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GEOLOGICAL SURVEY

Radioactive mineral spring precipitates, their analytical and statistical data, and the uranium connection

by

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Open-File Report 82-743

1982

This report is preliminary and has not
been reviewed for conformity with U.S.
Geological Survey editorial standards.

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ABSTRACT

Major radioactive mineral springs are probably related to deep zones of active metamorphism in areas of orogenic tectonism. The most common precipitate is travertine, a chemically precipitated rock composed chiefly of calcium carbonate, but also containing other minerals. The mineral springs are surface manifestations of hydrothermal conduit systems which extend downward many kilometers to hot source rocks. Conduits are kept open by fluid pressure exerted by carbon dioxide-charged waters rising to the surface propelled by heat and gas (CO_2 and steam) pressure.

On reaching the surface, the dissolved carbon dioxide is released from solution, and calcium carbonate is precipitated. Springs also contain sulfur species (for example, H_2S and HS^-), and radon, helium and methane as entrained or dissolved gases. The HS^- ion can react to form hydrogen sulfide gas, sulfate salts, and native sulfur. Chemical salts and native sulfur precipitate at the surface. The sulfur may partly oxidize to produce detectable sulfur dioxide gas.

Radioactivity is due to the presence of radium-226, radon-222, radium-228, and radon-220, and other daughter products of uranium-238 and thorium-232. Uranium and thorium are not present in economically significant amounts in most radioactive spring precipitates.

Most radium is coprecipitated at the surface with barite. Barite (barium sulfate) forms in the barium-containing spring water as a product of the oxidation of sulfur species to sulfate ions. The relatively insoluble barium sulfate precipitates and removes much of the radium from solution. Radium coprecipitates to a lesser extent with manganese-barium- and iron-oxy hydroxides.

R-mode factor analysis of abundances of elements suggests that 65 percent of the variance of the different elements is affected by seven factors interpreted as follows: (1) Silica and silicate contamination and precipitation; (2) Carbonate travertine precipitation; (3) Radium coprecipitation; (4) Evaporite precipitation; (5) Hydrous limonite precipitation and coprecipitated elements including uranium; (6) Rare earth elements deposited with detrital contamination (?); (7) Metal carbonate adsorption and precipitation.

Economically recoverable minerals occurring at some localities in spring precipitates are ores of iron, manganese, sulfur, tungsten and barium and ornamental travertine.

Continental radioactive mineral springs occur in areas of crustal thickening caused by overthrusting of crustal plates, and intrusion and metamorphism. Sedimentary rocks on the lower plate are trapped between the plates and form a zone of metamorphism. Connate waters, carbonate rocks and organic-carbon-bearing rocks react to extreme pressure and temperature to produce carbon dioxide, and steam. Fractures are forced open by gas and fluid pressures. Deep-circulating meteoric waters then come in contact with the reactive products, and a hydrothermal cell forms. When hot mineral-charged waters reach the surface they form the familiar hot mineral springs. Hot springs also occur in relation to igneous intrusive action or volcanism both of which may be products of the crustal plate overthrusting. Uranium and thorium in the sedimentary rocks undergoing metamorphism are sometimes mobilized, but mobilization is generally restricted to an acid hydrothermal environment; much is redeposited in favorable environments in the metamorphosed sediments. Radium and radon, which are highly mobile in both acid and alkaline aqueous media move upward into the hydrothermal cell and to the surface.

INTRODUCTION

Radioactive mineral springs occur commonly in most orogenic areas of the world. Many of the springs are surface manifestations of hydrothermal cells which extend thousands of meters below the Earth's surface. Similar springs are found on the ocean floors related to rift zones. Many of the radioactive mineral springs contain high concentrations of Ra, Rn, and products of their radioactive decay. Most of the springs also contain dissolved gases including CO_2, O_2, gaseous sulfur species (including H_2S), He, and Rn (Felmlee and Cadigan, 1982). Many springs form chemically precipitated mineral deposits at the Earth's surface. These deposits consist predominantly of calcite or aragonite in a rock form called travertine. Other precipitated deposits, some of economic value, are composed commonly of Mn-Ba-Fe oxides and hydroxides and more rarely native S, barite, W minerals and a varied suite of trace elements. Many of these mineral spring precipitates are more radioactive (by as much as 100 times) than the rocks on which they are deposited.

Historically, the springs have been of economic importance. For thousands of years many mineral springs became valued for their therapeutic properties. Cities grew up around the springs and many even at the present time are sites of health and recreation resorts. Spring waters and precipitates have been easily available sources of iron ore, sulfur, lime, medicinal tonics and other compounds for successive human cultures.

Purpose and scope of investigation

This investigation is part of a study of uranium occurrences, geochemistry, and resources being conducted by the U.S. Geological Survey. The current investigation was limited to deposits of spring precipitates in some of the western States and the State of Arkansas. Background values for 37 metals were determined for radioactive precipitates. Analytical data were tested statistically for covariation of elements, and interpretations of geochemical causes and effects were made based on element associations.

Objectives of the study are (1) to obtain data related to geochemical environments of radioactive mineral springs and geochemical processes which produced the spring precipitates at the Earth's surface, (2) to judge whether radiogeochemical data provided by precipitates provides information that can assist in geochemical exploration for economic uranium deposits, and (3) to determine whether radiochemical and geochemical data from precipitates could be applied to regional uranium resource estimates.

This study was not concerned with isotopic relationships among elements composing the mineral precipitates nor with relating the precipitates to particular subsurface formations. A considerable amount of such work has been done by earlier and contemporary investigators.

A companion report (Felmlee and Cadigan, 1982) has been prepared in which the geochemistry of the spring waters has been discussed for the same areas. Many of the sampled springs, however, are not producing precipitates. Another related report, a study of the mineralogy of some of the precipitate samples that we collected from the radium springs has been prepared (Bove and Felmlee, 1982).

Several reports have been published previously by us which are preliminary or are progress reports or are concerned with parts of the main investigation [for example, Cadigan and Felmlee, 1977, and references therein].

Geographic and geologic setting

The areas in which we collected samples are located in the states of Arizona, Arkansas, California, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming.

The physiographic provinces represented are the Southern Rocky Mountains, Colorado Plateau, Basin and Range, Wyoming Basins Northern Rocky Mountains, Sierra Nevada, and Central Lowlands (fig. 1).

The spring precipitates studied are located mostly on the surface of sedimentary rock terrane. Some, however, are in igneous rock; and some emerge from poorly consolidated valley fill. Most are related to subsurface jointing and faulting. Probably most, are related to major fault systems such as that recognized along the Wasatch Front in the Salt Lake City area of Utah, which extends southward into central Utah. A few specific geologic environments are noted in the related report on the properties of the mineral spring waters (Felmlee and Cadigan, 1982).

Previous work

Work on the radioactivity of hydrothermal springs had to wait for the development of means of measuring radioactivity. Pioneers were Curie and Laborde (1904) and Mache (1904) in Europe, and Boltwood (1905) in the United States. Headden (1905) worked on the Doughty Springs of Delta County, Colorado, one of the springs covered in our investigations (Cadigan, Felmlee, andRosholt, 1976). Headden determined radioactivity in precipitates in the springs using semiquantitative but effective methods, and determined the presence of Ra coprecipitated with barite.

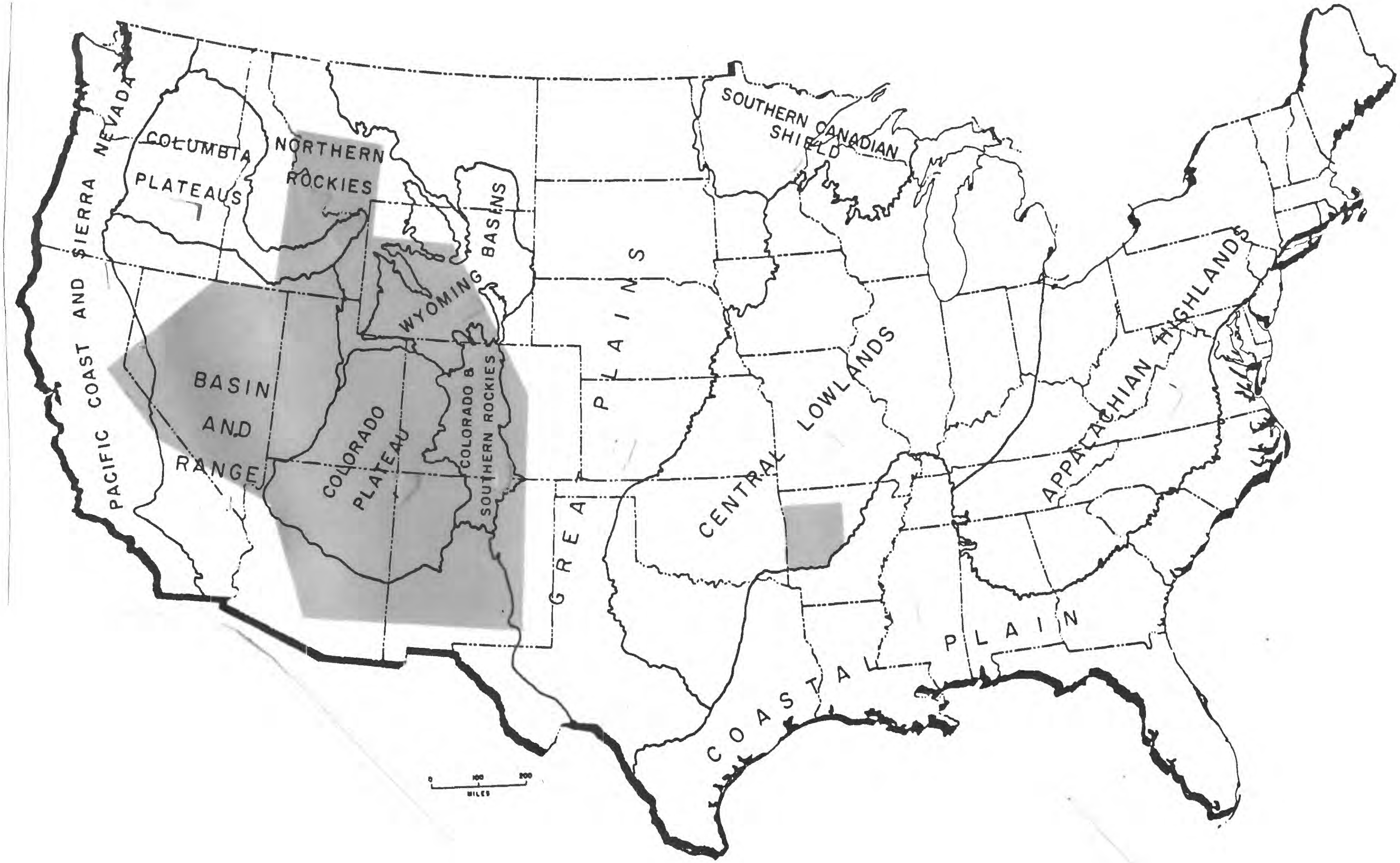

Figure 1.--Map showing physiographic province boundaries and general areas sampled (Shaded) for radioactive mineral spring precipitate study.

Interest in the radioactivity of hydrothermal mineral spring precipitates declined rapidly, but interest in the economic value of the mineral spring water and precipitates remained. This interest was indicated by descriptions of general benefits to health, agriculture, the mining industry and the tourist industry by Weed (1904). Other papers on specific hydrothermal spring mineral deposits were published. Lindgren (1905) reported on antimony deposits related to the Steamboat Springs in Nevada. Kerr (1940) discussed the probable hydrothermal spring origin of the tungsten and manganese deposits at Golconda, Nevada. Hewett and Fleischer (1960) and Hewett, Fleisher and Conklin (1963) studied manganese oxide ores found in mineral spring precipitate aprons and made comparisons with hypogene and stratified deposits, but did not comment on the radioactivity of the manganese ores.

New economic interest in the springs as sources of hydrothermal energy are reflected in such studies as those by White (1971) and others.

Craig, Boato, and White (1956) established evidence based on oxygen and deuterium isotopic data that hydrothermal springs yielded waters of mostly meteoric origin rather than of connate or magmatic origin. Friedman (1970) studied carbon isotope relationships in hydrothermal spring waters and precipitates. He found isotopic evidence that travertine deposits of predominantly aragonite and calcite were deposited by meteoric waters circulating within a hydrothermal cell. It is postulated that Ca is dissolved at depth in CO_2-charged waters, transported in an equilibrium solution of Ca^{2+}, HCO_3^-, CO_3^{2-} and H_2CO_3, and precipitated at the surface as calcium carbonate with loss from solution of dissolved carbon dioxide resulting from a decrease in gas pressure.

Leeman, Doe, and Whelan (1977) used Pb and Sr isotope data to investigate the character of possible sources of trace elements in hydrothermal spring precipitates. They concluded that sources could include both subsurface igneous intrusive and sedimentary rocks and that it was possible to identify the source rocks by means of isotopic composition of the surface precipitates.

Barnes, Irwin and White (1978) observed that carbon dioxide-charged mineral springs are concentrated in regions of tectonic activity throughout the world. The main source of the carbon dioxide is attributed to active metamorphism of subsurface or basement rocks. Feth and Barnes (1979) produced a catalogue of spring-produced travertine deposits in the western United States.

Waring (1965) published a compilation of spring locations and a wealth of data from thermal springs in the United States and other countries. It can be considered as a basic reference for hot spring investigations. Thermal springs generally seem to be related to volcanic activity within the volcanic belts of the world. Some springs, however, show no direct relationship to intrusive rocks and may transmit heat generated by other mechanisms, according to the author.

Our own studies of mineral springs and related precipitates (Cadigan and Felmlee, 1977 and 1979) suggest that the main sources of radioactivity of the spring sites are Ra and Rn. U is of minor importance in the precipitates. Metal-bearing waters move upward from a deep source of heat propelled by gas pressure. Propellant gases are principally carbon dioxide and steam, also present are gaseous sulfur species derived from the HS^- in solution, and entrained and dissolved air contributed by shallow aquifers. The quantity of Ra and Rn in the spring water can be used to estimate the minimum amount of U needed in the source rocks. The amount of U in the source can be substantial. Udy Hot springs (see table 1, Utah, locality 1 or UT, 1) requires at least 70,000 metric tons of U in the source rocks to maintain the current production of Ra and Rn from the springs (Cadigan and Felmlee, 1979).

The springs flow as the result of pressure from below, a combination of carbon dioxide gas pressure and hydrothermal convection. Some gas-charged springs form geysers at the surface. These have been mistaken in more than one occurrence as "artesian" springs. Spring flow is through a conduit system which leads downward directly or indirectly to the source of heat and carbon dioxide. The water moves upward at a high rate of speed--appropriate to the fluid pressure required to maintain the open conduits at depth.

Acknowledgments

Most of the precipitate samples used in the investigation were collected by us. A few precipitate samples, however, were collected by J. E. Peterson, S. E. Buell, and C. S. Spirakis.

Emission spectographic analyses were done principally by H. G. Neiman, but also by J. C. Hamilton, M. J. Malcolm, L. C. Stephenson, G. T. Burrow, L. A. Bradley, G. R. Mason, L. Castillo, G. O. Riddle, G. R. Mason, R. Lerner, M. Retzloff, and M. W. Solt. Equivalent uranium measurements were made by I. C. Frost, H. G. Neiman, V. James, and J. C. Negri. Sulfur and carbon determinations were made by P. H. Briggs, V. E. Shaw, and G. T. Burrow. Analytical supervisors were Claude Huffman, R. G. Havens, D. R. Norton, J. H. Christie, J. L. Seeley, P. J. Lamothe and F. E. Lichte.

Delayed neutron analysis for U and Th were done by and under the supervision of H. T. Millard, assisted by C. M. Ellis, C. McFee, A. J. Bartel, R. J. Knight, C. L. Shield, M. Schneider, W. R. Stang, M. F. Coughlin, M. W. Solt, R. B. Vaughn, R. D. Bies, B. A. Keaten, S. W. Lasater, and F. M. Luman.

Carbon isotope analyses of selected water samples were done by T. C. Coplen, III, project chief, and Carol Kendall, analyst. C. W. Adkisson assisted the precipitate study by executing computer tasks including programming, running programs and doing computer graphics. Ms. Adkisson gave advice and suggestions relative to computer applications to the data. She also assisted in the field work during the early part of the study. G. S. Davis assisted in preliminary computer runs on the precipitation data. B. A. Steele and R. E. Glanville assisted in the field work.

Data on radionuclides found in some precipitates were supplied by C. M. Bunker, J. N. Rosholt and J. R. Dooley. They analyzed the samples by gamma-ray spectrometry and identified isotopic differences in the sources of radioactivity in precipitates from several springs. They provided data for the section on radiogeochemistry in this report. Some results are reported in an earlier report by Cadigan, Felmlee, and Rosholt (1976). X-ray

Table 1.--Index of sample localities by States

Location No.	Name	County	Lat. (degrees)	Long. (degrees)	Number of Samples	Comments*
					Arizona	
** 2	Grand Canyon at river mile 34.1	Coconino	36.4783	111.8461	1	Travertine from stalactite mass on Redwell Ls., white, red-stained: (CF-2). Minerals identified: calcite, dolomite.
4	Grand Canyon at river mile 136.7	Coconino	36.3894	112.5167	1 1	Travertine, fresh, red-stained: (CF-9). Minerals identified: calcite.
5	Grand Canyon, spring at river mile 151.5	Coconino	36.3464	112.2247	1	Travertine, red, sandy: (CF-11). Minerals identified: calcite, amjudrote.
6	Grand Canyon, spring at river mile 147.9	Mohave	36.3456	112.6708	1	Travertine, red: (CF-10). Minerals identified: calcite.
7	Grand Canyon, spring at river mile 155.8	Mohave	36.3100	112.7625	1	Travertine, salt, and calcareous sand: (CF-12). Minerals identified: calcite.
8	Grand Canyon, spring at Havasu Canyon, mile 156.7	Coconino	36.3050	112.7589	1	Travertine, greenish white: (CF-13): w/plant material: Minerals identified: calcite, dolomite.
9	Grand Canyon, spring at Fern Glen Canyon, mile 168.	Mohave	36.2619	112.9175	1	Travertine mixed with white salt and calcareous sand: (CF-14). Minerals identified: calcite, dolomite (?).
10	Grand Canyon, spring at Garnet Canyon	Coconino	36.2139	112.4208	1	Precipitate coating red syenite, and biotite-chlorite gneiss: (CF-6). Minerals identified: gypsum.
11	Grand Canyon at river mile 115.5	Coconino	36.2003	112.7247	1	Precipitate from float. No active spring flow at surface: (CF-7). Minerals identified: gypsum.
12	Grand Canyon at river mile 116.5, Royal Arch Creek	Coconino	36.3100	112.7625	1	Travertine from float. No active spring flow at surface: (CF-8). Minerals identified: calcite.
13	Grand Canyon, Lava Falls warm springs, mile 179.3	Coconino	36.1942	113.0831	1	Precipitate composite sample from several locations: (CF-15). Minerals identified: gypsum.
14	Grand Canyon at river mile 77	Coconino	36.0458	111.9250	1	Travertine from dry spring at base of Bass Limestone: (CF-4). Minerals identified: calcite, dolomite (?).

Table 1.--Index of sample localities by states (continued)

Location No.	Name	County	Lat. (degrees)	Long. (degrees)	Number of Samples	Comments*
15	Grand Canyon, at Pumpkin Spring, mile 212.9	Conconino Conconino	35.9164 35.9164	113.3331 113.3331	1 1	Travertine and soft precipitates, a composite sample: (CF-16). Minerals identified: calcite.
16	The Salt Bank springs	Gila	33.8322	110.5969	9	Travertine, massive to highly rough and vesicular, yellow, gray, reddish black, orange and limonitic, soft limonitic precipitates, and hematite-streaked white travertine. Minerals identified: calcite, dolomite. Major spring system.
					Arkansas	
1	Simms flowing well (Mountainburg)	Crawford	35.6208	94.1656	6	Precipitates, soft, wet, black, gray or white in ditch draining well and in creek bottom. Minerals identified: none. Well depth reported: 4000 ft.
2	Flurry flowing well	Crawford	35.6992	94.3175	2	Precipitate, soft, gray, contains algae. Minerals identified: none. Well depth reported: 3600 ft.
3	Display Spring (Hot Springs Nat't Park)	Garland	34.5142	93.0528	1	Precipitate, contaminated, in pile of debris cleaned from pool. Minerals identified: none. Major spring system.
4	Iron Spring	Garland	34.7614	93.0739	1	Precipitate, soft, reddish orange, limonitic from pool. Minerals identified: none.
6	Bard Spring	Polk	34.3917	94.0103	1	Precipitate, soft, pale reddish orange from pool. Minerals identified: none. Flowing from black shale.
					California	
1	Grovers Hot Springs	Alpine	38.6986	119.8472	4	Travertine, reddish brown, pale orange, light to dark brown and black; hard to soft granular. Minerals identified: calcite.
4	Fales Hot Springs	Mono	38.3533	119.3958	5	Travertine, brown, in granular crusts, or massive; reddish orange, black; black granular precipitates; granular precipitates mixed with algae. Minerals identified: calcite, dolomite, goethite.
5	Travertine Hot Springs (Bridgeport)	Mono	38.2464	119.2033	3	Travertine, massive, brown, commercial decorative quality; precipitates, soft, white and yellowish gray. Minerals identified: calcite, aragonite, dolomite. Major spring system.

Table 1.—Index of sample localities by states (continued)

Location No.	Name	County	Lat. (degrees)	Long. (degrees)	Number of Samples	Comments*
9	Hot spring (Mono Lake)	Mono	38.0528	119.0806	1	Travertine, brown, hard. Minerals identified: calcite.
					Colorado	
1	Sulfur Springs (near Kremling)	Grand	40.0183	106.2639	1	Precipitate soft, gray, with yellow curds from ditch draining spring. Minerals identified: sulfur, gypsum.
2	Hot Sulfur Springs	Grand	40.0753	106.1122	2	Travertine, light brown, forming main apron; precipitate, yellow, soft from pool. Minerals identified: calcite, sulfur, dolomite.
3	Azure-Yampa Spring (Glenwood Springs)	Garfield	39.5503	107.3208	1	Travertine, pale brown. Minerals identified: calcite. Part of major spring system.
4	Sulfur Springs (Sulfur Mountain)	Park	39.0242	105.6297	3	Precipitates, soft, gray or yellow, sulfurous, collected from spring and drainage. Minerals identified: gypsum, calcite, dolomite.
5	Hartsel Hot Springs	Park	39.0183	105.7942	1	Travertine, cream colored, calcareous. From drainage. Minerals identified: calcite.
7	Salt Works spring (near Antero)	Park	38.9572	105.9408	2	Precipitates, white crust-forming, underlain by black, mud-like. Minerals identified: gypsum, calcite.
9	Sulfur Gulch spring	Delta	38.7867	107.8417	7	Precipitates, gray muds; brittle yellow, black, pink crusts; black muds; hard interstitial cement (calcareous). Minerals identified: none.
10	Austin springs	Delta	38.7856	107.9367	14	Precipitates, rough black and white crusts, brown travertine, purple mud, reddish brown travertine from geyser aprons. Minerals identified: none.
11	Adit spring (near fish hatchery)	Delta	38.7708	107.7667	4	Travertine, pale yellow; crusty, precipitate cement with clay-like material; black mud precipitate. Minerals identified: barite, clay mineral (?).

