UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

ANALYTICAL RESULTS FOR SOIL SAMPLES COLLECTED AT THE ROOSEVELT HOT SPRINGS KNOWN GEOTHERMAL RESOURCE AREA, UTAH 1976 - 1987

By

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Open-File Report 93-260

1993

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* Codes for data tables: G = greater than value shown. N = not detected at limit of detection, or at value shown. L = detected, but below limit of determination, or below value shown, B = not analyzed.

ABSTRACT

A total of 831 soil samples were collected during four soil-gas surveys conducted in 1976, 1977, 1985, and 1987 over and near the producing geothermal field at the Roosevelt Hot Springs Known Geothermal Resource Area (KGRA), Utah. The soil samples were analyzed for elemental content by several analytical methods over the course of time. The results of the analyses are summarized in this report.

INTRODUCTION

Roosevelt Hot Springs KGRA is located about 20 km northeast of the town of Milford, in Beaver County, southwestern Utah (fig. 1). The KGRA is associated with Quaternary silicic volcanic rocks, which occur as domes, flows, and tuffs. The hot-water-dominated system was named for a group of hot springs that discharged silica-rich waters until about 1966, when the flow stopped (Mundorff, 1970). The location of the hot springs is at the northern end of a wide north-south-trending fault zone called the Opal Mound fault. The producing part of the geothermal field is bounded by the Opal Mound fault on the west and the foothills of the Mineral Mountains on the east. The environment of the Roosevelt Hot Springs KGRA is arid.

Soil-gas surveys were conducted over and near the producing geothermal field at Roosevelt Hot Springs in 1976, 1977, 1985, and 1987. Table 1 lists the constituents analyzed in these surveys. Descriptions of the methods of collection used for the surveys, methods of analyses of soil-gases and of gases desorbed from soils, and results of these analyses were published in previous USGS reports (Hinkle and Harms, 1978; Hinkle and others, 1978; Hinkle, 1980; Hinkle and Botinelly, 1988).

A total of 831 soil samples (including duplicates) were collected and analyzed during the course of the different soil-gas surveys. The soils were later analyzed for their elemental contents by various techniques. The purpose of this report is to publish the results of these later analyses.

SAMPLE COLLECTION AND ANALYSIS

Figures 1 - 3 show locations of the sample sites for 1976, 1977, and 1985 through 1987, respectively. The figures were prepared by using the USGS program GSPOST (Selner and Taylor, 1992).

Soils in all of the surveys were sampled by scraping away surficial debris and collecting the soil at 0-5 cm depth. The soils were sieved to minus 30-mesh (less than 600 um) at each sample site, and were stored in plastic bags. At the laboratory, the samples were sieved to minus 80 mesh (less that 180 um) for chemical analysis.

All of the soil samples were analyzed by direct-current arc-emission spectrography (Grimes and Marranzino, 1968; Motooka and Grimes, 1976); limits of determination for the spectrographic method are shown in table 2. In addition, different groups of samples were analyzed for other constituents by the methods listed in table 3, which also shows the lower limits of determination for the methods.

DESCRIPTION OF DATA TABLES

Data from all the analyses were entered into an IBM personal computer and stored on disks, using both the STATPAC programs developed for personal computers by the U.S. Geological Survey (Grundy and Miesch, 1987) and the QuattroPro program (Borland International, Scotts Valley, CA).

Tables 4 - 6 include the maximum, minimum, and mean values for the 1976, 1977, and 1985 through 1987 data, respectively. Tables 7 - 9 on the included disk contain all the analytical data for samples collected in 1976, 1977, and combined data for 1985 through 1987. Data for soil-gases, Hg, and soil content also appear in these tables, even though these data were published earlier, so that all data for a particular year could be included on the disk.

ACKNOWLEDGMENT

I thank the many analysts in the USGS Branch of Geochemistry who worked on these samples over the course of time. The combined results of the analyses illustrate very well the geochemistry of the area. I thank the California Energy Company, Ridgecrest, California, for permission to publish the results of these analyses.

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Figure 1. Roosevelt Hot Springs Sample Sites- 1976

Figure 2. Roosevelt Hot Springs Sample Sites- 1977

Figure 3. Roosevelt Hot Springs Sample Sites: 1985–1987

Table 1. Previous analyses.

Constituent	Date collected
He---collected by hollow probe at approximately 0.6-m depth	1977, 1985, 1987
He---desorbed from soils	1976, 1977, 1985, 1987
COS and CS_2---collected on molecular sieve gas adsorbers	1976
CO_2 and O_2---collected by hollow probe at 0.6-m depth and desorbed from soils	1985, 1987
Hg in soils	1977
Sand, silt, and clay contents of soils	1985, 1987

Table 2.--Limits of determination for the spectrographic analysis of soils, based on a 10-mg sample.

