SEVENTH QUARTERLY REPORT

FOR THE PERIOD

1 DECEMBER 1980 - 28 FEBRUARY 1981

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LOW-TO-MODERATE TEMPERATURE GEOTHERMAL RESOURCE ASSESSMENT FOR NEVADA - AREA SPECIFIC STUDIES

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INTRODUCTION

December 1980 marks the beginning of the seventh quarter of a continuing program of area-specific geothermal resource assessment being conducted in Nevada by the DOE state-coupled team. This year's study includes two areas that will receive extensive investigation, Golconda and Hawthorne, and a third area of lesser emphasis, Fallon. The location of these areas is described in the previous quarterly report. Regional definition of the nature of the resource, its extent, and controls on that extent are the primary objectives of our research. The program is organized around the completion of nine tasks that pertain to area-specific resource evaluation and a tenth mission related to a continuing program of statewide assessment of resource parameters. Each of the work units is briefly described below.

1. Gather and examine existing information including: geological, geophysical, and hydrological literature, chemical data, lithologic and well completion logs, and appropriate aerial imagery.
2. Acquire relatively detailed information on the subsurface configuration through the use of gravity surveys employing station spacings of approximately 1/2 mile.
3. Collect and analyze soil samples for mercury content on regional (approximately 1 mile spacing) and smaller grids.
4. Obtain low sun-angle photography at a scale of 1:24,000 for use in studying surface structural and geomorphologic manifestations.
5. Conduct shallow depth temperature probe surveys to determine the near surface thermal regime on both regional (1 mile grid) and smaller, more localized grids.
6. Sample thermal and non-thermal groundwaters, and if possible, meteoric waters, and analyze for bulk chemical and stable light isotopic composition.

7. Collect and examine bulk rock samples for mineralogic composition. If appropriate, analyze selected samples for whole rock chemical composition. Compare rock mineralogic and chemical composition with the chemical composition and mineral equilibria of sampled fluids.
8. Based on the data obtained from 1-7 above, select sites for the drilling of three to five 100-250 meter temperature gradient holes. Determine lithology, temperature profile, and fluid chemical composition where possible.
9. Prepare a report detailing the results of the study.
10. Collect and analyze fluid samples, measure physical and chemical parameters, and prepare U.S. Geological Survey GEOTHERM forms for springs and wells lacking these data on a statewide basis.

During mid-September, 1980, the present contract was modified (Modification No. A006) to reflect the need for baseline data acquisition and preliminary reconnaissance for the MX-Missile geothermal energy system. The modified Statement of Work includes three (3) additional tasks as follows:

1. Conduct literature search and collect and compile geologic, hydrologic, geochemical, and geophysical data pertaining to the MX deployment area in Nevada.
2. Perform interpretations of existing 1:60,000-scale air photography from the same areas as in 1., above.
3. Include the results of 1. and 2., above, in the December, 1980 Quarterly Technical Report.

Continuing work performed under Modification No. A006 will be reported in a separate document to be submitted April 15, 1980.

GOLCONDA STUDY AREA

Golconda is located in north-central Nevada near the city of Winnemucca. The area of interest, Paradise Valley, is over 1800 km^2 and is bounded on the south by the Humboldt River, on the west and north by the Santa Rosa Range, and on the east by the Hot Springs Range and the Osgood Mountains. The elevation of the valley floor ranges from 4300 to 4400 feet above sea level, and peaks in the surrounding ranges rise to 8500 feet above sea level. A complete description of the geology of the area can be found in the previous report (Trexler and others, 1980).

Activities in the Golconda study area during the seventh quarter yielded preliminary results for the gravity survey in Paradise Valley, additional fluid chemistry data including both bulk chemical and stable light isotope analyses, and an analysis of linear features identified on low sun-angle photographs. These analyses were used in the selection of three drill sites for temperature-gradient studies. In addition, a tentative analysis of some of the program shortcomings was undertaken, including an analysis of the questionable results obtained from the two meter depth temperature probe survey and the soil-mercury survey.

Gravity Survey

Field work was completed for the gravity survey which began in September, 1980. The gravity survey covered approximately 1700 km^2 (650 $mi.^2$) and included 300 stations. A preliminary simple Bouguer gravity contour map was submitted in mid-February, 1981.

The preliminary results indicate that the depth to basement is approximately 2000 m. Furthermore, the greatest accumulation of alluvial material is not located in the center of the valley, but is shifted slightly east of center. Although steep gravity gradients occur throughout the valley, thermal fluids occur near or at the intersection of two or more linear trends in the gravity contours.

A gravity high in the vicinity of the Golconda thermal fluids appears to be the signature of the major structural control for those hot springs. The structure is probably a small fault-bounded tilted block of Osgood Mountain quartzite, the oldest rock described in this area.

The artesian hot well located in the south-central part of Paradise Valley is situated on what appears to be the fault-bounded subsurface extension of the Hot Springs Range. Thick clay-rich lake sediments were observed in all of the 2 m depth temperature probe holes in this area. Here, lacustrine deposits may form an aquaclude for the rising thermal fluids, directing them away from their intended point of discharge, and downslope to their present location.

Thermal fluids at the north end of the study area are also associated with a significant gravity high. Geologic data in this area suggest that the gravity high is the expression of a portion of the Hot Springs Range that continues in the subsurface to the northeast.

Preliminary data are presently being redrafted and will appear in the final report as a gravity contour map (scale 1:125,000), a depth to basement map (scale L:125,000), and in tabular form.

Chemical Analyses of Fluids

Three water samples were collected in addition to 15 fluids sampled and chemically analyzed in the previous quarter. These samples were analyzed for major, minor, and trace-element constituents as well as for stable isotopes of hydrogen and oxygen. These fluids were all sampled from non-thermal springs in an attempt to identify possible sources of recharge for the thermal fluids. Preliminary results from enthalpy-chloride plots do not offer any unique answers to the mixing problem. Additional mixing-models are still being formulated to aid with this investigation.

These new data were integrated with earlier data and with data obtained from 32 water samples cited in literature sources. The results are presented in Figure 1. This diagram illustrates the wide range of chemical compositions for non-thermal fluids. In contrast, thermal fluids plot in two discrete fields. The large compositional variation for non-thermal fluids is due in part to the effects of the local geology as well as losses and gains of chemical constituents by evaporation, precipitation and agricultural processes. Thermal fluids from this study area appear to be relatively unaffected by such surface processes, and may instead reflect the conditions of equilibrium within a single reservoir rock.

To support this claim, data for four thermal springs in the study area were plotted over a time span of 35 years, from 1945 through 1980 (figure 2). Not all of the springs have data sets that extend over the entire period of record. However, complete data sets indicate that within average analytical error, chemical compositions of thermal fluids have not changed measurably.

It is possible to calculate the amount of solid material removed from the flow path of circulating thermal fluids by combining these data with flow rate measurements. In the case of the Hot Springs at the north end of the study area, it is roughly estimated that a volume of material equivalent to one cubic kilometer is removed every decade.

