AMAX EXPLORATION, INC.
4704 HARLAN STREET • DENVER, COLORADO 80212

INTER-OFFICE MEMORANDUM

SUBJECT: A Preliminary Hydrogeochemical Report on the Livermore and Bieber Areas of California

DATE March 11, 1974

TO: Files

cc: W. M. Dolan
R. F. Horsnail
A. L. Lange
H. J. Olson
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FROM: F. Dellechaie

On December 11, 1973, Bill Dolan, Art Lange, Harry Olson and myself collected six water samples (X89558 through X89563) at the Livermore property with the aid of Bob Livermore. In the following two days Lange and myself collected six samples from the Bieber, California, area and one from Anderson Springs, 11.5 miles NW of the Livermore property. This report discusses sample chemistry and describes sample sites.

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Sample Locations

Samples X89558 through X89563 were collected on the Livermore property in sections 6, 7 and 8 of T9N, R6W. Sample X89570 was collected at Anderson Spring, 11.5 miles N W of the Livermore property in section 26 of T11N, R7W.

Samples X89564 through X89567 were collected in the southern half of Big Valley, southeast of Bieber, California, in Sections 12, 14 and 28 of T38N, R8E. Sample X89568 was collected from Vestal Warm Spring, 10 miles SW of Bieber in Section 28 of T37N, R6E. Sample X89569 was collected at Little Hot Spring, 16 miles WNW of Bieber in Section 9 of T29N, R5E.

Chemistry

Livermore Area

The elemental concentrations of the Livermore Springs (X89558, X89559, X89560, X89562 and X89563) coincide with that of Van Ness Creek (X89561) with the exception of sodium, calcium and silica. All samples exhibit a basic pH(7.2-8.0) and concentrations of fluoride and chloride that approach the lower detection limits of same (0.10-0.20 ppm and 0.10 ppm, respectively). Sulfate concentrations are very low (3-5 ppm). Silica ranges from 3 to 7 times that of background silica, while sodium and calcium range from 2 to 12 and from 1 to 4 times their background levels, respectively. Lithium and the trace metals show no distinct tendencies.

Anderson Spring (X89570) is similar to the Livermore Springs except for higher concentrations of sulphate, calcium, magnesium, and lithium.

The low $Na/_{Mg}$ and $Na/_{Ca}$ ratios shown in Table 1 are characteristic of non thermal ground waters. The calculated subsurface equilibrium temperatures shown in Table 1 have dubious significance for the following reasons: first, the miniscule discharge of the Livermore Springs indicates a strong resistance to the passage of fluids from the thermal reservoir or the ground water conductive heating zone to the surface so that wall rock reaction, absorption and precipitation are guaranteed; second, the thermal and chemical character of the hot fluids is also altered by dilution.

Bieber Area

All hot springs in the Bieber area exhibit a basic pH(7.2-8.7), moderate concentrations of fluoride (1.7-2.9 ppm), chloride (42-52 ppm) and sulphate (700-860 ppm). These levels are generally characteristic of hot water systems. Sodium is present at expected concentrations (180-220 ppm) while potassium is present at almost background levels (7 ppm) indicating absorption in valley sediments during transit. Lithium concentrations range from 9 to 13 times that of background lithium but are still not significant enough to indicate a magmatic fluid contribution.

The very low concentrations of magnesium (0.1 to 0.6 ppm) qualitatively indicates high subsurface equilibrium temperatures. Equilibrium temperatures by the silica method range from 90° to 95°C and are probably quite conservative on account of dilution effects. The $Na/_K$ equilibrium temperatures are not considered reliable because of the very low potassium concentrations already mentioned. Na-K-Ca equilibrium temperatures range from 180°C to 260°C.

Discussion

The chemical composition of samples taken from the Livermore property do not reflect deep subsurface conditions but rather very shallow conditions. Livermore Warm Spring (X89558) contains the largest thermal-chemical component and is probably derived in part from a ground water conductive heating zone above the capping horizon. The remaining springs appear to be almost entirely meteoric in origin. Further sampling over a broader area utilizing the volatile substances generally found in geothermal steam (B, NH_3, H_2S, CO_2) and age dating of water will lend a better understanding of the Livermore prospect.