Elements	Lower determination limit	Upper determination limit
	Weight Percent	
Calcium (CA)	0.05	20
Iron (Fe)	0.05	20
Magnesium (Mg)	0.02	10
Sodium (Na)	0.2	5
Phosphorus (P)	0.2	10
Titanium (Ti)	0.002	1
	Parts per million	
Silver (Ag)	0.5	5,000
Arsenic (As)	200	10,000
Gold (Au)	10	500
Boron (B)	10	2,000
Barium (Ba)	20	5,000
Beryllium (Be)	1	1,000
Bismuth (Bi)	10	1,000
Cadmium (Cd)	20	500
Cobalt (Co)	5	2,000
Chromium (Cd)	10	5,000
Copper (Cu)	5	20,000
Gallium (Ga)	5	500
Germanium (Ge)	10	100
Lanthanum (La)	20	1,000
Manganese (Mn)	10	5,000
Molybdenum (Mo)	5	2,000
Niobium (Nb)	20	2,000
Nickel (Ni)	5	5,000
Lead (Pb)	10	20,000
Antimony (Sb)	100	10,000
Scandium (Sc)	5	100
Tin (Sn)	10	1,000
Strontium (Sr)	100	5,000
Thorium (Th)	100	2,000
Vanadium (V)	10	10,000
Tungsten (W)	50	10,000
Yttrium (Y)	10	2,000
Zinc (Zn)	200	10,000
Zirconium (Zr)	10	1,000

Table 3. Other analytical methods used.

Element	Date collected	Lower determination limit (ppm)	Method
Hg	1976, 1977, 1985, 1987	0.02	Vaughn and McCarthy (1964) O'Leary, Crock, and Kennedy (1990)[1]
As, Sb	1977	1.0	Ward and others (1963)[2]
Zn	1977	0.5	Ward and others (1969)[2]
As	1985, 1987	0.60	Motooka (1988)[2]
Cd	"	0.05	"
Cu	"	0.05	"
Mo	"	0.09	"
Pb	"	0.60	"
Sb	"	0.60	"
Zn	"	0.05	"
F	1977	100	Hopkins (1977)
pH	1977, 1985, 1987		Jackson (1958)
soil content	1985, 1987		Day (1965) and Grigal (1973)

(1) Some of the samples were analyzed using USGS methods prior to their publication.

(2) These analytical methods are partial-analysis techniques that isolate and measure those elements that are adsorbed by secondary Fe and Mn oxides, and are not tightly bound in the silicate lattice of minerals.