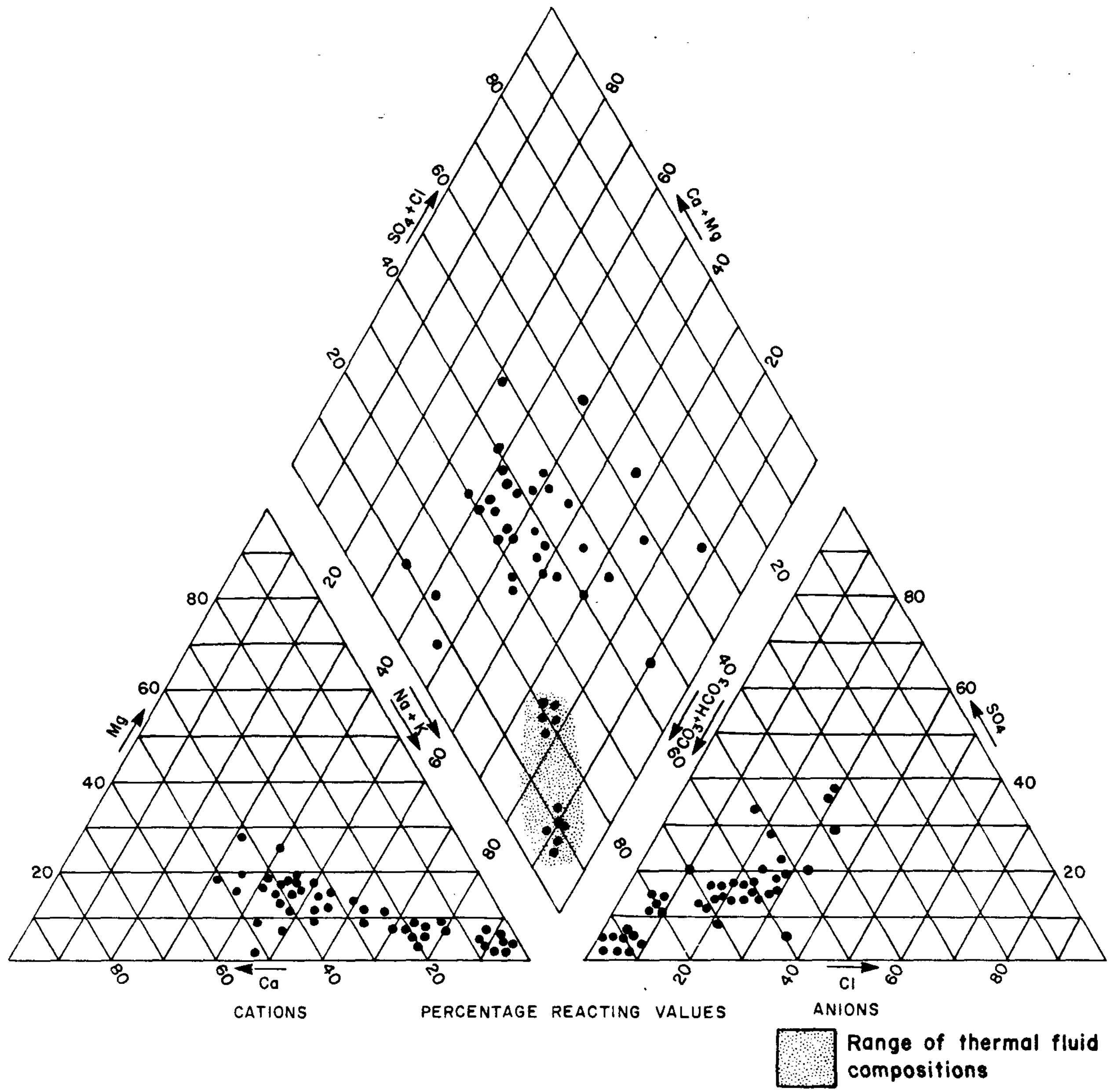

Figure 1. Chemical characteristics of thermal and non-thermal fluids in the Paradise Valley study area.

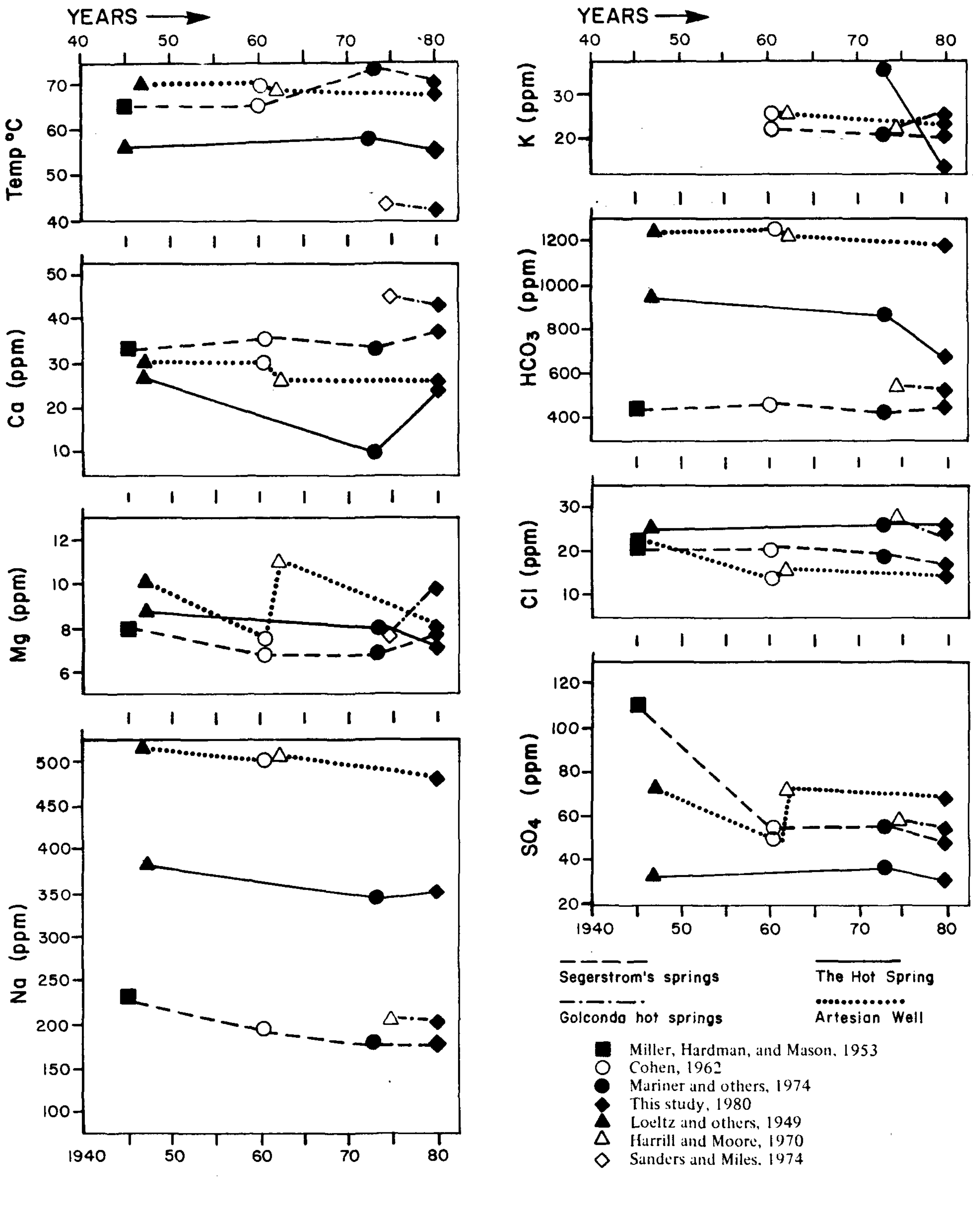

Figure 2. Chemical composition of selected thermal fluids in the Golconda study area, 1945-1980.

Low Sun-Angle Photography

In October, 1980 an aerial photo survey was conducted in selected areas of Paradise Valley. Several linear features were identified through the use of the stereoscope and diffraction-grating lineament-enhancement techniques. Many of the features found on the photographs were not fault-related such as primitive roads and old pipeline routes and hand-dug irrigation trenches. Linear features determined to be related to faults are illustrated in Figure 3. Lineaments plotted as solid lines represent actual faults; those plotted as dashed lines may be faults, old shorelines, steeply eroded stream banks, or a combination of two or three of these features.

In Figure 3 the westernmost lineaments appear to be directly related to the Hot Springs Range and may represent the range-bounding faults resulting from Basin and Range-style deformation. Lineaments mapped in the Hot Springs Range are probably older, and appear to be related to the mineralized zones that were targets for the area's gold, silver, mercury, and tungsten mining activity.

No widespread evidence of faulting was observed in large portions of the study area and in particular, in the vicinity of any hot springs. Several factors may be responsible for this including recent erosion and deposition by the Humboldt River system, the presence of sand dunes over the southern one-third portion of the study area, and the widespread agricultural activity throughout the area.

Hydrologic Test Holes

The selection of three sites to drill test holes to a depth of 122 m (400 ft.) was based upon three primary factors: the location of intersecting fault zones indicated by the gravity survey, the location of faults that were either mapped or identified on air photos or other imagery, and the accessibility