Table 1.--Index of sample localities by states (continued)

Location No.	Name	County	Lat. (degrees)	Long. (degrees)	Number of Samples	Comments*
12	Doughty Springs	Delta	38.7700	107.7600	19	Precipitates, black, yellow, gray mud-like; brown soil-like; travertine, pale brown from large thick apron; pale yellow sulfurous mud; breccia-like crusts from plants. Minerals identified: calcite, barite. Major spring system.
13	Alum Gulch	Delta	38.7667	107.7647	1	Precipitate, white crystalline at site of spring-like seep. Thick deposit. Minerals identified: alunite.
14	Yellow Soda Spring	Park	38.7386	105.5300	7	Precipitate, red, mud-like; travertine, yellowish red; from steep mound. Minerals identified: calcite, aragonite.
15	Taylor Soda Spring	Fremont	38.6028	105.5500	10	Precipitates; red, mud-like or algaeous; granular, white or red; travertine, reddish brown apron-forming. Minerals identified: calcite, gypsum, halite, aragonite. Major spring system.
17	Poncha Hot Springs	Chaffee	38.4967	106.0764	5	Precipitates; clinker-like, black, red, white, yellow; concretionary crystal mats surrounded by mud-like precipitate. Deposits form hard spongy-looking slope. Minerals identified: calcite, aragonite. Major spring system.
18	Spring (near Powderhorn)	Gunnison	38.2806	107.1097	1	Travetine, pale brown forms small concretionary slabs on ground. Minerals identified: calcite.
19	Mineral Hot Springs	Saguache	38.1689	105.9167	3	Travertine, brown; forms multiple mounds; precipitates, gray, limonite-colored, mud-like with calcareous granules. Minerals identified: calcite.
20	Lower Red Creek soda springs	Pueblo	38.7083	105.4903	1	Travertine, brown; from old apron—no longer active. Minerals identified: calcite.
22	Ouray hot springs (Box Canyon Hotel)	Ouray	38.0186	107.6739	3	Travertine, black, reddish brown, with white layers. Forms spongy slope. Minerals identified: goethite, calcite, manganite, pyrolusite, gypsum, amorphous, manganese minerals. Major spring system.
23	Ophir Iron Spring	San Miguel	37.8606	107.8094	2	Precipitate, reddish brown, brown, spongy to granular; both young and old deposits; old deposit has been mined. Minerals identified: goethite.

Table 1.--Index of sample localities by states (continued)

Location No.	Name	County	Lat. (degrees)	Long. (degrees)	Number of Samples	Comments*
24	Dunton Hot Springs	Dolores	37.7711	108.0928	1	Travertine, brown, in thin brittle sheets over swampy drainage. Minerals identified: calcite, aragonite.
27	Bakers Bridge hot springs (north of Golden Horseshoe Ranch)	La Plata	37.4494	107.8064	1	Travertine, pale yellow with iron oxide staining. Forms steeply-sloping 100-meter long apron. Minerals identified: calcite.
28	Pagosa Springs (spring)	Archuleta	37.4494	107.8	1	Precipitate, white; forms thin crust or film on rocks over which main spring drains. Minerals identified: sulfur, gypsum, calcite (?).
					Idaho	
1	Heise Hot Springs	Jefferson	43.6428	111.6875	3	Precipitate, gray, soft; travertine, brown to yellow, hard. Minerals identified: calcite.
2	Fall Creek Mineral Springs	Bonneville	43.4236	111.4142	2	Travertine, light brown, hard, from active apron- and cone-shaped deposits. Minerals identified: calcite.
3	Soda Springs (geyser)	Caribou	42.6569	111.5794	2	Travertine, yellow, reddish brown, white, in apron around active geyser with active continuous discharge. Carbon dioxide-powered? Artesian? Minerals identified: calcite.
6	Private spring	Franklin	-----	-----	2	Precipitates, reddish brown, mud-like; collected from pool. Minerals identified: calcite, aragonite, goethite.
					Montana	
1	Broadwater hot well	Jefferson	46.1983	112.0950	1	Precipitate, gray, limy, highly contaminated. Minerals identified: calcite, dolomite.
2	White Sulfur Springs	Madison	45.4619	112.4742	2	Precipitates, gray, soft, mud-like; from pool. Minerals identified: calcite.
3	Alhambra hot springs	Jefferson	46.4478	111.9825	5	Precipitates, reddish brown, yellowish brown; yellowish white, present as scale and flaky granules; travertine, pale yellowish white from dry apron deposit. Minerals identified: calcite.

Table 1.--Index of sample localities by states (continued)

Location No.	Name	County	Lat. (degrees)	Long. (degrees)	Number of Samples	Comments*
5	Boulder Hot Springs	Jefferson	46.1983	112.0950	1	Precipitate, white flaky scale on pipe fittings controlling spring flow. Minerals identified: calcite, aragonite, amorphous silica.
6	Warm Springs (near State Hospital)	Deer Lodge	46.1778	112.7950	5	Precipitates, reddish brown, yellowish brown, white, hard brittle granular spongy. Form high truncated cone-shaped mound. Surrounded by swampy apron. Minerals identified: calcite, gypsum, goethite.
11	Biltmore Hot Springs	Madison	45.4619	112.4712	1	Precipitate, whitish-gray, thin brittle crust on algae. Minerals identified: gypsum, calcite.
14	La Duke Hot Spring	Park	45.0900	110.7733	3	Precipitate, brown, black, crusty; travertine, yellow to light brown in actively-forming apron on stream bank. Minerals identified: calcite, aragonite.
					Nevada	
4	Hot springs (near Wells)	Elko	41.1819	114.9892	1	Precipitate, light brown to cream-colored; from top of travertine apron. Minerals identified: calcite.
5	Threemile Sulfur Spring	Elko	41.1536	114.9850	1	Travertine, brown; forms thin crust on wet drainage slope. Minerals identified: none.
6	Golconda Hot Spring	Humboldt	40.9614	117.4931	6	Precipitates, gray to black muds; travertine, brown, dark brown, black and light gray, granular. Minerals identified: calcite, amorphous silica.
10	Sulfur Hot Springs (in Ruby Valley)	Elko	40.5869	115.2853	1	Precipitates, gray; collected from sulfurous pool. Minerals identified: amorphous silica.
11	The Geysers (Beowawe)	Eureka	40.5664	116.5889	2	Precipitates, white granular; deposited from cooling spray; travertine, red brittle, at base of eastern geyser. Minerals identified: calcite, amorphous silica.
12	Kyle Hot Springs	Pershing	40.4069	117.8831	6	Precipitates, gray, yellowish, (sulfurous?), black, yellowish green; travertine, yellowish white, hard. Minerals identified: calcite, gypsum, sulfur, barite, halite.

Table 1.--Index of sample localities by states (continued)

Location No.	Name	County	Lat. (degrees)	Long. (degrees)	Number of Samples	Comments*
14	Buffalo Valley Hot Springs	Lander	40.3672	117.3294	4	Precipitates, gray mud; travertine, soft, yellow. Minerals identified: calcite, aragonite. Major spring system.
15	Sou Hot Springs	Pershing	40.0896	117.7244	2	Travertine, yellowish brown, hard. Large travertine deposit, small spring. Minerals identified: calcite.
*** 18	Monte Neva Hot Springs	White Pine	39.6592	114.8050	11	Precipitates, white, yellow, orange, black, yellowish brown, soft; collected in stream drainage; travertine pale yellowish gray, soft (clays) to very hard. Huge travertine dome. Minerals identified: calcite, aragonite, dolomite. Major spring.
19	Bartine Hot Springs	Eureka	39.5583	116.3589	3	Precipitates, gray, black, reddish brown; collected in pool and drainage area. Minerals identified: calcite.
22	Spencer Hot Springs	Lander	39.3242	116.8494	2	Precipitates, black, mud-like; travertine, yellow in drainage. Minerals identified: calcite.
26	Darrough Hot Springs	Nye	38.8217	117.1833	1	Precipitate, white; collected around plumbing fixtures controlling flow. Minerals identified: calcite, amorphous silica.
29	Grant View hot springs	Lyon	38.9900	118.9733	1	Precipitate, gray, granular; highly contaminated with rock fragments. Minerals identified: calcite.
30	Soda Springs (at Sodaville)	Mineral	38.3428	118.1028	2	Precipitates, white crystalline, black amorphous. Minerals identified: thenardite, calcite, gypsum.
33	Gap Spring	Esmeraldo	37.9794	117.9919	3	Precipitates, gray, mud-like; travertine, yellow, black, iron-red; old and new travertine collected. Minerals identified: calcite, dolomite (?).
34	Alkali Hot Spring	Esmeraldo	37.8247	117.3369	3	Precipitates, white, greenish white; travertine, brownish red; precipitates collected from coating on aluminum pipe. Minerals identified: calcite.

Table 1.--Index of sample localities by states (continued)

Location No.	Name	County	Lat. (degrees)	Long. (degrees)	Number of Samples	Comments*
					New Mexico	
1	Soda Dam Hot Springs	Sandoval	35.7911	106.6858	1	Precipitates, black with travertine crusts. Travertine structure forms large bridge over Jemez River. Minerals identified: calcite.
5	Faywood Hot Springs	Grant	32.5547	107.9950	1	Precipitates, grayish brown travertine mounds with soft soil-like layers. Minerals identified: none.
					Utah	
1	Udy Hot Springs	Box Elder	41.8583	112.1569	2	Precipitates, gray mud in hydrothermal boiling mud pots; travertine, cream-colored. Major travertine deposits have been removed. Minerals identified: calcite, dolomite. Major spring system.
5	Crystal Springs	Box Elder	41.6594	112.0869	1	Travertine, in cream-colored crusts in drainage area. Minerals identified: calcite, dolomite.
6	Poison Spring	Box Elder	41.6278	112.2669	1	Precipitate, pink, mud-like; collected from pool. Swampy area. Minerals identified: calcite, dolomite.
7	Painted Rock spring	Box Elder	41.6208	112.2675	1	Travertine, white; collected from inactive cone-like deposit. Swampy area. Minerals identified: calcite.
9	Stinking Hot Springs	Box Elder	41.5772	112.2319	7	Precipitate, soft, gray; travertine, gray, hard, mostly covered by dry soil-like precipitates. Minerals identified: calcite, barite, dolomite, sulfur. Almost pure barite deposit. Major spring system.
10	Utah Hot Springs	Box Elder	41.3389	112.0289	3	Precipitates, reddish brown, granular-spongy, like iron ore. Minerals identified: calcite.
11	Ogden Hot spring	Weber	41.2358	111.9211	1	Precipitates, soft, black and limonitic looking. Minerals identified: calcite.
12	Hooper Hot Springs	Weber	41.1369	112.1758	1	Precipitate, soft, black, silt-like. Minerals identified: calcite, dolomite.
13	Grantsville Warm Springs	Tooele	40.6464	112.5222	2	Precipitate, dark brown, crusty; travertine, black to gray; many flattened crater-shaped travertine mounds. Minerals identified: calcite.

Table 1.—Index of sample localities by states (continued)

Location No.	Name	County	Lat. (degrees)	Long. (degrees)	Number of Samples	Comments*
14	Midway Hot Springs	Wasatch	40.5264	111.4869	1	Travertine, gray to yellowish gray. Low (1-meter) to high (10-meter) travertine mounds scattered over several-square-mile area. Minerals identified: calcite. Major spring system (formerly?).
*** 18	Wilson Health Springs	Juab-Tooele	39.9094	113.4258	27	Precipitates gray, black, greenish muds; crust-forming salts; massive travertine flat craters of brown to reddish brown travertine. Minerals identified: calcite, gypsum, dolomite. Major spring system. Major regional radioactively anomalous area.
19	Wildhorse Spring	Juab	39.7892	113.1933	4	Precipitates, gray, black, mud-like in spring; travertine, pale grayish yellow, in apron above present spring and in thin crusts on drainage surfaces (watering trough). Minerals identified: calcite. Contamination.
20	Cane Springs	Juab	39.7572	113.4700	2	Travertine, yellow, brown, reddish brown, forms thin crusts in drainage. Peat beds present. Minerals identified: calcite, gypsum.
22	Lime Spring	Juab	39.6633	113.9167	1	Precipitate, gray mud, contaminated. No travertine structures. Minerals identified: calcite, dolomite.
23	Baker Hot Springs	Millard	39.6133	112.7283	4	Precipitates, black, reddish brown, yellowish brown, white with red and black inclusions, rough, hard, spongy. Area has been mined. Minerals identified: calcite, gypsum, hematite, manganite (?), aragonite. Major spring system.
27	Coyote Spring (in Tule Valley)	Millard	39.4239	113.4867	1	Precipitate, dark gray, mud-like. Collected in drainage. Minerals identified: none.
36	Stinking springs (south of Manti)	Sanpete	39.2369	111.6564	2	Precipitate, black, mud-like, travertine, yellowish brown to black gritty fragments. Minerals identified: calcite, dolomite.
41	Monroe Hot Springs	Sevier	38.6406	112.0981	2	Precipitate, granular, hard, reddish brown, black, white. Partly mined. Forms red hill. Minerals identified: calcite, hematite manganite (?), gypsum.
42	Joseph Hot Springs	Sevier	38.6144	112.2019	1	Precipitate, black, reddish brown, hard. Forms part of travertine apron 50 m. by 100 m. dimensions. Minerals identified: calcite, gypsum.

Table 1.--Index of sample localities by states (continued)

Location No.	Name	County	Lat. (degrees)	Long. (degrees)	Number of Samples	Comments*
43	Thermo Hot Springs	Beaver	38.1733	113.2056	1	Precipitate, white, dry, powdery. No apron. Desert environment. Minerals identified: calcite.
44	Dixie Hot Springs	Washington	37.1900	113.2711	1	Precipitate, white travertine-like deposits forming thick coatings on rocks, branches. Minerals identified: calcite, gypsum.
45	Bergan mine	Utah	39.9472	110.7733	1	Travertine, precipitated from mine water; reddish brown. Minerals identified: none.
					Wyoming	
1	Taylor flowing well (at Thermopolis)	Hot Springs	43.6653	108.1944	2	Travertine, white, crystalline; flowing well; apron of travertine on drainage area. Feeds small lake. Minerals identified: calcite.
2	Ulcer spring (at Thermopolis)	Hot Springs	43.6553	108.1978	1	Precipitate, white and reddish brown, soft to gritty, collected from small pool. Minerals identified: calcite.
4	Wedding of the Waters spring	Hot Springs	43.5819	108.2125	1	Precipitate, black mud from bottom of pool. Probably much contamination. Minerals identified: calcite.
5	Granite Creek Hot Spring	Teton	43.3697	110.4450	1	Precipitate, gray, clayey; deposited prior to deversion of spring drainage to swimming pool. Minerals identified: calcite, dolomite.
6	Astoria Mineral Hot Springs	Teton	43.3003	110.7744	1	Precipitate, pale, brown, laced with green algae; drains into river. Minerals identified: calcite.
8	Washakie Mineral Hot Springs	Fremont	43.0078	108.8353	1	Precipitate, light gray mud from west edge of pond adjacent to swimming pool. Minerals identified: calcite.
9	Auburn sulfur spring	Lincoln	42.8308	110.9989	5	Precipitate, yellowish gray, soft; travertine, gray, soft to very hard, forms low mound containing pool. Soft precipitates mined for sulfur. Minerals identified: calcite, sulfur, gypsum, anhydrite, dolomite.
10	Sulfur Springs (at Doty Mountain)	Carbon	41.4928	107.5567	2	Precipitates, black mud; collected from pools. No travertine. Minerals identified: dolomite.

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*Minerals shown are probable precipitate minerals identified by Bove (written commun., 1981). More complete mineralogical data are given in Bove and Felmlee (1981). Other comments are based on field observations recorded when we collected the samples.

**Grand Canyon samples from: J.E. Peterson, S. E. Buell, and C. S. Spirakis, 1977. See: U.S.G.S. Open-File Report 77-36. (Mileages measured down stream on the Colorado River from Lee's Ferry, Arizona.)

***Most radioactive spring areas.

diffractometer analyses of some of the collected precipitate samples were done by R. E. Glanville and D. Bove. Results of the X-ray analyses, combined with petrographic and radiographic studies have been published separately (Bove and Felmlee, 1982).

MINERAL SPRING PRECIPITATE SAMPLES

Location

Precipitate samples were collected at 105 localities in 10 States. A map (fig. 2) shows the geographic location of the springs that were sampled. Names of the springs, geographic coordinates, state and county of origin are listed in table 1. Approximately half of the springs visited were found to contain precipitates. The presence of precipitates is a function of the dissolved ions in the spring water, the abundance of dissolved metals, and the subsurface environment, and surface environment at the spring site.

Morphology

Mineral spring precipitates are deposited in different appearing forms and appearances. The most common form is what is referred to in the literature as a travertine[1/] apron. Figure 3 shows the travertine apron which dominates the city of Thermopolis, Wyoming. The apron is composed principally of calcium carbonate. It extends westward from the Big Spring. Lining the west bank of the Big Horn River is travertine of older age than that in the center of the picture which is now actively forming. Samples were not collected at this site, because it is a State Park, and samples were available at nearby sites, Taylor spring and Ulcer Spring, (WY, 1 and 2, table 1).

Other mineral spring precipitate deposits are more complex. Doughty Springs (CO, 12), forms a travertine apron on the bank of the North Fork of the Gunnison River (fig. 4). The apron is actively growing but is at the same time being undercut and removed by the Gunnison River (fig. 5). The apron is being built by the major springs or clusters of springs. The travertine apron is composed chiefly of calcite and barite. At least one of the major springs is precipitating native S. Precipitates include not only the hard, crystalline laminated travertine, but also wet cryptocrystalline calcareous soft white, gray or yellowish gray muds in the eastern half of the site and soft brown soil-like, or wet yellowish brown and black slime-like precipitates at the western end of the site. The soft precipitates are deposited near the

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[1/] The term travertine, as used here is a field classification of a type of sedimentary rock deposited by chemical precipitation. While its chief component is, in most occurrences, calcium carbonate, many travertines are a mixture of minerals made up of Ca, Sr, Ba, Mg, Fe, and Mn compounds. Conventionally, travertine is a hard, crusty or abrasive rock. This ability to form a resistant surface separates travertine from the other precipitates for field classification purposes. The work of Friedman (1970) and our own observations suggest to us that calcium carbonate is in most instances precipitated as aragonite which recrystallizes at most localities to calcite. (See also Bove and Felmlee, 1982).

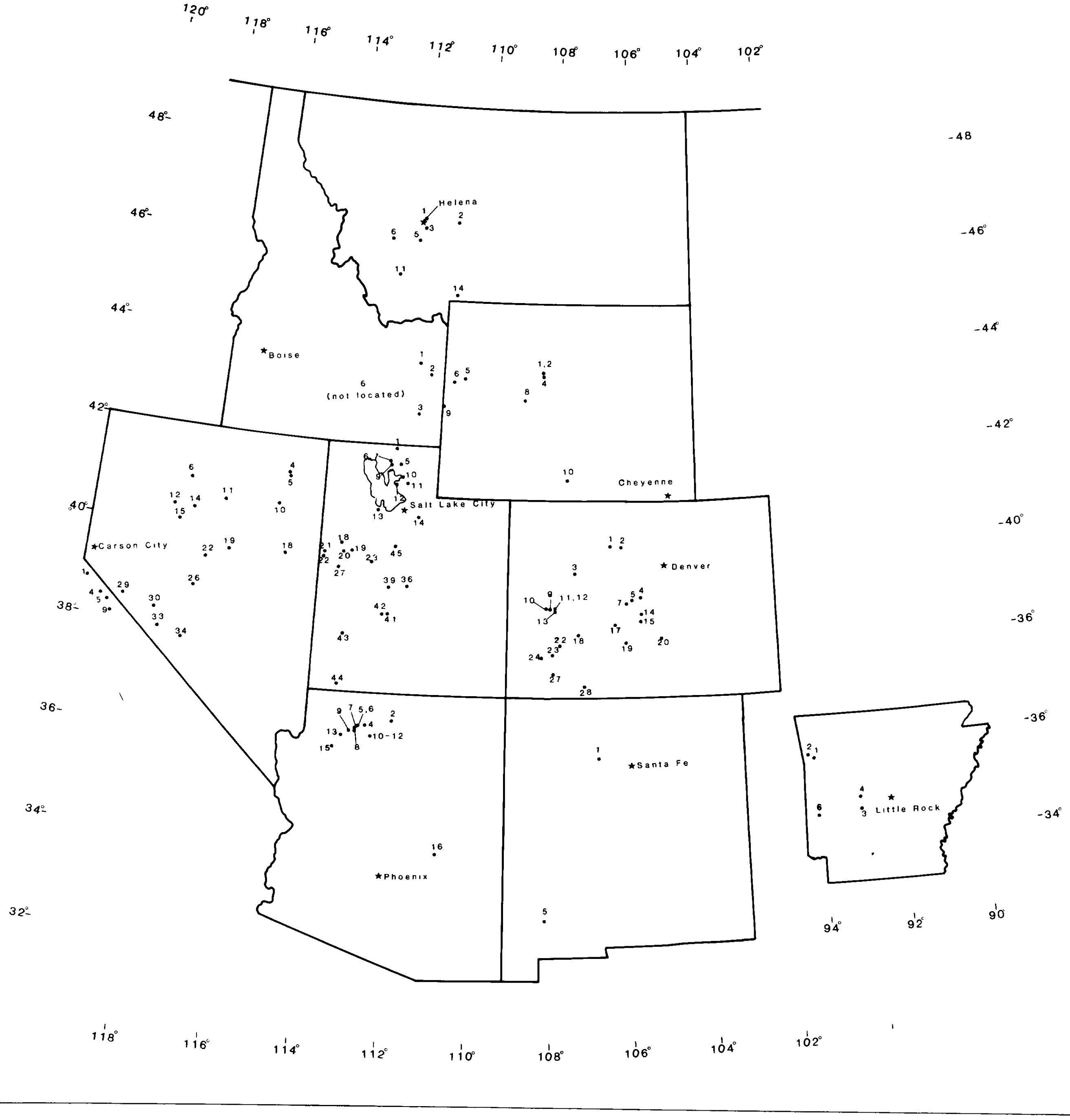

Figure 2. Sample locality map.

Figure 3.--Travertine deposits at Thermopolis, Wyoming. A, Travertine (active). View to the southwest. Big Horn River to the right, flowing southward. Travertine apron (white) in foreground. Dark circular forms are pools of water. Big Spring is to the left and is not visible in the picture. B, Old (inactive) massive travertine deposit related to an ancient (Pleistocene?) spring site. Human figure (circled) seated at left foreground. The travertines range in color from pale brown to cream.

