and magnesium. Subsurface temperatures may be adversely affected by the calcium. Temperatures range from 120 to 202°C.

Getty Oil leased federal land in October and December of 1976.

W-10993	
County	Pershing
Temp (C)	54.
Flow (GPM)	0
pH	7.18
Cl	2400.
F	4.5
SO_4	100.
HCO_3	180.
CO_3	0
SiO_2	72.
Na	1000.
K	110.
Ca	130.
Mg	6.6
Li	2.9
Cu	70.
B	6.5
MO	3.
NH_3	1.1
TDS	4086.6
$TSiO_2$	120.
TNa-K	195.
TNa-K-Ca	202.

Table 27. Analysis of the Colado Hot Well.

SALT WELLS

The Borax Works Hot Spring is 2 kilometers south of Salt Wells in Section 7 of Township 17 North, Range 30 East (Plate 21). The water

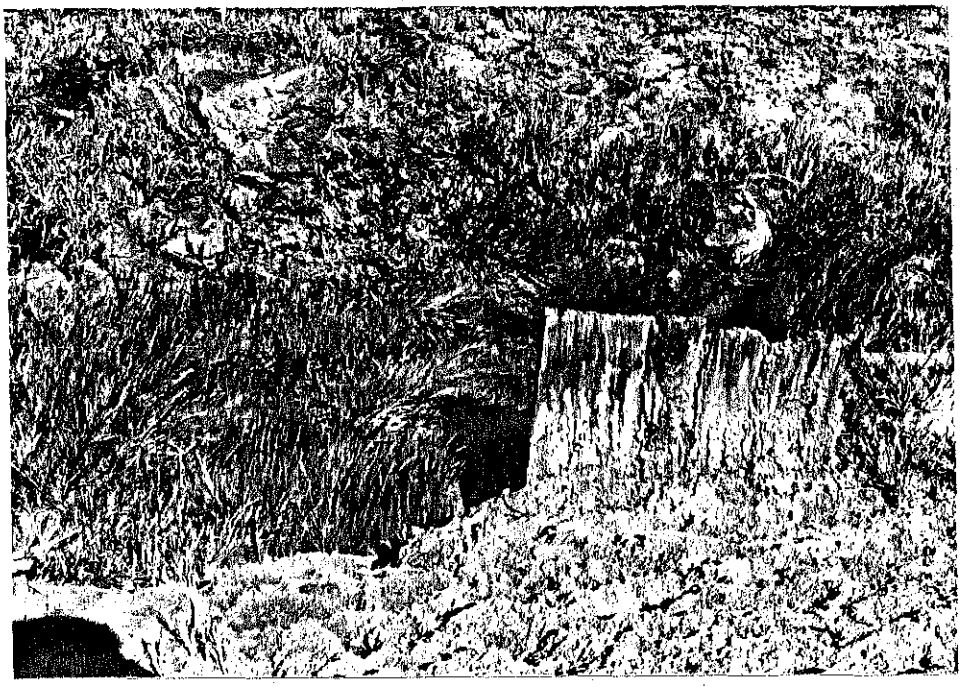

Plate 21. Borax Works Hot Spring, 54°C.

rises out of the Salt Wells Basin north of the Bunejug Mountains (Figure 27). The rocks both north and south of the spring are late Miocene and early Pliocene andesite and basalt flows. The springs flow from a topographic and structural high wich may be related to the north trending horst which controls the Stillwater geothermal field to the north.

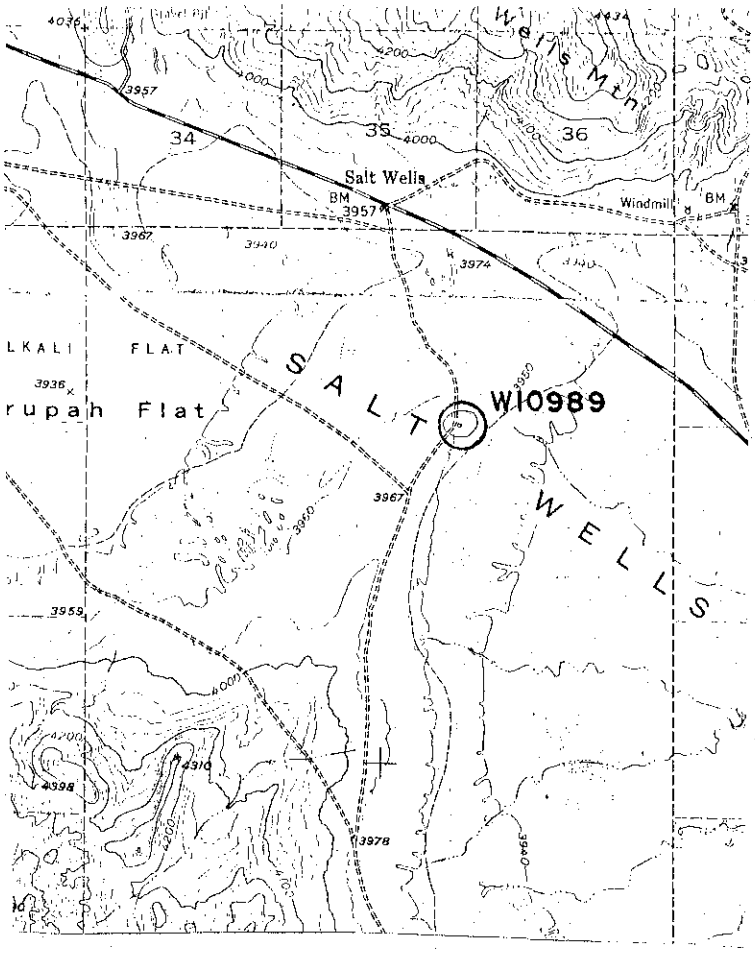

Figure 27. Location of Borax Works Hot Spring.

The thermal water is the sodium chloride variety:

$Cl > SO_4 > HCO_3$ $Na > K > Ca > Mg$.

The concentrations of boron, silica, lithium and ammonia are interesting (Table 28). Subsurface temperatures range from 186 to 195°C.

Anadarko and Occidental have the commanding land position. Their leases were applied for in January 1974. Union Oil, Hunt, Walter Leftwich and W. P. Carver also hold federal leases.

W-10989	
County	Churchill
Temp (C)	54.
Flow (GPM)	10.
pH	7.48
Cl	1200.
F	7.6
SO_4	330.
HCO_3	208.4
CO_3	0
SiO_2	220.
Na	900.
K	72.
Ca	31.
Mg	2.4
Li	2.1
Cu	0
B	5.7
MO	0
NH_3	.55
TDS	2979.7
$TSiO_2$	186.
TNa-K	159.
TNa-K-Ca	195.

Table 28. Analysis of the Borax Works Hot Spring.