Table 4. UNIVARIATE STATISTICS for 1976 DATA

VAR	COLUMN	MINIMUM	MAXIMUM	MEAN	DEVIATION	VALID	B	L	N	G	OTHER
1	Latitude	3.848E+01	3.850E+01	3.849E+01	6.9115E-03	181	0	0	0	0	0
2	Longitud	1.128E+02	1.129E+02	1.129E+02	1.1449E-02	181	0	0	0	0	0
3	Fe-%	3.000E+00	1.000E+01	5.597E+00	1.5556E+00	181	0	0	0	0	0
4	Mg-%	1.000E+00	2.000E+00	1.528E+00	2.9214E-01	181	0	0	0	0	0
5	Ca-%	5.000E-01	2.000E+01	3.120E+00	4.0340E+00	181	0	0	0	0	0
6	Ti-%	2.000E-01	1.000E+00	5.901E-01	1.5638E-01	181	0	0	0	0	0
7	Mn-ppm	7.000E+02	2.000E+03	1.157E+03	2.9177E+02	181	0	0	0	0	0
8	Ag-ppm	5.000E-01	1.000E+01	5.525E-01	7.0613E-01	1	0	0	180	0	0
9	B-ppm	3.000E+01	2.000E+02	6.989E+01	2.1985E+01	181	0	0	0	0	0
10	Ba-ppm	5.000E+01	1.500E+03	6.929E+02	2.7672E+02	181	0	0	0	0	0
11	Be-ppm	1.500E+00	5.000E+00	2.834E+00	9.5606E-01	181	0	0	0	0	0
12	Bi-ppm	1.000E+01	1.000E+01	1.000E+01	1.0000E+35	0	0	0	181	0	0
13	Cd-ppm	2.000E+01	2.000E+01	2.000E+01	1.0000E+35	0	0	0	181	0	0
14	Co-ppm	1.000E+01	7.000E+02	3.727E+01	5.7767E+01	181	0	0	0	0	0
15	Cr-ppm	3.000E+01	2.000E+03	3.078E+02	5.7475E+02	181	0	0	0	0	0
16	Cu-ppm	1.000E+01	5.000E+01	2.577E+01	6.0744E+00	181	0	0	0	0	0
17	La-ppm	7.000E+01	7.000E+02	1.421E+02	6.0443E+01	181	0	0	0	0	0
18	Mo-ppm	5.000E+00	2.000E+01	5.221E+00	1.4741E+00	58	0	0	123	0	0
19	Nb-ppm	2.000E+01	7.000E+01	3.188E+01	1.0791E+01	180	0	1	0	0	0
20	Ni-ppm	1.000E+01	1.500E+02	2.917E+01	1.7373E+01	181	0	0	0	0	0
21	Pb-ppm	2.000E+01	1.000E+02	4.006E+01	1.4472E+01	181	0	0	0	0	0
22	Sc-ppm	7.000E+00	2.000E+01	1.338E+01	2.4321E+00	181	0	0	0	0	0
23	Sn-ppm	1.000E+01	2.000E+01	1.006E+01	7.4329E-01	1	0	0	180	0	0
24	Sr-ppm	1.500E+02	7.000E+02	3.831E+02	1.2273E+02	181	0	0	0	0	0
25	V-ppm	5.000E+01	2.000E+02	1.186E+02	2.7871E+01	181	0	0	0	0	0
26	W-ppm	5.000E+01	5.000E+01	5.000E+01	1.0000E+35	0	0	0	181	0	0
27	Y-ppm	2.000E+01	1.000E+02	4.840E+01	1.4344E+01	181	0	0	0	0	0
28	Zn-ppm	2.000E+02	2.000E+02	2.000E+02	1.0000E+35	0	0	0	181	0	0
29	Zr-ppm	1.500E+02	1.000E+03	6.671E+02	2.7087E+02	151	0	0	0	30	0
30	As-ppm	1.000E+01	1.000E+01	1.000E+01	1.0000E+35	1	0	1	179	0	0
31	Sb-ppm	1.000E+00	1.000E+00	1.000E+00	1.0000E+35	4	0	56	121	0	0
32	Hg-ppm	1.000E+01	3.500E+03	9.138E+01	2.7858E+02	181	0	0	0	0	0
33	ppbHe(s)	.000E+00	6.700E+01	1.241E+01	1.0414E+01	181	0	0	0	0	0