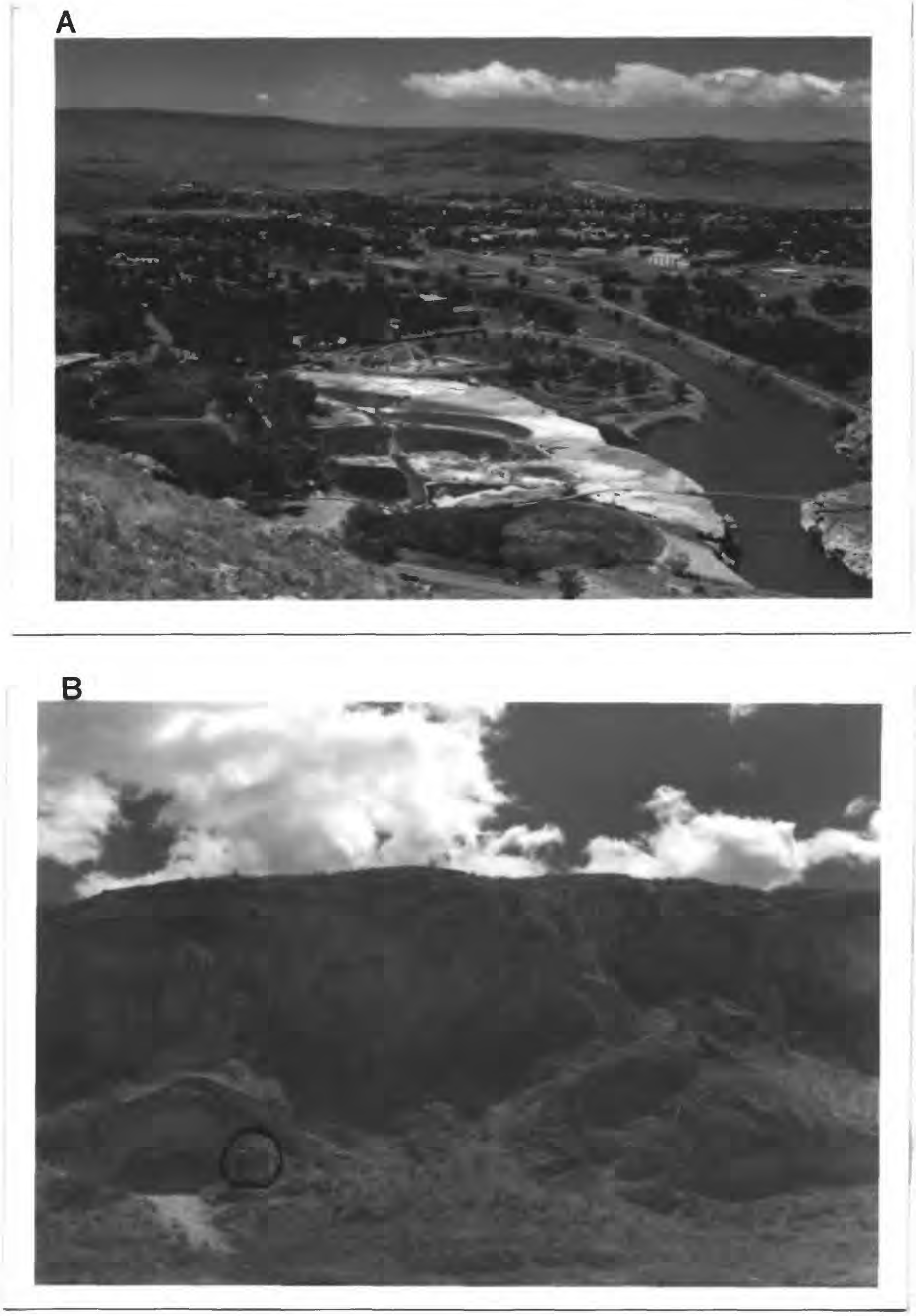

Figure 4.--A composite photo of the Doughty Springs site, Colorado. The Gunnison River flows to the right (westward). Approximately 150 meters of the apron along the north bank of the river is shown. The apron averages 50 meters in width. The west end of the apron is marked by a 2-meter-high post. Other springs are present for about 50-75 meters east of the area in the picture. White drainage channels drain separate groups of springs. The channels contain light-colored soft precipitates, mostly west clay-textured calcium carbonate, barium sulfate and sulfur.

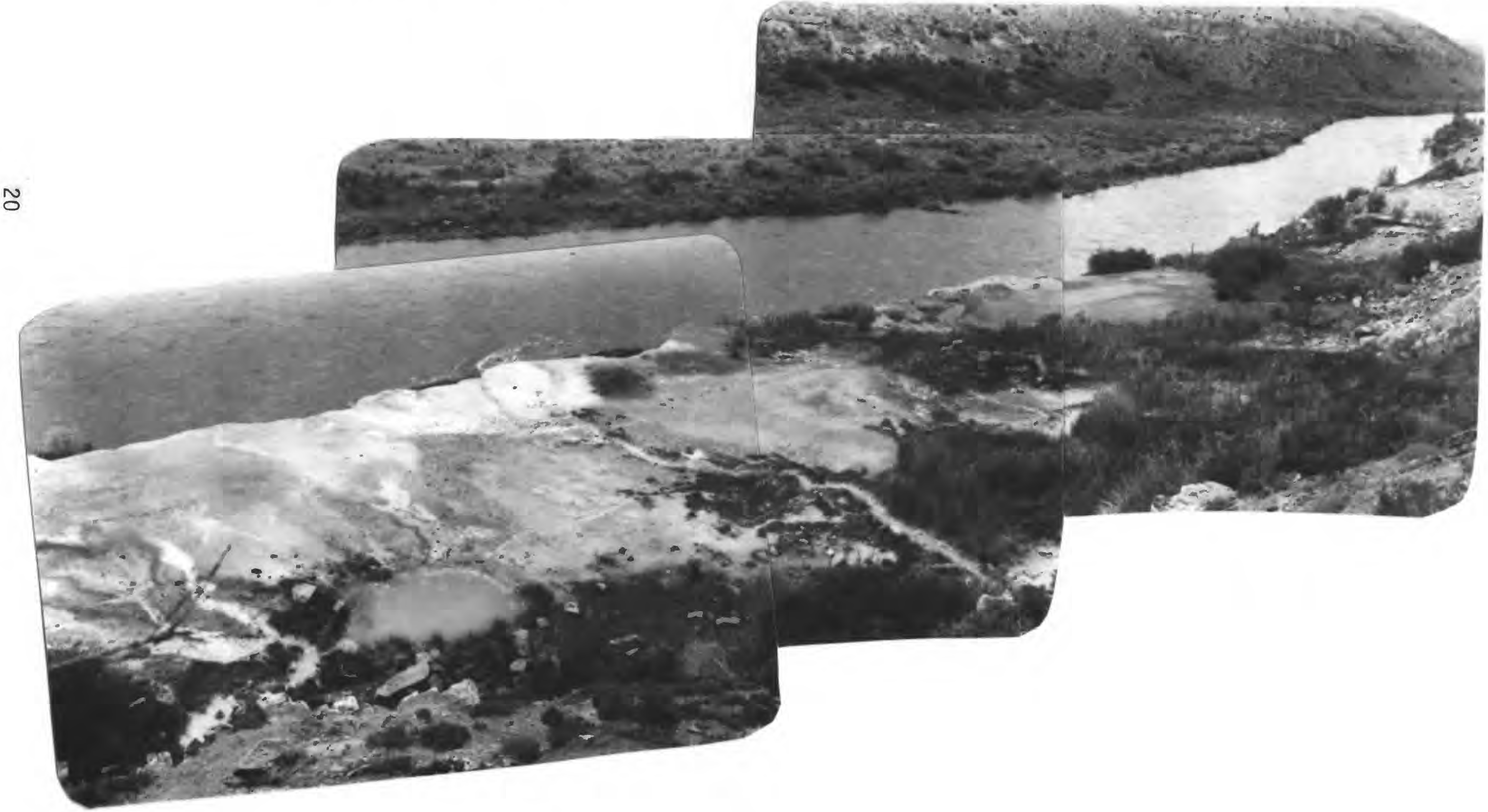

Figure 5.--Precipitates at Doughty Springs. A, Radioactive spring precipitates to the right of geologist's head are barite, surfur, and calcium carbonate with a soft mud-like consistency. B, Broken slabs of laminated travertine undercut by the North Fork of the Gunnison River. Travertine slabs are about 2 m thick at this point.

spring orfices or along the drainage channels, several of which are visible in fig. 4. One pool, in the left foreground, called the Bathtub, contains translucent milky spring water, and is according to Headden (1905) a site of precipitation of barite and coprecipitation of Ra. The precipitate at the bottom of the pool is a soft pale gray mud. Algae growth in the pool is profuse due to the abundant nutrients in the spring water.

Travertine also occurs in spring-constructed mounds (fig. 6, A), as seen at Yellow Soda Spring, or it may fill a small valley (fig. 6, B) as it does at Taylor Sulfur Spring (CO, 14 and 15). Other morphological occurrences of mineral precipitates are illustrated in figures 7 and 8. Because of publication restraints, the varied colors of spring precipitates cannot be illustrated. The iron-rich precipitates vary from light to dark reddish brown. Manganese precipitates tend to be black but are often mixed with interbedded reddish iron precipitates, white gypsum crystals according to Bove and Felmlee (1982), and light brown calcium carbonate travertine. Barium sulfate tends to be gray, or yellowish gray to pale yellow if mixed with free sulfur. Calcium carbonate and barium sulfate in some instances occur as a dry soil-like soft deposit. In the majority of occurrences, however, they form hard massive rock, or brittle thin crusts. In pools or drainage channels, precipitates may be mixed with various luxuriant algae growths and may assume rather botryoidal or exotic forms of greenish white, yellow and pale brown shades. Mineral spring precipitate deposits occur in many different forms and in many different environments. More detailed descriptions of the mineral assemblage in some of the precipitate samples are given in Bove and Felmlee (1982).

Sampling methods

The collection of precipitates from mineral spring deposits was affected by a deliberate bias. The study was oriented toward radioactive springs. For this reason, we tried to collect samples from the most radioactive parts of the deposits as determined by a hand-held scintillometer. Commonly, though, the background radiation at any one of the sample sites was high enough to obscure variations in radioactivity of the precipitates. Background radiation resulted chiefly from the presence of Ra and Rn and their daughter products in the spring waters and precipitates. Measured radiation at any point at a spring site tends to be a resultant of radiation from the immediate surrounding environment or what is called mass effect. Mass effect radiation is quite high at some localities. The order of magnitude of radioactivity of the spring sites varied from 10 times to more than 100 times local backgrounds.

Both wet and dry discrete samples were collected. Sample size ranged from about 100 grams (dry weight) to 2000 grams and averaged about 300 grams. Where samples were collected for routine spectrographic and delayed neutron activation analyses, 200 to 400 grams were collected. Precipitates that showed unusually concentrated radioactivity were sampled in quantities of 2 kg or more so that, if desired, gamma-ray spectrographic analysis could be done in addition to routine analyses. Some precipitates occur in small quantities or in forms such as egg-shell-like coatings on rocks or limonitic slimes. In view of the difficulty of collecting samples of such precipitates, minimum amounts (100± grams) were collected. At sites where precipitate was plentiful, two or more samples were collected. At sites containing sparse precipitate, one sample was collected.

Figure 6.--Travertine deposits at Yellow Soda Spring and Taylor Soda Spring, Colorado. A, Travertine mound(active) at Yellow Soda Spring. Mound is formed when there is a single major orifice which is confined by its hard chemical precipitates. Seepage of spring water through the mound tends to seal off potential alternate orifices. B, Travertine at Taylor Soda Springs. This travertine deposit, 1-4 m thick, probably started as an apron but in time occupied the whole valley. Drainage of meteoric water down the valley eroded the apron to some extent, but was not competent to prevent the growth of the travertine deposit. Several springs contribute to deposition of the travertine. View facing down the valley, to the east. The valley plain is all travertine.

A

B

Figure 7.--Precipitate deposits at Wilson Health Springs, Utah. The site is on the southern edge of the Great Salt Lake "Desert." Several very large hot springs issuing from large flat circular travertine craters flood the old lake bed with radium-bearing water to create one of the largest radioactivity anomalies in the United States. A, Precipitates form mineral crusts, as in the foreground, underlain by black, gray and pale green calcareous muds. View to the northeast. B, Edge of travertine crater. Rippled surface in immediate foreground is a deep hot (70°C) pool. Arc-shaped structure is the rim of the crater. Lake beyond is maintained by spring flow. View to the east. The site must be described as hazardous, because of the scalding hot waters and treachous surface formed by interlayered hard and soft precipitates.

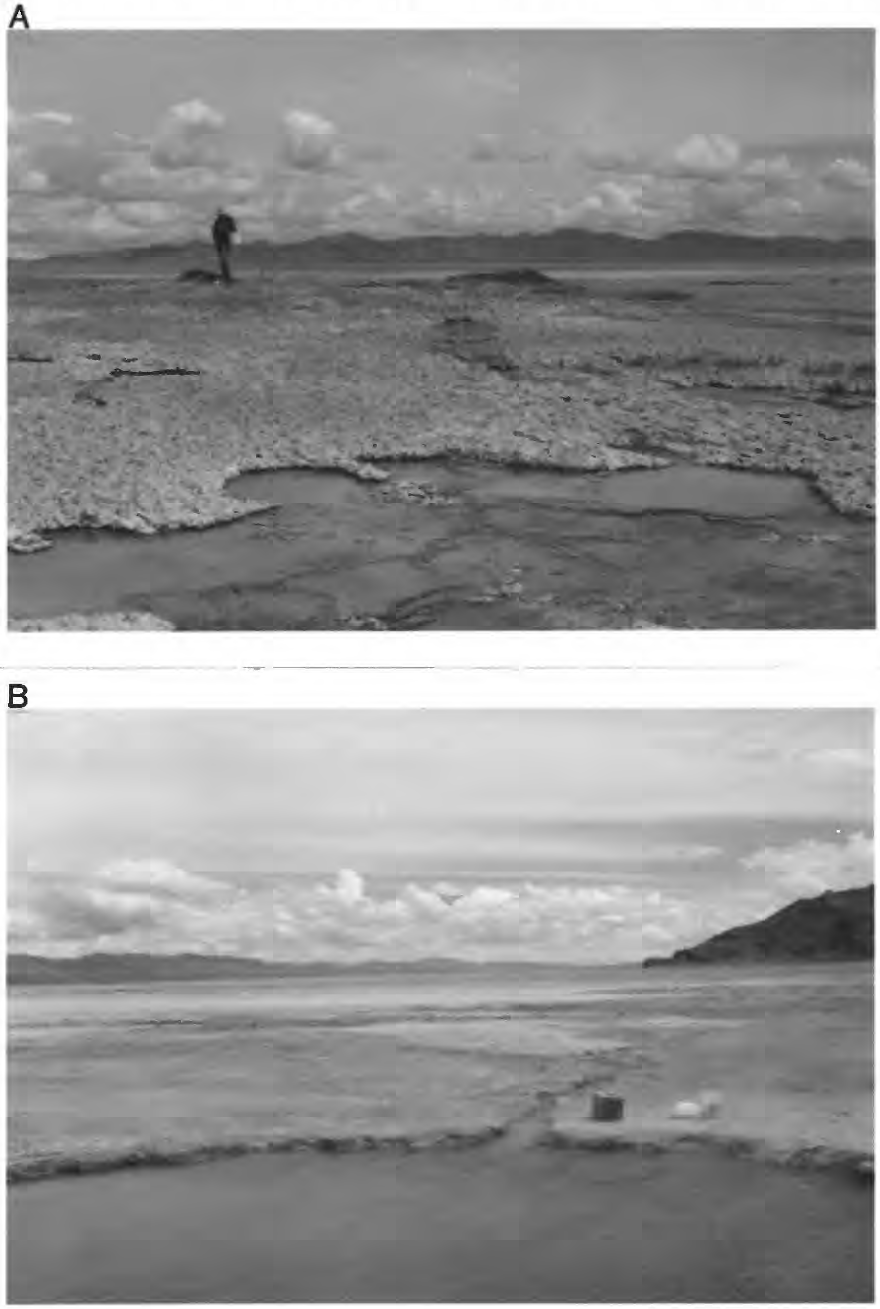

Figure 8.--Travertine deposits at Soda Dam Hot Springs, New Mexico and Poncha Hot Springs, Colorado. A, Massive travertine formation bridging the Jemez River at Soda Dam Springs. Size and age of the "dam" suggests that the spring was much more active in the past. B, Precipitates forming a large, but in the photograph, almost invisible apron on this slope from which Poncha Hot Springs flow. Apron consists of alternating thin light-colored travertine interbedded with coarsely porous spongy-textured dark-colored iron and manganese-rich precipitates.

A

B

We collected samples from both young, presently forming precipitate deposits and older inactive deposits. At radioactive spring sites, 6000-year-old or older precipitate deposits will tend to be nonradioactive because of the radioactive decay of Ra-226--the parent of most of the persistent radioactivity--the half life of which is about 1600 years. This critera was generally used to identify what constituted "older" precipitates; and this combined with geomorphology of the area gave us a feeling about the general age of the spring site. Isolated, dry, nonradioactive travertine deposits, which seem to be related to a nearby active spring system, are probably ancient spring sites of the same system.

Spring systems at some localities are reported to have changed locations of principal orifices, or rates of flow within the memories of local inhabitants. These changes are often attributed to earthquakes or to human activities (excavation, mining, or drilling) at or near the spring sites.

Analytical methods

Most chemical analyses are semi-quantitative. Analysts used a six-step spectrographic method slightly modified from the three-step technique described by Myers, Havens, and Dunton (1961). U and Th were also measured using a delayed neutron method described by Millard (1976). S was determined using the ASTME 30-56 method: combustion iodometric titration. Precision of these methods is discussed in the indicated references. Equivalent uranium (eU) was measured using a beta-gamma scaler calibrated with known U standards. The measured radioactivity is in this study attributed to Ra, because U is present in only trace amounts.

Elements used in the study of spring precipitates are shown in Table 2. Listed in the table are lower reporting limits, upper reporting limits, analytical methods and elements looked for but not detected in any of the samples.

Lower reporting limit is defined as the lowest quantity for which a semiquantitative abundance can be consistently detected and reported. Elements can be observed in trace amounts at levels of abundance below the established lower reporting limit. Such trace amounts are reported as "L values" using the symbol "<" with the detection limit. For example <10 (ppm) means that for a particular sample, the element was detected in an amount less than the lower reporting limit, 10 ppm. Such a reported value is referred to as a qualified value. When an element is not detected it is reported as "N". An element not looked for is reported as "B". An element whose abundance cannot be determined because of chemical interference is reported as "H". A reported value of 50 H (ppm) would mean that owing to chemical interference the lowest detection limit is 50 ppm and none was detected at that level.

The upper reporting limit is the highest value that can be distinguished semiquantitatively. For spectrochemical analyses of the type used, the upper reporting limit is commonly 10 percent or 100,000 ppm. Abundances of an element greater than the upper reporting limit are reported as >10 or >100,000. "Greater than" or G values like the other letter modifiers, L, B, H and N are considered for statistical methods to be qualified values. Real numbers, unqualified values, are termed valid values.

Table 2.--Chemical elements used in the geochemical study of radioactive mineral spring precipitates, methods of analysis, reporting and detection limits

Element	Reported as	Detection limit	Upper Reporting limit	Analytical method
Uranium**	eU ppm	10.	--	Gamma spectrometer
Uranium	U ppm	.1	--	Delayed neutron analysis
Thorium	Th ppm	3	--	Delayed neutron analysis
Sulfur	T-S%	.01	10	Titrachemical
Aluminum	Al%-S	.05	10	Spectrochemical
Calcium	Ca%-S	.07	10 or 20	Spectrochemical
Iron	Fe%-S	.005	10	Spectrochemical
Potassium	K%-S	.7	10	Spectrochemical
Magnesium	Mg%-S	.015	10	Spectrochemical
Sodium	Na%-S	.03	10	Spectrochemical
Silicon	Si%-S	.01	10	Spectrochemical
Titanium	Ti%-S	.0001	10	Spectrochemical
Arsenic	As ppm S	1000	100,000	Spectrochemical
Boron	B ppm S	20	100,000	Spectrochemical
Barium	Ba ppm S	2	100,000	Spectrochemical
Beryllium	Be ppm S	1.5	100,000	Spectrochemical
Cesium	Ce ppm S	200	100,000	Spectrochemical
Cobalt	Co ppm S	5	100,000	Spectrochemical
Cromium	Cr ppm S	1	100,000	Spectrochemical
Copper	Cu ppm S	1	100,000	Spectrochemical
Gallium	Ga ppm S	5	100,000	Spectrochemical
Lanthanum	La ppm S	50	100,000	Spectrochemical
Lithium	Li ppm S	100	100,000	Spectrochemical
Manganese	Mn ppm S	1	100,000	Spectrochemical
Molybdnum	Mo ppm S	3	100,000	Spectrochemical
Niobium	Nb ppm S	10	100,000	Spectrochemical
Nickel	Ni ppm S	5	100,000	Spectrochemical
Lead	Pb ppm S	10	100,000	Spectrochemical
Scandium	Sc ppm S	5	100,000	Spectrochemical
Strontium	Sr ppm S	5	100,000	Spectrochemical
Germanium	Ge ppm S	10	100,000	Spectrochemical
Vanadium	V ppm S	7	100,000	Spectrochemical
Tungsten	W ppm S	100	100,000	Spectrochemical
Yttrium	Y ppm S	10	100,000	Spectrochemical
Yterbium	Yb ppm S	1	100,000	Spectrochemical
Zinc	Zn ppm S	300	100,000	Spectrochemical
Zirconium	Zr ppm S	10	100,000	Spectrochemical

In the spectrochemical method the following elements were standardly looked for but were not detected in the precipitate samples, by this method.

Silver
Gold
Paladium
Platinum
Antimony
Tin
Tellurium
Hafnium
Indium
Uranium
Thallium
Thorium

**Equivalent uranium--mostly due to radium.

Table 3 shows the number of valid and qualified values for each of the 37 elements detected or measured in the 297 samples of spring precipitate samples.

RADIOGEOCHEMISTRY

J. N. Rosholt, C. M. Bunker, J. R. Dooley and Amanulla Nasir Kahn (written commun., 1975, 1976) did a study of sources of radioactivity in selected samples of our mineral spring precipitates. They used gamma ray spectrometry, with a lithium-drifted germanium detector, which provides better resolution between gamma-ray energy peaks than the conventional sodium iodide detector.

They determined that the samples of mineral precipitates on which they worked contain relatively high abundances of Ra-226 of the U-238 series. Samples of relatively fresh precipitate from the Doughty Springs (CO, 12) (samples CD 6217 and CD 6985) and Taylor Soda Springs (CO, 15) (sample 75MS18) were also found to contain unexpectedly large amounts of Ra-228 of the Th-232 series. Rosholt found that sample CD 6217, a soft cream-colored precipitate from one of the Doughty Springs, which contains only 0.4 ppm U-238 and 1 ppm Th-232, contains 1800 ppm Ra-226 equivalent U. This means that 1800 ppm U would be required for equilibrium support and the Ra-226 is, thus, far in excess of the equilibrium amount.

The sample CD 6217 also contains Ra-228 in amounts that would require 7500 ppm of its parent, Th-232, for equilibrium support. Th-228, the immediate daughter of Ra-228 is present in amounts that would require 4000 ppm Th-232 for equilibrium. The Ra-228 and Th-228 are not in equilibrium; there is a excess of Ra-228. The Ra-228 (half-life: 6.7 years) since being precipitated has yielded the relatively insoluble Th-228 (half-life: 1.9 years). The time required to do this is about 2.5 years. Based on the Th-228 and Ra-228 amounts this suggests that the precipitate is 2.5 years old.

Ra-226 and Ra-228 tend to be more mobile in hydrothermal solution than their parents, because usually the U-238 is in an insoluble unoxidized form in the source rocks and Th minerals are generally not soluble. Ra is easily coprecipitated by barite which forms at or near many of the natural orifices at Doughty Springs. The orifice is the surface expression of a distributary conduit through which the hydrothermal solutions flow. Sample CD 6217 contains greater than 100,000 ppm barium.

Radioactive decay rates of the Ra-228 and Th-228 indicated to Rosholt that the original abundance of Ra-228 was close to 9000 ppm in the precipitate. The original amount of Ra-226 has remained about the same because of its slower rate of decay. The relative abundances of the two Ra isotopes suggest that the mineralizing source rocks contained Th-232 to U-238 in the ratio of 6:1.