TEELS MARSH

Company Warm Springs is 48 kilometers southeast of Hawthorne in Section 31 of Township 4 North, Range 33 East (Plate 22). The waters rise from alluvium at the south margin of Teels Marsh (Figure 28). The

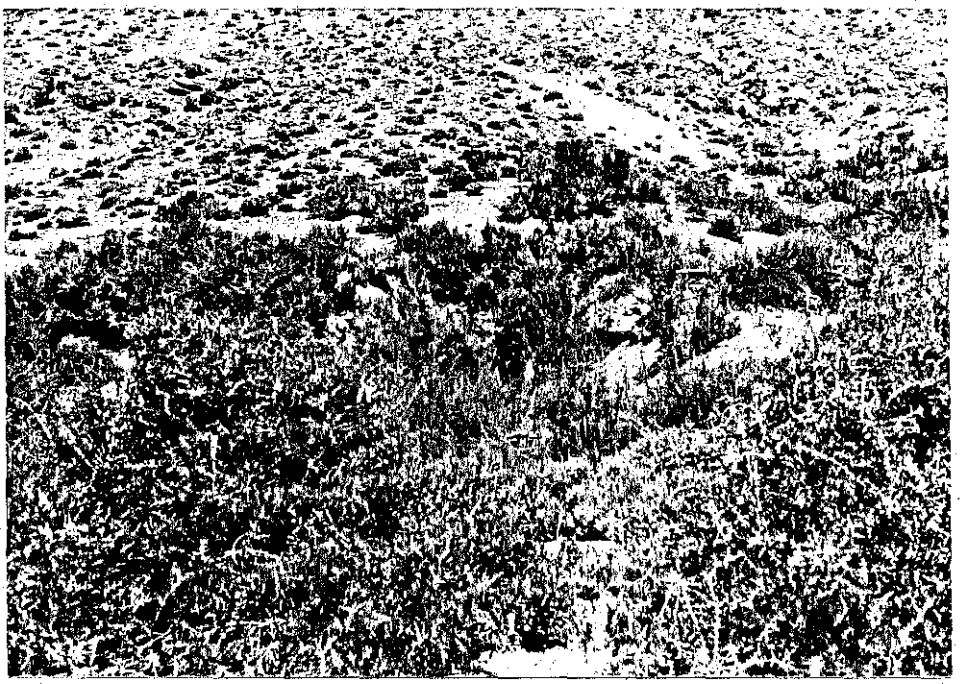

Plate 22. Company Warm Spring, 23°C.

youngest rocks in the area are Miocene and Pliocene andesites and basalts which are underlain by Jurassic granites and diorite. A nearby warm spring has deposited a large quantity of travertine.

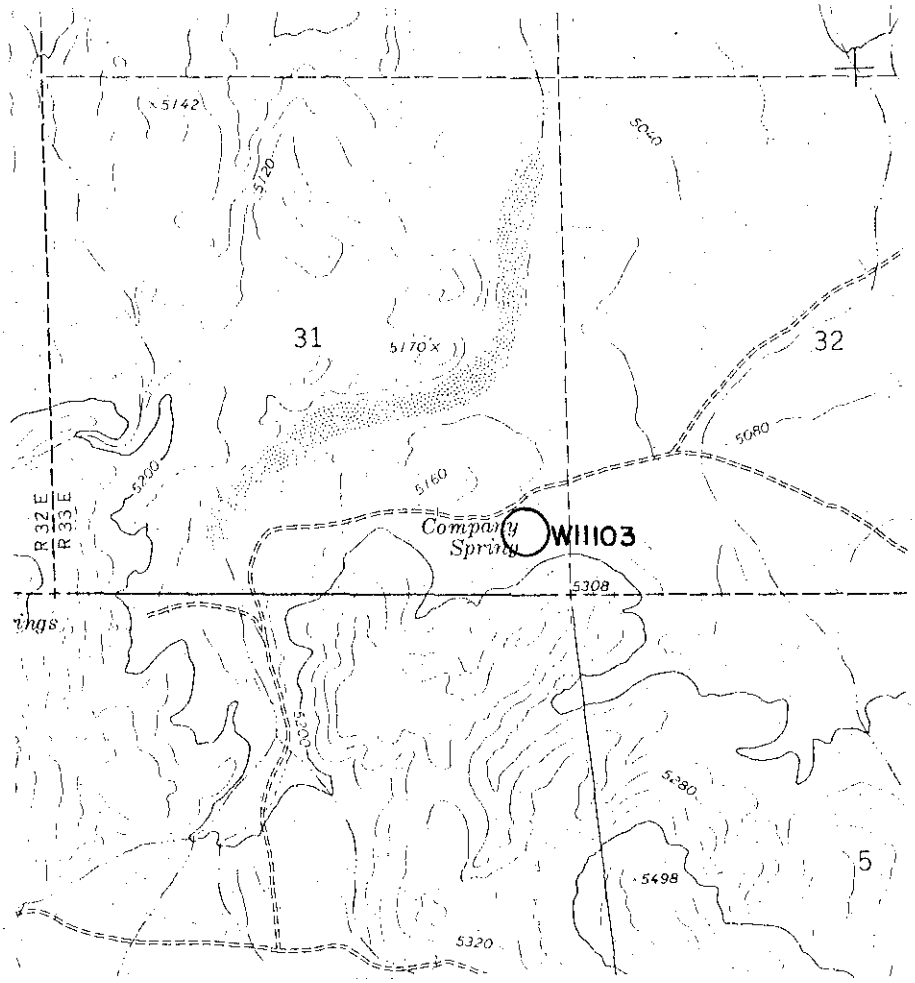

Figure 28. Location of Company Warm Spring.

The waters contain bicarbonate as the principle ion:

HCO_3 > Cl > SO_4 Na > K > Ca > Mg.

Boron is found at a high concentration. Subsurface temperatures via chemistry show a discordance and range from 121 to 204°C (Table 29).

W-11103	
County	Esmeralda
Temp (C)	23.
Flow (GPM)	10.
pH	8.3
Cl	130.
F	1.5
SO_4	95.
HCO_3	318.6
CO_3	0
SiO_2	81.
Na	190.
K	29.
Ca	28.
Mg	11.
Li	.5
Cu	0
B	3.4
MO	0
NH_3	0
TDS	888.0
$TSiO_2$	121.
TNa-K	239.
TNa-K-Ca	204.

Table 29. Analysis of Company Warm Spring.

COLUMBUS SALT MARSH

Columbus Warm Well is about 62 kilometers west of Tonopah in Section 18 of Township 3 North, Range 36 East (Plate 23). The well was drilled at the northwest margin of the Columbus Salt Marsh to

Plate 23. Columbus Warm Well, 17°C.

a depth of 76 meters in alluvium (Figure 29). The Candelaria Hills to the north consist of Triassic and Jurassic granodiorite and quartz monzonite which have intruded Ordovician sediments. The area contains some Miocene tuffs and rhyolites.

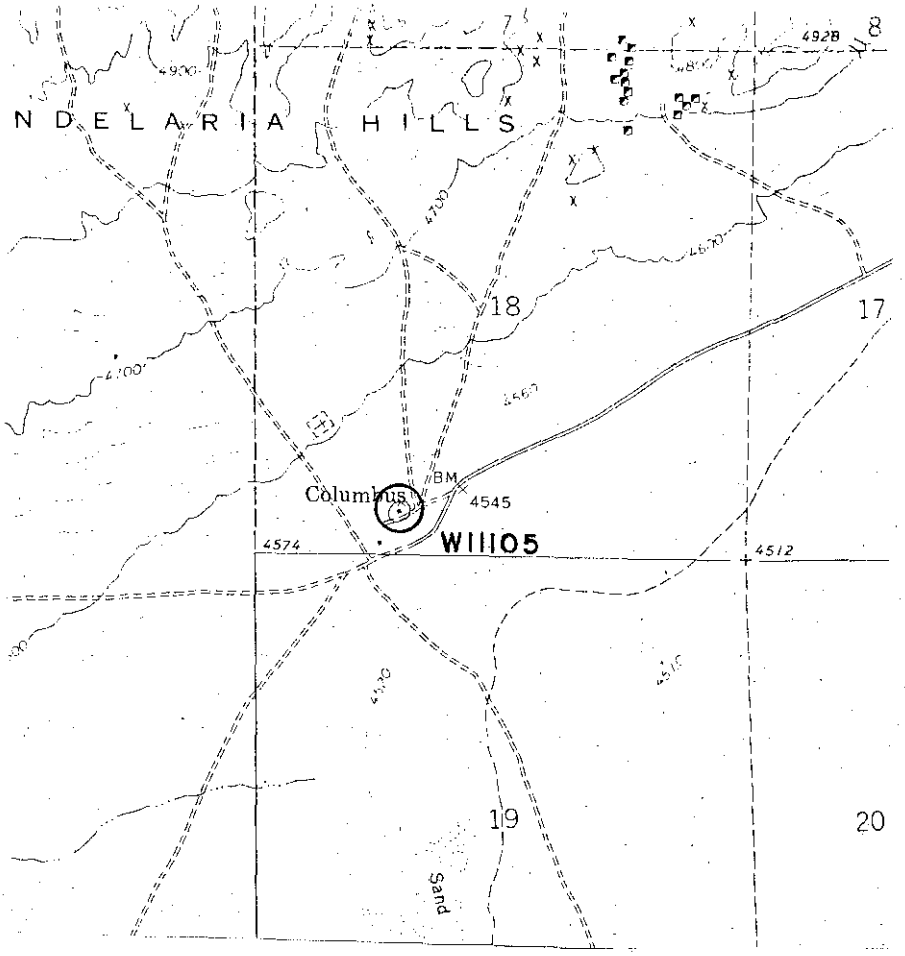

Figure 29. Location of Columbus Warm Well.