Table 5. UNIVARIATE STATISTICS for 1977 DATA

VAR	COLUMN	MINIMUM	MAXIMUM	MEAN	DEVIATION	VALID	B	L	N	G	OTHER
1	Latitude	3.847E+01	3.851E+01	3.849E+01	6.3811E-03	477	0	0	0	0	0
2	Longitud	1.128E+02	1.130E+02	1.129E+02	2.5255E-02	477	0	0	0	0	0
3	Fe-%	1.000E+00	1.500E+01	3.307E+00	1.7252E+00	477	0	0	0	0	0
4	Mg-%	5.000E-01	3.000E+00	1.378E+00	4.8695E-01	477	0	0	0	0	0
5	Ca-%	5.000E-01	1.500E+01	2.328E+00	2.0081E+00	477	0	0	0	0	0
6	Ti-%	2.000E-01	7.000E-01	5.530E-01	1.6506E-01	477	0	0	0	0	0
7	Mn-ppm	2.000E+02	1.500E+03	7.933E+02	3.3443E+02	477	0	0	0	0	0
8	Ag-ppm	5.000E-01	5.000E+00	5.128E-01	2.1150E-01	7	0	4	466	0	0
9	B-ppm	1.500E+01	3.000E+02	1.086E+02	5.1782E+01	477	0	0	0	0	0
10	Ba-ppm	1.500E+02	1.500E+03	6.225E+02	2.2068E+02	477	0	0	0	0	0
11	Be-ppm	1.000E+00	7.000E+00	2.219E+00	7.6471E-01	477	0	0	0	0	0
12	Co-ppm	5.000E+00	7.000E+01	1.238E+01	5.2618E+00	473	0	4	0	0	0
13	Cr-ppm	1.000E+01	2.000E+02	7.085E+01	4.2020E+01	475	0	2	0	0	0
14	Cu-ppm	5.000E+00	7.000E+01	2.087E+01	7.9842E+00	477	0	0	0	0	0
15	La-ppm	3.000E+01	3.000E+02	1.020E+02	6.2893E+01	477	0	0	0	0	0
16	Mo-ppm	5.000E+00	7.000E+00	5.004E+00	9.1574E-02	1	0	225	251	0	0
17	Nb-ppm	2.000E+01	7.000E+01	2.547E+01	9.8325E+00	308	0	169	0	0	0
18	Ni-ppm	5.000E+00	1.500E+02	1.541E+01	1.2941E+01	473	0	4	0	0	0
19	Pb-ppm	1.000E+01	1.500E+02	5.045E+01	2.7793E+01	475	0	2	0	0	0
20	Sc-ppm	5.000E+00	3.000E+01	1.329E+01	4.8878E+00	477	0	0	0	0	0
21	Sn-ppm	1.000E+01	1.000E+01	1.000E+01	1.0000E+35	1	0	2	474	0	0
22	Sr-ppm	1.000E+02	7.000E+02	2.720E+02	1.1240E+02	476	0	1	0	0	0
23	V-ppm	5.000E+01	3.000E+02	1.355E+02	3.9726E+01	477	0	0	0	0	0
24	Y-ppm	1.500E+01	3.000E+02	5.747E+01	2.1210E+01	477	0	0	0	0	0
25	Zr-ppm	1.500E+02	1.000E+03	5.861E+02	3.1136E+02	361	0	0	0	116	0
26	Th-ppm	5.000E+01	7.000E+02	6.296E+01	3.7839E+01	12	0	4	461	0	0
27	Hg-ppm	2.000E-02	3.000E+00	8.950E-02	2.9468E-01	477	0	0	0	0	0
28	Sb-ppm	.000E+00	1.200E+01	1.479E+00	1.2216E+00	268	2	144	63	0	0
29	Zn-ppm	1.500E+01	1.300E+02	5.639E+01	1.5557E+01	477	0	0	0	0	0
30	F-ppm	.000E+00	1.900E+03	1.053E+03	2.4127E+02	475	2	0	0	0	0
31	As-ppm	.000E+00	9.000E+00	2.727E+00	2.3793E+00	286	191	0	0	0	0
32	ppbHe(p)	4.650E+03	5.250E+03	4.785E+03	6.8265E+01	477	0	0	0	0	0
33	ppbHe(s)	5.790E+02	3.744E+04	6.552E+03	3.2901E+03	477	0	0	0	0	0
34	H-ppb	3.000E-03	2.500E+04	8.803E+01	1.1459E+03	477	0	0	0	0	0