The Taylor Soda Springs sample suggest a Th/U ratio of 2:1. Rosholt pointed out that such ratios have meaning only when applied to fresh precipitates. Assuming that Ra-226 and Ra-228 are precipitated in abundances with a ratio of 1 to 6, and knowing the half lives of Ra-226 and Ra-228 to be 1600 yr and 6.7 yr respectively. The ratio would drop to 1 to 3 in 6.7 years,

Table 3.--Showing elements and numbers of valid values, qualified values, total number of analyses and percent of valid values. (Abbreviations: G, greater than reporting value; L, less than detection value; N, none detected; H, interference in reading; B, not looked for)

		Qualified values						
Element	Valid values	G	L	N	B	H	Total analyses	Percent valid values
Ra eU	246	0	42	1	4	0	293	85
U	238	0	48	2	9	0	288	83
Th*	77	0	133	28	59	0	238	32
S	182	0	6	7	102	0	195	93
Al	281	6	10	0	0	0	297	95
Ca	112	185	0	0	0	0	297	38
Fe	265	27	5	0	0	0	297	89
K	133	0	5	159	0	0	297	45
Mg	297	0	0	0	0	0	297	100
Na	281	6	8	2	0	0	297	95
Si	209	57	31	0	0	0	297	70
Ti	275	0	14	8	0	0	297	93
As	30	3	38	227	0	0	297	10
B	95	0	65	137	0	0	297	32
Ba	282	15	0	0	0	0	297	95
Be	216	0	9	72	0	0	297	73
Ce*	8	0	41	245	0	3	294	3
Co	84	0	31	182	0	0	297	28
Cr	262	0	9	26	0	0	297	88
Cu	259	0	14	24	0	0	297	87
Ga	122	0	49	126	0	0	297	41
La	53	0	23	222	0	0	297	18
Li	55	0	38	198	0	3	294	20
Mn	284	10	2	1	0	0	297	96
Mo	47	0	44	206	0	0	297	16
Nb	35	0	74	188	0	0	297	12
Ni	141	0	37	119	0	0	297	47
Pb	108	0	29	160	0	0	297	36
Sc	78	0	50	169	0	0	297	26
Sr	288	9	0	0	0	0	297	97
Ge	74	0	11	176	36	0	261	28
V	173	0	22	102	0	0	297	58
W*	22	0	39	235	0	1	296	7
Y	135	0	45	117	0	0	297	45
Yb	81	0	28	152	36	0	261	31
Zn	33	0	23	236	0	5	292	11
Zr	178	0	11	108	0	0	297	60

*Elements with too few valid values to be used in a data matrix.

1 to 1.5 in 13.4 years, and in 40 years all but 1.5 percent of the Ra-228 would have disintegrated. The Th-228, with a 1.9-yr half life would be essentially gone.

Most of the radioactive precipitates sampled, particularly the recrystalized hard precipitates can, therefore, be expected to contain predominately Ra-226 and daughter products. All other radiation in the greater than 50-year-old precipitates would be from the small amounts of U-238 and Th-232 and their daughters. Most mineral spring precipitate deposits are probably hundreds to hundreds of thousands of years old. The original Ra-226 in a precipitated mineral deposit would be essentially undetectable in the field after 6500 years.

In summary, radioactivity as measured at spring localities would have as its sources, Ra-226, recently precipitated Ra-228 and daughter Th-228, Rn-222, and Rn-220 (thoron) and daughters, and the trace amounts of U-238 and Th-232. Rn is present in both spring water and precipitates. The radioactivity of the average spring deposit is dominated by the relatively long-lived Ra-226. Rn-222 and Rn-220 entrained in the spring waters can be detected separately using a "radon detector", but while a semi-quantitative measurement can be made of the quantity of Rn-222, only a qualitative sensing can be made for Rn-220 because of its short half-life (55 sec.) and the present equipment used. A high thoron (Rn-220) content of water from a mineral spring would suggest a relatively high abundance of Th-232 in the source rocks and a high rate of deposition of Ra-228--if Ra is being precipitated at the spring site.

For reasons discussed above, the persistence of the Ra-226, all equivalent uranium (eU) values obtained from samples of radioactive mineral spring precipitates are assigned to Ra, and treated as a measure of Ra-226.

The final stable products of the radioactive disintegration of Ra-226 and Ra-228 are the radiogenic lead isotopes Pb-206 and Pb-208. When old hydrothermal mineral deposits are found to contain these lead isotopes significantly in excess of equilibrium with the accompanying U-238 and Th-232, it is highly probable that the parent elements precipitated in the mineral deposit were Ra-226 and Ra-228.

Mineral springs arising from the ocean deeps, although rich in polymetalic sulfides, may not be radioactive. Samples collected by Alexander Malahoff (written commun., 1982) deposited from springs issuing from the Galepagos Rift are not radioactive. The springs precipitate minerals that are apparently products of sea water reaction with molten tholeiitic basalts. (See also Malahoff, 1982).

STATISTICAL ANALYSIS

Data

Table 4 shows the raw analytical data on which the statistical analysis is based. The data are listed by State and by State location number. The location numbers are the same as those listed in table 1 and shown on figure 2. All qualified values are shown. The letter "G" has been replaced by the

">" (greater than) symbol and the letter "L" has been replaced by the "<" (less than) symbol. The "not-looked-for" letter "B" has been replaced by dashes "- - - ". The interference symbol "H" has not been replaced.

Table 4 consists of 297 samples and 40 columns. Three of the columns are sample identification and location parameters. The other 37 are analytical parameters. Based on table 4, a modified data matrix was prepared for computer applications of statistical programs.

The modified data matrix is designed to use as much of the analytical parameters as possible. Numerical values were substituted for the G and L qualified values. The G values were replaced by numerical values equal to twice that of the upper reporting limit. The qualified value 20G or >20, for example, was replaced by the value 40. The L values are replaced by numerical values four "steps" down from the given lower reporting limit. The steps used in the "six-step" method of reporting spectrochemical results are the series 10, 7, 5, 3, 2, 1.5, 1.0, 0.7, 0.5. and so on. The qualified value <10, or 10L, for example, was replaced by the numerical value 2.0.

The substituted numerical values in the modified data matrix were treated for statistical purposes as valid values in order to increase the amount of usable information available from the basic data of table 4. No substitution was made for the N-qualified (none detected) values.

Table 5 is a summary of estimates of population statistical parameters of the chemical elements that make up the mineral spring precipitate samples based on the modified data matrix. It includes geometric means and estimated ranges of means at the 95 percent confidence levels, maximum and minimum values in the data matrix, standard deviations of the logarithmic distributions of the element values, and the number of values in the data matrix for each element.

Histograms of the data values for each element are shown in figures 9-12. The class midpoints on the histograms are natural logarithms of the analytical values. The purpose of the figures is to show the general shape of the value frequency distributions. Log values are used because the frequency distributions tend to be log-normal. Class intervals used were selected by the computer according to the U.S. Geological Survey STATPAC program D0036 (George VanTrump, unpub. program, 1978).

Element abundances

Elements in table 5 are shown in order of their abundance. Geometric mean values are estimates of the average abundance for Ca, Si, Fe, Na, Al, Ba, Mn, and As. In some samples, the proportions of these elements exceed the upper reporting limit of the analytical method. This is particularly true of Ca. Two different spectrochemical systems were used for the samples. The two systems produced results of comparable precision, but had different reporting limits for some elements. Reported Ca abundances were most affected. One system had an upper reporting limit of 10 percent (10G); the other system had an upper limit of 20 percent (20G). We estimated these maximum values as 20 percent and 40 percent respectively. Thus, if one of our samples was composed

Table 4 Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states.

[<, less than, >, greater than, --, not analyzed; N, not detected; H, analytical interference.]

LOC.	Sample	LAB. NO.	eU ppm	U ppm	Th ppm	T-S%	Al%-S	Ca%-S	Fe%-S	K%-S
					ARIZONA					
02	CF2	180,960	<10	1.3200	<1.80	--	.70	>10.00	.200	N
04	CF9	180,965	20	5.7600	<3.30	--	2.00	>10.00	.700	.70
05	CF11	180,967	<10	4.7400	<3.20	--	.50	>10.00	.200	N
06	CF10	180,966	<10	2.8500	<2.60	--	1.50	>10.00	.700	.70
07	CF12	180,968	<10	3.2100	<2.90	--	.30	>10.00	.100	N
08	CF13	180,969	<10	1.9700	<2.10	--	.07	>10.00	.020	N
09	CF14	180,970	<10	.8800	<1.70	--	.15	>10.00	.050	N
10	CF6	180,962	10	.2300	<1.40	--	.07	>10.00	.030	N
11	CF7	180,963	10	.3400	<1.20	--	.50	>10.00	.030	N
12	CF8	180,964	<10	1.7300	<1.80	--	.30	>10.00	.020	N
13	CF4	180,961	10	.8400	<1.80	--	.30	>10.00	.150	N
13	CF15	180,971	<10	4.4800	<2.90	--	1.00	>10.00	.700	N
15	CF16	180,972	20	4.3800	8.20	--	2.00	>10.00	1.000	1.50
16	CD76-2	179,494	<10	2.1000	<2.80	--	.50	1.50	1.500	N
16	CD76-3	179,495	50	3.3400	<3.80	--	>10.00	10.00	2.000	10.00
16	CD76-4	179,496	<10	2.6200	<3.50	--	>10.00	>10.00	3.000	10.00
16	CD76-5B	179,497	2,380	4.0500	5.30	--	5.00	2.00	>10.000	3.00
16	CD76-6B	179,498	510	4.3700	8.00	--	1.00	>10.00	>10.000	N
16	CD76-7	179,499	200	8.1500	<5.20	--	1.50	>10.00	10.000	N
16	CD76-8	179,500	10	2.5600	<3.00	--	1.50	>10.00	1.500	N
16	CD76-9B	179,501	1,520	7.3100	<4.80	--	.30	>10.00	>10.000	N
16	CD76-10	179,502	140	9.7100	<5.60	--	.50	>10.00	2.000	N
					ARKANSAS					
01	CD77-91	195,105	190	1.2300	3.27	19.93	1.00	.50	3.000	N
01	CD77-92	195,106	380	2.4200	8.72	2.53	7.00	10.00	3.000	3.00
01	CD77-93	195,107	330	1.6000	--	8.20	2.00	>10.00	1.500	.70
01	CD77-64	195,108	--	2.2400	--	21.54	1.50	5.00	1.500	.70
01	CD77-65	195,109	500	2.8000	10.07	5.96	3.00	1.50	3.000	1.50
01	CD77-66	195,110	560	2.8900	7.81	9.29	3.00	1.50	2.000	1.50
02	CD77-67	195,111	340	3.3200	11.97	1.06	5.00	1.00	3.000	1.50
02	CD77-68	195,112	190	1.3500	5.20	7.21	1.50	.20	3.000	N
03	CD77-69	195,113	70	2.7500	5.24	.10	2.00	2.00	3.000	1.00
04	CD77-70	195,114	<10	2.9700	5.62	.12	3.00	.15	10.000	1.00
06	CD77-72	195,116	--	--	--	.95	1.50	.30	>10.000	1.50
					CALIFORNIA					
01	79KF46	215,622	290	< 1400	<1.30	.07	<.25	>20.00	.400	.16
01	79KF47	215,623	100	.1800	2.60	.09	<.25	>20.00	.860	.17
01	79KF48	215,624	70	<.1100	<1.30	.08	<.25	>20.00	.060	.14
01	70KF50	215,625	100	.1700	1.60	.22	<.25	>20.00	.610	.18
04	CD77-18	189,949	280	2.7600	5.31	.02	1.50	>10.00	1.500	1.50

Table 4. Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states-Continued.

[<, less than; >, greater than; --, not analyzed; N, not detected; H, analytical interference.]

Sample	Mg%-S	Na%-S	Si%-S	Ti%-S	As ppm-S	B ppm-S	Ba ppm-S	Be ppm-S	Ce ppm-S	Co ppm-S
					ARIZONA					
CF2	1.500	.200	1.00	.0150	N	N	200.0	N	N	N
CF9	1.500	.500	7.00	.0500	N	<5.00	300.0	N	N	N
CF11	.700	.150	1.50	.0150	N	N	30.0	N	N	N
CF10	1.000	.700	7.00	.0500	N	N	150.0	N	N	N
CF12	.700	.200	3.00	.0150	N	N	30.0	N	N	N
CF13	1.000	.150	.20	.0002	N	N	500.0	N	N	N
CF14	.200	.050	1.00	.0070	N	N	20.0	N	N	N
CF6	.005	.700	.20	.0010	N	20.00	5.0	N	N	N
CF7	.150	<.03	.07	.0005	N	N	15.0	N	N	N
CF8	.200	<.03	.07	.0005	N	N	70.0	N	N	N
CF4	.100	.500	2.00	.0150	N	50.00	30.0	N	N	N
CF15	.700	.300	5.00	.0500	N	N	500.0	N	N	N
CF16	.700	1.000	>10.00	.1000	N	<20.00	700.0	1.0	N	2.0
CD76-2	.300	.070	>10.00	.0150	1,500.0	150.00	1,500.0	15.0	N	200.0
CD76-3	2.000	.700	>10.00	.0500	N	50.00	300.0	2.0	300.0000	10.0
CD76-4	.700	.700	>10.00	.1500	N	150.00	500.0	10.0	N	30.0
CD76-5B	1.500	1.500	>10.00	.3000	100,000.0	50.00	700.0	200.0	N	100.0
CD76-6B	.500	7.000	3.00	.0300	>100,000.0	150.00	200.0	500.0	N	N
CD76-7	1.000	1.000	3.00	.0150	50,000.0	100.00	200.0	100.0	N	30.0
CD76-8	2.000	1.000	1.00	.1500	N	N	300.0	1.5	N	5.0
CD76-9B	.500	1.500	.70	.0015	>100,000.0	70.00	1,000.0	200.0	N	100.0
CD76-10	.700	2.000	.70	.0200	3,000.0	<20.00	70.0	30.0	N	5.0
					ARKANSAS					
CD77-91	.150	.500	>10.00	.0700	N	<20.00	200.0	N	N	<5.0
CD77-92	.500	.700	10.00	.3000	N	30.00	500.0	1.5	N	10.0
CD77-93	.500	.700	10.00	.1500	N	<20.00	500.0	N	N	<5.0
CD77-64	.200	1.000	>10.00	.1500	N	30.00	500.0	1.5	N	5.0
CD77-65	.300	.700	>10.00	.5000	N	50.00	500.0	2.0	N	15.0
CD77-66	.300	2.000	>10.00	.3000	N	50.00	500.0	2.0	N	10.0
CD77-67	.500	.300	>10.00	.3000	N	50.00	300.0	2.0	N	15.0
CD77-68	.200	.300	>10.00	.1000	N	20.00	150.0	N	N	7.0
CD77-69	.300	.200	>10.00	.1500	N	20.00	3,000.0	3.0	N	10.0
CD77-70	.150	.500	>10.00	.1500	N	<20.00	200.0	1.5	N	30.0
CD77-72	.200	2.000	10.00	.1000	N	20.00	150.0	1.5	N	<5.0
					CALIFORNIA					
79KF46	.200	<.150	<10.00	<.0300	<200.0	<10.00	760.0	11.0	<100.0000	9.7
79KF47	.300	.170	<10.00	<.0300	<200.0	<10.00	630.0	8.5	<100.0000	8.7
79KF48	160	.290	<10.00	<.0300	<200.0	<10.00	590.0	6.0	<100.0000	9.1
70KF50	.240	<.150	<10.00	<.0300	<200.0	<10.00	520.0	11.0	<100.0000	9.2
CD77-18	1.500	1.000	5.00	.1500	N	70.00	1,000.0	30.0	N	<5.0

Table 4. Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states-Continued.

[<, less than, >, greater than; --, not analyzed; N, not detected; H, analytical interference.]

Sample	Cr ppm-S	Cu ppm-S	Ga ppm-S	La ppm-S	Li ppm-S	Mn ppm-S	Mo ppm-S	Nb ppm-S	Ni ppm-S	Pb ppm-S
					ARIZONA					
CF2	15.0	1.5	N	N	N	200	N	N	N	N
CF9	7.0	7.0	5	N	N	70	N	N	N	N
CF11	2.0	1.0	N	N	N	15	N	N	N	N
CF10	15.0	7.0	5	N	N	70	N	N	3.0	N
CF12	2.0	1.5	N	N	N	20	N	N	N	N
CF13	2.0	N	N	N	N	5	N	N	N	N
CF14	2.0	1.0	N	N	N	10	N	N	N	N
CF6	2.0	N	N	N	N	7	N	N	N	N
CF7	2.0	N	N	N	N	7	N	N	N	N
CF8	3.0	1.5	N	N	N	5	N	N	N	N
CF4	7.0	1.0	N	N	N	100	N	N	N	N
CF15	15.0	3.0	5	N	N	70	N	N	5.0	N
CF16	50.0	5.0	7	30	N	300	N	N	3.0	10
CD76-2	7.0	150.0	<5	<30	N	50,000	20	<10	30.0	150
CD76-3	10.0	15.0	20	200	N	700	N	N	7.0	70
CD76-4	15.0	20.0	30	N	N	1,500	5	<10	10.0	70
CD76-5B	50.0	20.0	15	N	N	7,000	10	<10	50.0	30
CD76-6B	10.0	5.0	N	N	N	500	N	<10	3.0	1,500
CD76-7	7.0	15.0	5	N	N	3,000	N	N	30.0	N
CD76-8	15.0	15.0	<5	N	N	1,500	N	N	10.0	N
CD76-9B	3.0	15.0	N	N	N	10,000	20	<10	50.0	700
CD76-10	5.0	7.0	<5	N	N	1,000	N	N	5.0	15
					ARKANSAS					
CD77-91	300.0	70.0	N	N	N	150	N	N	15.0	200
CD77-92	150.0	15.0	10	<30	<100	300	N	N	30.0	15
CD77-93	70.0	10.0	7	N	<100	200	N	N	10.0	10
CD77-64	70.0	20.0	7	N	<100	150	N	N	10.0	15
CD77-65	70.0	20.0	15	N	<100	300	N	<10	30.0	30
CD77-66	100.0	20.0	15	N	<100	300	N	10	20.0	30
CD77-67	100.0	30.0	15	<30	<100	700	N	10	50.0	50
CD77-68	50.0	20.0	7	N	N	300	N	N	20.0	100
CD77-69	50.0	70.0	10	N	N	>10,000	N	<10	150.0	70
CD77-70	50.0	20.0	15	N	N	500	N	<10	30.0	20
CD77-72	20.0	20.0	N	N	N	700	N	<10	15.0	15
					CALIFORNIA					
79KF46	15.0	4.7	<10	53	<50	2,600	<10	<50	13.0	<10
79KF47	13.0	4.8	<10	39	<50	1,400	<10	<25	11.0	15
79KF48	14.0	4.7	<10	46	<50	1,100	<10	<50	12.0	<10
70KF50	14.0	5.7	<10	43	<50	2,300	<10	<50	12.0	<10
CD77-18	7.0	15.0	5	N	N	1,500	3	N	10.0	<10

Table 4. Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states-Continued.

[<, less than, >, greater than; --, not analyzed; N, not detected; H, analytical interference.]

Sample	Sc ppm-S	Sr ppm-S	Ge ppm-S	V ppm-S	W ppm-S	Y ppm-S	Yb ppm-S	Zn ppm-S	Zr ppm-S
				ARIZONA					
CF2	N	700.00	N	5	N	N	N	N	50
CF9	N	700.00	N	15	N	N	N	N	70
CF11	N	1,500.00	N	5	N	N	N	N	N
CF10	N	1,000.00	N	15	N	N	N	N	200
CF12	N	1,000.00	N	5	N	N	N	N	50
CF13	N	500.00	N	N	N	N	N	N	N
CF14	N	700 00	N	N	N	N	N	N	N
CF6	N	1,000.00	N	N	N	N	N	N	N
CF7	N	70.00	N	N	N	N	N	N	N
CF8	N	200.00	N	N	N	N	N	N	N
CF4	N	2,000 00	N	N	N	N	N	N	30
CF15	N	300.00	N	15	N	N	N	N	50
CF16	N	1,000.00	N	10	N	15	2.0	N	500
CD76-2	<5	300.00	N	100	N	30	2.0	300	20
CD76-3	7	500.00	N	150	N	20	2.0	N	70
CD76-4	7	200.00	N	150	N	20	5.0	N	100
CD76-5B	10	500.00	100	100	N	50	N	500	150
CD76-6B	50	3,000.00	100	100	N	150	15.0	N	70
CD76-7	N	5,000.00	50	15	N	20	1.0	N	70
CD76-8	<5	2,000.00	N	50	N	N	N	N	15
CD76-9B	70	2,000.00	70	100	N	150	15.0	700	70
CD76-10	7	10,000.00	N	20	N	N	N	N	10
				ARKANSAS					
CD77-91	<5	70.00	N	15	N	10	1.0	N	150
CD77-92	7	1,000.00	N	70	N	30	3.0	N	150
CD77-93	<5	1,500.00	N	30	N	15	1.5	N	100
CD77-64	7	500.00	N	30	N	15	1.5	N	200
CD77-65	7	200.00	N	50	N	20	3.0	300	200
CD77-66	7	300.00	N	50	N	20	3.0	N	150
CD77-67	7	150.00	N	70	N	20	3.0	300	200
CD77-68	<5	50.00	N	20	N	15	2.0	N	150
CD77-69	<5	150.00	N	100	N	20	3.0	300	150
CD77-70	5	70.00	N	30	N	15	N	300	150
CD77-72	<5	150.00	N	30	N	10	N	N	70
				CALIFORNIA					
79KF46	<10	>5,000 00	--	31	<100	14	--	H	<20
79KF47	<10	>5,000.00	--	27	<100	12	--	H	<20
79KF48	<10	>5,000.00	--	25	<100	<10	--	H	<20
70KF50	<10	>5,000.00	--	26	<100	16	--	H	<20
CD77-18	N	3,000.00	N	30	N	<10	<1.0	N	70

Table 4 Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states-Continued.

[<, less than; >, greater than, --, not analyzed; N, not detected; H, analytical interference.]