The waters contain sulfate as the principle ion (Table 30):

SO_4 > Cl > HCO_3 Na > Ca > K > Mg.

The waters are rich in calcium which adversely affects geothermometry. Subsurface temperatures range from 120 to 173°C.

W-11105	
County	Esmeralda
Temp (C)	17.
Flow (GPM)	0
pH	7.99
Cl	320.
F	1.1
SO_4	800.
HCO_3	223.6
CO_3	0
SiO_2	110.
Na	400.
K	37.
Ca	170.
Mg	95.
Li	.1
Cu	2.
B	3.4
MO	40.
NH_3	.12
TDS	2092.3
$TSiO_2$	120.
TNa-K	175.
TNa-K-Ca	173.

Table 30. Analysis of Columbus Warm Well.

FISH LAKE VALLEY

Rhyolite Ridge Hot Well is about 64 kilometers southwest of Tonopah in Section 16 of Township 1 South, Range 36 East (Plate 24). The well was drilled to an unknown depth at the west margin of the

Plate 24. Rhyolite Ridge Hot Well, 38°C.

Fish Lake Playa (Figure 30). The immediate area is covered with Miocene rhyolite flows and tuffs.

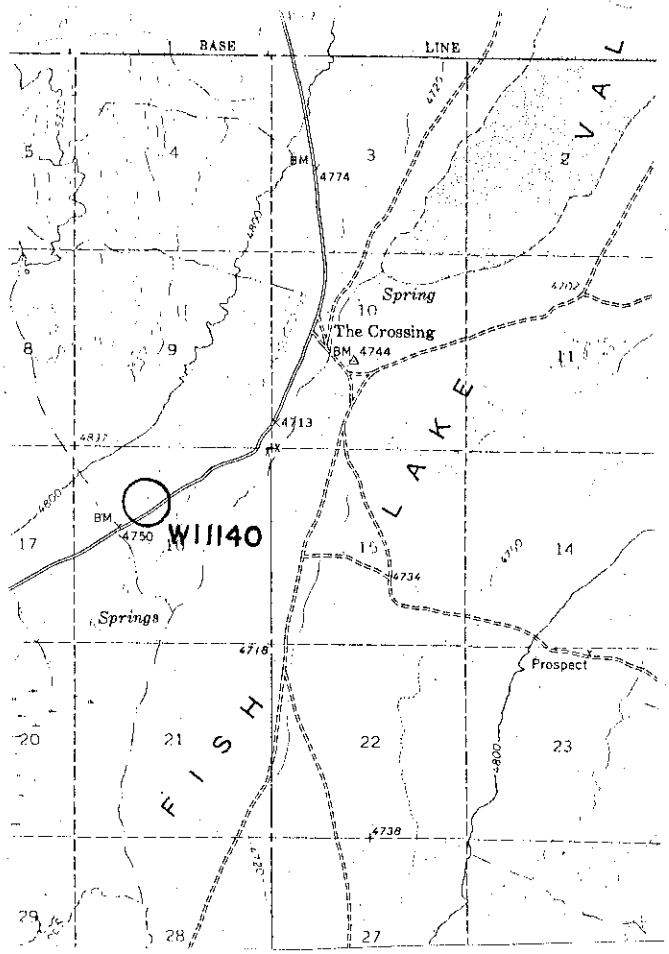

Figure 30. Location of Rhyolite Ridge Hot Well.

The waters have a basic pH. The major ions are arranged as follows:

$Cl > HCO_3 > SO_4$ $Na > K > Ca > Mg$.

Boron, lithium and ammonia are found in high concentrations. Subsurface temperatures should be realistic. Temperatures range from 112 to 202°C (Table 31).

Magma Power and Ronald Stone are the Federal lessors.

W-11140	
County	Esmeralda
Temp (C)	38.
Flow (GPM)	1600.
pH	9.08
Cl	290.
F	2.4
SO_4	60.
HCO_3	193.4
CO_3	56.
SiO_2	62.
Na	320.
K	30.
Ca	5.
Mg	.9
Li	.8
Cu	40.
B	4.8
MO	10.
NH_3	.24
TDS	1075.5
$TSiO_2$	112.
TNa-K	176.
TNa-K-Ca	202.

Table 31. Analysis of Rhyolite Ridge Hot Well.

AREAS OF GEOCHEMICAL AND HEAT FLOW INTEREST

SOUTHEASTERN NEVADA

BIG SMOKY VALLEY

Spencer Hot Springs are in Sections 18 and 19 of Township 17 North, Range 46 East, about 25 kilometers southeast of Austin (Plate 25). The

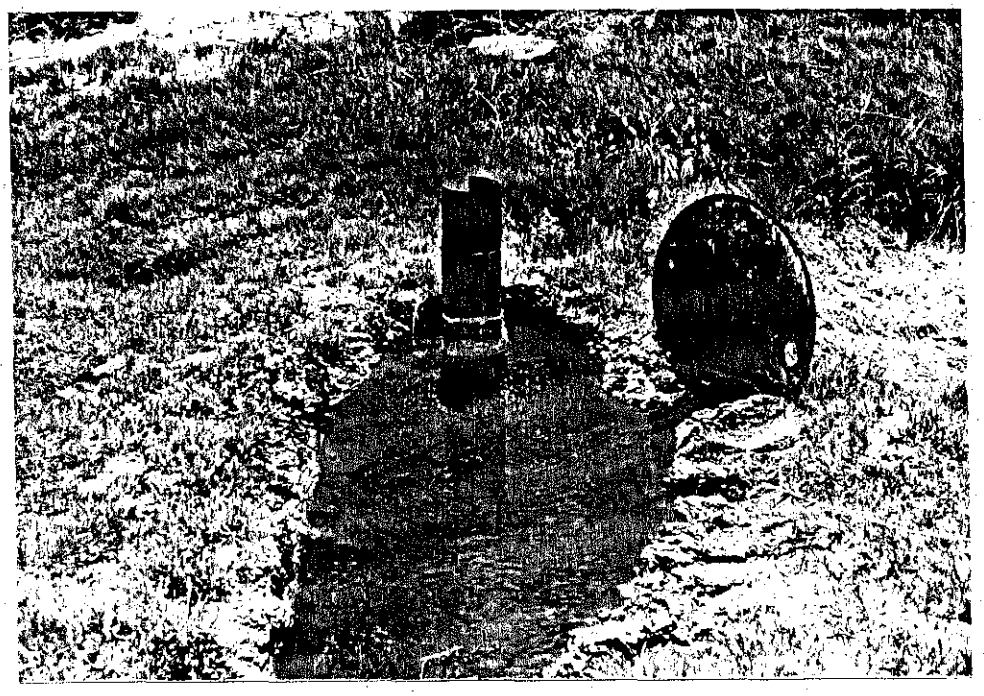

Plate 25. Spencer Hot Spring, 60°C.

thermal waters flow from the Ordovician Vinini Formation at the northwest end of the Toquima Range (Figure 31). The Tungsten ore of the nearby Linka Mine is closely related to an overthrust of the Eureka Quartzite over the Vinini Formation. The thrust is visible near the spring. The thermal water has deposited abundant travertine.