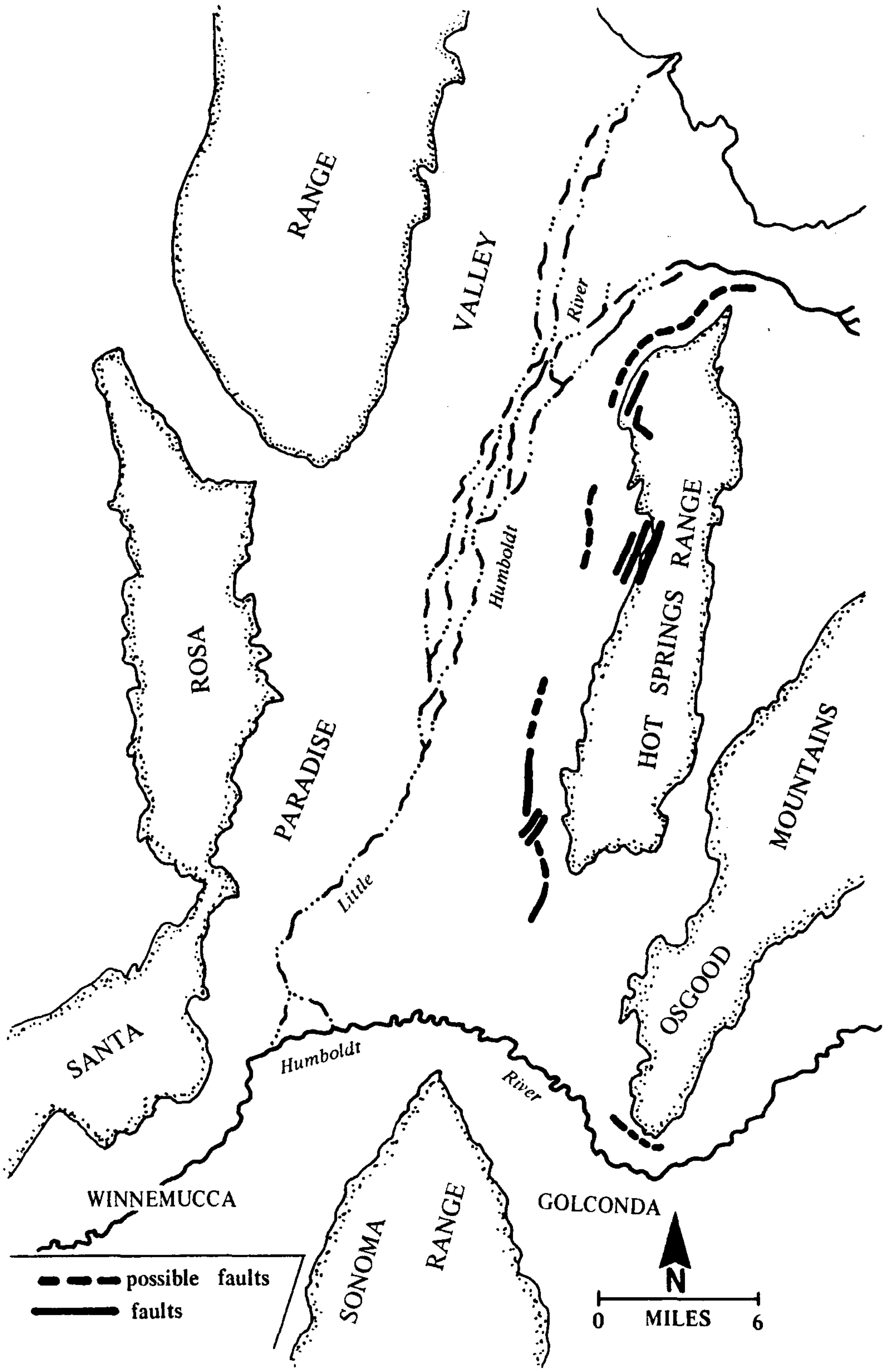

Figure 3. Linear and curvilinear features interpreted from low sun-angle photography in the Paradise Valley study area.

of the proposed site for drilling test holes. Figure 4 shows the location of the three sites selected.

In addition, these sites were selected because they represent areas where little drill-hole information exists. Many sites throughout the study area were rejected because, although they appeared to be promising from a geophysical standpoint, chemical analyses obtained from deep nearby water wells showed no indication of thermal fluids.

Drilling has been tentatively scheduled for late March, 1981. The completed six-inch diameter drill holes will be cased with two-inch diameter PVC pipe. Temperature gradient profiles will be attempted immediately after drilling and at various intervals thereafter.

Soil-Mercury Survey

Four additional soil-mercury surveys were conducted during the sixth and seventh quarters of the investigation. The results from these surveys became available during the seventh quarter.

Data from this recent study indicate two important problems. First, it is reasonable to assume that mercury mines in the vicinity of the study site created large mercury anomalies in the survey samples, thereby masking true soil-mercury values. Secondly, there exists no simple quantitative method to determine a background value of mercury in the soils under study. Therefore, estimates of anomalous mercury values are largely subjective.

A simple statistical analysis confirmed that the soil-mercury survey is inadequate for this particular study area. Soil samples collected in the field were described as either sand, silt or clay. Most of the 116 soil samples contained less than 250 ppb mercury. Three or four samples contained 1000 ppb mercury or more and were eliminated from the computations. An average value

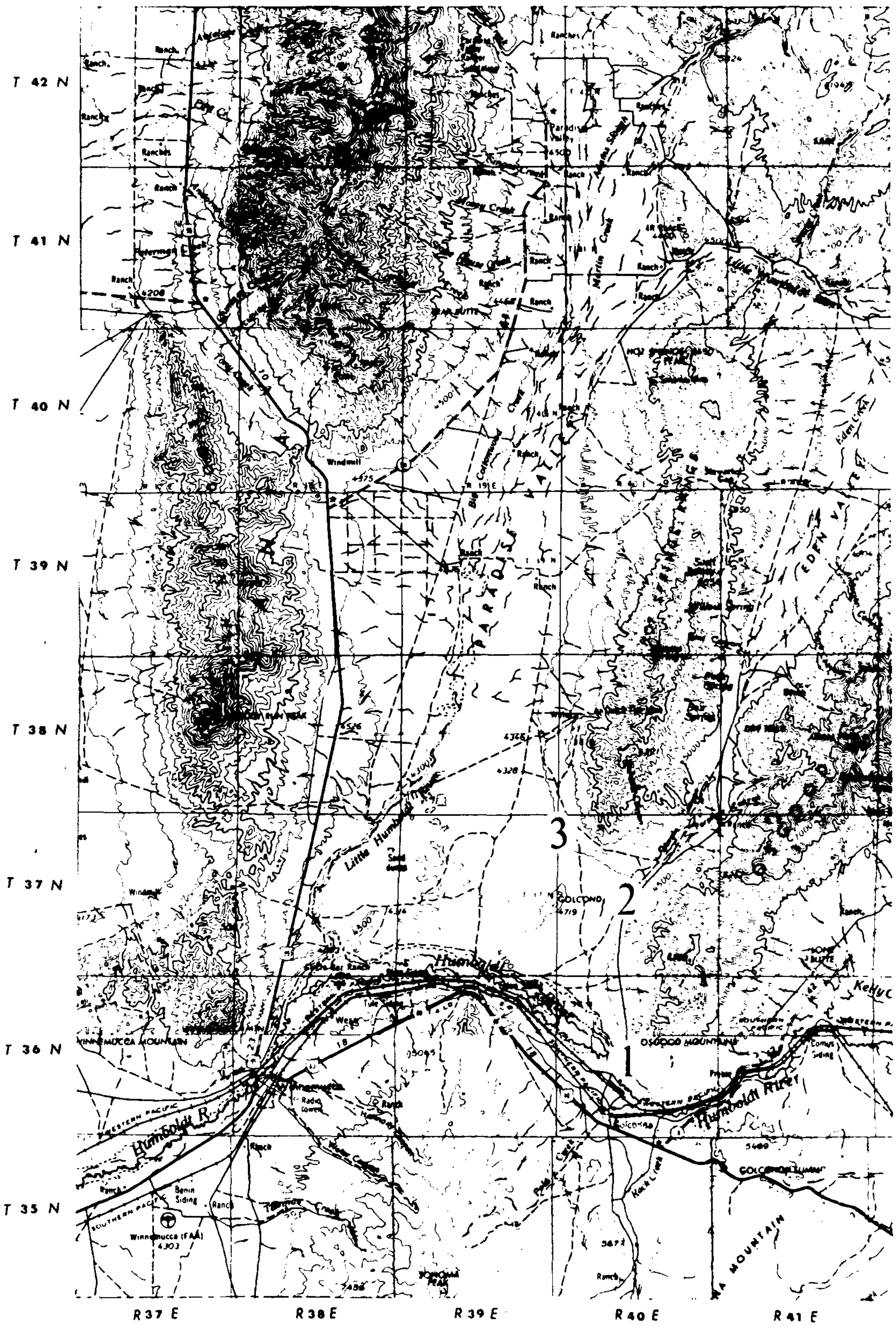

Figure 4. Location of drill sites for temperature gradient studies, Paradise Valley study area.

for soil type (sand, silt, clay) was computed. Although its been shown in the past that mercury vapors have a preference for absorption on clays, our results indicated no analytically measurable difference in the amount of mercury found in any of the soil types.

Two Meter Temperature Probe Survey

The data from 50 two-meter depth temperature probe holes is still being evaluated. However, two facts have already emerged regarding the temperature distribution in Paradise Valley: the areal extent of thermal anomalies is extremely limited and cannot be identified at distances greater than .5 km from thermal fluid sources, temperature measurements are greatly affected by shallow groundwater, and dry soils will probably have higher measured temperatures than wet soils. The data for Paradise Valley show that temperatures decrease near surface waters (the Humboldt River, for instance) and increase near outcrops of bedrock. No linear patterns of isotherms could be identified near any of the hot springs.

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HAWTHORNE STUDY AREA

The Hawthorne study area is located in west-central Nevada approximately 40 miles from the California border. It encompasses an area of approximately 120 square miles and includes a large portion of the land belonging to the U.S. Army Ammunition Plant as well as the communities of Hawthorne and Babbitt.

During the seventh quarter, data was reduced and examined to determine resource controls and characteristics. Results from shallow temperature probe surveys suggest that thermal waters do not travel in the near surface (200 m) along well-defined fault zones. Bulk chemical data demonstrate marked similarities in thermal waters which are spatially widely distributed. Chemical data also showed the differences between these fluids and various cold meteoric waters and groundwaters in the area. The probable meteoric origin of recharge to the thermal system is indicated by hydrogen and oxygen stable light isotopic ratios in the waters sampled.

Subcontracted gravity data supplied during the seventh quarter was not sufficiently reliable to be used for locating test hole drill sites. Consequently, a revised gravity survey is being conducted.