The Bieber area appears in the context of this preliminary study to be a potentially interesting source of hot water of reasonable quality. Further sampling including age dating should indicate the capacity and extent of the reservoir underlying Big Valley. Also, analysis of the volatile elements and gases from bubbling springs may indicate the existence of a steam reservoir at depth.

F. Dellechaie

FD/d

Sample Description

Livermore Area

X89558 - Livermore Warm Spring
- Water issues from bedding crack in gray sandy limestone.
- Said to flow year round; in winter, steam visible over adjacent pool.
- Very mild sulpherous odor, bitter taste, colorless
- Discharge about 2 $l/_m$
- Temperature 21°C - 12/11/73
  24°C - 2/15/74 by A. Lange

X89559 - Caldera Spring
- Water issues from crack in brown volcanic rock; many such cracks are present often filled with white to tan siliceous material.
- Odorless, tasteless and colorless
- Said to flow year round
- Discharge about 2 $l/_m$
- Temperature = 18°C, - 12-11-73

X89560 - Leaf Spring
- Water issues out of soil and fills small pool about 1 foot square; pool filled with soil, green algae, and leaves
- Odorless, tasteless and colorless
- Discharge about 4 $l/_m$
- Temperature = 18°C - 12/11/73

X89561 - Van Ness Creek
- Taken as control
- Sampled about 40 feet from Leaf Spring (X89560)

X89562 - Creek Bank Spring
- Issues from brown volcanic rock (appears similar to that mentioned for Caldera Spring (X89559)
- Odorless, colorless, tasteless
- Discharge is about 2 $l/_m$
- Temperature = 15°C - 12/11/73

X89563 - Livermore Drinking Spring
- Issues into bottom of 10 foot by 5 foot brickwork pool
- Used by Livermores for drinking water
- Odorless, colorless and tasteless
- Discharge is about 25 $l/_m$
- Temperature = 12.5°C - 12/11/73

X89570 - Anderson Spring
- Water issues from redish-brown travertine in small canyon, SE of Signal Oil Geothermal Field
- Sulpherous odor, bitter taste, light orange color.
- Pool (5'x5') lined with red gelatinous material.
- Some elementary sulphur
- Discharge is about 5 $l/_m$
- Temperature = 33°C - 12/13/73

Bieber Area

X89564 - Bassett Hot Spring
- Issues out of S.S. and fills warm pond about 50 feet by 25 feet.
- Much white and yellowish salt, some elemental sulphur
- Strong sulpherous odor
- Vigorous bubbling locally
- Water used for heating Packwoods home ($1.50 per month), watering cattle.
- Many Indian artifacts found in pool bottom
- Discharge about 750 $l/_m$
- Temperature = 81.5°C - 12/12/73
  78°C - 2/16/74

owned by Gerrald Packwood
Rt. 229
Bieber, California

X89565 - Kellog Hot Spring West
- Water issues in bottom of cement pool (6 foot diameter, 9 foot depth).
- Much salt present (white and yellow)
- Strong sulpherous odor
- Bubbling locally
- Adjacent to old spa
- Discharge about 750 $l/_m$
- Temperature = 77.5°C - 12/12/73
  88°C - 2/16/74

X89566 - Kellog Hot Spring East
- Water issues out of valley fill to supply two pools about 20 feet in diameter.
- Sulpherous odor
- Bubbling locally
- Discharge about 750 $l/_m$
- Temperature = 58°C - 12/12/73
  61°C - 2/16/74

X89567 - Richman Spring
- Taken as control
- Water issues out of iron pipe
- Used to water cattle
- Discharge about 2 $l/_m$