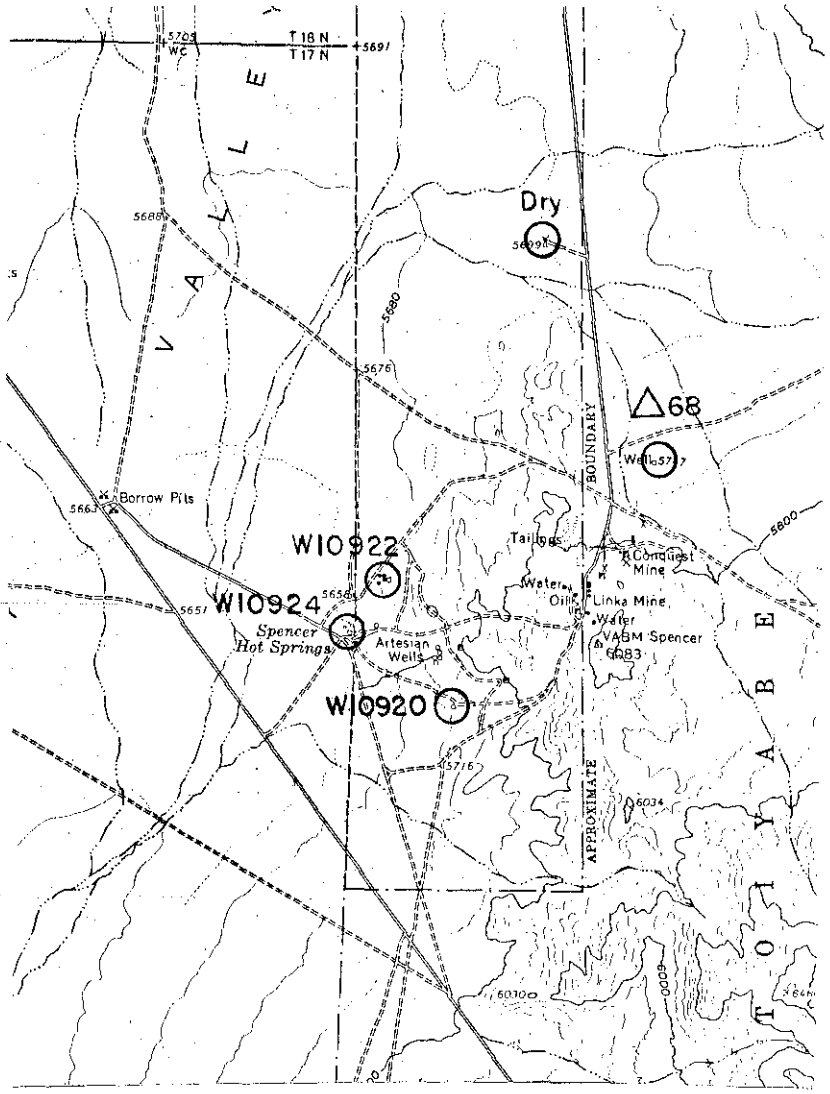

Figure 31. Location of Spencer Hot Spring.

The thermal waters have a slightly acid pH and have the major ions constituted as follows:

$HCO_3 > SO_4 > Cl$ Na > Ca > K > Mg.

Lithium and boron are abundant. Saturation with calcium carbonate is evident. Subsurface temperatures are suspect. The temperatures range from 173 to 203°C (Table 32).

W-10922	
County	Lander
Temp (C)	60.
Flow (GPM)	10.
pH	6.62
Cl	22.
F	4.7
SO_4	44.
HCO_3	547.8
CO_3	0
SiO_2	180.
Na	200.
K	34.
Ca	60.
Mg	10.
Li	1.9
Cu	0
B	2.2
MO	6.
NH_3	.22
TDS	1112.8
$TSiO_2$	173.
TNa-K	255.
TNa-K-Ca	203.

Table 32. Analysis of Spencer Hot Spring.

Hot Springs occur further south in the Big Smoky Valley near the Millet Range. The springs are in section 34 of Township 14 North, Range 43 East, about 50 kilometers south of Austin (Figure 32). The spring

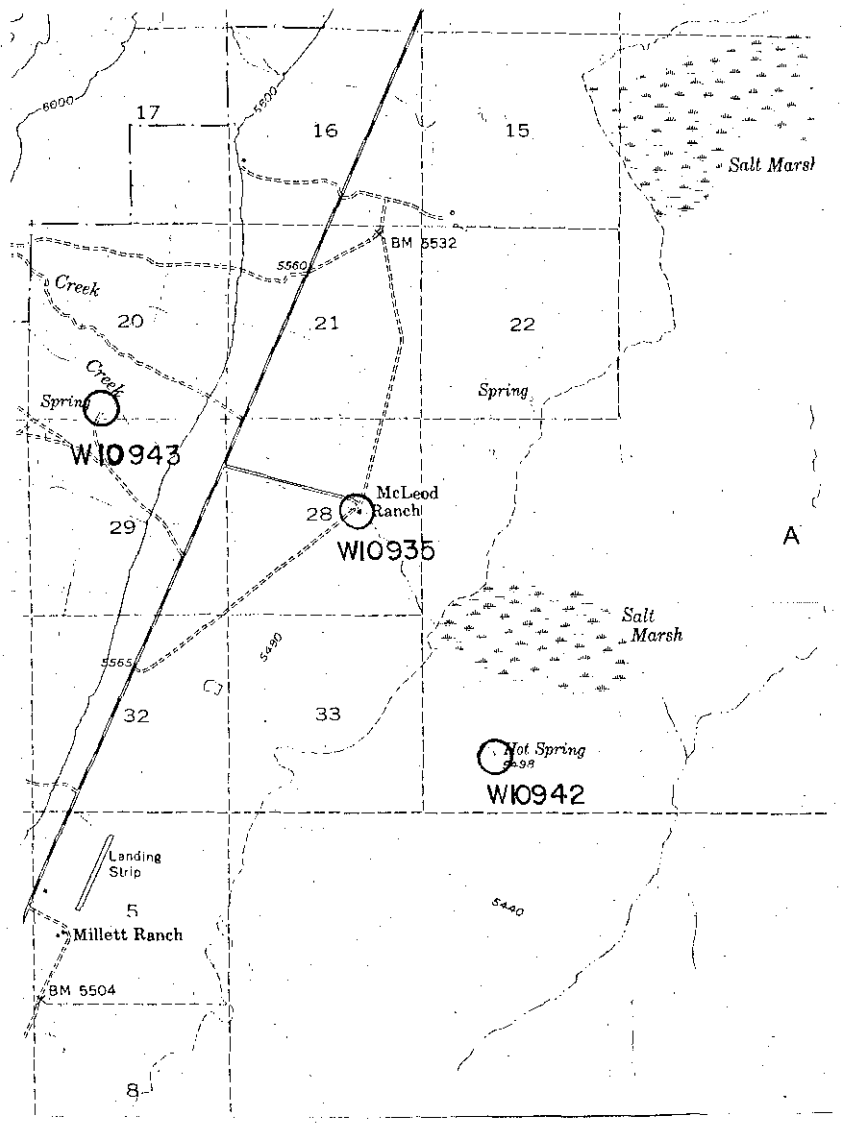

Figure 32. Location of 5498 Hot Spring, 55°C.

flows from unconsolidated playa deposits off the east flank of the Toiyabe Range. No structure is evident in the local area. The youngest rocks in the adjacent Toiyabe Mountains are Cretaceous granites.