Table 6. UNIVARIATE STATISTICS for 1985-1987 DATA

VAR	COLUMN	MINIMUM	MAXIMUM	MEAN	DEVIATION	VALID	B	L	N	G	OTHER
1	Latitude	3.846E+01	3.853E+01	3.848E+01	1.8009E-02	173	0	0	0	0	0
2	Longitud	1.128E+02	1.130E+02	1.129E+02	3.2118E-02	173	0	0	0	0	0
3	Fe-%	1.000E+00	2.000E+01	3.445E+00	1.8048E+00	173	0	0	0	0	0
4	Mg-%	3.000E-01	7.000E+00	9.468E-01	7.2099E-01	173	0	0	0	0	0
5	Ca-%	5.000E-01	1.500E+01	1.624E+00	1.9005E+00	173	0	0	0	0	0
6	Ti-%	1.000E-01	1.000E+00	4.587E-01	1.8657E-01	173	0	0	0	0	0
7	Mn-ppm	3.000E+02	1.000E+03	7.208E+02	1.8434E+02	173	0	0	0	0	0
8	B-ppm	2.000E+01	1.000E+02	3.855E+01	1.3060E+01	173	0	0	0	0	0
9	Ba-ppm	2.000E+02	1.000E+03	5.526E+02	1.9095E+02	173	0	0	0	0	0
10	Be-ppm	1.000E+00	7.000E+00	2.023E+00	6.2834E-01	173	0	0	0	0	0
11	Co-ppm	5.000E+00	3.000E+01	1.380E+01	3.9868E+00	170	0	2	1	0	0
12	Cr-ppm	1.000E+01	1.500E+02	5.543E+01	3.2205E+01	172	0	1	0	0	0
13	Cu-ppm	5.000E+00	3.000E+01	2.042E+01	7.6706E+00	173	0	0	0	0	0
14	La-ppm	2.000E+01	3.000E+02	8.890E+01	4.6773E+01	172	0	1	0	0	0
15	Mo-ppm	5.000E+00	5.000E+00	5.000E+00	1.0000E+35	0	0	1	172	0	0
16	Nb-ppm	2.000E+01	5.000E+01	2.624E+01	8.0903E+00	141	0	31	1	0	0
17	Ni-ppm	5.000E+00	5.000E+01	1.643E+01	8.9982E+00	163	0	9	1	0	0
18	Pb-ppm	5.000E+00	1.000E+02	3.370E+01	1.7047E+01	170	0	3	0	0	0
19	Sc-ppm	5.000E+00	1.500E+01	8.353E+00	2.1907E+00	170	0	3	0	0	0
20	Sn-ppm	1.000E+01	1.000E+01	1.000E+01	1.0000E+35	0	0	3	170	0	0
21	Sr-ppm	1.500E+02	5.000E+02	3.003E+02	9.2053E+01	173	0	0	0	0	0
22	V-ppm	5.000E+01	2.000E+02	9.358E+01	2.3150E+01	173	0	0	0	0	0
23	Y-ppm	1.000E+01	1.000E+02	4.072E+01	1.5370E+01	173	0	0	0	0	0
24	Zr-ppm	1.000E+02	1.000E+03	5.855E+02	2.5935E+02	163	0	0	0	10	0
25	Th-ppm	1.000E+02	2.000E+02	1.009E+02	8.4805E+00	2	0	1	170	0	0
26	Hg-ppb	2.000E+01	2.000E+03	4.855E+01	1.9875E+02	93	0	80	0	0	0
27	Moist-%	1.180E+00	1.310E+01	4.701E+00	2.3475E+00	173	0	0	0	0	0
28	CO2(p)-%	3.000E-02	8.860E+00	7.095E-01	1.3541E+00	173	0	0	0	0	0
29	O2(p)-%	1.850E+01	2.190E+01	2.070E+01	6.2137E-01	173	0	0	0	0	0
30	He(p)ppb	3.528E+03	8.350E+03	5.366E+03	5.1861E+02	173	0	0	0	0	0
31	He(s)ppb	3.030E+03	1.857E+04	6.526E+03	1.9800E+03	173	0	0	0	0	0
32	CO2(s)-%	.000E+00	7.060E+01	9.816E+00	1.2777E+01	172	1	0	0	0	0
33	O2(s)-%	.000E+00	2.490E+02	3.263E+01	4.7183E+01	172	1	0	0	0	0
34	As-ppm-*	.000E+00	1.300E+01	3.475E+00	1.3778E+00	173	0	0	0	0	0
35	Cd-ppm-*	.000E+00	4.800E-01	2.247E-01	8.3975E-02	172	1	0	0	0	0
36	Cu-ppm-*	.000E+00	2.900E+01	1.436E+01	3.7038E+00	172	1	0	0	0	0
37	Mo-ppm-*	.000E+00	2.500E+00	6.336E-01	2.0668E-01	172	1	0	0	0	0
38	Pb-ppm-*	.000E+00	2.600E+01	1.348E+01	3.1540E+00	172	1	0	0	0	0
39	Sb-ppm-*	.000E+00	4.500E+00	1.861E-01	5.0556E-01	172	1	0	0	0	0
40	Zn-ppm-*	.000E+00	1.300E+02	6.399E+01	2.0450E+01	172	1	0	0	0	0
41	Sand-%	2.110E+01	8.290E+01	5.789E+01	1.1122E+01	173	0	0	0	0	0
42	Silt-%	.000E+00	4.710E+01	2.315E+01	1.0138E+01	173	0	0	0	0	0
43	Clay-%	7.700E+00	5.570E+01	1.899E+01	5.4545E+00	173	0	0	0	0	0
44	Mtmr-%-#	.000E+00	1.240E+02	7.382E+00	1.3969E+01	173	0	0	0	0	0
45	Mica-%	2.000E+00	5.700E+01	1.351E+01	8.2099E+00	173	0	0	0	0	0
46	Klnt-%-#	1.000E+00	2.100E+01	8.000E+00	3.6232E+00	173	0	0	0	0	0
47	Quartz-%	2.000E+00	7.800E+01	3.172E+01	2.3322E+01	173	0	0	0	0	0
48	Flsp-%-#	2.000E+00	4.800E+01	1.376E+01	6.0951E+00	173	0	0	0	0	0
49	Calcite%	.000E+00	8.000E+01	8.220E+00	1.7599E+01	173	0	0	0	0	0
50	H-ppb	.000E+00	7.940E+02	9.240E+01	1.1408E+02	165	8	0	0	0	0