Temperature = 11°C - 12/12/73

X89568 - Vestal Warm Spring
- Issues into bottom of large pond bordered on southern side by cattle pens and on the east by Cenozoic Basalt Ridge.
- Salt on basalt near water line near point of inflow.
- Sample should show contamination and extreme dilution
- Discharge is unknown
- Temperature = 17°C - 12/12/73

owned by family of June Vestal, MacArthur, California

X89569 - Little Hot Spring
- Water issues out of pool (10 feet square) in meadow at base of basalt ridge.
- Strong sulpherous odor.
- Vigorous bubbling locally
- Seen steaming from road
- Discharge about 100 $l/_m$
- Temperature = 71°C - 12/12/73

TABLE 1

Chemical Analyses, Calculated Ratios and Subsurface Temperatures for Samples from the Livermore property, Anderson Spring, and the Bieber area

	LIVERMORE							BIEBER AREA					
Spring	Livermore Warm Spring X89558	Caldera Spring X89559	Leaf Spring X89560	Van Ness Creek Water (Control) X89561	Creek Bank Spring X89562	Livermore Drinking Spring X89563	Anderson Spring X89570	Bassett Hot Spring X89564	Kellog Hot Spring West X89565	Kellog Hot Spring East X89566	Richman Spring (Control) X89567	Vestal Warm Spring X89568	Little Hot Spring X89569
Temperature° C	21°C	18°C	16°C	8.5°C	15°C	12.5°C	33°C	81.5°C	88°C	61°C	11°C	17°C	71°C
pH	8.0	7.8	7.6	7.3	8.0	7.2	6.9	8.7	8.5	8.4	8.0	7.2	7.7
F (ppm)	0.20	0.13	0.10	< 0.10	< 0.10	< 0.10	0.17	2.1	2.8	2.9	0.10	0.13	1.7
Cl (ppm)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	42	52	52	< 10	< 10	43
SO_4 (ppm)	3	3	3	5	5	5	200	750	860	810	3	3	700
$CaCO_3$ (ppm)	260	250	200	50	280	70	280	90	80	90	430	220	100
Na (ppm)	35	18	15	3	27	6	19	175	190	220	15	14	180
K (ppm)	3	3	3	2	5	3	5	4	7	7	5	4	7
SiO_2 (ppm)	34	34	74	11	34	24	22	30	40	43	36	34	40
Ca (ppm)	4.4	11.8	9.4	2.8	9.8	3.0	42.0	22.4	22.2	23.4	22.9	8.0	35.2
Mg (ppm)	0.5	2.1	3.0	1.3	1.5	1.3	6.0	0.2	< 0.1	< 0.1	9.8	6.3	0.6
Li (ppm)	0.1	0.1	0.1	< 0.1	0.1	<0.1	1.2	0.8	0.9	1.0	< 0.1	<0.1	1.3
Zn (ppm)	0.1	0.2	0.2	< 0.1	<0.1	< 0.1	< 0.1	0.1	0.1	0.1	0.1	<0.1	<0.1
Mo (ppb)	< 1	< 1	<1	1	1	< 1	<1	35	40	60	<1	1	35
Cu (ppb)	< 1	1	4	2	<1	3	<1	< 1	< 1	2	<1	<1	< 1
Fe (ppb)	<100	<100	200	<100	400	<100	400	<100	<100	<100	<100	<100	200
Mn (ppb)	< 10	<10	<10	<10	<10	<10	90	<10	< 10	<10	<10	<10	< 10
$TSiO_2$ °C	70°C	70°C	112°C		70°C	-	-	-	90°C	95°C		70°C	90°C
Na/K (atomic)	19.8	10.2	8.5		9.2	3.4	6.5	74.4	46.1	53.4		6.0	43.7
TNa/K °C	168°C	243°C	290°C		275°C	-	325°C	-	104°C	94°C		-	106°C
Na-K-Ca	1.17	1.04	0.97		0.92	0.62	0.92	0.99	0.80	0.88		0.81	1.42
TNa-K-Ca °C	220°C	230°C	240°C		245°C	290°C	245°C	237°C	260°C	248°C		258°C	180°C
Cl/F (atomic)	< 26	< 41	< 53		-	-	< 31	11	9.9	9.6		< 41	13
Na/Mg (atomic)	74	9.1	5.3		19.1	4.9	3.4	927	> 2014	>2332		2.4	318
Na/Ca (atomic)	14	2.7	2.8		4.8	3.5	0.8	14	15	16		3.0	8.8