Temperature Probe Survey

Data from previous field excursions were examined to determine the nature of two meter depth temperature variations over a large portion of the study area. Reliable isotherm configurations could not be developed using the available data. The observed patterns do not conform to linear arrangements which are usually associated with the upward flow of thermal fluids along fault zones. Instead, the data suggest broad zones with a limited temperature range ($3^{\circ}C$ - at a depth of two meters) and localized, irregularly-shaped highs (figure 5). Measured temperatures can vary abruptly over small distances and because of

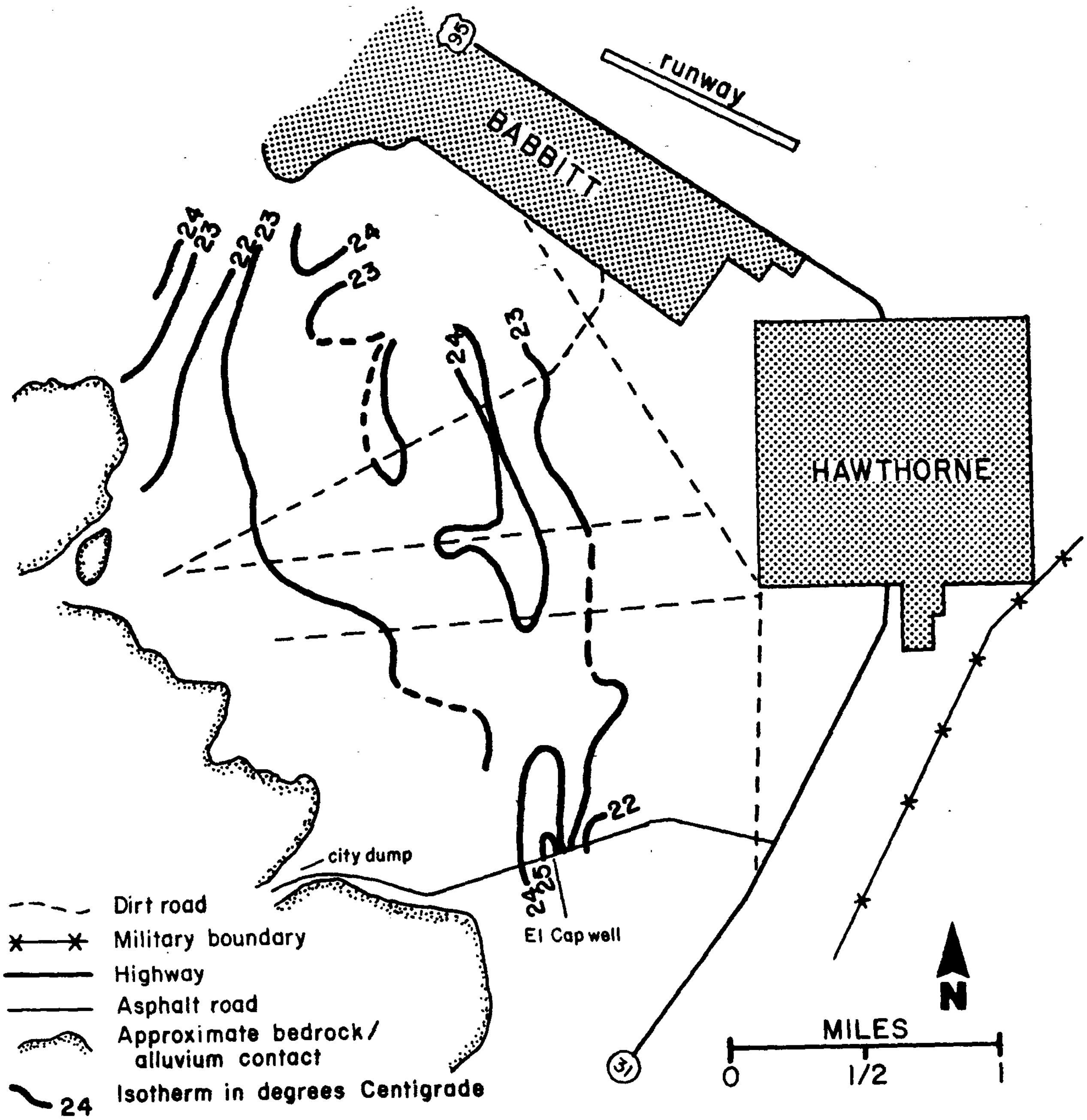


Figure 5. Possible isotherm configuration at a depth of 2 meters. See text for detail.

this, the proper placement of isotherms is problematical even with probe spacings as small as 300 m (1000 ft.). This may partially account for the irregular shape and localization of areas with elevated temperatures.

It is tentatively hypothesized that the isotherm patterns are created by a widespread, relatively uniform layer of thermal fluid which lacks well-defined avenues to the surface. Several lines of evidence support this conceptual picture. No surface manifestations of geothermal activity are known in the Walker Lake Basin. The location or linear arrangement of surface geothermal occurrences would confirm the role of faults or linear structures in controlling the near surface (100 - 200 m) distribution of thermal waters. Temperature profiles for two wells with surface temperatures of $42^{o}C$ and $41^{o}C$ were essentially isothermal from water surface to hole bottom, a distance of approximately 60 meters (200 ft.). The wells are also separated by a distance of 10 kilometers (6 mi.) and have very similar chemistries. Finally, a soil-mercury study in the area did not yield any definite trends.

Chemical Analyses of Fluids

Fifteen water samples were collected and analyzed for bulk chemistry, and oxygen and hydrogen-stable light isotopic composition to help explain the nature of thermal fluids and flow and/or recharge paths. Results of the analyses for major and minor dissolved constituents are presented in Table 1. Data reported for samples taken during the present study are designated using the letters "HAW" followed by a one or two digit number. Data extracted from literature sources are indicated by other appropriate alphanumeric combinations.

Two problems are associated with the analyses results for the HAW series. Silica concentrations reported by the analysts of the HAW series are consistently lower than those reported in the literature, although both samples were taken from the same fluid source. For example, two measurements of silica made on

Table 1. FLUID CHEMISTRY IN THE HAWTHORNE STUDY AREA

SAMPLE DESIGNATION	TEMP. C°	pH	Ca	Mg	Na	K	Li	Sr	Al	Cl	SO_4	CO_3	HCO_3	NO_3	F	B	SiO_2 THIS STUDY	SiO_2 OTHER STUDY	CATION/ ANIONS (EQUIV.)
HAW-1 (HAAP#1)	42/51	7.4	66.9	4.33	185	8	0.17	1.03	<0.3	68.9	384	0	43.9	0.24	1.96	1.12	18.8	31.8‡	1.12
HAW-2 (HAAP#5)	41	7.4	42.9	0.41	276	10	0.60	1.11	<0.3	89.2	491	0	51.2	0.10	7.48	2.27	32.3	50HAAP	1.10
HAW-3 (HAAP#6)	/24	7.3	87.0	17.9	165	7	0.04	0.555	<0.3	85.8	369	0	85.4	0.41	1.61	1.59	13.9	23.8‡	1.17
HAW-4 (HAAP#3)	40.8/	8.1	42.3	4.74	242	16	0.22	0.426	<0.3	105	350	0	117	<0.05	5.15	2.79	38.1	54‡	1.11
HAW-5 (HAAP#4)	/23	7.5	128	26.3	95	6	0.03	0.610	<0.3	95.5	325	0	100	0.96	0.747	1.40	16.3	30‡	1.15
HAW-6 (El Cap)	97/	7.4	40.4	0.08	260	11	0.50	1.46	<0.3	85.2	436	0	95.2	<0.05	7.28	2.19	40.8	76DRI	1.02
HAW-7 (Alum Creek)	6.5/	3.2	186	91.3	26	3	0.06	0.553	109	6.8	1390	0	0	1.34	1.89	0.112	39.0		1.02
HAW-8 (Cottonwood Cr.) 4800'	9.7/	7.4	40.2	8.06	18	2	<0.01	0.208	<0.3	6.0	34.1	0	109.8	<0.05	0.315	0.049	14.2		1.29
HAW-9 (Cottonwood Cr.) 7500'	6.9/	7.5	35.1	6.85	12	1	<0.01	0.126	<0.3	3.63	12.0	0	100	<0.05	0.097	0.036	10.9		1.42
HAW-10 (Cottonwood Cr.) 9000'	3.1/	7.3	28.6	6.81	9	2	<0.01	0.140	<0.3	3.06	4.51	0	102.5	1.15	0.085	0.027	15.4	39HAAP	1.20
HAW-12 (Coreyville)	5.7/	7.1	24.9	4.13	13	3	<0.01	0.170	<0.3	5.88	10.2	0	90.3	<0.05	0.092	0.041	12.4		1.19

Table 1. Fluid Chemistry in the Hawthorne Study Area (Cont.)