The thermal waters are not saturated with respect to calcium carbonate. Concentration of fluoride, lithium and boron are interesting (Table 33). Major ions are distributed thusly:

$HCO_3 > SO_4 > Cl$ Na > K > Ca > Mg.

Geothermometer temperatures range from 134 to 177°C.

The National Geothermal Corporation applied for federal land in February of 1978.

W-10942	
County	Nye
Temp (C)	55.
Flow (GPM)	7.
pH	7.25
Cl	49.
F	13.
SO_4	80.
HCO_3	1172.4
CO_3	0
SiO_2	95.
Na	600.
K	35.
Ca	14.
Mg	2.
Li	1.8
Cu	0
B	1.9
MO	0
NH_3	.27
TDS	2064.4
$TSiO_2$	134.
TNa-K	128.
TNa-K-Ca	177.

Table 33. Analysis of 5498 Hot Spring.

ANTELOPE VALLEY

The Bartine Ranch Warm Spring is in Section 18 of Township 19 North, Range 50 East, about 40 kilometers northwest of Eureka (Plate 26).

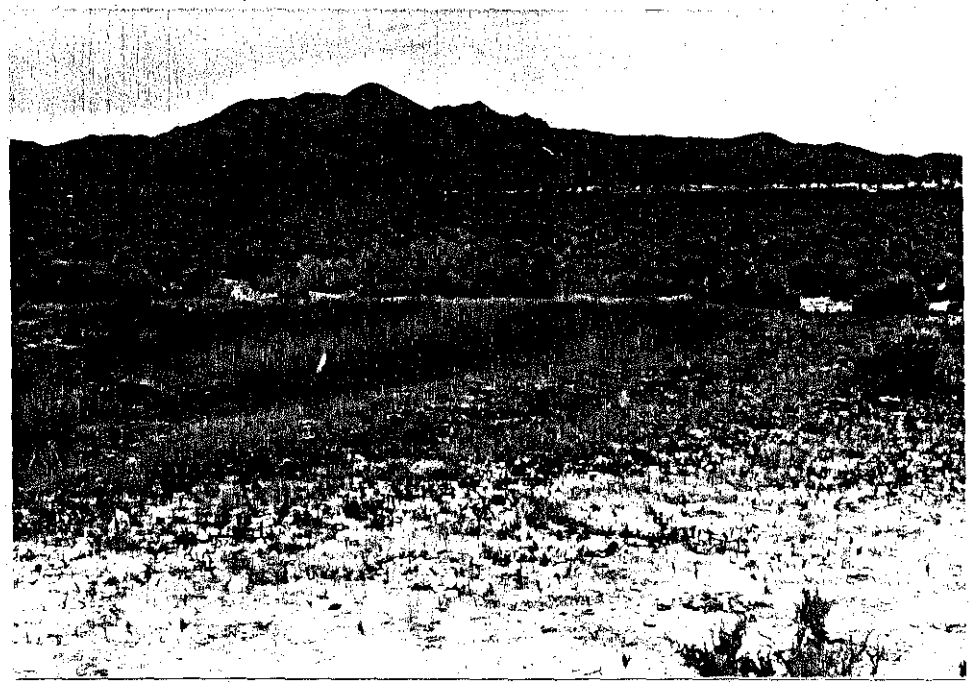

Plate 26. Bartine Ranch Warm Spring, 20°C.

The spring flows from unconsolidated deposits in the Antelope Valley (Figure 33). The nearest rocks at Lone Mountain are Ordovician carbonates of the Eastern Assemblage. No local structure is evident.

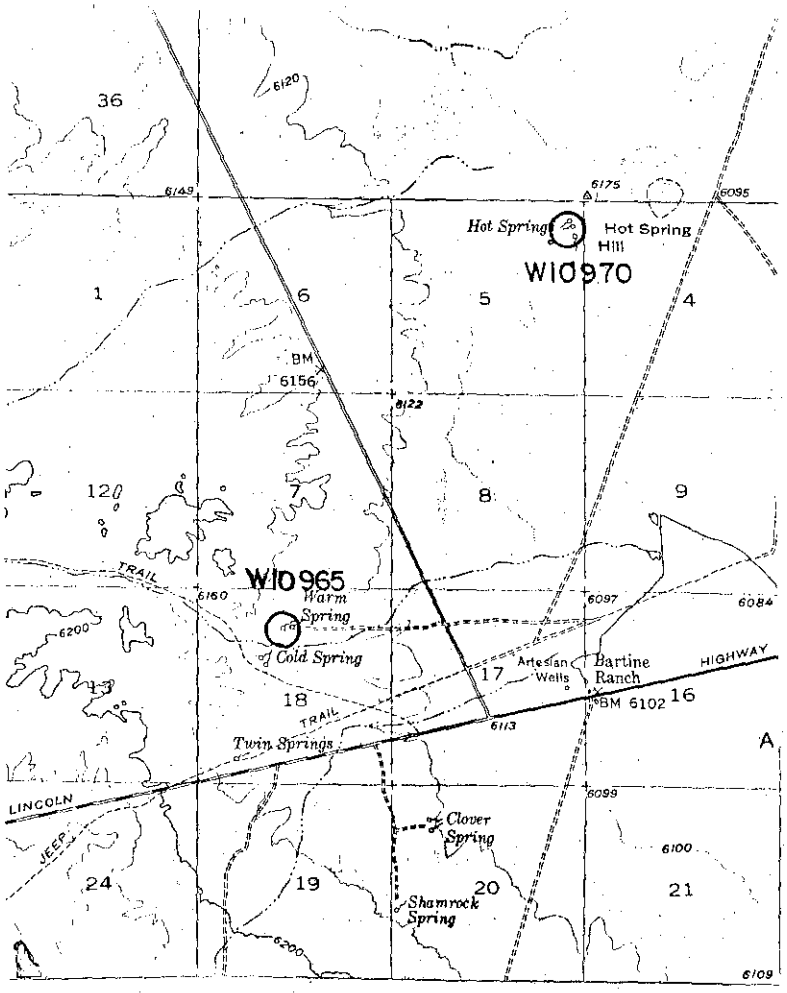

Figure 33. Location of Bartine Ranch Warm Spring.

The waters are very dilute (Table 34). Major ions are distributed thusly:

$HCO_3 > SO_4 > Cl$ $Na > K > Ca > Mg$.

Geothermometers are probably not reliable. Temperatures range from 118 to 195°C.

W-10965	
County	Eureka
Temp (C)	20.
Flow (GPM)	
pH	7.05
Cl	10.
F	2.
SO_4	29.
HCO_3	118.2
CO_3	0
SiO_2	69.
Na	62.
K	9.5
Ca	7.
Mg	1.
Li	0
Cu	0
B	0
MO	12.
NH_3	.35
TDS	320.
$TSiO_2$	118.
TNa-K	240.
TNa-K-Ca	195.

Table 34. Analysis of Bartine Ranch Warm Spring.