Sample No	T °C	Location	Ph	Cl^- in ppm	F^-
1	21°	LIVERMOORE	8.6	2.7	0.22
2	18°	"	7.4	2.3	0.14
3	16°	"	6.1	2.5	0.11
4	8.5°	"	6.6	2.5	> 0.10
5	15°	"	7.8	1.8	0.12
6	12.5°	"	6.0	2.0	> 0.10
7	81.5°	BIEBER AREA	9.2	105	2.0
8	77.5°	"	9.1	125	2.6
9	58°	"	8.9	120	3.1
10	11°	"	7.7	2.0	0.1
11	17°	"	7.8	2.2	0.14
12	71°	LITTLE HOT SPR.	8.2	118	1.9
13	33°	ANDERSON Hot Spr.	8.0	1.7	0.2

LIVERMOORE

1) T = 21°C
discharge ≈ 2 l/m
issues out of Lms w/ chert xtals on surface
Fm underlain by shale horizon
sulphurous odor
a few bubbles
Bitter taste to Charles.

2) T = 18°C
discharge ≈ 1-2 l/m
issues out of coarse grained Brown volcanic rock, and by many dikes of lighter more felsic rx.

3) T = 16°C
discharge ≈ 4 l/m
small pond ≈ 1 ft sq on side, filled w/ green algae and leaves.
odorless - colorless, tasteless

4) T = 8.6°C
Stream ≈ 40' from sample #3

5) T = 15°C
discharge ≈ 2 l/m
issues from fine coarse grained volcanic rock surrounded by soil
about 20' above stream bed
odorless - colorless - tasteless

6) T = 12.5°C
discharge < 25 l/m
pool ≈ 10' X 5' surrounded by brickwork
used by owners as drinking water
odorless - tasteless - colorless
good to drink

BIEBER Area

7) Bassett Hot Spr. 2.5 mi ENE of BIEBER
T = 81.5°C
discharge ≈ 200 gal/min
issues out of S.S., much white and yellow salts, some elemental S., some sinter
Strong sulphurous odor
Vigorous bubbling
pool = 50' X 25'
water used for bathing house, drinking

water used for heating house, irrigation and drinking
rising steam may be seen from road

Call - Gerrald Packwood
RT 299
BIEBER, Calif.

8) Kellogg Hot Springs (6.0 mi E of BIEBER on Susanville Rd)
T = 77.5°C (probably higher than this)
discharge = 200 gal/min.
cement pool - used as cattle feed.
some leaching visible
several other pools visible
much salt (unknown type) present
vigorous bubbing from hole.

9) Kellogg East (6.6 mi E of BIEBER on Susanville Rd)
T = 68°C
discharge ≈ 200 gal/m
2 large pools about 20' diam.
out of S.S.
sulphurous odor
some bubbling
located behind abandoned house

10) Richman Spring (.75 mi SE of #9)
T = 11°C
discharge = 2 l/m.
out of iron pipe at base of hill.
used for cattle.
Taken as control

11) Hot Spring owned by (½ 6mi SW of BIEBER)
Jane Vestal
Mac Arthur, Calif.

a) T = 17°C
B) dis. = unknown
c) issues into large pond surrounded on one side by cattle pens at base of ext. basalt ridge

d) Inflow @ bottom of pond, not visible
e) Salt deposits @ base of some rocks ~~on~~ at inflow location.

Send Jane copy of analysis

12) LITTLE Hot Spring in LITTLE Hot Spring Valley (20 mi NW of BIEBER)

a) T = 71°C
B) dis = 100 l/m

c) issues out of bubbling pool in meadow at base of basalt ridge.
d) sulphurous smell
e) ground is saturated w/ water and bubbling sound is heard

f) Seen steaming from road

J. Dellenbaugh

13) Anderson Hot Spring
T = 33°C
dis ± 5 l/m
issues out of travertine in narrow
canyon just below Signal Oil
geothermal project
much elemental S and Ferric oxides
sulpherous odor
water has a red tint