SAMPLE DESIGNATION	TEMP. C°	pH	Ca	Mg	Na	K	Li	Sr	Al	Cl	SO_4	CO_3	HCO_3	NO_3	F	B	SiO_2 THIS STUDY	SiO_2 OTHER STUDY	CATION/ ANIONS (EQUIV.)
HAW-13 (Cottonwood Spr.)	14.7/	7.9	160	27.8	69	6	0.02	0.957	<0.3	45.8	177	0	390.4	<0.05	0.710	0.131	18.5		1.17
HAW-14 (HUD 5)	35.0/	7.4	99.4	13.4	82	6	0.02	0.987	<0.3	21.4	272	0	136.6	1.59	0.179	0.103	14.9	25‡	1.14
HAW-15 (Corey Canyon Well)	11.1/	7.5	87.4	14.1	28	4	0.02	0.669	<0.3	16.0	96.9	0	180.6	1.54	0.163	0.067	9.5		1.03
HAW-16 (Walker Warm Spr.)	34.5/	7.2	27.9	0.66	212	3	0.40	1.23	<0.3	4.44	68.2	0	43.9	0.18	7.89	1.83	21.3		1.29
BLM * (Whiskey Flat Windmill)	/43	--	6.0	0.9	116		--		--	64	109	9	47	0.1	4.8	--		37	--
6/31 b2 * (Whiskey Flat Irrigation)	/11	8.1	30	13	44		--		--	38	93	0	90	--	--	--		--	--
NAD2 ‡	/27.5	7.5	82	9.7	187.5	11.9	--	--	--	85.6	405	0	134	--	1.09	--		58.4	--
NAD7 ‡	/21	8.6	18.2	0.25	135	135	--	--	--	60.4	204	0	61	--	3.35	--		136	--
NAD8 ‡	/26.5	7.4	74	8.4	137.5	7.4	--	--	--	52.9	193	0	259	--	2.85	--		43.9	--

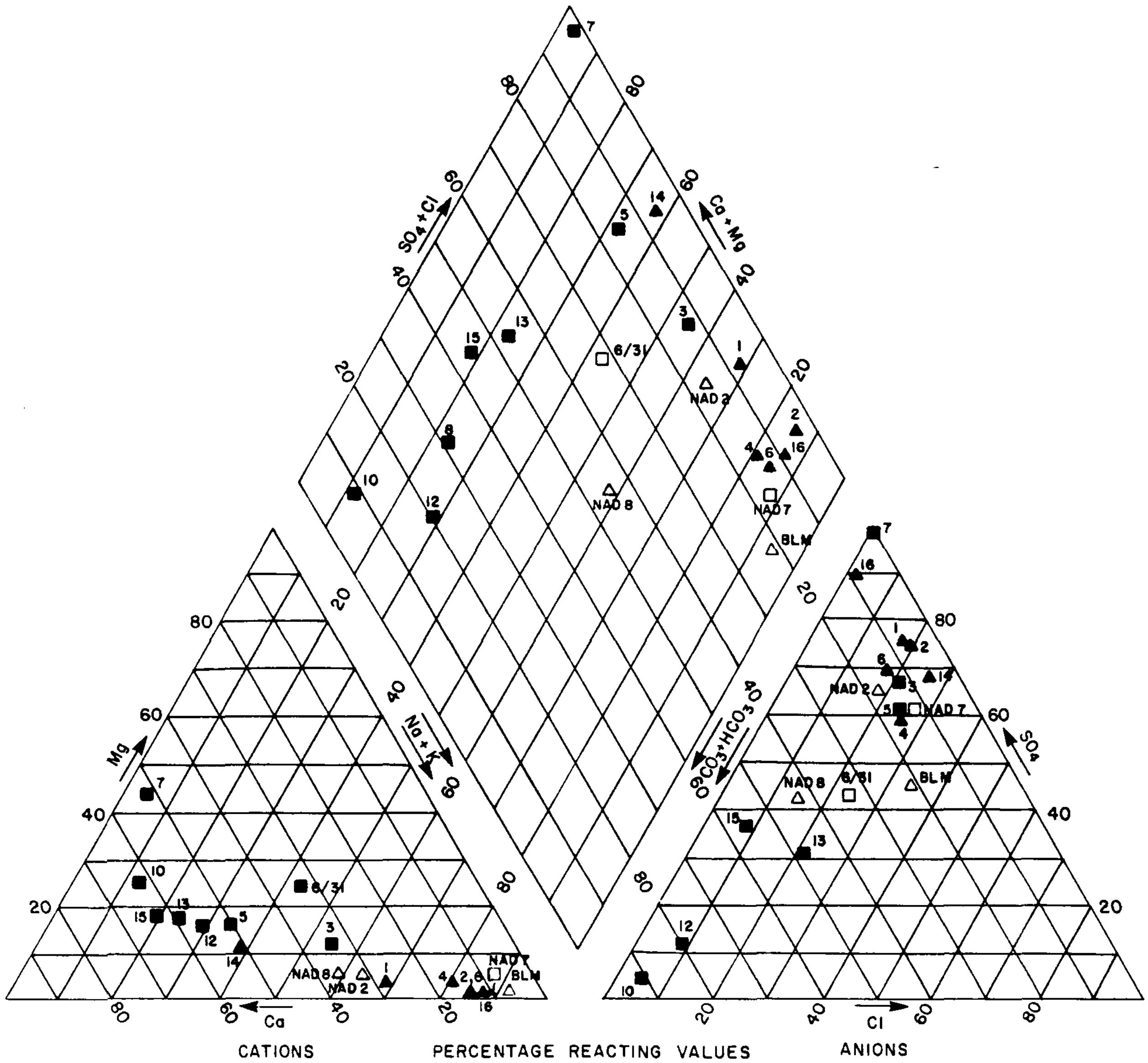
* = Data from Everett, D.E. and Rush, F.E. (1967)
‡ = Data from Bohm, B.W. and Jacobson, R.L.(1977)
HAAP = Data from Hawthorne Army Ammunition Plant records.
DRI = Data from files of Desert Research Institute, Univeristy of Nevada System, Reno.

fluid extracted from the same location, HAW-6, in May and August of 1980 revealed values of 78 and 74 ppm, respectively. Our sample taken in October, 1980 contained only 40.8 ppm according to the results reported to us. The problem again becomes apparent when comparing reported values in the two SiO_2 columns in Table 1. Lengthy discussions with the analysts together with reanalysis of several samples failed to produce any satisfactory explanation of this problem. Due to this unusual situation, all silica concentrations from our study should be considered suspect.

In addition to low silica values, several analyses from the HAW sample series exhibit relatively poor ionic balances. Ordinarily this would imply that an important species was omitted from the analysis suite. However, the analysis suite was comprehensive. The completeness of the analytical suite and the composition of probable source rocks for dissolved constituents argue strongly against omission error. Reanalysis of several samples produced similar values. Literature data describing the same fluid sources indicate lower calcium and higher bicarbonate values than our analyses. Such differences bias the ionic balances toward the cation side, which is also the nature of the imbalance seen in our data.

Gross chemical characteristics of fluids in the study area are shown in the form of a trilinear plot in Figure 6 where the cutoff for designation as a thermal fluid has been arbitrarily set at $25^{\circ}C$. Although a considerable diversity exists, thermal fluids tend to be richer in Na+K and SO_4+Cl than non-thermal waters. Numbers 7, 8, 10 and 12 are surface samples collected from flowing streams while the remainder of the fluids are groundwaters taken from springs or wells.

Modified Stiff diagrams provide a method of depicting the spatial variations of bulk chemistry. This format is used in Figure 7 to present data from



1- HAAP well no. 1
2- HAAP well no. 5
3- HAAP well no. 6
4- HAAP well no. 3
5- HAAP well no. 4
6- El Cap. well
7- Alum Creek
8- Cottonwood Cr. 4800'
10- Cottonwood Cr. 9000'
12- Coreyville
13- Corey Canyon - Cottonwood Springs
14- HUD well no. 5
15- Corey Canyon well (HUD no. 4 ?)
16- Walker Warm Springs
BLM Whiskey Flat Well
6/31b irrigation well Whiskey Flat
NAD 7
NAD 8
NAD 2

■ **COLD** (Less than 25 degrees Centigrade)

▲ **HOT** (Greater than 25 degrees Centigrade)

Figure **6**. Chemical characteristics of thermal and non-thermal fluids in the Hawthorne study area. Numbers refer to those in Table **1**.