AREAS OF HIGH HEAT FLOW

RALSTON VALLEY

A 220 meter drill hole was probed at the northwest flank of the McKinney Mountains in Township 7 North, Range 45 East (Figure 34). The hole has a straight and consistent gradient of 54°C/kilometer and a

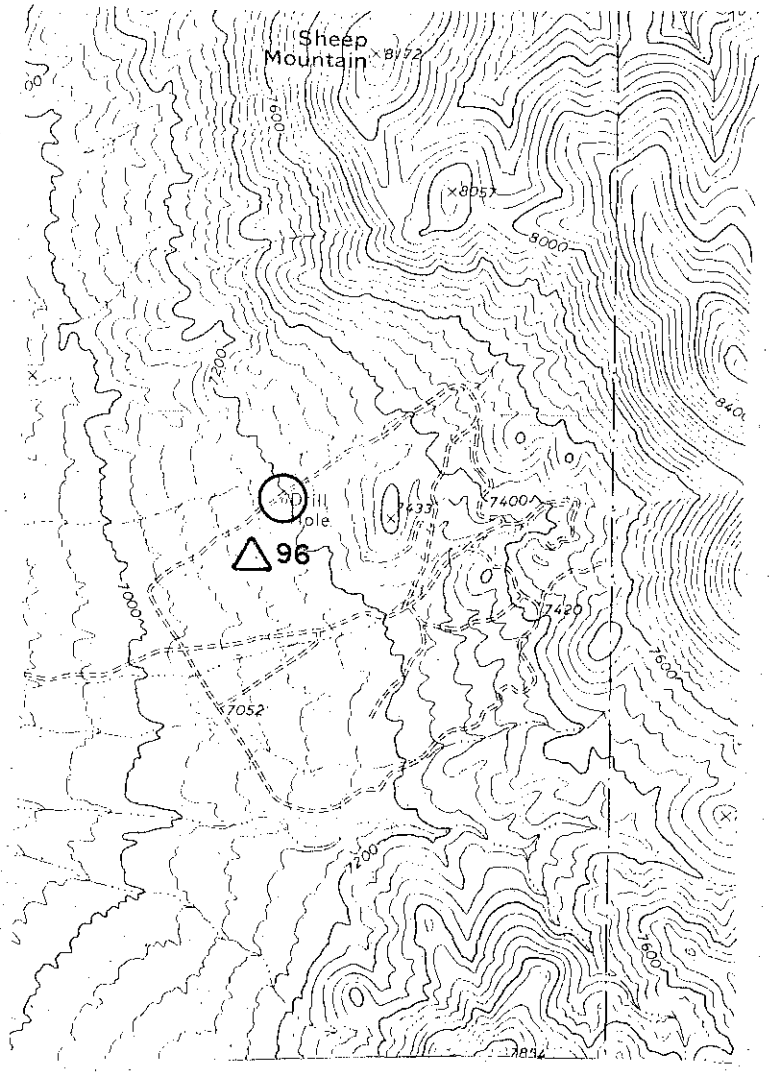

Figure 34. Location of Δ96.

heat flow of 3.24 with an assumed conductivity of 6.0. The hole was drilled in an Oligocene welded tuff. The local environment consists almost entirely of Oligocene acid extrusives and intrusives.

SHEEP CREEK RANGE

A 45 meter water well was probed at the northwest flank of the Sheep Creek Range in Section 36 of Township 36 North, Range 45 East (Figure 35). Water was encountered at approximately 20 meters. The

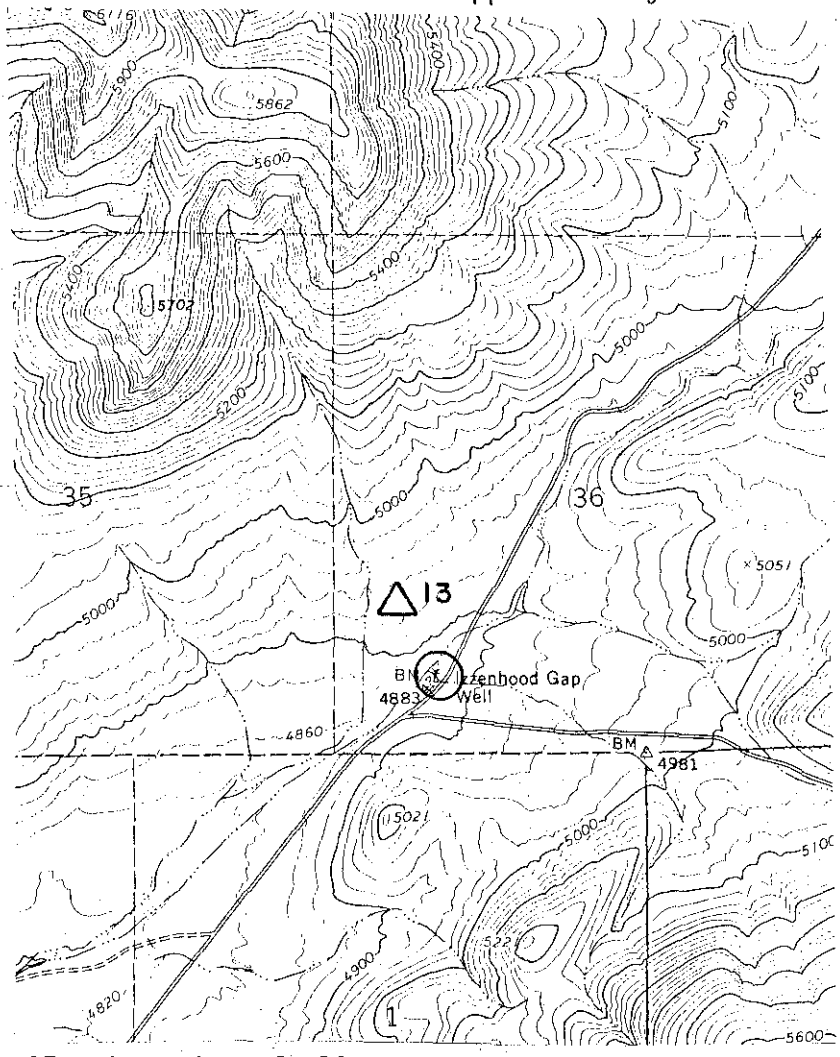

Figure 35. Location of Δ13.

well exhibits a straight and uniform gradient of 110°C/kilometer and a heat flow of 3.52 with an assumed conductivity of 3.2. The hole was probably bottomed in alluvium. The rocks surrounding the well consist of late Miocene rhyolite and basalt flows.

TUSCARORA MOUNTAINS

A 20 meter water well was probed on the west flank of the Tuscarora Mountains in Section 3 of Township 34 North, Range 51 East (Figure 36). The well has a straight and uniform gradient of 108°C/kilometer from