LOC.	Sample	LAB. NO.	eU ppm	U ppm	Th ppm	T-S%	Al%-S	Ca%-S	Fe%-S	K%-S
				CALIFORNIA --continued						
04	CD77-19	189,950	480	2.1100	--	.83	.70	10.00	>10.000	N
04	CD77-20	189,951	290	3.7700	--	.34	.70	7.00	.700	N
04	CD77-21	189,952	200	5.1500	9.90	.37	7.00	5.00	3.000	3.00
04	79KF53	215,626	10	1.8600	<2.10	.07	.32	>20.00	<.010	.34
05	CD77-26	189,957	10	.9900	--	.15	.07	>10.00	.300	N
05	CD77-27	189,958	10	.7000	--	.24	.50	>10.00	.200	N
05	CD77-28	189,959	30	6.2200	16.89	2.56	7.00	7.00	3.000	3.00
09	79KF28	215,621	20	<.1400	1.40	.03	<.25	>20.00	<.050	.15
					COLORADO					
01	CD76-24	182,685	60	.6600	<2.80	57.74	1.00	.30	.700	N
02	CD76-25A	182,686	130	.3600	<1.80	.06	.70	>10.00	.300	N
02	CD76-25B	182,687	20	--	--	28.65	5.00	.70	.700	3.00
03	CD76T1	186,029	10	.2900	<1.50	2.13	.30	>10.00	1.000	N
04	CD76T6	186,035	30	3.9900	16.90	4.92	10.00	.70	2.000	3.00
04	CD76T7	186,036	20	5.3300	14.40	1.15	>10.00	1.50	5.000	3.00
04	CD76T8	186,037	10	2.4600	10.40	.05	10.00	>10.00	3.000	3.00
05	CD76T5	186,034	20	.9000	3.70	2.03	3.00	>10.00	1.500	1.50
07	CD76T3	186,032	20	.7100	<2.30	12.76	1.00	>10.00	.700	N
07	CD76T4	186,033	30	2.1000	8.63	1.42	7.00	>10.00	1.500	3.00
09	CD5903	JAA53	60	23.1000	N	1.05	5.00	>10.00	.700	2.00
09	CD5906	JAA56	<30	3.2000	N	13.00	1.50	>10.00	5.000	.70
09	CD5911	JAA61	<30	1.4800	N	14.00	1.50	>10.00	.200	N
09	CD5913	JAA63	<30	2.2100	5.40	.17	5.00	>10.00	1.500	3.00
09	CD5929	JAA82	<30	--	N	N	7.00	10.00	2.000	1.50
09	CD5930	JAA83	<30	--	N	14.00	1.00	.15	1.500	N
09	CD5994	JAA603	50	4.1000	7.20	1.23	2.00	>10.00	.700	.70
10	CD5884	JAA33	<30	N	N	N	5.00	3.00	3.000	2.00
10	CD5888	JAA36	<30	N	1.20	N	.30	.20	.070	.70
10	CD5889	JAA37	50	.3900	N	N	1.50	>10.00	.700	N
10	CD5892	JAA40	<30	.3800	2.10	N	1.00	>10.00	.150	N
10	CD5993	JAA602	<30	--	N	N	.20	.70	.030	3.00
10	CD6172	JAA660	<30	--	N	.10	.20	>10.00	.070	2.00
10	CD6173	JAA661	N	.2100	N	N	.15	>10.00	.030	N
10	CD6177	JAA665	60	1.3200	4.69	.08	2.00	>10.00	>.001	N
10	CD6178	JAA666	<30	13.1000	N	.10	.30	>10.00	.100	N
10	CD6179	JAA667	50	39.2000	N	.90	.70	>10.00	2.000	<.70
10	CD6182	JAA670	<30	13.2000	N	1.00	.70	>10.00	1.500	N
10	CD6188	JAA676	60	30.6000	N	.60	.15	>10.00	1.000	N
10	CD6189	JAA677	90	--	N	.70	.30	>10.00	2.000	N

Table 4 Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states-Continued.

[<, less than; >, greater than, --, not analyzed, N, not detected; H, analytical interference.]

Sample	Mg%-S	Na%-S	Si%-S	Ti%-S	As ppm-S	B ppm-S	Ba ppm-S	Be ppm-S	Ce ppm-S	Co ppm-S
CALIFORNIA --continued										
CD77-19	.700	.300	3.00	.0200	3,000.0	70.00	300.0	30.0	N	5.0
CD77-20	.700	.700	3.00	.0150	N	20.00	200.0	15.0	N	N
CD77-21	.700	3.000	>10.00	.2000	N	50.00	700.0	15.0	<200	<5.0
79KF53	.480	<.300	<10.00	<.0600	<400.0	<20.00	320.0	30.0	<200	12.0
CD77-26	.700	.500	.15	<.0001	N	N	150.0	15.0	N	N
CD77-27	2.000	.700	1.00	.0150	N	N	200.0	20.0	N	N
CD77-28	1 000	3.000	>10.00	.3000	N	30.00	3,000.0	10.0	<200	5.0
79KF28	2.000	.240	<10 00	<.0300	<200.0	<10.00	140.0	<1.0	<100	6.9
COLORADO										
CD76-24	.050	.300	7.00	.0700	N	<20.00	1,000.0	N	N	N
CD76-25A	1 000	.500	.70	.0100	N	N	1,500.0	30.0	N	<5.0
CD76-25B	.070	1 500	>10.00	.1000	N	<20.00	700.0	N	N	N
CD76T1	.500	.700	.50	.0070	N	N	70.0	5.0	N	<5.0
CD76T6	.150	1.000	>10.00	.0300	N	20.00	1,500.0	3.0	<200	<5.0
CD76T7	.300	1.500	>10.00	.2000	N	30.00	7,000.0	10.0	<200	70.0
CD76T8	.700	.700	>10.00	.2000	N	30.00	300.0	2.0	N	10.0
CD76T5	.700	.700	>10.00	.1000	N	<20.00	300.0	N	N	<5.0
CD76T3	.300	1.500	3.00	.0300	N	<20.00	100.0	N	N	<5.0
CD76T4	.700	3.000	>10.00	.2000	N	50.00	700.0	N	<200	<5.0
CD5903	.700	3.000	7.00	1000	N	30.00	300.0	N	N	<3.0
CD5906	.500	1.500	7 00	.0700	N	20.00	200.0	30.0	N	5.0
CD5911	.500	.700	5.00	.0200	N	<20.00	70.0	15.0	N	N
CD5913	1.000	1.500	>10 00	.1500	N	20.00	300.0	N	N	7.0
CD5929	700	1 500	>10.00	.1500	N	50.00	200.0	5.0	N	7.0
CD5930	500	.002	.30	.0050	N	N	15.0	N	N	7.0
CD5994	.700	2.000	10 00	.0700	N	50.00	300.0	30.0	N	N
CD5884	.500	1.500	>10.00	.1500	N	50.00	300.0	3.0	N	5.0
CD5888	200	>.050	1.00	0050	N	150.00	15.0	N	N	N
CD5889	.700	3 000	7.00	.0300	N	30.00	100.0	5.0	N	N
CD5892	.500	.700	2 00	.0200	N	N	70.0	1.5	N	N
CD5993	.100	>10.000	.30	0050	N	1,500.00	1,500.0	N	N	N
CD6172	1.000	N	.50	.0050	N	N	70.0	7.0	N	N
CD6173	1.000	2 000	.10	.0010	N	N	100.0	2.0	N	N
CD6177	.500	1.000	5.00	.0500	1,500.0	100.00	300.0	7.0	N	<5.0
CD6178	2 000	1.000	.70	.0100	N	N	100.0	5.0	N	N
CD6179	500	5.000	2.00	.0300	1,000.0	100.00	100.0	30.0	N	N
CD6182	300	3.000	1 50	.0200	<1,000.0	50.00	70.0	15.0	N	N
CD6188	1 000	3.000	30	.0100	1,500.0	150.00	20.0	15.0	N	N
CD6189	.700	3.000	50	.0070	7,000.0	150.00	50.0	50.0	N	N

Table 4 Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states-Continued.

[<, less than, >, greater than, --, not analyzed; N, not detected; H, analytical interference.]

Sample	Cr ppm-S	Cu ppm-S	Ga ppm-S	La ppm-S	Li ppm-S	Mn ppm-S	Mo ppm-S	Nb ppm-S	Ni ppm-S	Pb ppm-S
					CALIFORNIA --continued					
CD77-19	10.0	30.0	10	N	<100	1,500	3	<10	15.0	150
CD77-20	2.0	7.0	N	N	<100	700	5	N	<5.0	15
CD77-21	30.0	70.0	15	<30	<100	500	3	<10	7.0	30
79KF53	20.0	9.0	<20	<40	<100	1,300	<20	<50	16.0	<50
CD77-26	3.0	3.0	N	N	100	70	<3	N	15.0	<10
CD77-27	7.0	7.0	<5	N	N	50	<3	<10	<5.0	N
CD77-28	30.0	20.0	15	70	N	300	N	15	15.0	20
79KF28	12.0	4.3	<10	<20	<50	1,200	<10	<25	9.6	<10
					COLORADO					
CD76-24	7.0	7.0	<5	<30	N	50	N	N	5.0	N
CD76-25A	5.0	20.0	<5	<30	N	5,000	N	<20	7.0	N
CD76-25B	7.0	7.0	15	<30	N	100	N	10	N	15
CD76T1	15.0	200.0	N	N	N	300	N	N	70.0	15
CD76T6	30.0	7.0	15	<30	N	70	5	30	<5.0	20
CD76T7	50.0	30.0	20	70	150	100	5	30	20.0	20
CD76T8	50.0	20.0	15	50	100	300	3	15	20.0	15
CD76T5	15.0	10.0	7	N	N	1,500	3	N	5.0	100
CD76T3	7.0	7.0	<5	N	N	150	N	N	<5.0	N
CD76T4	20.0	15.0	7	<30	N	300	N	15	10.0	15
CD5903	30.0	7.0	7	N	N	500	<3	<10	20.0	15
CD5906	15.0	7.0	7	<30	N	1,500	3	<10	15.0	<10
CD5911	7.0	3.0	<5	N	<50	1,500	3	N	<5.0	N
CD5913	30.0	10.0	10	<30	N	300	N	<10	15.0	15
CD5929	30.0	15.0	10	<30	300	70	3	<10	20.0	15
CD5930	7.0	7.0	7	N	200	30	3	<10	7.0	N
CD5994	20.0	7.0	7	N	<100	2,000	N	N	5.0	<10
CD5884	20.0	20.0	15	<30	<50	200	50	<10	15.0	30
CD5888	1.5	1.0	N	N	700	20	N	N	<5.0	N
CD5889	7.0	3.0	<5	N	200	3,000	N	N	5.0	N
CD5892	7.0	2.0	N	N	N	150	N	N	<5.0	N
CD5993	N	<1.0	N	N	5,000	30	N	N	N	N
CD6172	1.0	1.5	N	N	N	10,000	N	N	N	N
CD6173	N	N	N	N	N	1,000	N	N	N	N
CD6177	7.0	2.0	10	N	N	10,000	N	N	5.0	10
CD6178	1.0	<1.0	N	N	N	5,000	<3	N	N	N
CD6179	2.0	2.0	N	N	N	700	3	N	N	N
CD6182	2.0	2.0	N	N	N	500	3	N	5.0	N
CD6188	N	<1.0	N	N	150	300	5	N	N	N
CD6189	N	2.0	N	N	150	500	<3	N	N	N

Table 4 Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states-Continued.

[<, less than; >, greater than; --, not analyzed; N, not detected; H, analytical interference.]

Sample	Sc ppm-S	Sr ppm-S	Ge ppm-S	V ppm-S	W ppm-S	Y ppm-S	Yb ppm-S	Zn ppm-S	Zr ppm-S
CALIFORNIA --continued									
CD77-19	N	1,500.00	30	15	N	<10	N	7,000	N
CD77-20	N	7,000.00	N	7	N	<10	N	N	15
CD77-21	7	1,500.00	10	70	N	15	1.5	N	150
79KF53	<20	>5,000.00	--	48	<200	<20	--	<100	<40
CD77-26	N	30,000.00	N	<7	N	<10	N	N	N
CD77-27	N	15,000.00	N	7	N	N	N	N	N
CD77-28	7	7,000.00	15	30	N	20	1.5	N	300
79KF28	<10	1,900.00	--	22	<100	<10	--	<50	<20
COLORADO									
CD76-24	N	50.00	N	15	N	N	N	N	30
CD76-25A	N	3,000.00	N	7	N	N	N	N	70
CD76-25B	N	150.00	N	20	N	N	1.0	N	50
CD76T1	N	1,500.00	N	N	N	N	N	N	N
CD76T6	7	150.00	N	30	N	30	3.0	N	200
CD76T7	15	500.00	15	70	N	50	3.0	N	100
CD76T8	10	500.00	N	70	N	30	3.0	N	70
CD76T5	7	2,000.00	15	15	N	20	2.0	N	30
CD76T3	7	2,000.00	N	7	N	<10	<1.0	N	30
CD76T4	5	700.00	N	30	N	30	3.0	N	200
CD5903	5	7,000.00	N	50	N	15	1.5	N	70
CD5906	70	1,000.00	30	70	N	200	10.0	N	100
CD5911	70	3,000.00	N	30	N	30	2.0	N	30
CD5913	7	1,500.00	N	70	N	15	1.5	N	70
CD5929	10	1,500.00	N	100	N	20	2.0	N	70
CD5930	N	15.00	N	7	N	N	N	N	N
CD5994	100	2,000 00	15	100	N	70	5.0	N	70
CD5884	15	300 00	N	50	N	20	2.0	N	150
CD5888	N	150.00	N	7	N	N	N	N	N
CD5889	30	7,000.00	30	50	N	10	N	N	30
CD5892	30	5,000.00	N	15	N	<10	N	N	30
CD5993	<5	300.00	N	20	N	N	N	N	N
CD6172	70	5,000.00	N	10	N	N	N	N	N
CD6173	30	15,000.00	N	N	N	N	N	N	N
CD6177	100	1,000.00	200	150	N	20	N	N	70
CD6178	50	7,000.00	N	N	N	N	N	N	N
CD6179	N	5,000.00	N	10	N	N	N	N	20
CD6182	N	5,000.00	N	5	N	N	N	N	30
CD6188	N	10,000 00	N	N	N	N	N	N	N
CD6189	N	10,000.00	N	N	N	N	N	N	N

Table 4. Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states-Continued.

[<, less than; >, greater than, --, not analyzed; N, not detected; H, analytical interference.]

LOC.	Sample	LAB. NO.	eU ppm	U ppm	Th ppm	T-S%	Al%-S	Ca%-S	Fe%-S	K%-S
				COLORADO --continued						
10	CD6191A	JAA680	80	23.8000	N	.60	.70	>10.00	1.500	N
11	CD5979	JAA571	2,200	2.4300	6.20	5.30	3.00	.30	.300	1.00
11	CD5991	JAA583	2,500	2 4300	6.20	6.50	3.00	.50	.500	.70
11	CD5992	JAA584	50	3.5000	N	46.00	1.50	2.00	7.000	N
11	80KF6	227,303	2,500	6.9200	--	6.86	2.00	.15	1.000	.70
12	CD6216	169,359	20	8.6900	17.50	14.00	7.00	.30	7.000	N
12	CD6217	169,360	2,270	.3600	<1.50	40.20	.70	7.00	.200	N
12	75MS31	174,709	790	5.5300	--	--	.15	1.00	>10.000	N
12	75MS33	174,710	2,940	.9300	2.70	--	1.00	5.00	.300	N
12	75MS34	174,711	2,010	4.3600	5.80	--	1.50	>10.00	.300	N
12	CD5982	JAA574	600	--	N	5.90	5.00	>10.00	2.000	.70
12	CD5983	JAA575	1,100	--	N	5.80	3.00	10.00	1.500	.70
12	CD5985	JAA577	500	2.1300	N	59.00	.10	.50	.070	N
12	CD5986	JAA578	140	.7700	N	1.47	.20	>10.00	.100	N
12	CD5987	JAA579	70	.5200	N	.61	.30	>10.00	.100	N
12	CD5988	JAA580	250	.2400	N	.68	.30	>10.00	.300	N
12	CD5989	JAA581	140	1.3100	N	.70	.15	>10.00	.050	N
12	CD5990	JAA582	70	1.1900	N	63.00	.30	5.00	.150	N
12	CD5995	JAA586	270	.1900	N	.65	.15	>10.00	.050	N
12	CD6107	JAA598	450	.3700	N	1.96	.10	>10.00	.050	N
12	CD6108	JAA599	500	.2200	N	2.63	.30	>10.00	.150	N
12	CD6208	JAA698	<30	<1.3000	<.14	--	7.00	>10.00	.030	3.00
12	CD6209	JAA699	50	<1.4000	<.15	--	10.00	>10.00	.030	3.00
12	80KF5	227,302	280	1.2300	--	1.18	.30	>10.00	.150	N
13	75MS36	175,621	<10	7.6900	22.10	--	5.00	.07	.200	N
14	75MS1	174,685	590	12.6000	<8.60	--	.70	7.00	>10.000	.70
14	75MS2	174,686	100	33.4000	<12.00	--	.30	>10.00	2.000	N
14	75MS3	174,687	60	25.6000	<9.30	--	.07	>10.00	.500	N
14	75MS4	174,688	300	--	--	--	.50	>10.00	>10.000	.70
14	75MS5	174,689	70	11.5000	<6.10	--	.05	>10.00	1.000	N
14	80KF1	227,298	70	19.6000	--	<.01	.70	>10.00	2.000	1.00
14	80KF2	227,299	50	34.4000	--	.06	.07	>10.00	.700	N
15	75MS11	174,694	2,010	9.7500	11.61	--	.30	5.00	>10.000	.70
15	75MS12	174,695	20	9.2200	30.50	--	3.00	3.00	.500	7.00
15	75MS13	174,696	790	50.5000	<16.00	--	.30	>10.00	2.000	<.70
15	75MS14	174,697	2,540	1 8300	<4.60	--	1.00	7.00	>10.000	2.00
15	75MS16	174,698	--	61 6000	--	--	.50	>10.00	>10.000	N
15	75MS17	174,699	3,830	14.7000	<9.80	--	.70	7.00	>10.000	.70
15	75MS15	179,488	790	12.3000	<6.90	--	2.00	>10.00	>10.000	1.00
15	CD80-3	227,296	5,400	16.6000	--	.03	.30	7.00	>10.000	<.70
15	CD80-4	227,297	1,900	11.5000	--	.02	.30	7.00	>10.000	<.70
15	80KF3	227,300	560	61.6000	--	.04	.70	>10.00	1.500	<.70
17	75MS25	174,704	2,000	.3600	--	--	1.00	3.00	>10.000	N
17	75MS26	174,705	10	< 1300	<1.20	--	.20	>10.00	.500	N
17	75MS27	174,706	1,970	.5700	5.97	--	.70	7.00	1.000	N

Table 4 Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states-Continued.

[<, less than; >, greater than; --, not analyzed; N, not detected; H, analytical interference.]

Sample	Mg%-S	Na%-S	Si%-S	Ti%-S	As ppm-S	B ppm-S	Ba ppm-S	Be ppm-S	Ce ppm-S	Co ppm-S
					COLORADO --continued					
CD6191A	.500	3.000	2.00	.0150	2,000.0	70.00	150.0	10.0	N	N
CD5979	.100	.500	>10.00	.1500	N	<20.00	>100,000.0	N	N	N
CD5991	.150	.500	>10.00	.1500	N	20.00	>100,000.0	<1.5	<200.0000	N
CD5992	.300	.500	5.00	.1500	N	<20.00	7,000.0	2.0	<200.0000	5.0
80KF6	.100	.100	10.00	.1500	N	N	>100,000.0	N	N	N
CD6216	.050	.200	>10.00	.1000	N	150.00	700.0	10.0	N	N
CD6217	.070	.200	5.00	.0200	N	<20.00	>100,000.0	3.0	N	N
75MS31	.020	.050	1.00	N	7,000.0	N	15,000.0	200.0	N	7.0
75MS33	.050	.200	2.00	.0200	N	N	>100,000.0	5.0	N	N
75MS34	.200	.300	2.00	.0200	N	15.00	>100,000.0	5.0	N	N
CD5982	.700	2.000	7.00	.0700	N	100.00	>100,000.0	15.0	N	N
CD5983	.500	1.000	7.00	.0700	N	150.00	>100,000.0	20.0	N	N
CD5985	.020	.300	.30	.0050	N	N	100,000.0	N	N	N
CD5986	.500	.500	.70	.0050	N	<20.00	10,000.0	7.0	N	N
CD5987	1.500	1.000	.50	.0070	N	<20.00	30,000.0	7.0	N	N
CD5988	.500	.500	.10	.0003	N	N	70,000.0	10.0	N	N
CD5989	1.500	.700	.15	.0010	N	<20.00	70,000.0	7.0	N	N
CD5990	.070	.200	2.00	.0150	N	N	7,000.0	1.5	N	N
CD5995	.500	.300	.15	.0010	N	N	100,000.0	15.0	N	N
CD6107	.500	.300	.10	.0015	N	N	>100,000.0	15.0	N	N
CD6108	500	.300	.30	.0050	N	<20.00	>100,000.0	20.0	N	N
CD6208	.500	.150	>10.00	.0020	N	N	3,000.0	2.0	N	N
CD6209	.500	.200	>10.00	.0020	N	N	7,000.0	3.0	N	N
80KF5	.700	.300	.70	.0150	N	N	3,000.0	3.0	N	N
75MS36	3.000	7.000	.15	.0015	N	N	5.0	1.5	N	70.0
75MS1	.300	3.000	7.00	.0150	3,000.0	N	700.0	70.0	N	N
75MS2	.700	1.000	2.00	.0150	N	N	150.0	20.0	N	N
75MS3	1.000	2.000	.30	.0050	N	N	150.0	7.0	N	N
75MS4	.700	2.000	7.00	.0200	2,000.0	N	500.0	50.0	N	N
75MS5	.300	.700	.20	.0020	N	N	100.0	10.0	N	N
80KF1	.500	1.000	3.00	.0300	N	N	300.0	10.0	N	N
80KF2	.700	.500	.30	.0050	N	N	70.0	2.0	N	N
75MS11	.300	2.000	3.00	.0100	100,000.0	50.00	1,000.0	300.0	N	N
75MS12	.200	>10.000	.50	.0150	N	700.00	500.0	1.5	100.0000	N
75MS13	.500	1.000	.50	.0070	1,000.0	N	150.0	30.0	N	N
75MS14	.300	>10.000	3.00	.0200	20,000.0	200.00	1,000.0	300.0	N	N
75MS16	.300	3.000	2.00	.0100	20,000.0	30.00	1,000.0	200.0	N	N
75MS17	.300	3.000	2.00	.0150	100,000.0	50.00	1,000.0	300.0	N	N
75MS15	.700	2.000	5.00	.0200	30,000.0	70.00	1,000.0	300.0	N	N
CD80-3	.100	1.000	3.00	.0150	20,000.0	<20.00	700.0	150.0	N	N
CD80-4	.150	.700	3.00	.0150	50,000.0	20.00	700.0	200.0	N	N
80KF3	.500	.700	2.00	.0200	N	N	300.0	20.0	N	N
75MS25	.100	.300	5.00	.0050	N	N	100,000.0	100.0	N	5.0
75MS26	.150	.050	.30	.0020	N	N	500.0	7.0	N	N
75MS27	.150	.300	3.00	.0150	N	N	>100,000.0	50.0	N	N

Table 4. Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states-Continued.

[<, less than, >, greater than; --, not analyzed; N, not detected; H, analytical interference.]

Sample	Cr ppm-S	Cu ppm-S	Ga ppm-S	La ppm-S	Li ppm-S	Mn ppm-S	Mo ppm-S	Nb ppm-S	Ni ppm-S	Pb ppm-S
COLORADO --continued										
CD6191A	2.0	1.0	N	N	N	500	<3	N	N	N
CD5979	30.0	3.0	10	<50	N	20	N	<10	N	10
CD5991	30.0	3.0	10	N	N	30	N	<10	N	10
CD5992	20.0	30.0	7	N	N	500	3	<10	15.0	15
80KF6	20.0	15.0	7	N	N	30	N	N	<5.0	N
CD6216	20.0	15.0	15	<30	N	700	7	<10	<5.0	30
CD6217	2.0	2.0	N	N	N	1,000	N	N	N	N
75MS31	N	N	15	N	N	>100,000	15	20	3.0	1,500
75MS33	2.0	1.5	3	N	N	500	N	N	N	N
75MS34	5.0	3.0	3	N	N	1,500	7	N	N	N
CD5982	15.0	15.0	5	N	300	2,000	N	N	<5.0	10
CD5983	15.0	7.0	7	N	200	2,000	N	N	<5.0	10
CD5985	1.5	1.0	<5	N	N	50	N	N	N	N
CD5986	1.5	2.0	N	N	N	3,000	N	N	N	N
CD5987	3.0	1.5	N	N	200	3,000	N	N	N	N
CD5988	1.5	<1.0	N	N	N	5,000	N	N	N	N
CD5989	1.5	<1.0	N	N	N	2,000	N	N	N	N
CD5990	2.0	3.0	N	N	N	300	N	N	N	N
CD5995	1.0	<1.0	N	N	N	5,000	N	N	N	N
CD6107	1.0	<1.0	N	N	N	5,000	N	N	N	N
CD6108	1.0	<1.0	N	N	N	5,000	N	N	N	N
CD6208	1.5	<1.0	15	N	150	2,000	N	N	N	N
CD6209	2.0	<1.0	20	N	200	2,000	N	N	N	N
80KF5	5.0	2.0	N	N	N	3,000	N	N	<5.0	N
75MS36	7.0	150.0	N	N	N	700	N	N	50.0	N
75MS1	3.0	20.0	5	N	N	150	N	N	3.0	20
75MS2	3.0	5.0	N	N	N	200	N	N	N	N
75MS3	2.0	1.5	N	N	N	300	N	N	N	N
75MS4	7.0	5.0	5	N	N	200	N	N	7.0	N
75MS5	N	N	N	50	N	300	N	N	N	N
80KF1	5.0	5.0	5	N	N	700	N	N	<5.0	N
80KF2	1.0	2.0	N	N	N	200	N	N	<5.0	N
75MS11	1.5	3.0	5	30	N	150	N	N	N	N
75MS12	1.0	2.0	7	70	3,000	100	N	N	N	N
75MS13	N	3.0	N	N	N	500	N	N	N	N
75MS14	5.0	15.0	5	N	300	70	N	N	N	15
75MS16	1.5	2.0	5	N	N	100	N	N	N	N
75MS17	1.5	5.0	7	N	N	70	N	N	N	15
75MS15	10.0	10.0	10	N	N	700	N	<10	<5.0	N
CD80-3	<1	5.0	N	N	N	150	N	N	N	N
CD80-4	1.0	5.0	N	N	N	1,500	N	N	N	N
80KF3	15.0	7.0	N	N	N	500	N	N	N	N
75MS25	2.0	3.0	150	N	N	>100,000	20	15	N	N
75MS26	N	N	5	N	N	1,000	N	10	N	N
75MS27	2.0	7.0	70	N	N	>100,000	50	20	2.0	50

Table 4. Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states-Continued.