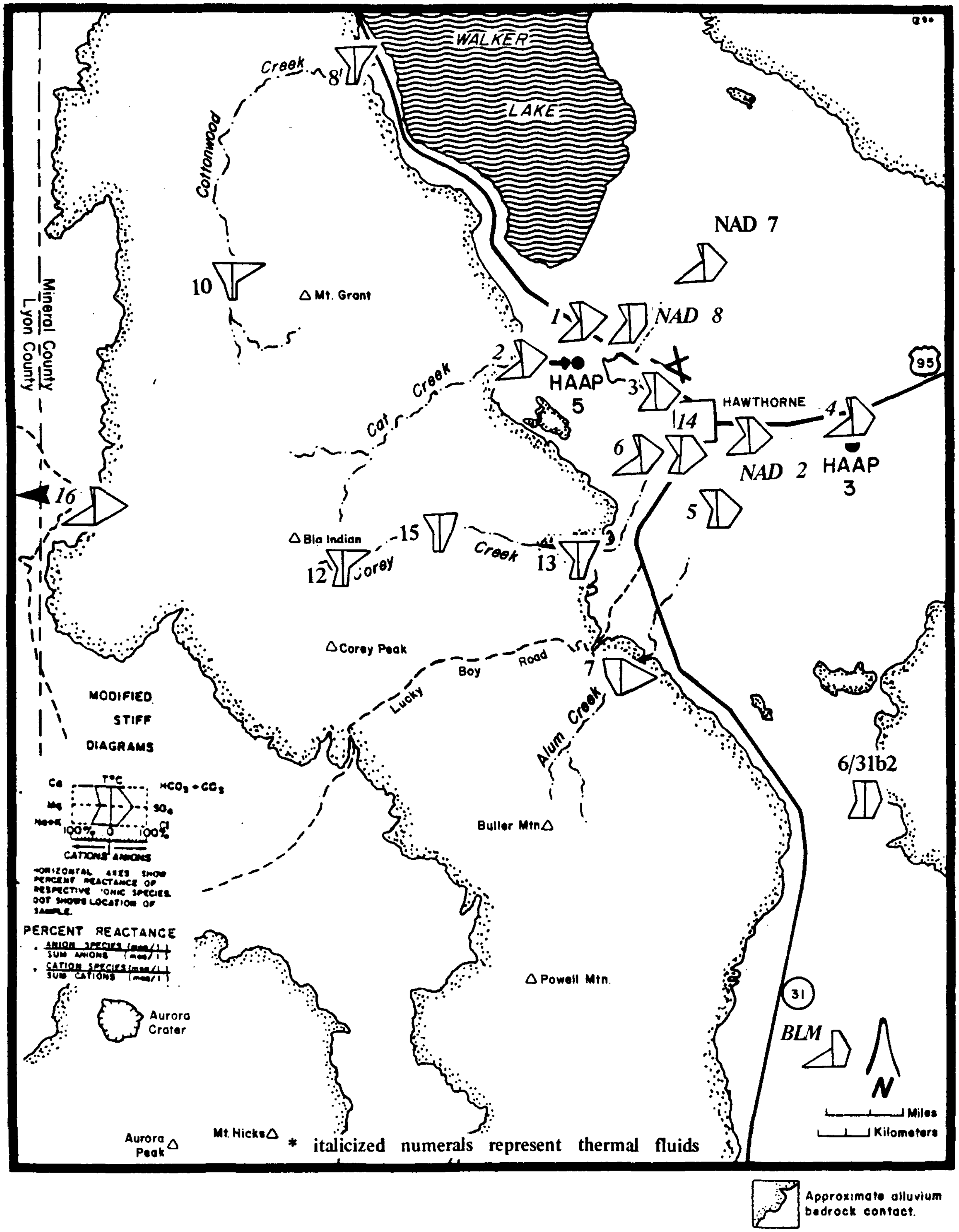


Figure 7. Chemical variations in fluids sampled throughout the Hawthorne study area. Numbers refer to those in Table 1.

the study area and its surroundings. Figure 7 indicates that waters tend to fall into distinct groups. For example, numbers 2, 4, 6, 16 and NAD7 are remarkably similar although spatially widely distributed. Similarly, samples 1, 3 and NAD2 and samples 5 and 14 form additional assemblages. All of these waters are notably different from cold surface waters and groundwaters such as numbers, 8, 10, 12, 13 and 15. In contrast to the chemical parities of the fluids discussed above, waters like 6/31b2, 7 and NAD8 stand apart from each other and bear little or no resemblance to other study area waters. The significance of these similarities and disparities is not clear at this time.

Data on the hydrogen and oxygen stable light isotopic compositions of fifteen area fluids became available during the seventh quarter. These data are listed in Table 2 and plotted in Figure 8. The point labeled "3" in Figure 8 exhibits a relatively large oxygen shift compared to the meteoric water line and compared to other samples from the study. This shift is not the result of water-rock interaction. It was caused when the sealed sample bottle cracked before analysis and exposed the fluid to atmospheric oxygen. Since the deuterium value should not be affected by this process, it may be used for discussion purposes. Error limits provided to us by the analysts are $\pm$ $3^{o}/oo$ for deuterium and $\pm$ $0.2^{o}/oo$ for oxygen. These limits are depicted to scale in Figure 8 as a cross in the lower left hand corner of the plot.

In general, the location of points in Figure 8 shows a relatively small variation among many of the waters, and the deviation shrinks even further when analytical error limits are considered. Samples 11 and 16 are analyses of duplicates collected during a single visit. The same is the case with numbers 12 and 17. Waters 7, 8, 9 and 10 are taken from surface streams with 8, 9 and 10 representing different elevations along the same water

Table 2. RESULTS OF FLUID ISOTOPIC ANALYSIS, HAWTHORNE AREA

SAMPLE DESIGNATION	$\delta^{18}O$ °/oo	δD °/oo
HAW-1	-15.2	-126.
-2	-15.3	-127.
-3	-13.6	-124.
-4	-15.6	-123.
-5	-15.3	-132.
-6	-15.4	-130.
-7	-14.8	-116./-117.*
-8	-15.2	-119.
-9	-15.3/-15.5*	-115.
-10	-16.1	-124.
-11	-16.2	-127.
-12	-15.7	-119.
-13	-15.1	-123.
-14	-15.2	-122.
-15	-15.2	-124.
-16	-16.2	-133./-131.*
-17	-15.8	-124.

* Values separated by slashes represent duplicate analyses of a single sample.

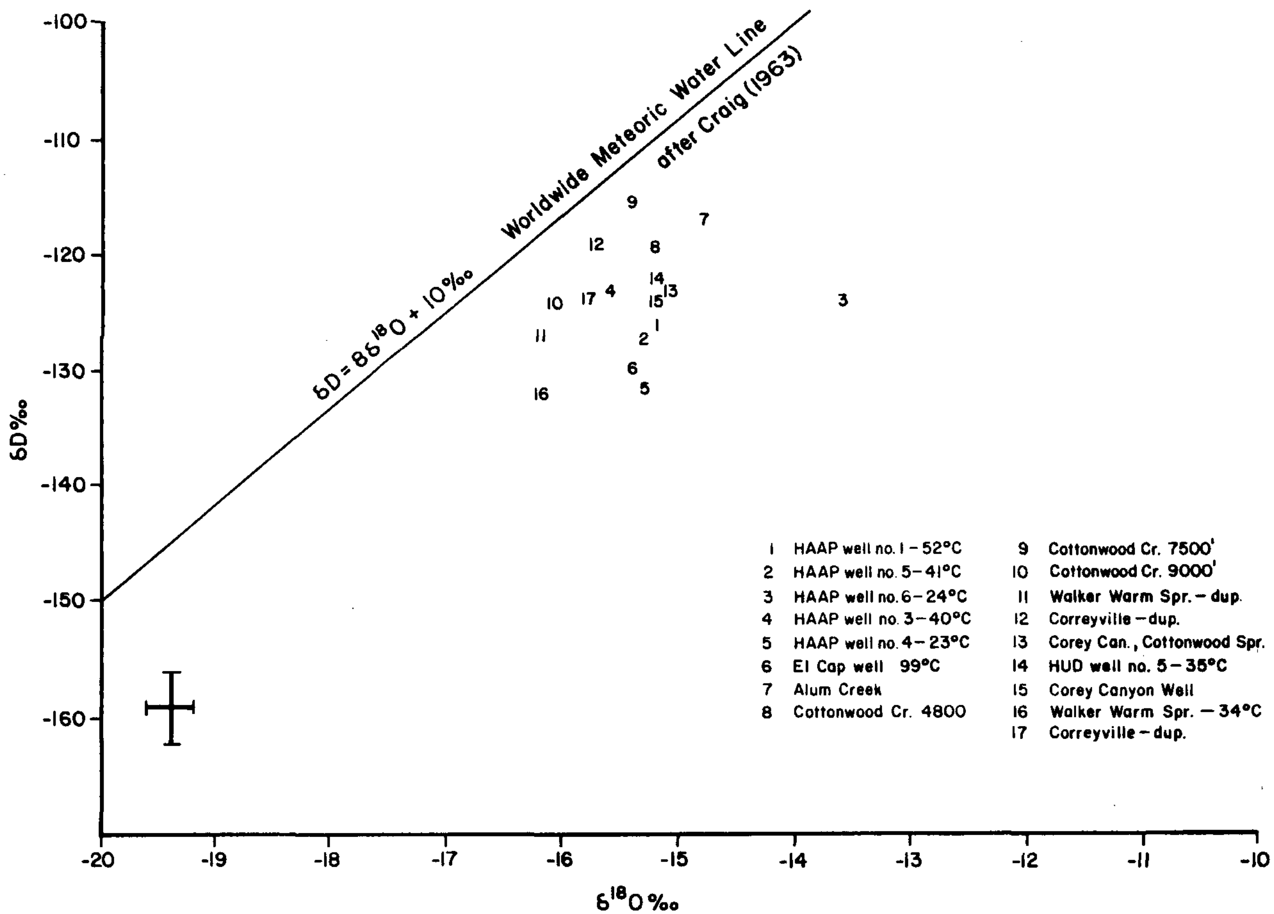


Figure 8. Stable light isotopic composition of Hawthorne area waters - reference SMOW

body. Number 10 was collected at the highest elevation (9000 ft.) and, as expected, exhibits the isotopically lightest signature. However, samples 8 and 9 are indistinguishable within analytical error limits even though they differ by approximately 2700 feet in collection point elevation. This situation may reflect the nature of infeed waters at different elevations along the main creek. No large shifts in oxygen values of thermal waters are noted. Shifts to heaver isotopic compositions would be expected if the fluids were exposed to high temperature (>200^{o}C) unless the system has a very large water-rock ratio or rapid throughput.