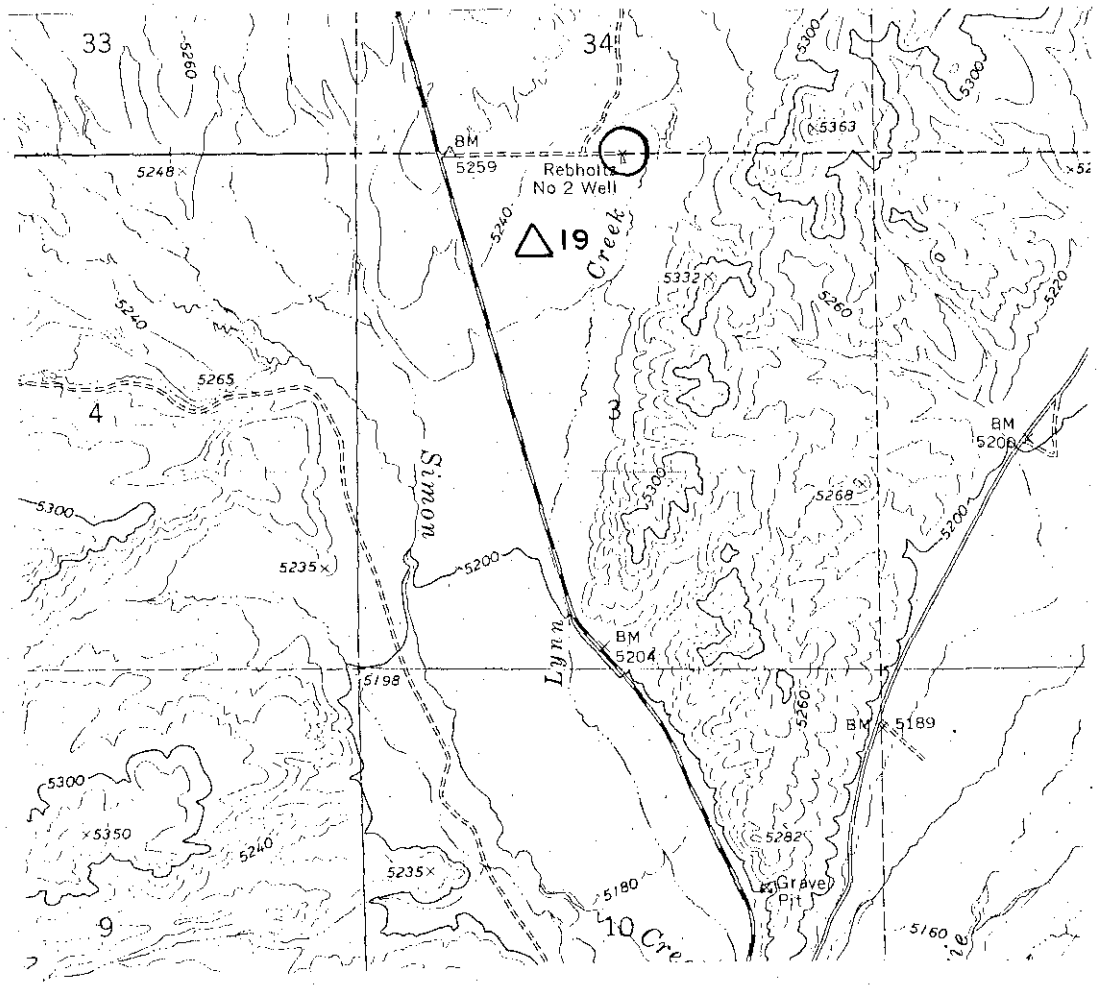

Figure 36. Location of Δ19.

8 to 20 meters. The heat flow is 3.24 with an assumed conductivity of 3.0. The hole was probably bottomed in alluvium. The surrounding rocks are Miocene tuffaceous sedimentary rocks.

EDWARDS CREEK VALLEY

A 50 meter water well was probed at the north flank of the Desatoya Mountains in Section 1 of Township 19 North, Range 38 East (Figure 37).

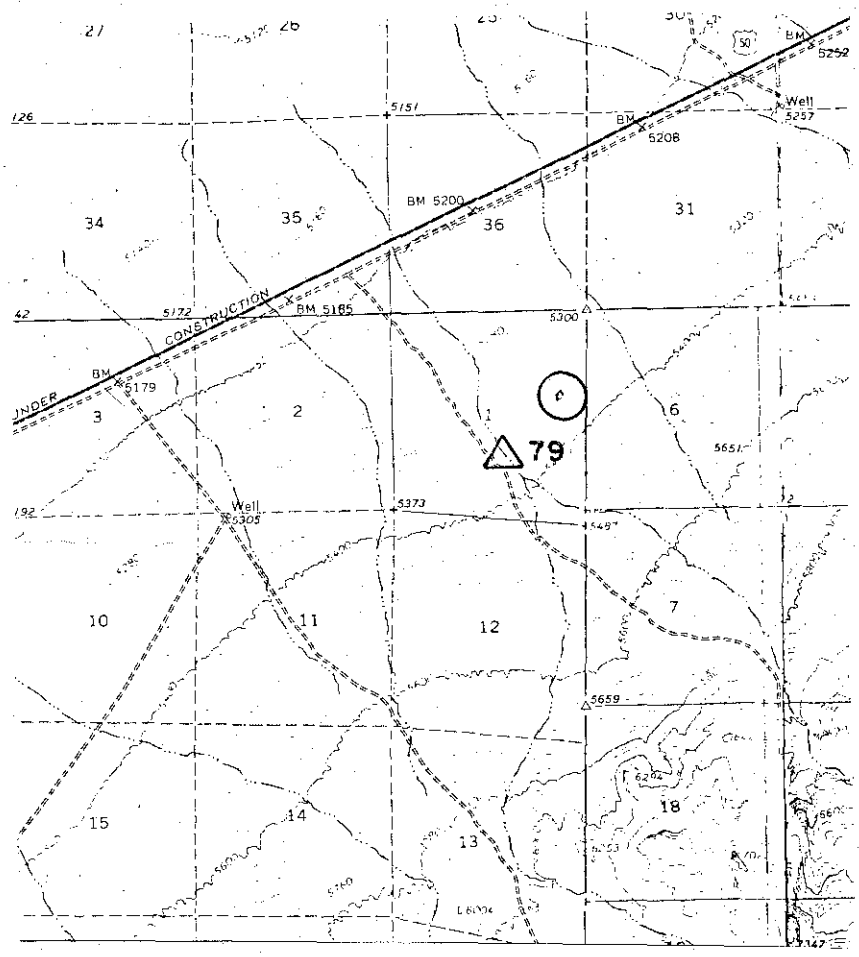

Figure 37. Location of Δ79.

The well exhibits a straight and regular gradient of 127°C/kilometer and a heat flow of 4.45 with an assumed conductivity of 3.5. The well was probably bottomed in unconsolidated pediment deposits. The northern Desatoya Mountains consist of late Oligocene welded and non-welded tuffs.

REFERENCES CITED

Goldstein, NE, H. Beyer, R. Corwin, D. E. di Somma, E. Majer, T. V. Mc Evilly, H. F. Morrison, H. A. Wollenburg and R. Grannel, 1976, open file report Geosciences Studies in the Buena Vista Valley, Nevada, Lawrence Berkeley Laboratory, U. of C., Berkeley, 41p.

Olmsted, F. H., P. A. Glancy, J. R. Harrill, F. E. Rush and A. S. Van Denburg, 1975, U.S.G.S. open file report, 75-56, 267p.

APPENDIX I

GEOGRAPHIC AREA	THERMAL FEATURE	FEDERAL LESSOR	DATE OF APPLICATION
		Northeastern Nevada	
Whirlwind Valley	Beowawe Hot Spring	Getty	1/74, 12/74
		Chevron	1/74, 12/74
		GRI	1/74, 12/74
		Supron	6/76, 5/77
		Diablo Exploration	1/74, 12/74
		Delta Funds	1/74
		American Thermal Res.	1/74
Battle Mountain	Stony Point Hot Spring	Chevron	2/76, 3/76, 9/76
		Supron	5/77
Crescent Valley	Dewey Dan	Chevron	1/74, 9/74, 11/75, 8/77
		Diablo Expl. (assigned from Chevron)	12/74
Reese River Valley	Mound Warm Springs	----------	----------
Grass Valley	Hot Springs Point Hot Spring	----------	----------
Elko	Elko Hot Hole	----------	----------
Mary's River	Mary's River Hot Spring	----------	----------
Ruby Valley	Sulfur Hot Springs	Union	4/74, 8/76, 9/76
		Thermex	4/74

GEOGRAPHIC AREA	THERMAL FEATURE	FEDERAL LESSOR	DATE OF APPLICATION
	Northeastern Nevada		
Bruneau River	Bruneau River Hot Spring	----------	----------
Wells	Unnamed Hot Spring	----------	----------
Rose Creek	Unnamed Hot Spring	----------	----------
	Northwestern Nevada		
Gerlach	Great Boiling Hot Spring	Supron Sunoco Kirk Greene Calvert Hunt	11/75 1/74, 1/76 6/76, 9/75 4/75 3/74
Gridley Lake	Gridley Lake Hot Spring	EPC, USGC, TRI	5/77, 7/77, 12/77
Black Rock Desert	Sulfur Warm Spring	Hunt Alta Energy	3/74 6/76
Winnemucca Lake	Manure Canyon Warm Spring	----------	----------
Snake Creek Desert	Bonham Ranch Warm Well	----------	----------