[<, less than; >, greater than; --, not analyzed; N, not detected; H, analytical interference.]

Sample	Sc ppm-S	Sr ppm-S	Ge ppm-S	V ppm-S	W ppm-S	Y ppm-S	Yb ppm-S	Zn ppm-S	Zr ppm-S
COLORADO --continued									
CD6191A	N	7,000.00	N	5	N	N	N	N	30
CD5979	20	1,000.00	N	50	N	15	1.5	N	100
CD5991	30	2,000.00	<500	70	N	15	1.5	N	150
CD5992	15	200.00	15	20	N	15	1.5	3,000	100
80KF6	20	3,000.00	N	30	N	15	2.0	N	200
CD6216	15	150.00	N	70	N	50	3.0	N	150
CD6217	70	3,000.00	N	15	N	50	2.0	N	200
75MS31	N	7,000.00	50	N	7,000	15	15.0	1,000	15
75MS33	100	10,000.00	N	20	N	20	2.0	N	70
75MS34	70	15,000.00	N	10	N	15	1.5	N	100
CD5982	100	5,000.00	10	50	N	50	3.0	N	70
CD5983	100	5,000.00	10	50	N	50	5.0	N	50
CD5985	5	2,000.00	N	N	N	N	<1.0	N	N
CD5986	50	5,000.00	<500	N	N	10	<1.0	N	N
CD5987	30	5,000.00	<500	N	N	<10	<1.0	N	N
CD5988	50	3,000.00	N	N	N	N	<1.0	N	N
CD5989	30	5,000.00	N	N	N	N	N	N	N
CD5990	10	150.00	N	<7	N	10	<1.0	N	N
CD5995	70	5,000.00	N	N	N	N	N	N	N
CD6107	70	5,000.00	N	N	N	20	<1.0	N	N
CD6108	100	5,000.00	N	<7	N	30	1.5	N	N
CD6208	20	7,000.00	N	N	N	<10	<1.0	N	N
CD6209	30	7,000.00	N	N	N	10	<1.0	N	N
80KF5	50	2,000.00	N	<7	N	20	2.0	N	N
75MS36	N	10.00	N	N	N	N	N	N	N
75MS1	7	5,000.00	30	10	N	150	15.0	N	50
75MS2	N	10,000.00	N	N	N	15	1.0	N	20
75MS3	N	10,000.00	N	N	N	N	N	N	N
75MS4	3	10,000.00	15	10	N	100	10.0	N	10
75MS5	N	10,000.00	N	N	N	10	N	N	20
80KF1	<5	3,000.00	N	7	N	20	1.5	N	30
80KF2	N	7,000.00	N	N	N	<10	N	N	N
75MS11	N	3,000.00	30	N	N	50	N	N	30
75MS12	N	2,000.00	N	20	N	15	1.0	N	70
75MS13	N	15,000.00	N	N	N	N	N	N	20
75MS14	3	5,000.00	15	15	N	30	N	N	20
75MS16	N	7,000.00	15	N	N	15	N	N	30
75MS17	N	7,000.00	20	N	N	30	N	N	20
75MS15	5	7,000.00	30	30	N	30	N	N	70
CD80-3	N	2,000.00	20	<7	N	50	N	N	30
CD80-4	N	1,500.00	30	<7	N	20	N	N	70
80KF3	N	7,000.00	N	<7	N	<10	N	N	50
75MS25	N	1,500.00	30	N	5,000	500	50.0	N	N
75MS26	N	3,000.00	N	N	N	15	1.5	N	N
75MS27	N	5,000.00	N	N	10,000	200	10.0	N	500

Table 4. Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states-Continued.

[<, less than; >, greater than; --, not analyzed; N, not detected; H, analytical interference.]

LOC.	Sample	LAB. NO.	eU ppm	U ppm	Th ppm	T-S%	Al%-S	Ca%-S	Fe%-S	K%-S
					COLORADO --continued					
17	CD80-1	227,294	4,000	.6300	4.90	.04	2.00	3.00	3.000	N
17	80KF4	227,301	570	--	--	.03	1.00	>10.00	1.000	N
18	75MS29	174,708	<10	.2400	2.80	--	.10	>10.00	.150	N
19	75MS20	174,701	160	<.1400	<1.50	--	.10	>10.00	1.500	N
19	75MS21	174,702	200	.2600	<1.70	--	.10	>10.00	1.000	N
19	75MS22	174,703	50	.4300	15.20	--	.03	>10.00	.200	N
20	75MS19	174,700	30	--	--	--	.05	>10.00	.300	N
22	75MS30	175,684	710	.7199	--	.97	.15	7.00	>10.000	N
22	75MS122	176,742	2,370	--	--	--	.10	>10.00	.700	N
22	CD80-2	227,295	1,800	1.1500	--	.97	.30	3.00	>10.000	N
23	75MS120	179,491	<10	2.2600	<3.10	--	2.00	.70	>10.000	N
23	75MS121	179,492	20	49.5000	<16.00	--	3.00	.07	>10.000	N
24	75MS119	176,741	<10	.3500	<1.60	--	.05	>10.00	.300	N
27	75MS123	176,743	40	.5600	<2.00	--	.02	>10.00	1.000	N
28	75MS124	176,744	--	--	--	--	.20	1.50	.100	N
					IDAHO					
01	CD76-41	182,704	60	<.1900	<1.70	.70	.30	>10.00	.100	N
01	CD76-42	182,705	30	<.1400	<1.10	1.25	.05	>10.00	.050	N
01	CD76-43	182,706	70	6.3000	27.90	.06	>10.00	1.00	1.500	7.00
02	CD76-39	182,702	<10	.3900	<1.70	.20	.07	>10.00	1.500	N
02	CD76-40	182,703	10	.2500	<1.60	.23	.10	>10.00	.500	N
03	CD76-44	182,707	20	<.1800	<1.60	.84	.20	>10.00	7.000	N
03	CD76-45	182,708	<10	<.1500	<1.10	.93	.05	>10.00	1.000	N
06	CD76-46A	182,709	30	.5200	<2.00	.16	.20	>10.00	2.000	N
06	CD76-46B	182,710	100	2.2600	6.80	.54	7.00	7.00	>10.000	2.00
					MONTANA					
01	CD78R12	206,041	20	6.1000	20.50	.21	7.00	5.00	3.000	3.00
02	CD78R19	206,048	30	2.7800	11.20	.72	7.00	5.00	2.000	3.00
03	CD78R4	206,033	520	<.7900	<7.60	.14	.15	>10.00	5.000	N
03	CD78R5	206,034	410	<1.1000	<14.00	.23	3.00	7.00	1.500	3.00
03	CD78R8	206,037	390	<.7000	<6.50	.05	.02	>10.00	.200	N
03	CD78R9	206,038	640	<.7900	<7.20	.06	.10	>10.00	.300	N
03	CD78R10	206,039	70	.1700	<1.30	.19	.05	>10.00	.150	N
05	CD78R13	206,042	<10	.4000	<2.20	.62	.15	5.00	1.000	N
06	CD78R14	206,043	100	<.0900	<1.30	.54	.05	>10.00	7.000	N
06	CD78R15	206,044	100	<.0800	<1.40	.56	.01	>10.00	.700	N
06	CD78R16	206,045	10	<.0800	<1.10	.24	<.05	>10.00	.300	N
06	CD78R17	206,046	130	<.5200	<5.10	.33	<.05	1.50	>10.000	<.70
06	CD78R18	206,047	30	<.0800	<1.10	.68	<.05	>10.00	1.000	N
11	CD78R20	206,049	40	.2000	<1.80	6.18	.15	>10.00	.150	N
14	CD78R1	206,030	20	1.2400	<1.80	.86	.05	>10.00	.200	N

Table 4. Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states-Continued.

[(, less than,), greater than; --, not analyzed; N, not detected; H, analytical interference.]

Sample	Mg%-S	Na%-S	Si%-S	Ti%-S	As ppm-S	B ppm-S	Ba ppm-S	Be ppm-S	Ce ppm-S	Co ppm-S
COLORADO --continued										
CD80-1	.070	.200	3.00	.0150	N	N	100,000.0	150.0	N	5.0
80KF4	.070	.300	5.00	.0500	N	N	5,000.0	30.0	N	(5.0
75MS29	1.500	.200	.20	.0030	N	N	500.0	7.0	N	N
75MS20	.300	.050	.50	.0050	N	N	5,000.0	3.0	N	N
75MS21	.500	.300	.50	.0070	N	N	2,000.0	5.0	N	N
75MS22	1.000	.200	.70	.0010	N	N	500.0	3.0	N	N
75MS19	1.000	.200	.15	.0005	N	N	150.0	7.0	N	N
75MS30	.020	.070	.70	.0007	3,000.0	N	3,000.0	100.0	N	N
75MS122	.030	.070	1.00	.0070	N	N	15,000.0	50.0	N	20.0
CD80-2	.020	.100	1.50	.0015	2,000.0	N	10,000.0	100.0	N	10.0
75MS120	.020	(.03	3.00	.0100	N	N	30.0	2.0	N	30.0
75MS121	.015	(.03	1.50	.0050	N	N	20.0	10.0	N	N
75MS119	.300	.150	.30	.0015	N	N	70.0	N	N	N
75MS123	.200	2.000	.15	N	N	N	70.0	7.0	N	N
75MS124	.050	.300	1.00	.0100	N	N	150.0	N	N	N
IDAHO										
CD76-41	.300	.700	1.50	.0070	N	(20.00	70.0	5.0	N	N
CD76-42	.700	.700	.03	N	N	N	30.0	3.0	N	N
CD76-43	.300	3.000	)10.00	.1500	N	20.00	1,500.0	5.0	(200	N
CD76-39	.500	.300	.07	(.0005	N	N	50.0	N	N	(5.0
CD76-40	.300	.500	.15	.0005	N	(20.00	70.0	N	N	(5.0
CD76-44	.300	.150	.30	(.0001	N	N	50.0	5.0	N	N
CD76-45	.200	.150	.05	N	N	N	30.0	N	N	N
CD76-46A	.500	.500	.50	.0020	N	(20.00	300.0	7.0	N	N
CD76-46B	.700	1.000	)10.00	.2000	20,000.0	30.00	1,000.0	100.0	N	7.0
MONTANA										
CD78R12	1.500	3.000	)10.00	.2000	N	100.00	700.0	3.0	N	5.0
CD78R19	.700	2.000	)10.00	.2000	N	20.00	500.0	1.5	N	5.0
CD78R4	1.000	.300	2.00	.0050	N	(20	200.0	7.0	N	N
CD78R5	1.000	2.000	)10.00	.0700	N	20.00	500.0	3.0	N	N
CD78R8	.150	.100	.15	.0002	N	N	150.0	7.0	N	N
CD78R9	.300	.100	.50	.0050	N	N	300.0	7.0	N	N
CD78R10	.200	.150	.30	.0020	N	N	150.0	7.0	N	N
CD78R13	.050	3.000	)10.00	.0070	N	700.00	150.0	1.5	N	N
CD78R14	.100	.100	1.00	.0005	N	N	70.0	10.0	N	N
CD78R15	.050	.100	.07	0002	N	N	70.0	1.5	N	N
CD78R16	.050	150	07	N	N	N	20.0	1.5	N	N
CD78R17	.070	.150	3.00	N	2,000.0	N	200.0	50.0	N	N
CD78R18	.100	.100	.15	N	N	N	50.0	3.0	N	N
CD78R20	.700	.200	1.00	.0070	N	(20.00	50.0	N	N	N
CD78R1	.150	.200	.20	.0050	N	N	50.0	N	N	N

Table 4. Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states-Continued.

[<, less than; >, greater than; --, not analyzed; N, not detected; H, analytical interference.]

Sample	Cr ppm-S	Cu ppm-S	Ga ppm-S	La ppm-S	Li ppm-S	Mn ppm-S	Mo ppm-S	Nb ppm-S	Ni ppm-S	Pb ppm-S
COLORADO --continued										
CD80-1	2.0	15.0	150	N	N	>20,000	20	N	<5.0	N
80KF4	7.0	5.0	50	N	N	>20,000	10	N	<5.0	N
75MS29	N	N	N	N	N	700	N	N	N	N
75MS20	N	N	3	N	N	1,000	N	N	N	N
75MS21	1.0	N	3	N	N	150	N	N	N	N
75MS22	N	N	N	N	N	200	N	N	N	N
75MS19	N	N	N	N	N	100	N	N	3.0	N
75MS30	N	1.5	N	N	N	70,000	7	15	5.0	700
75MS122	N	1.5	N	N	N	>100,000	20	15	N	N
CD80-2	N	2.0	N	N	N	>20,000	30	N	<5.0	300
75MS120	1.5	200.0	N	N	N	2,000	N	<10	5.0	10
75MS121	7.0	1,000.0	N	N	N	20	10	<10	<5.0	70
75MS119	N	N	N	N	N	3,000	N	N	N	N
75MS123	N	N	N	N	N	1,000	N	N	N	N
75MS124	1.5	1.5	N	N	N	70	N	N	N	N
IDAHO										
CD76-41	3.0	N	N	N	N	2,000	N	N	N	N
CD76-42	2.0	<1.0	N	N	N	1,000	N	N	N	N
CD76-43	15.0	5.0	30	150	N	300	N	70	<5.0	50
CD76-39	2.0	1.0	N	<30	N	300	N	N	7.0	N
CD76-40	2.0	2.0	N	N	N	500	N	N	<5.0	N
CD76-44	1.5	5.0	N	N	N	100	N	N	N	N
CD76-45	2.0	<1.0	N	N	N	70	N	<10	N	N
CD76-46A	<2.0	<1.0	N	N	N	1,500	N	N	N	N
CD76-46B	30.0	15.0	15	N	N	700	N	15	20.0	30
MONTANA										
CD78R12	30.0	70.0	70	50	150	700	N	<10	10.0	100
CD78R19	50.0	30.0	15	<30	N	200	N	<10	15.0	300
CD78R4	2.0	15.0	N	N	150	300	N	N	N	15
CD78R5	10.0	50.0	10	50	<100	150	N	N	7.0	20
CD78R8	1.0	N	N	N	N	500	N	N	N	N
CD78R9	1.0	5.0	N	N	N	1,000	N	N	N	N
CD78R10	1.0	2.0	N	N	N	100	N	N	N	N
CD78R13	1.5	70.0	150	N	<100	150	10	N	N	20
CD78R14	1.5	50.0	5	N	N	500	N	N	N	10
CD78R15	1.5	15.0	N	N	N	500	N	N	N	N
CD78R16	1.0	10.0	N	N	N	200	N	N	N	N
CD78R17	N	20.0	70	N	N	150	N	<10	7.0	N
CD78R18	<1.0	30.0	N	N	N	300	N	N	N	N
CD78R20	2.0	7.0	N	N	N	50	N	N	N	N
CD78R1	3.0	N	N	50	N	100	N	N	N	N

Table 4. Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states-Continued.

[<, less than, >, greater than, --, not analyzed; N, not detected; H, analytical interference.]

Sample	Sc ppm-S	Sr ppm-S	Ge ppm-S	V ppm-S	W ppm-S	Y ppm-S	Yb ppm-S	Zn ppm-S	Zr ppm-S
COLORADO --continued									
CD80-1	N	2,000.00	50	N	7,000	500	50.0	N	N
80KF4	5	1,500.00	15	10	1,500	70	7.0	N	50
75MS29	N	7,000.00	N	N	N	N	N	N	N
75MS20	N	1,000.00	N	N	70	N	N	N	N
75MS21	N	1,500.00	N	N	70	N	N	N	N
75MS22	N	2,000.00	10	N	N	N	N	N	N
75MS19	N	7,000.00	N	N	N	N	N	N	N
75MS30	N	5,000.00	30	N	3,000	15	2.0	700	N
75MS122	N	15,000.00	N	N	3,000	N	N	N	N
CD80-2	N	15,000 00	30	N	5,000	10	N	700	N
75MS120	N	100.00	N	10	N	20	N	1,500	20
75MS121	N	10.00	N	300	N	<20	N	700	N
75MS119	N	3,000.00	N	N	N	N	N	N	N
75MS123	N	5,000.00	N	N	N	N	N	N	N
75MS124	N	500.00	N	N	N	N	N	N	N
IDAHO									
CD76-41	N	3,000.00	<10	N	N	N	N	N	N
CD76-42	N	2,000.00	N	N	N	N	N	N	N
CD76-43	<5	150.00	N	20	N	70	7.0	N	500
CD76-39	N	700.00	N	<7	N	N	N	N	N
CD76-40	N	700.00	N	N	N	N	N	N	N
CD76-44	N	1,500.00	N	N	N	N	<1.0	N	N
CD76-45	N	1,000.00	N	N	N	N	N	N	N
CD76-46A	N	>10,000 00	N	N	N	N	N	N	N
CD76-46B	7	700.00	50	30	N	20	N	N	150
MONTANA									
CD78R12	10	500.00	10	70	N	30	3.0	300	100
CD78R19	7	500.00	N	50	N	10	2.0	500	150
CD78R4	N	5,000.00	15	N	N	N	N	300	N
CD78R5	<5	2,000.00	20	30	N	<10	1.0	1,000	30
CD78R8	N	1,500.00	N	N	N	N	N	N	N
CD78R9	N	2,000.00	10	N	N	N	N	N	N
CD78R10	N	2,000.00	N	N	N	N	N	N	N
CD78R13	N	1,000.00	10	N	N	N	N	N	N
CD78R14	N	700.00	<10	N	N	N	N	N	N
CD78R15	N	200.00	N	N	N	N	N	N	N
CD78R16	N	150.00	N	N	N	N	N	N	N
CD78R17	N	150.00	70	N	2,000	<10	N	N	N
CD78R18	N	1,000.00	N	N	N	N	N	N	N
CD78R20	N	300.00	10	N	N	N	N	N	N
CD78R1	N	1,500.00	N	N	N	10	N	N	N

Table 4. Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states-Continued.

[<, less than; >, greater than, --, not analyzed; N, not detected; H, analytical interference.]

LOC.	Sample	LAB. NO.	eU ppm	U ppm	Th ppm	T-S%	Al%-S	Ca%-S	Fe%-S	K%-S
				MONTANA --continued						
14	CD78R2	206,031	20	.2900	<1.50	.75	.02	>10.00	.300	N
14	CD78R3	206,032	2,500	<9.4000	<99.00	.07	10.00	3.00	5.000	2.00
					NEVADA					
04	CD77-55	189,921	90	<.2000	<2.00	.10	.30	>10.00	.050	N
05	CD77-54	189,920	100	.1900	<1.50	.02	.50	>10.00	.100	N
06	CD77-3	189,932	1,600	--	--	.06	.20	>10.00	1.500	N
06	CD77-4	189,933	120	.8200	--	.21	1.50	>10.00	1.000	.70
06	CD77-5	189,934	480	4.3300	18.59	.31	7.00	1.50	2.000	3.00
06	CD77-6	189,935	4,500	.7300	--	.27	1.00	>10.00	1.500	.70
06	CD77-7	189,936	50	.2600	<1.60	.11	.70	>10.00	.700	.70
06	80KF50	230,321	<10	<.0700	<.99	.02	.07	>10.00	.700	N
10	CD77-53	189,919	<10	.9300	--	.10	.70	.30	.100	N
11	CD77-1	189,930	<10	1.3000	--	<.01	.70	.30	.300	.70
11	CD77-2	189,931	10	2.5600	11.84	.26	5.00	.30	1.500	2.00
12	CD77-12	189,943	70	1.6600	--	.86	2.00	7.00	1.000	1.50
12	CD77-13	189,944	150	1.6200	--	.78	3.00	7.00	1.500	1.50
12	CD77-14	189,945	90	1.1700	--	12.01	1.50	3.00	1.500	1.50
12	CD77-15	189,946	930	1.5300	--	2.18	.15	.07	.050	N
12	CD77-16	189,947	560	.4100	4.50	.64	10.00	.15	1.500	.70
12	CD77-17	189,948	950	2.1600	--	2.26	3.00	1.00	1.000	1.50
14	CD77-8	189,937	50	<.1100	<1.20	.04	.15	>10.00	.150	N
14	CD77-9	189,938	50	.6700	--	.10	1.50	>10.00	.300	.70
14	CD77-10	189,939	30	<.1300	<1.40	.02	.50	>10.00	.150	N
14	CD77-11	189,940	20	2.1500	--	.53	5.00	>10.00	.700	1.50
15	KF1	189,941	10	<.1100	<1.10	.37	.07	>10.00	.300	N
15	KF2	189,942	40	<.1200	<1.30	.02	.50	>10.00	1.000	N
18	CD77-46	189,912	120	.1700	<1.40	<.01	.02	>10.00	.020	N
18	CD77-47	189,913	70	<.1000	<.96	<.01	.05	>10.00	.200	N
18	CD77-48	189,914	250	.5000	--	.01	1.00	>10.00	.200	N
18	CD77-49	189,915	940	1.2000	--	.11	2.00	>10.00	.300	1.00
18	CD77-50	189,916	130	<.1300	<1.30	.01	.10	>10.00	.020	N
18	CD77-51	189,917	250	2.7100	--	1.85	1.50	3.00	.500	1.00
18	CD77-52	189,918	60	--	--	.09	.07	>10.00	.150	N
18	CD78R21	206,050	1,200	<.8100	<7.10	.11	.05	>10.00	.050	N
18	CD78R22	206,051	390	<.9000	<8.00	.05	.05	>10.00	.070	N
18	CD78R23	206,052	30	<.0800	<1.20	.02	.02	>10.00	.050	N
18	CD80-69	230,323	830	2.0300	<6.90	.06	.02	>10.00	.050	N
19	CD77-43	189,909	90	.7300	--	.10	1.00	>10.00	.200	1.00

Table 4. Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states-Continued.

[<, less than; >, greater than; --, not analyzed; N, not detected; H, analytical interference.]