Gravity Survey

Reliable gravity data are not yet available for the Hawthorne study area. A survey was conducted and the data reduced to a simple Bouguer map. However, the data reduction program indicated several unreliable measurements had been taken. Contours on the map prepared from the data reflect geologically unreasonable conditions, thus substantiating errors detected by the reduction program. The subcontractor performing the survey is in the process of correcting the problems at this time.

Hydrologic Test Holes

A total of 1200 feet of drilling is scheduled in the study area. This footage will be proportioned between a minimum of two holes with more holes drilled if the resource is encountered at shallow depths. Two general areas have been selected for drilling although specific site selection has been deferred until the gravity data becomes available. A late March to early April starting time is currently projected. Negotiations have been completed and permission granted to conduct the test hole drilling program on Hawthorne Army Ammunition Plant property.

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SOUTHERN CARSON SINK STUDY AREA

The southern Carson Sink is bordered by several mountain ranges including the Stillwater and Lahontan Mountains to the east, the Bunejug Mountains to the southeast, the Desert Mountains to the south and the Dead Camel Mountains to the west.

The seventh quarter brought about the completion of the soil-mercury survey. An interpretation of aerial photography was also performed using Landsat imagery. Tasks continuing into the eighth quarter include a geochemistry study of thermal and non-thermal fluids, interpretation and integration of gravity data, and a review of NURE (National Uranium Resource Evaluation) aeromagnetic data.

Aerial Image Interpretation

The aerial image interpretation has been an ongoing task during the previous three quarters. Various image types have been studied and interpreted, including EDIS color Landsat at 1:250,000 scale, black and white low sun-angle aerial photography at 1:40,000 scale, and black and white AMS aerial photography at 1:60,000. Aerial photography was flown in stereo coverage with approximately 60% forelap and 20% sidelap coverage. Both regional and local trends were analyzed for relationships with known geothermal areas and young volcanics.

Regional interpretations were limited primarily to Landsat images although a few regional trends were found in black and white aerial photography. Figure 9 shows major regional lineaments interpreted from Landsat imagery.

These four major trends are related to regional tectonics of the area. The northwest trending lineaments are related to the Walker Lane structure which controls some major Tertiary structural development in the area

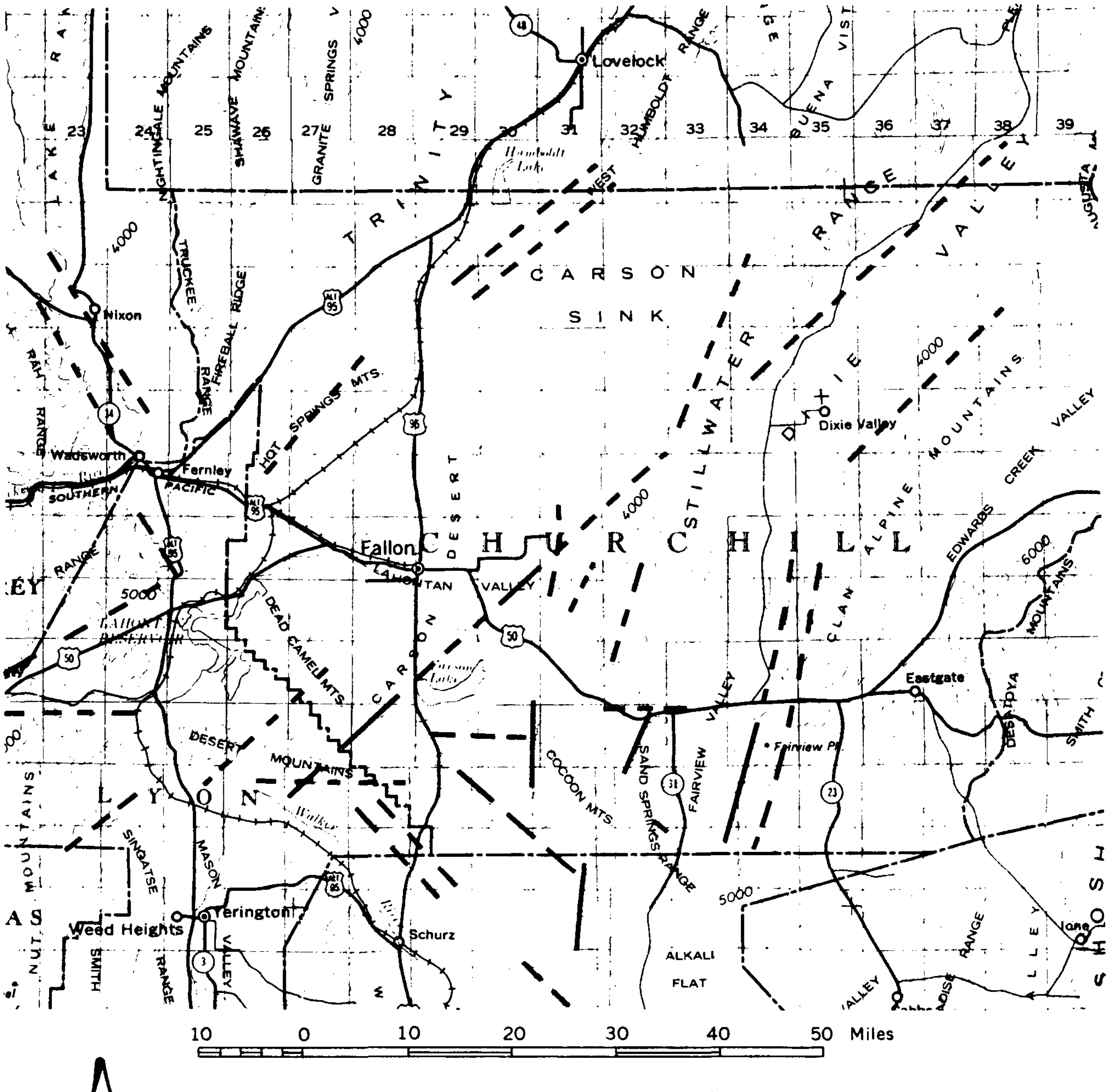

Figure 9. Regional lineaments (dashed where inferred).

(Trexler and others, 1978). Northeast trending lineaments are associated with the Carson Lineament and Midas Trench identified by Rowan and Wetlaufer (1973). These northeast trends appear to be associated with several geothermal areas, and can be seen by projecting them onto the Nevada Geothermal Resources Map (Trexler and others, 1979).

Two lineament trends of lessor importance are the north-northeast trending lineaments characteristic of the Basin and Range structures in this area, and an east-west trending set of lineaments which may be conjugates of the Basin and Range structure to the west of the study area (Trexler and others, 1978).

Localized lineaments along with other structural trends and geologic units were derived from the black and white aerial photography. Low sun-angle photography was very valuable in differentiating fault traces from shorelines in the southern portion of the study area. Figure 10 was derived using low altitude black and white imagery and other published data sources along with information from field activities. Several curvilinear features shown in Figure 10 are faults enhanced by shoreline development, especially in the southern regions (Bell, personal communication, 1980).

Gravity Survey

Reduction of the field data for the Southern Carson Sink has been delayed while data reduction for the Hawthorne and Paradise Valley study areas is being prepared. Reduced gravity data for the Southern Carson Sink study area will also be available in the eighth quarter, and structural interpretations will be made at that time.