GEOGRAPHIC AREA	THERMAL FEATURE	FEDERAL LESSOR	DATE OF APPLICATION
	Northwestern Nevada		
Golconda	Golconda Hot Spring	----------	----------
Pumpernickel Valley	Hot Springs Ranch Hot Spring	Supron	11/75, 4/76
Leach Hot Spring	Leach Hot Spring	Aminoil Sidney Glenn G. M. Booth Wm. Bucklin	10/76, 9/77 9/75, 10/75, 2/76 2/76, 5/76, 10/76, 12/76, 1/78 12/76
Buffalo Valley Hot Spring	Buffalo Valley Hot Spring	Mobil Oil	1/74
Jersey Valley	Jersey Valley Hot Spring	Supron	11/75
Buena Vista Valley	Kyle Hot Springs	----------	----------
	Southwestern Nevada		
Reno	Steamboat Hot Springs	Gulf Hunt Wm. Hendrey Pacific Energy	1/74, 9/75, 10/75 5/75 5/77 1/74
Hazen	Hazen Hot Spring	Union Geo. Products Corp. Supron	6/76 1/74 3/77

GEOGRAPHIC AREA	THERMAL FEATURE	FEDERAL LESSOR	DATE OF APPLICATION
		Southwestern Nevada	
Desert Peak	Desert Peak	Supron	9/74, 6/76, 3/77, 5/78
	Warm Spring	Thermal Power	12/74
		W. O. Dorley	6/76
		GRI	9/74
		Phillips	1/74
Lovelock	Colado Hot Well	Getty	10/76, 12/76
Salt Wells	Borax Works	Walter Leftwich	9/77
	Hot Spring	Anadarko	1/74
		Union	3/76, 5/76
		W. P. Carver	9/77
		Occidental Geo.	1/74
		Hunt	3/74, 5/75
Teels Marsh	Company	----------	----------
	Warm Spring		
Columbus Salt Marsh	Columbus	----------	----------
	Warm Well		
Fish Lake Valley	Rhyolite Ridge	Magma Power	1/74, 7/74, 10/77, 11/77
	Hot Well	Ronald Stone	4/74

GEOGRAPHIC AREA	THERMAL FEATURE	FEDERAL LESSOR	DATE OF APPLICATION
	Southeastern Nevada		
Big Smoky Valley	Spencer Hot Spring	----------	----------
Big Smoky Valley	5498 Hot Spring	National Geo. Corp.	2/78
Antelope Valley	Bartine Ranch Warm Spring	----------	----------

APPENDIX II SUMMARY TABLE

Name	County	Surface Water T°C	Spring Deposits	Water Type	Subsurface T°C	Subsurface Temp. Credibility 1-10	Mineralization	Coincidence of Heatflow	Most Youthful Rocks Nearby	Land
Northeastern Nevada										
Beowawe H.S.	Eureka	88	SiO_2	$Na\text{-}HCO_3$	199-183	10	Hg	coincident	Tertiary Andesites	heavily leased
Stony Point H.S.	Lander	45	none	$Na\text{-}HCO_3$	130-188	5	none	?	Tertiary Andesites	leased
Dewey Dan H.S.	Eureka	82	SiO_2	$Na\text{-}HCO_3$	180-218	8	Hg, As	coincident	Jurassic Granite	leased
Mound W.S.	Lander	35	$CaCO_3$	$Na\text{-}HCO_3$	124-216	3	none (?)	?	Silurian Sediments	open
H.S. Point H.S.	Lander	57	none	$Na\text{-}HCO_3$	128-231	3	none	?	Silurian Sediments	open
Elko Hot Hole	Elko	55	$CaCO_3$	$Na\text{-}HCO_3$	115-229	3	none	?	Tertiary Sediments	open
Mary's River H.S.	Elko	38	none	$Na\text{-}HCO_3$	161-197	4	none	?	Silurian Sediments	open
Sulfur H.S.	Elko	97	SiO_2	$Na\text{-}HCO_3$	174-177	8	none	coincident	Ordovician Sediments	heavily leased
Bruneau River H.S.	Elko	27	none	$Na\text{-}HCO_3$	126-225	2	none	?	Tertiary Sediments	open
Unnamed Wells near...	Elko	49	$CaCO_3$	$Na\text{-}HCO_3$	143-174	2	none	?	Silurian Sediments	open
Northwestern Nevada										
Great Boiling H.S.	Pershing	92	$CaCO_3$	Na-Cl	179-192	6	none	coincident	Cretaceous Granites	heavily leased
Gridley Lake H.S.	Humboldt	40	none	$Na\text{-}HCO_3$	114-205	2	none	?	Miocene Welded Tuffs	leased
Sulfur W.S.	Washoe	25	none	$Na\text{-}HCO_3$	126-181	3	S	?	Tertiary Rhyolite	open
Manure Canyon W.S.	Washoe	25	none	$Na\text{-}HCO_3$	117-201	2	none	?	Tertiary Andesites	open
Bonham Ranch W.W.	Washoe	31	none	Na-Cl	132-174	4	none	?	Tertiary Basalts	open
Rose Creek W.S.	Humboldt	19	SiO_2(?)	$Na\text{-}HCO_3$	126-185	4	none	?	Jurassic Sediments	open
Golcanda H.S.	Humbodlt	77	none	$Na\text{-}HCO_3$	114-196	3	none	?	Pleistocene Sediments	open
H.S. Ranch H.S.	Humboldt	78	SiO_2	$Na\text{-}HCO_3$	157-187	6	Hg	?	Cretaceous Granite	open
Leach H.S.	Pershing	91	SiO_2	$Na\text{-}HCO_3$	168-191	6	none	coincident	Permian Sediments	leased
Buffalo Valley H.S.	Lander	54	$CaCO_3$	$Na\text{-}HCO_3$	137-185	2	none	coincident	Pleistocene Basalt	leased
Jersey Valley H.S.	Pershing	42.5	SiO_2	$Na\text{-}HCO_3$	152-181	4	none	?	Tertiary Welded Tuffs	leased
Kyle H.S.	Pershing	80	$CaCO_3$	Na-Cl	165-209	3	none	coincident	Tertiary Granites	leased
Southwestern Nevada										
Steamboat H.S.	Storey	91	SiO_2	Na-Cl	190-210	10	Pb, Ag, Hg	coincident	Pleistocene Rholites	heavily leased
Hazen H.S.	Lyon	92	none	Na-Cl	165-194	6	none	?	Pleistocene Sediments	leased
Desert Peak W.S.	Churchill	18	NaCl	Na-Cl	137-221	10	none	coincident	Tertiary Rholites	heavily leased
Colado H.W.	Pershing	54	none	Na-Cl	120-202	3	none	?	Miocene Rhyolites	leased
Borax Works H.S.	Churchill	54	none	Na-Cl	126-195	7	B	?	Pliocene Andesites	heavily leased
Company W.S.	Esmeralda	23	none	$Na\text{-}HCO_3$	121-204	3	none	?	Jurassic Granites	open
Columbus W.W.	Esmeralda	17	none	$Na\text{-}SO_4$	120-173	3	none	?	Miocene Rholites	open
Rhyolite Ridge H.W.	Esmeralda	38	none	Na-Cl	112-202	5	none	?	Miocene Rholites	leased
Southeastern Nevada										
Spencer H.S.	Lander	60	$CaCO_3$	$Na\text{-}HCO_3$	173-203	5	W	?	Ordovician Sediments	open
5498 H.S.	Nye	55	none	$Na\text{-}HCO_3$	134-177	4	none	?	Cretaceous Granites	leased
Bartine Ranch W.S.	Eureka	20	none	$Na\text{-}HCO_3$	118-195	2	none	?	Ordovician Sediments	open