Sample	Mg%-S	Na%-S	Si%-S	Ti%-S	As ppm-S	B ppm-S	Ba ppm-S	Be ppm-S	Ce ppm-S	Co ppm-S
MONTANA--continued										
CD78R2	.150	.200	.10	.0020	N	N	50.0	N	N	N
CD78R3	.700	2.000	>10.00	.3000	N	<20.00	2,000.0	3.0	N	200.0
NEVADA										
CD77-55	.700	.500	3.00	.0100	N	N	2,000.0	15.0	N	N
CD77-54	.500	.200	1.00	.0100	N	N	1,000.0	30.0	N	N
CD77-3	.500	.300	.70	.0070	N	N	7,000.0	10.0	N	N
CD77-4	.700	.700	3.00	.0500	N	<20.00	700.0	5.0	N	<5.0
CD77-5	.700	1.000	>10.00	.2000	N	70.00	1,500.0	7.0	<200	5.0
CD77-6	.500	.300	1.50	.0200	N	N	15,000.0	10.0	N	<5.0
CD77-7	1.000	.700	1.50	.0150	N	150.00	700.0	3.0	N	<5.0
80KF50	.500	.150	.30	.0050	N	N	700.0	<1.0	N	7.0
CD77-53	.050	.500	>10.00	.0200	N	100.00	70.0	2.0	N	N
CD77-1	.030	1.000	>10.00	.0300	N	150.00	150.0	7.0	N	N
CD77-2	.200	.700	>10.00	.2000	N	70.00	1,000.0	5.0	<200	<5.0
CD77-12	.700	1.000	>10.00	.0700	N	70.00	1,500.0	10.0	N	<5.0
CD77-13	1.000	1.000	>10.00	.0700	N	50.00	2,000.0	7.0	N	<5.0
CD77-14	.300	3.000	5.00	.0700	N	<20.00	1,000.0	3.0	N	<5.0
CD77-15	.015	.050	>10.00	.0700	N	30.00	20,000.0	15.0	N	N
CD77-16	1.500	3.000	>10.00	.1000	N	150.00	15,000.0	3.0	N	N
CD77-17	.300	3.000	>10.00	.2000	N	50.00	20,000.0	5.0	N	<5.0
CD77-8	.700	.150	.15	.0050	N	N	700.0	5.0	N	N
CD77-9	.700	.500	2.00	.0300	N	<20.00	500.0	7.0	N	N
CD77-10	.500	.200	.50	.0070	N	N	500.0	3.0	N	N
CD77-11	.500	.500	5.00	.1500	N	<20.00	300.0	7.0	N	<5.0
KF1	.700	150	.15	.0010	N	N	100.0	5.0	N	N
KF2	.300	.150	.70	.0070	N	N	1,500.0	7.0	N	N
CD77-46	.300	.050	.20	.0010	N	N	500.0	1.5	N	N
CD77-47	.300	.020	.07	.0010	N	N	100.0	N	N	N
CD77-48	.700	.200	1.50	.0200	N	N	300.0	N	N	N
CD77-49	1.000	.500	7.00	.0500	N	<20.00	2,000.0	N	N	<5.0
CD77-50	.700	.050	.20	.0030	N	N	300.0	1.5	N	N
CD77-51	.500	.700	5.00	.0700	N	<20.00	200.0	7.0	N	N
CD77-52	.500	.150	.20	.0020	N	N	100.0	N	N	N
CD78R21	.500	.200	.70	.0020	N	N	1,000.0	N	N	N
CD78R22	2.000	.100	2.00	.0010	N	N	1,000.0	N	N	N
CD78R23	.200	N	05	.0005	N	N	100.0	N	N	N
CD80-69	.700	.100	.30	.0020	N	N	2,000.0	N	N	N
CD77-43	1.000	2.000	3.00	.0200	N	30.00	1,000.0	N	N	N

Table 4. Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states-Continued.

[<, less than; >, greater than; --, not analyzed; N, not detected; H, analytical interference.]

Sample	Cr ppm-S	Cu ppm-S	Ga ppm-S	La ppm-S	Li ppm-S	Mn ppm-S	Mo ppm-S	Nb ppm-S	Ni ppm-S	Pb ppm-S
MONTANA --continued										
CD78R2	2.0	N	N	N	N	70	N	N	N	N
CD78R3	70.0	50.0	20	70	N	10,000	N	<10	70.0	20
NEVADA										
CD77-55	2.0	1.0	N	N	N	150	N	N	N	N
CD77-54	2.0	1.0	N	N	N	3,000	N	N	N	N
CD77-3	7.0	15.0	N	N	150	20,000	N	15	20.0	N
CD77-4	15.0	15.0	7	N	100	3,000	N	N	15.0	<10
CD77-5	30.0	20.0	20	<30	<100	3,000	N	15	15.0	30
CD77-6	7.0	10.0	5	N	N	>20,000	N	20	15.0	N
CD77-7	7.0	15.0	<5	N	150	2,000	N	N	15.0	10
80KF50	N	2.0	N	N	N	5,000	N	N	N	N
CD77-53	5.0	2.0	50	N	N	20	N	N	N	N
CD77-1	1.5	5.0	30	N	<100	30	N	10	<5.0	10
CD77-2	7.0	10.0	50	70	<100	150	N	20	<5.0	20
CD77-12	20.0	70.0	20	N	150	200	N	10	7.0	30
CD77-13	30.0	30.0	30	N	200	150	N	<10	7.0	50
CD77-14	10.0	20.0	20	N	150	30	N	<10	5.0	<10
CD77-15	2.0	1.5	<5	N	N	30	N	<10	<5.0	N
CD77-16	30.0	7.0	150	N	700	30	N	<10	<5.0	15
CD77-17	20.0	10.0	200	N	300	50	N	15	5.0	15
CD77-8	3.0	7.0	N	N	N	300	N	N	10.0	N
CD77-9	7.0	5.0	7	N	N	300	3	N	<5.0	N
CD77-10	5.0	7.0	<5	N	N	700	5	N	<5.0	N
CD77-11	20.0	15.0	20	N	<100	700	N	<10	30.0	10
KF1	3.0	5.0	N	N	N	700	N	N	10.0	N
KF2	5.0	7.0	15	N	N	20,000	N	20	15.0	N
CD77-46	1.0	7.0	N	N	N	30	N	N	N	N
CD77-47	1.0	1.0	N	N	N	200	N	N	N	N
CD77-48	5.0	10.0	<5	N	N	100	N	N	N	N
CD77-49	10.0	30.0	<5	N	N	500	N	N	5.0	N
CD77-50	N	1.0	N	N	N	50	N	N	N	N
CD77-51	10.0	30.0	7	N	N	100	20	N	5.0	N
CD77-52	2.0	10.0	N	N	N	200	N	N	N	N
CD78R21	1.0	1.5	N	N	N	30	N	N	N	N
CD78R22	N	2.0	N	N	N	30	N	N	N	N
CD78R23	1.0	1.0	N	N	N	150	N	N	N	N
CD80-69	N	N	N	N	N	N	N	N	N	N
CD77-43	3.0	3.0	<5	N	<100	150	N	N	<5.0	N

Table 4. Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states-Continued.

[<, less than; >, greater than; --, not analyzed; N, not detected; H, analytical interference.]

Sample	Sc ppm-S	Sr ppm-S	Ge ppm-S	V ppm-S	W ppm-S	Y ppm-S	Yb ppm-S	Zn ppm-S	Zr ppm-S
MONTANA --continued									
CD78R2	N	5,000.00	N	N	N	N	N	N	N
CD78R3	15	1,000.00	15	70	300	15	2.0	N	150
NEVADA									
CD77-55	N	1,000 00	10	N	N	N	N	N	N
CD77-54	N	1,500.00	10	N	N	N	N	N	10
CD77-3	N	1,500.00	30	7	300	<10	<1.0	N	15
CD77-4	N	700.00	15	15	N	15	<1.0	N	50
CD77-5	7	300.00	15	70	N	30	3.0	N	150
CD77-6	N	500.00	15	7	300	10	<1.0	N	20
CD77-7	N	1,500.00	<10	7	N	<10	N	N	15
80KF50	N	1,000.00	N	N	N	10	N	N	N
CD77-53	N	70.00	70	7	N	N	N	N	N
CD77-1	N	150.00	N	<7	N	20	<1.0	N	30
CD77-2	7	300.00	N	20	N	20	2.0	N	150
CD77-12	<5	200.00	10	30	N	<10	<1.0	<300	30
CD77-13	5	300.00	15	30	N	10	<1.0	<300	30
CD77-14	N	150.00	<10	20	N	<10	<1.0	N	30
CD77-15	N	150.00	N	<7	<100	<10	<1.0	N	70
CD77-16	7	150.00	<10	150	<100	N	<1.0	N	100
CD77-17	5	300.00	<10	50	100	<10	<1.0	N	100
CD77-8	N	10,100.00	N	N	N	<10	N	N	N
CD77-9	N	7,000.00	<10	15	N	<10	N	N	15
CD77-10	N	7,000.00	N	<7	N	<10	N	N	N
CD77-11	7	1,500.00	N	50	N	10	<1.0	N	30
KF1	N	10,000.00	N	<7	N	<10	N	N	N
KF2	N	2,000.00	15	<7	700	<10	N	N	N
CD77-46	N	700.00	N	N	N	N	N	N	N
CD77-47	N	70.00	N	N	N	N	N	N	N
CD77-48	N	500.00	N	5	N	N	N	N	20
CD77-49	N	1,000.00	N	15	N	N	N	N	50
CD77-50	N	700.00	N	N	N	N	N	N	50
CD77-51	N	70.00	20	15	N	10	<1.0	N	100
CD77-52	N	70.00	N	N	N	N	N	N	N
CD78R21	N	200.00	N	N	N	N	N	N	N
CD78R22	N	1,000.00	N	N	N	N	N	N	N
CD78R23	N	70.00	N	N	N	N	N	N	N
CD80-69	N	300.00	N	N	N	N	N	N	N
CD77-43	N	1,000.00	N	7	N	N	N	N	20

Table 4. Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states-Continued.

[<, less than; >, greater than; --, not analyzed; N, not detected; H, analytical interference.]

LOC.	Sample	LAB. NO.	eU ppm	U ppm	Th ppm	T-S%	Al%-S	Ca%-S	Fe%-S	K%-S
NEVADA --continued										
19	CD77-44	189,910	30	1.0400	--	.65	2.00	>10.00	.500	1.00
19	CD77-45	189,911	50	1.3700	--	.11	2.00	>10.00	5.000	1.00
22	CD77-41	189,907	30	<.1200	<1.30	<.01	.07	>10.00	.100	N
22	CD77-42	189,908	20	1.0900	--	.23	.20	>10.00	1.000	1.00
26	CD77-40	189,906	<10	.7800	--	.29	1.00	1.50	.200	N
29	CD77-24	189,955	100	12.8100	21.89	.20	10.00	1.50	2.000	3.00
30	CD77-32	189,963	<10	1.3500	--	14.46	3.00	3.00	.300	1.50
30	CD77-33	189,964	10	2.9000	--	6.38	3.00	2.00	1.500	3.00
33	CD77-34	189,965	120	6.7700	--	.75	3.00	7.00	1.000	3.00
33	CD77-35	189,966	40	2.6600	--	.19	.70	>10.00	.300	N
33	CD77-36	189,967	60	2.7800	--	.27	.20	>10.00	.500	N
34	CD77-39	189,905	20	2.6600	15.66	<.01	>10.00	3.00	5.000	5.00
34	CD77-37	189,968	10	.4000	--	.06	1.00	>10.00	.700	.70
34	CD77-38	189,969	10	1.7900	--	.08	2.00	7.00	.700	1.50
NEW MEXICO										
01	75MS40	175,622	4,480	1.3600	5.07	--	1.00	>10.00	2.000	N
05	CD76-1B	179,493	180	<.1300	<1.20	--	.05	>10.00	.500	N
UTAH										
01	CD76-13	180,950	20	2.0300	6.20	--	3.00	>10.00	.500	1.00
01	CD76-14	180,951	20	.5600	<2.20	--	1.50	>10.00	.500	N
05	CD76-12	180,949	110	1.2500	<2.50	--	1.00	>10.00	2.000	.70
06	CD76-16	180,953	<10	.3800	<2.80	--	1.00	>10.00	.300	.70
07	CD76-15	180,952	10	.7700	<2.10	--	1.00	>10.00	.500	N
09	75MS101B	176,725	6,010	.1200	1.80	--	.20	>10.00	.070	N
09	75MS102B	176,726	710	.9300	7.24	--	1.50	>10.00	.300	1.00
09	75MS103B	176,727	590	1.3400	3.70	--	2.00	>10.00	.500	1.50
09	CD76-11B	180,948	10,200	.1800	<1.10	11.64	.30	.50	.050	N
09	CD76-19	180,954	130	1.2000	<2.80	15.66	2.00	>10.00	.700	1.50
09	80KF51	230,322	<10	.8600	<1.40	--	.05	>10.00	.700	N
09	CD80-72	230,324	7,400	<4.8000	<39.00	10.17	.30	>10.00	.150	N
10	75MS104B	176,728	410	.1600	1.30	--	.15	>10.00	5.000	N
10	75MS105	176,729	80	<.1400	<1.50	--	.02	>10.00	5.000	N
10	CD76-20B	180,955	1,050	<.1700	<1.80	--	.20	>10.00	>10.000	N
11	75MS105B	176,730	430	.7800	3.00	--	1.50	>10.00	5.000	.70
12	75MS107	176,731	1,040	.8500	2.60	--	1.50	5.00	2.000	3.00
13	CD76-21	180,956	410	.4900	<2.00	.28	.70	>10.00	1.000	N
13	CD76-22	180,957	30	.5900	<1.90	--	.50	>10.00	.300	N
14	75MS108	176,732	<10	.5500	<1.90	--	.10	>10.00	.100	N

Table 4. Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states-Continued.

[<, less than; >, greater than; --, not analyzed; N, not detected; H, analytical interference.]

Sample	Mg%-S	Na%-S	Si%-S	Ti%-S	As ppm-S	B ppm-S	Ba ppm-S	Be ppm-S	Ce ppm-S	Co ppm-S
					NEVADA --continued					
CD77-44	.500	.700	3.00	.0300	N	N	500.0	1.5	N	N
CD77-45	.700	.700	7.00	.0300	N	N	1,000.0	2.0	N	N
CD77-41	.300	.300	.50	.0005	N	N	500.0	1.5	N	N
CD77-42	.700	.700	5.00	.0300	N	N	500.0	5.0	N	N
CD77-40	.050	1.000	>10.00	.0050	N	200.00	100.0	7.0	N	N
CD77-24	.700	3.000	>10.00	.2000	N	30.00	700.0	3.0	<200	<5.0
CD77-32	.300	>10.000	3.00	.0300	N	20.00	100.0	N	N	<5.0
CD77-33	.300	>10.000	10.00	.0700	N	300.00	500.0	1.5	N	<5.0
CD77-34	2.000	1.500	7.00	.0700	N	100.00	150.0	3.0	N	<5.0
CD77-35	.700	.500	.50	.0070	N	N	50.0	3.0	N	N
CD77-36	.700	.500	.30	.0070	N	<20.00	70.0	3.0	N	N
CD77-39	1.000	.700	>10.00	.5000	N	100.00	700.0	3.0	N	10.0
CD77-37	.300	.500	1.50	.0200	N	N	200.0	3.0	N	N
CD77-38	.700	2.000	>10.00	.0700	N	70.00	300.0	3.0	N	<5.0
					NEW MEXICO					
75MS40	.200	.500	1.50	.0300	3,000.0	N	10,000.0	30.0	N	N
CD76-1B	.500	.500	.07	.0002	N	N	500.0	<1.5	N	N
					UTAH					
CD76-13	.700	1.500	7.00	.0700	N	N	500.0	N	N	2.0
CD76-14	.300	.500	1.50	.0200	N	N	500.0	N	N	N
CD76-12	1.000	3.000	5.00	.0200	N	N	2,000.0	1.0	N	N
CD76-16	.700	7.000	5.00	.0200	N	50.00	200.0	N	N	N
CD76-15	1.500	.500	2.00	.0300	N	N	700.0	N	N	N
75MS101B	.300	.700	.50	.0070	N	N	>100,000.0	N	N	N
75MS102B	.700	.500	5.00	.0700	N	N	100,000.0	N	N	N
75MS103B	2.000	1.500	7.00	.0700	N	30.00	70,000.0	N	N	N
CD76-11B	.030	.200	1.50	.0070	N	N	>100,000.0	N	N	N
CD76-19	2.000	5.000	>10.00	.0500	N	20.00	20,000.0	N	N	N
80KF51	3.000	<0.030	2.00	.0070	N	N	1,000.0	N	N	N
CD80-72	.200	.200	1.00	.0300	N	N	>100,000.0	N	N	N
75MS104B	.100	3.000	1.00	.0070	N	30.00	1,500.0	20.0	N	N
75MS105	.020	2.000	.50	N	N	N	1,000.0	20.0	N	N
CD76-20B	.070	1.000	1.50	.0020	N	N	2,000.0	100.0	N	N
75MS105B	.200	.500	5.00	.0300	N	N	1,000.0	15.0	N	N
75MS107	.700	1.000	>10.00	.0700	N	150.00	30,000.0	N	N	5.0
CD76-21	.500	1.500	1.50	.0100	N	N	1,000.0	N	N	10.0
CD76-22	.500	2.000	1.00	.0100	N	N	100.0	N	N	15.0
75MS108	.500	.150	.50	.0070	N	N	200.0	1.0	N	N

Table 4. Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states-Continued.

[<, less than; >, greater than; --, not analyzed; N, not detected; H, analytical interference.]

Sample	Cr ppm-S	Cu ppm-S	Ga ppm-S	La ppm-S	Li ppm-S	Mn ppm-S	Mo ppm-S	Nb ppm-S	Ni ppm-S	Pb ppm-S
NEVADA --continued										
CD77-44	5.0	10.0	5	N	N	70	N	N	<5.0	15
CD77-45	10.0	50.0	5	N	N	300	N	N	5.0	30
CD77-41	1.0	<1.0	N	N	N	100	N	N	N	N
CD77-42	7.0	10.0	10	N	<100	300	N	N	<5.0	70
CD77-40	2.0	20.0	200	N	<100	70	5	N	N	N
CD77-24	15.0	15.0	30	<30	<100	300	<3	10	7.0	30
CD77-32	10.0	10.0	<5	N	100	100	7	N	7.0	15
CD77-33	15.0	70.0	10	N	150	10,000	15	20	7.0	100
CD77-34	10.0	10.0	10	N	200	150	15	<10	30.0	15
CD77-35	7.0	3.0	N	N	N	70	3	N	20.0	N
CD77-36	7.0	3.0	N	N	N	300	N	N	30.0	N
CD77-39	70.0	30.0	30	50	<100	200	N	10	30.0	50
CD77-37	7.0	7.0	5	N	150	1,500	N	<10	<5.0	N
CD77-38	15.0	15.0	10	N	300	700	N	<10	7.0	15
NEW MEXICO										
75MS40	5.0	10.0	N	N	N	50,000	N	N	5.0	N
CD76-1B	2.0	3.0	N	N	N	700	N	<10	N	N
UTAH										
CD76-13	20.0	15.0	7	N	N	100	N	N	3.0	10
CD76-14	20.0	1.5	N	N	N	100	N	N	N	N
CD76-12	15.0	5.0	5	N	N	50	N	N	3.0	10
CD76-16	10.0	7.0	N	N	N	150	<3	N	2.0	10
CD76-15	10.0	7.0	N	N	N	1,000	N	N	7.0	N
75MS101B	2.0	2.0	N	N	N	100	N	N	N	N
75MS102B	20.0	15.0	3	N	N	200	N	N	N	N
75MS103B	30 0	10.0	5	N	50	150	N	N	3.0	20
CD76-11B	5.0	1.0	N	N	N	7	N	N	N	N
CD76-19	30.0	300.0	7	N	50	100	N	N	3.0	15
80KF51	30.0	1.5	N	N	N	100	N	N	<5.0	N
CD80-72	2.0	3.0	N	N	N	200	N	N	N	N
75MS104B	1.0	5.0	N	N	N	20,000	7	N	N	N
75MS105	N	N	N	N	N	10,000	N	N	N	N
CD76-20B	5.0	1.0	N	N	N	5,000	7	N	N	N
75MS105B	15.0	5.0	3	N	N	10,000	N	N	3.0	N
75MS107	20.0	30.0	5	N	150	50,000	30	N	5.0	N
CD76-21	3.0	5.0	N	N	50	10,000	7	N	15.0	N
CD76-22	10.0	20.0	N	N	N	3,000	<3	N	70.0	30
75MS108	3.0	2.0	N	N	N	70	N	N	N	N

Table 4. Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states-Continued.

[<, less than; >, greater than; --, not analyzed; N, not detected; H, analytical interference.]

Sample	Sc ppm-S	Sr ppm-S	Ge ppm-S	V ppm-S	W ppm-S	Y ppm-S	Yb ppm-S	Zn ppm-S	Zr ppm-S
NEVADA --continued									
CD77-44	N	700.00	N	10	N	<10	<1.0	N	50
CD77-45	N	700.00	N	10	N	<10	<1.0	300	50
CD77-41	N	2,000.00	N	N	N	N	N	N	N
CD77-42	N	1,500.00	15	15	N	10	<1.0	N	30
CD77-40	N	300.00	15	N	N	N	N	N	15
CD77-24	7	500.00	N	70	N	15	1.5	N	150
CD77-32	N	1,500.00	N	15	N	<10	N	N	20
CD77-33	<5	700.00	30	30	1,000	10	1.0	N	70
CD77-34	<5	700.00	50	30	N	15	1.5	1,000	30
CD77-35	N	700.00	N	N	N	<10	N	N	N
CD77-36	N	1,000.00	15	N	N	<10	N	1,000	N
CD77-39	20	500.00	30	100	<100	30	2.0	N	150
CD77-37	N	1,000.00	15	7	N	<10	N	N	30
CD77-38	<5	700.00	70	20	N	<10	1.5	N	30
NEW MEXICO									
75MS40	10	700.00	20	20	1,000	20	5.0	N	30
CD76-1B	N	700.00	N	N	N	N	N	N	N
UTAH									
CD76-13	N	15,000.00	N	10	N	15	1.5	N	70
CD76-14	N	2,000.00	N	7	N	N	N	N	10
CD76-12	N	2,000 00	N	5	N	N	N	N	30
CD76-16	N	1,500.00	N	5	N	N	N	N	50
CD76-15	N	1,000.00	N	10	N	N	N	N	20
75MS101B	N	15,000.00	N	N	N	N	N	N	30
75MS102B	N	7,000.00	N	15	N	7	.7	N	50
75MS103B	N	7,000.00	N	30	N	10	1.0	N	70
CD76-11B	N	10,000.00	N	5	N	N	N	500	N
CD76-19	2	700.00	N	10	N	15	1.5	N	50
80KF51	N	150 00	N	10	N	10	N	N	15
CD80-72	N	7,000.00	N	7	N	<10	N	N	20
75MS104B	N	5,000.00	30	N	N	N	N	N	N
75MS105	N	3,000.00	20	N	N	N	N	N	N
CD76-20B	N	1,000.00	50	N	N	N	N	N	N
75MS105B	N	2,000.00	10	10	N	20	2.0	N	30
75MS107	N	3,000.00	15	30	N	7	.7	N	70
CD76-21	N	1,000.00	N	10	<100	N	N	N	N
CD76-22	N	1,000.00	N	7	N	N	N	500	10
75MS108	N	3,000.00	N	N	N	N	N	N	N

Table 4. Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states-Continued.

[<, less than; >, greater than; --, not analyzed; N, not detected; H, analytical interference.]