Aeromagnetic Data Interpretation

No substantial data has been derived from the NURE program aeromagnetic profiles to date. However, emphasis will be placed on this task in the eighth

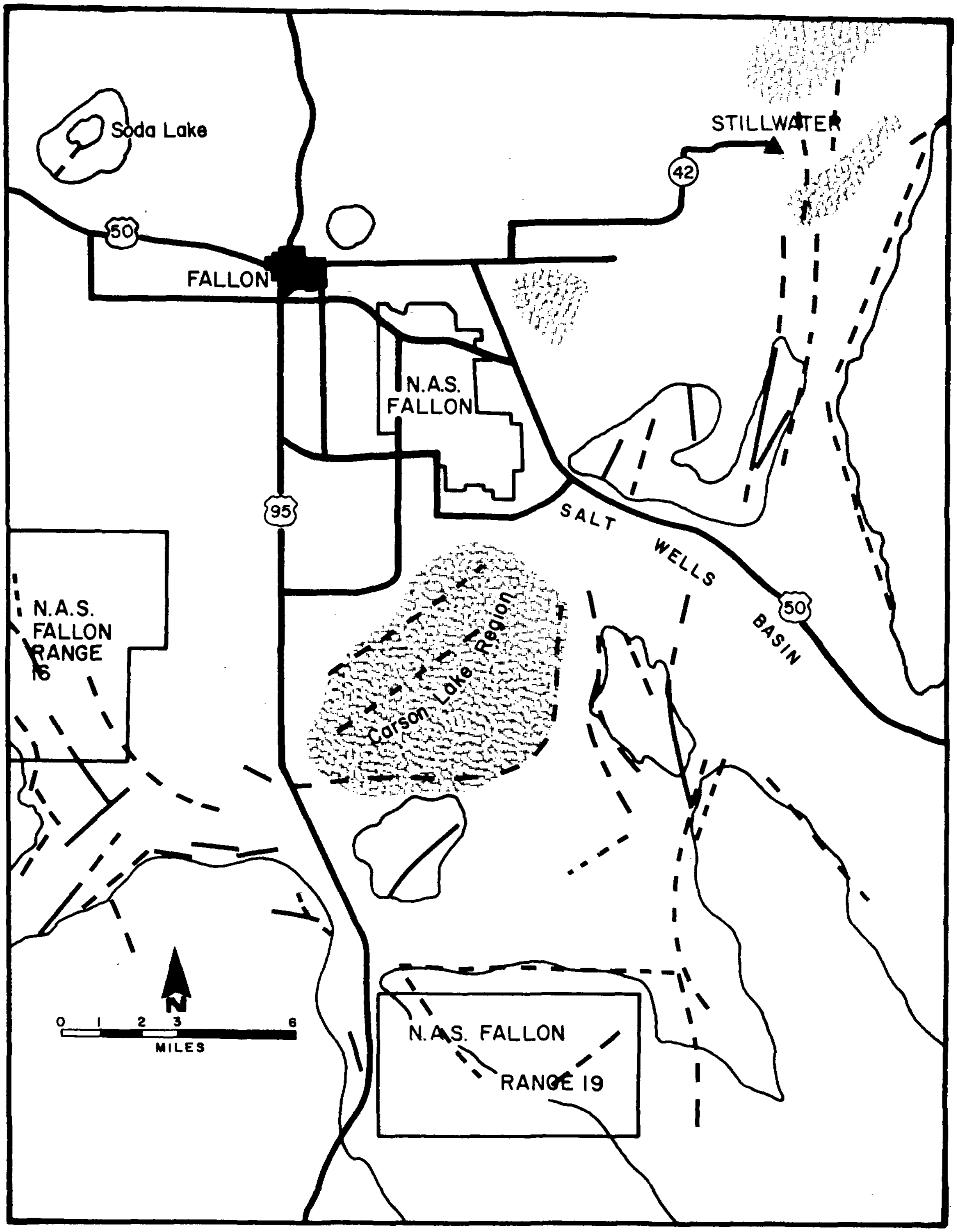

Figure 10. Faults (dashed where inferred).

quarter in an attempt to correlate the aeromagnetic data to the gravity survey data.

Soil-Mercury Survey

The soil-mercury survey expanded the information base of a similar soil-mercury survey performed by the Navy at the Fallon Naval Air Station (Bruce, 1979). An additional 125 samples were taken outside the boundaries of the Navy study area. Several samples were collected within the Navy study area to ascertain a uniformity of soil-mercury values among samples from both past and present studies. A reasonable percent error between the past and present surveys allowed nearly accurate correlation between the two studies. The comparison and correlation of the data was based on general trends of anomalous zones rather than direct correlations of sample points. Figure 11 is a composite diagram from the two soil-mercury surveys and identifies the general anomalous trends of high soil-mercury concentrations.

Analyses for this study were conducted using a Jerome Gold-film analyzer which collects mercury vapors on a thin gold foil from a heated sample. An electrical resistance measurement is then measured across the foil. Sensitivity of the instrument is approximately 1×10^{-10} ppb Hg. A value of mercury concentration in parts per billion (ppb) is obtained through a simple calculation sequence.

The anomalies shown in Figure 11 are generally not associated with thermal areas except for the north-northwest trend just south of the Naval Air Station (N.A.S.). This dog-leg trend shows a soil-mercury anamoly greater than 500 ppb. It is located directly over a thermal trend with subsurface waters of 77.8°C at a depth of a few hundred feet, and indicates Na-K-Ca geothermometer readings of 156° to 206°C (Bruce, 1979). The northeast trend showing higher

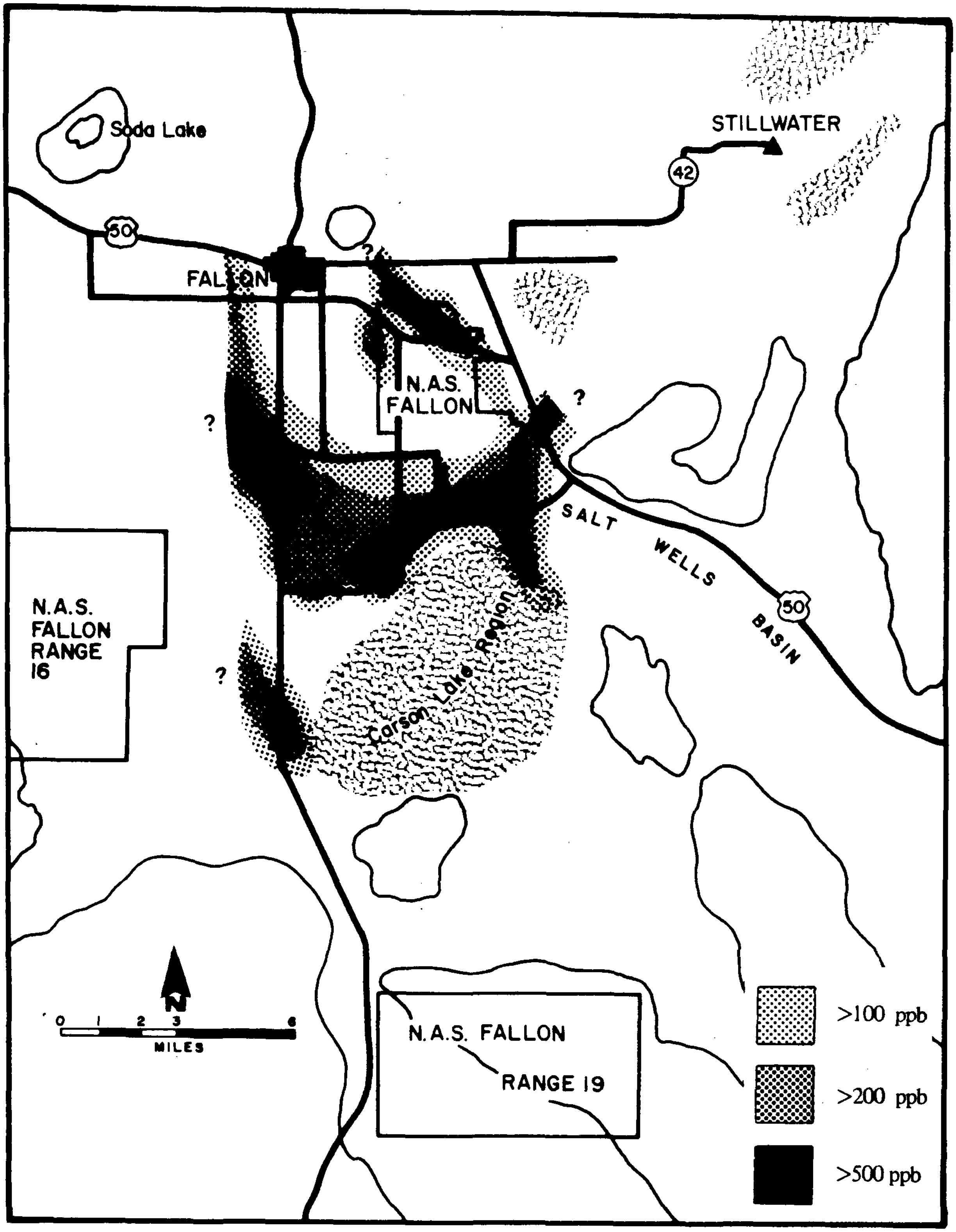

Figure 11. Soil mercury anomalies.

soil-mercury anomalies is subparallel to the trends of the Carson Lineament and the Midas Trench lineaments which transect the region. No direct correlation can be derived without additional structural data.

Chemical Analyses of Fluids

A fluid chemistry study was initiated during the seventh quarter. Eight fluid samples were collected for analysis of major and minor chemical constituents. This data along with published data on thermal waters, and data from the State of Nevada Division of Consumer Health Protection will be assembled into a semi-regional study. This study will try to establish relationships and controls between thermal and non-thermal groundwaters.

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