LOC.	Sample	LAB. NO.	eU ppm	U ppm	Th ppm	T-S%	Al%-S	Ca%-S	Fe%-S	K%-S
UTAH --continued										
18	CD77-56	189,922	20	.4200	--	16.22	.02	>10.00	.020	N
18	CD77-57	189,923	150	.3200	--	.51	.30	>10.00	2.000	N
18	CD77-58	189,924	100	.7700	--	1.75	1.00	>10.00	1.500	N
18	CD77-59	189,925	20	<.1600	<1.70	15.70	.02	>10.00	.030	N
18	CD77-60	189,926	820	.9600	--	1.47	2.00	>10.00	5.000	1.00
18	CD77-61	189,927	1,200	.5100	--	1.05	.15	>10.00	5.000	N
18	CD77-62	189,928	480	1.0100	--	.72	1.50	>10.00	2.000	1.00
18	CD77-63	189,929	100	.1600	<1.40	.97	.10	>10.00	1.000	N
18	MBQ339	213,820	630	1.2100	<3.20	.74	.78	16.00	3.000	.46
18	MBQ783	214,080	320	.7200	3.50	--	.85	20.00	1.400	.43
18	MBQ784	214,081	10	.2100	1.80	--	.27	>20.00	<.050	.21
18	MBQ785	214,082	250	.8100	2.60	--	.77	17.00	.890	.36
18	MBQ786	214,083	260	.5200	4.10	--	.76	18.00	1.800	.41
18	MBQ787	214,084	390	1.0100	<2.30	--	.72	19.00	1.400	.35
18	MBQ788	214,085	480	.8200	3.50	--	.81	>20.00	.450	.37
18	MBQ789	214,086	300	.5000	3.00	--	.55	18.00	1.000	.29
18	MBQ790	214,087	210	.2600	2.30	--	.36	>20.00	.750	.24
18	MBQ791	214,088	360	1.0500	2.80	--	1.10	19.00	1.600	.60
18	MBQ792	214,089	450	.4900	<1.90	--	.48	>20.00	.780	.55
18	MBQ793	214,090	520	1.0600	5.53	--	1.40	16.00	1.200	.62
18	MBQ794	214,091	280	.9000	3.10	--	1.10	>20.00	1.200	.43
18	MBQ841	214,282	330	<2.2000	<20.00	--	.82	19.00	.650	.51
18	MBQ842	214,283	140	<1.7000	<20.00	--	1.60	22.00	.720	3.00
18	MBQ837	214,349	270	.8400	<3.30	--	.84	18.00	.480	.45
18	MBQ838	214,350	340	<1.8000	<16.00	--	1.30	28.00	.200	2.70
18	MBQ839	214,351	580	<1.8000	<21.00	--	1.60	19.00	1.500	.77
18	MBQ840	214,352	280	.7000	<3.10	--	.83	17.00	.850	.39
19	MBQ350	213,831	40	12.6000	54.90	.15	7.50	.92	1.600	3.50
19	MBQ759	213,832	30	14.5000	56.80	.07	3.60	12.00	.450	1.60
19	MBQ760	213,833	60	27.4000	54.80	.22	6.30	5.70	2.400	1.80
19	MBQ761	213,834	30	19.4000	<8.20	.31	.40	39.00	.240	.25
19	MBQ763	213,836	10	16.4000	<7.20	.15	1.20	19.00	<.050	.65
20	MBQ346	213,827	30	.8900	<2.00	.28	<.25	32.00	<.050	.14
20	MBQ347	213,828	20	1.8800	<3.00	.74	<.25	34.00	2.800	.15
22	MBQ344	213,825	20	5.3400	<4.80	.08	1.50	14.00	.370	.45
23	75MS109	176,733	250	.6800	4.50	--	.70	>10.00	>10.000	N
23	75MS110	176,734	<10	.1500	<1.40	--	.50	>10.00	2.000	N
23	75MS111	179,489	250	.3000	<2.00	--	1.50	>10.00	>10.000	N
23	MBQ340	213,821	1,900	<.7700	<7.00	.38	1.60	18.00	.770	.37
27	MBQ345	213,826	<10	3.8000	<4.00	.16	1.10	16.00	.390	.48
36	75MS112	176,735	370	1.5300	6.40	--	1.50	>10.00	1.000	2.00
36	CD76-23B1	180,958	740	<.1400	<1.50	.36	.15	>10.00	.050	N
36	CD76-23B2	180,959	330	.3900	<1.80	--	1.00	>10.00	.300	N
41	75MS113	176,736	2,300	.1300	1.80	--	.50	10.00	>10.000	N
41	75MS114	176,737	190	<.1200	<1.10	--	.05	>10.00	2.000	N

Table 4. Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states-Continued.

[<, less than; >, greater than; --, not analyzed; N, not detected; H, analytical interference.]

Sample	Mg%-S	Na%-S	Si%-S	Ti%-S	As ppm-S	B ppm-S	Ba ppm-S	Be ppm-S	Ce ppm-S	Co ppm-S
UTAH --continued										
CD77-56	.200	.200	.30	.0020	N	N	15.0	N	N	N
CD77-57	.500	2.000	.70	.0030	N	N	70.0	5.0	N	N
CD77-58	.500	2.000	2.00	.0200	N	N	70.0	5.0	N	N
CD77-59	.200	.500	.30	.0020	N	N	15.0	N	N	N
CD77-60	1.500	3.000	5.00	.0500	N	20.00	200.0	10.0	N	N
CD77-61	.500	3.000	1.50	.0070	N	30.00	150.0	15.0	N	N
CD77-62	1.000	3.000	5.00	.0500	N	20.00	200.0	10.0	N	N
CD77-63	.500	2.000	.50	.0050	N	N	50.0	5.0	N	N
MBQ339	1.100	1.200	<10.00	.0400	<200.0	34.00	330.0	5.3	<100.0000	5.9
MBQ783	1.500	1.100	<10.00	.0400	<200.0	<10.00	250.0	5.4	130.0000	8.7
MBQ784	.700	1.200	<10.00	<.0300	<200.0	<10.00	86.0	<1.0	H	8.2
MBQ785	2.200	1.300	<10.00	.0400	<200.0	16.00	310.0	1.7	<100.0000	5.6
MBQ786	1.700	1.200	<10.00	.0400	<200.0	<10.00	260.0	6.4	<100.0000	6.4
MBQ787	.950	.980	<10.00	.0400	<200.0	<10.00	240.0	5.2	100.0000	7.2
MBQ788	.810	.840	<10.00	.0400	<200.0	<10.00	370.0	4.0	H	7.2
MBQ789	1.600	1.000	<10.00	.0300	<200.0	<10.00	340.0	5.2	<100.0000	6.0
MBQ790	.980	.930	<10.00	<.0300	<200.0	<10.00	170.0	4.4	H	7.4
MBQ791	1.300	1.200	<10.00	.0600	<200.0	<10.00	310.0	6.7	<100.0000	6.4
MBQ792	1.100	3.600	<10.00	.0300	<200.0	20.00	200.0	4.4	<200.0000	4.0
MBQ793	1.500	1.900	<10.00	.0700	<200.0	<10.00	570.0	4.5	<100.0000	5.1
MBQ794	1.500	1.300	<10.00	.0500	<200.0	<10.00	370.0	2.9	<100.0000	7.8
MBQ841	1.500	1.900	<10.00	.0400	<200.0	<10.00	400.0	2.9	110.0000	7.4
MBQ842	1.600	1.800	<10.00	.0600	<200.0	<20.00	280.0	2.4	<200.0000	5.6
MBQ837	1.400	1.400	<10.00	.0600	<200.0	<10.00	290.0	2.5	110.0000	6.7
MBQ838	1.600	1.000	<10.00	.0600	<200.0	<20.00	320.0	2.8	<200.0000	9.0
MBQ839	1.500	1.100	<10.00	.0800	<200.0	<10.00	560.0	4.5	<100.0000	7.1
MBQ840	1.500	.780	<10.00	.0500	<200.0	<10.00	280.0	4.0	110.0000	6.8
MBQ350	.500	3.300	36.00	.1600	<200.0	12.00	270.0	14.0	<100.0000	4.4
MBQ759	.270	1.300	19.00	.0400	<200.0	<10.00	220.0	12.0	<100.0000	3.6
MBQ760	1.200	1.200	26.00	.2600	<200.0	22.00	410.0	21.0	<100.0000	6.9
MBQ761	.640	.320	<10.00	.0300	<200.0	<10.00	120.0	15.0	<200.0000	9.1
MBQ763	.540	.490	<10.00	.0400	<200.0	<10.00	150.0	32.0	<100.0000	7.2
MBQ346	.650	.230	<10.00	<.0300	<200.0	<10.00	310.0	<1.0	<200.0000	11.0
MBQ347	.700	.340	<10.00	<.0300	<200.0	<10.00	96.0	1.5	<200.0000	11.0
MBQ344	.780	.290	21.00	.0800	<200.0	<10.00	370.0	1.0	<100.0000	3.8
75MS109	.200	.500	2.00	.0150	N	N	5,000.0	15.0	N	N
75MS110	1.000	.200	2.00	.0100	N	N	200.0	1.5	N	N
75MS111	.700	.700	3.00	.0200	1,000.0	N	10,000.0	20.0	N	N
MBQ340	.580	.200	<10.00	.0400	<200.0	<10.00	>26,000.0	15.0	110.0000	12.0
MBQ345	1.400	.390	<10.00	.0700	<200.0	<10.00	510.0	<1.0	<100.0000	5.6
75MS112	1.500	1.000	>10.00	.1000	N	30.00	10,000.0	N	N	N
CD76-23B1	1.000	.300	.15	.0010	N	N	10,000.0	N	N	N
CD76-23B2	1.000	.700	3.00	.0200	N	N	5,000.0	N	N	N
75MS113	.100	1.000	1.50	.0150	>100,000.0	N	7,000.0	50.0	N	N
75MS114	.050	.200	.10	.0010	1,000.0	N	1,500.0	5.0	N	N

Table 4. Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states-Continued.

[<, less than; >, greater than; --, not analyzed; N, not detected; H, analytical interference.]

Sample	Cr ppm-S	Cu ppm-S	Ga ppm-S	La ppm-S	Li ppm-S	Mn ppm-S	Mo ppm-S	Nb ppm-S	Ni ppm-S	Pb ppm-S
UTAH --continued										
CD77-56	1.0	1.0	N	N	N	30	N	N	N	N
CD77-57	2.0	1.0	N	N	N	1,000	N	N	<5.0	N
CD77-58	5.0	7.0	N	N	N	700	7	N	<5.0	10
CD77-59	1.0	2.0	N	N	N	15	N	N	N	N
CD77-60	10.0	15.0	10	N	<100	5,000	N	N	7.0	N
CD77-61	1.0	2.0	<5	N	N	5,000	N	N	5.0	15
CD77-62	10.0	10.0	5	N	<100	500	N	N	5.0	10
CD77-63	N	1.0	N	N	N	700	N	N	N	N
MBQ339	15.0	6.5	<10	60	140	4,100	<10	<25	10.0	<10
MBQ783	12.0	5.7	<10	75	250	2,000	<10	<25	13.0	<10
MBQ784	10.0	4.6	<10	77	H	<200	<10	<25	10.0	19
MBQ785	10.0	5.6	<10	55	170	1,900	<10	<25	9.3	<10
MBQ786	10.0	5.1	<10	60	180	1,100	<10	<25	10.0	<10
MBQ787	10.0	4.5	<10	65	110	1,800	<10	<25	11.0	<10
MBQ788	11.0	4.8	<10	70	76	810	<10	<25	12.0	<10
MBQ789	<10.0	5.2	<10	60	140	380	<10	<25	9.5	15
MBQ790	11.0	7.1	<10	75	H	640	<10	<25	11.0	29
MBQ791	12.0	7.0	<10	58	80	830	<10	<25	12.0	40
MBQ792	<20.0	7.8	<20	48	170	640	<10	<25	8.8	<20
MBQ793	12.0	7.0	<10	49	130	410	<10	<25	11.0	19
MBQ794	13.0	7.8	<10	68	H	870	<10	<25	12.0	15
MBQ841	15.0	5.2	<10	69	130	930	<10	<25	11.0	<10
MBQ842	20.0	7.8	<20	50	120	480	<20	<50	12.0	<20
MBQ837	15.0	6.0	<10	68	240	1,100	<10	<25	11.0	40
MBQ838	22.0	7.2	<20	78	370	1,300	<10	<50	14.0	<10
MBQ839	18.0	6.8	<10	62	150	490	<10	<25	12.0	11
MBQ840	16.0	6.6	<10	68	230	950	<10	<25	10.0	30
MBQ350	17.0	9.3	29	27	120	350	<10	50	8.6	12
MBQ759	<10.0	3.8	13	47	120	790	<10	<50	11.0	<10
MBQ760	28.0	14.0	18	50	75	330	<10	<25	16.0	42
MBQ761	11.0	5.8	<10	84	<100	320	<10	<25	12.0	<20
MBQ763	<10.0	4.9	<10	63	<50	220	<10	39	12.0	<10
MBQ346	13.0	4.5	<10	110	<100	940	<10	<25	14.0	<10
MBQ347	13.0	27.0	<10	81	<100	2,200	<10	<25	23.0	<10
MBQ344	38.0	6.6	<10	55	<50	<200	<10	<25	16.0	<10
75MS109	3.0	1.5	10	N	N	10,000	N	N	N	N
75MS110	2.0	N	N	N	70	200	N	N	N	N
75MS111	7.0	10.0	10	<30	N	50,000	N	10	<5.0	N
MBQ340	<10.0	7.8	23	91	<50	>50,000	<10	<25	10.0	11
MBQ345	15.0	11.0	<10	58	69	280	<10	<25	11.0	110
75MS112	15.0	7.0	7	N	N	100	N	N	3.0	N
CD76-23B1	2.0	N	N	N	N	70	N	N	N	N
CD76-23B2	5.0	2.0	N	N	N	150	N	N	N	N
75MS113	1.0	10.0	15	N	N	50,000	N	10	N	N
75MS114	N	N	N	N	N	5,000	N	N	N	N

Table 4. Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states-Continued.

[<, less than; >, greater than; --, not analyzed; N, not detected; H, analytical interference.]

Sample	Sc ppm-S	Sr ppm-S	Ge ppm-S	V ppm-S	W ppm-S	Y ppm-S	Yb ppm-S	Zn ppm-S	Zr ppm-S
UTAH --continued									
CD77-56	N	700.00	N	N	N	N	N	N	N
CD77-57	N	1,500.00	N	N	N	N	N	N	N
CD77-58	N	1,500.00	N	5	N	N	N	N	30
CD77-59	N	1,000.00	N	N	N	N	N	N	N
CD77-60	N	1,500.00	10	15	N	<10	<1.0	N	20
CD77-61	N	1,000.00	10	N	N	N	N	N	N
CD77-62	N	1,500.00	10	10	N	<10	<1.0	N	50
CD77-63	N	1,500.00	N	N	N	N	N	N	N
MBQ339	<10	2,000.00	--	20	<100	22	--	69	110
MBQ783	<10	3,700.00	--	22	<100	12	--	<50	160
MBQ784	<10	>5,000.00	--	18	<100	<10	--	<50	<20
MBQ785	<10	4,100.00	--	10	<100	<10	--	<50	73
MBQ786	<10	3,700.00	--	12	<100	10	--	<50	94
MBQ787	<10	3,700.00	--	16	<100	10	--	<50	120
MBQ788	<10	3,200 00	--	15	<100	11	--	54	110
MBQ789	<10	3,600.00	--	<10	<100	<10	--	<50	33
MBQ790	<10	3,100.00	--	12	<100	<10	--	H	77
MBQ791	<10	1,400.00	--	12	<100	12	--	<50	160
MBQ792	<10	>5,000.00	--	<20	<200	21	--	<50	<40
MBQ793	<10	1,700.00	--	12	<100	16	--	<50	210
MBQ794	<10	4,000.00	--	18	<100	12	--	<50	100
MBQ841	<10	1,800.00	--	23	<100	11	--	<50	90
MBQ842	<20	1,900.00	--	<20	<100	<20	--	<50	<40
MBQ837	<10	4,000.00	--	19	<100	11	--	<50	130
MBQ838	<20	3,900.00	--	34	<100	<20	--	<100	<40
MBQ839	<10	1,700.00	--	28	<100	16	--	<50	170
MBQ840	<10	>5,000.00	--	22	<100	12	--	110	67
MBQ350	<10	130.00	--	17	<100	180	--	<50	340
MBQ759	<10	250.00	--	<10	<100	220	--	<50	210
MBQ760	<10	360.00	--	36	<100	330	--	52	400
MBQ761	<10	2,600.00	--	16	<100	840	--	8,600	210
MBQ763	<10	960.00	--	<10	<100	1,600	--	<50	360
MBQ346	<10	2,300 00	--	19	<100	<10	--	<100	38
MBQ347	<10	2,100.00	--	13	<100	<10	--	580	31
MBQ344	<10	210.00	--	18	<100	24	--	67	320
75MS109	N	1,500.00	N	N	200	15	N	N	50
75MS110	N	5,000.00	N	N	N	N	N	N	N
75MS111	N	15,000.00	N	10	300	15	N	N	15
MBQ340	<10	5,900.00	--	10	H	15	--	68	200
MBQ345	<10	1,500.00	--	21	<100	14	--	170	280
75MS112	N	5,000.00	15	10	N	10	<.7	N	70
CD76-23B1	N	5,000.00	N	N	N	N	N	N	N
CD76-23B2	N	5,000 00	10	5	N	N	N	N	50
75MS113	N	2,000.00	100	N	1,000	20	N	N	N
75MS114	N	2,000.00	N	N	100	N	N	N	N

Table 4. Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states-Continued.

[<, less than; >, greater than; --, not analyzed; N, not detected; H, analytical interference.]

LOC.	Sample	LAB. NO.	eU ppm	U ppm	Th ppm	T-S%	Al%-S	Ca%-S	Fe%-S	K%-S
					UTAH --continued					
41	75MS115	179,490	30	<.1400	<1.60	--	.15	>10.00	1.500	N
42	75MS116	176,738	290	.6800	3.10	--	2.00	>10.00	3.000	.70
43	75MS117	176,739	50	1.0200	4.60	--	1.50	7.00	.700	1.50
44	75MS118	176,740	60	.2500	<1.60	--	.02	>10.00	.030	N
45	MBQ303	200,531	130	3.2300	<3.10	--	.40	35.00	3.000	1.60
					WYOMING					
01	CD76-29	182,691	30	1.1500	<2.10	.66	.07	>10.00	.070	N
01	CD76-30	182,692	<10	.2600	<1.50	.13	.10	>10.00	.100	N
02	CD76-31A	182,693	30	.2200	<1.70	2.38	.70	>10.00	.300	N
04	CD76-31B	182,694	20	3.8400	9.69	.30	10.00	>10.00	3.000	2.00
05	CD76-32	182,695	200	.3600	<1.70	.07	1.00	>10.00	.300	N
06	CD76-33	182,696	10	.8000	<2.00	.42	.20	>10.00	.200	N
08	CD76-28	182,690	440	.5400	<2.30	.35	1.50	>10.00	.200	N
09	CD76-34	182,697	590	7.2500	<5.10	.44	1.50	>10.00	.200	N
09	CD76-35	182,698	50	.9500	<3.50	41.66	2.00	10.00	.150	1.00
09	CD76-36	182,699	20	<.3000	<2.50	64.14	.20	.50	.030	N
09	CD76-37	182,700	20	1.0900	<2.30	8.50	.10	>10.00	.070	N
09	CD76-38	182,701	50	<.1900	<1.60	1.25	.15	>10.00	.070	N
10	CD76-26	182,688	20	2.6800	12.10	1.65	>10.00	1.50	7.000	3.00
10	CD76-27	182,689	20	2.5000	8.43	1.06	10.00	1.50	3.000	3.00

Table 4. Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states-Continued.

[<, less than; >, greater than, --, not analyzed; N, not detected; H, analytical interference.]

Sample	Mg%-S	Na%-S	Si%-S	Ti%-S	As ppm-S	B ppm-S	Ba ppm-S	Be ppm-S	Ce ppm-S	Co ppm-S
UTAH --continued										
75MS115	.300	.500	.15	.0100	N	N	300.0	3.0	N	N
75MS116	.700	1.000	3.00	.0200	1,000.0	N	2,000.0	10.0	N	N
75MS117	1.000	1.000	>10.00	.0500	N	100.00	500.0	10.0	N	N
75MS118	.300	.700	.10	.0007	N	N	100.0	N	N	N
MBQ303	.200	.940	1.00	.0630	2,000.0	<10.00	460.0	11.0	<100	50.0
WYOMING										
CD76-29	.500	.300	.15	<.0001	N	N	70.0	N	N	N
CD76-30	.300	.150	.20	.0020	N	N	30.0	N	N	N
CD76-31A	.700	.700	2.00	.0150	N	N	100.0	<1.5	N	N
CD76-31B	2.000	2.000	>10.00	.2000	N	30.00	700.0	<1.5	<200	7.0
CD76-32	1.000	.150	2.00	.0150	N	N	500.0	3.0	N	N
CD76-33	.700	.300	.70	.0050	N	N	70.0	N	N	N
CD76-28	.700	.300	2.00	.1500	N	N	500.0	N	N	N
CD76-34	.300	.300	3.00	.0200	N	N	700.0	10.0	N	N
CD76-35	.050	.500	>10.00	.1000	N	<20.00	300.0	N	N	N
CD76-36	.015	.070	5.00	.0300	N	N	150.0	N	N	N
CD76-37	.300	1.000	.70	.0030	N	<20.00	50.0	2.0	N	N
CD76-38	.500	.700	.70	.0050	<1000.0	N	70.0	3.0	N	N
CD76-26	1.000	1.000	>10.00	.3000	N	70.00	700.0	2.0	<200	7.0
CD76-27	.700	1.000	>10.00	.2000	N	50.00	1,000.0	1.5	<200	7.0

Table 4. Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states-Continued.

[<, less than; >, greater than; --, not analyzed; N, not detected; H, analytical interference.]

Sample	Cr ppm-S	Cu ppm-S	Ga ppm-S	La ppm-S	Li ppm-S	Mn ppm-S	Mo ppm-S	Nb ppm-S	Ni ppm-S	Pb ppm-S
UTAH --continued										
75MS115	5.0	5.0	N	N	N	700	N	N	<5.0	N
75MS116	1.0	10.0	N	N	N	20,000	7	N	3.0	N
75MS117	10.0	5.0	15	N	300	150	N	N	3.0	10
75MS118	N	N	N	N	N	50	N	N	N	N
MB0303	75.0	24.0	23	200	<200	3,000	40	<25	78.0	1,800
WYOMING										
CD76-29	3.0	1.5	N	N	N	100	N	N	N	N
CD76-30	2.0	3.0	N	N	N	70	N	N	N	N
CD76-31A	7.0	7.0	N	N	N	150	N	N	<5.0	10
CD76-31B	70.0	15.0	15	50	N	300	N	10	30.0	15
CD76-32	7.0	7.0	5	N	N	3,000	N	N	N	30
CD76-33	2.0	1.5	N	N	N	300	N	N	N	N
CD76-28	5.0	5.0	N	N	N	150	N	N	N	10
CD76-34	5.0	7.0	7	N	N	2,000	N	N	N	N
CD76-35	15.0	5.0	5	N	N	10	N	10	N	<10
CD76-36	5.0	7.0	N	<30	N	3	N	N	N	N
CD76-37	2.0	2.0	N	N	N	500	N	N	N	N
CD76-38	<1.0	1.0	N	N	N	700	N	N	N	<10
CD76-26	70.0	70.0	20	50	N	300	N	15	20.0	30
CD76-27	70.0	30.0	15	50	N	300	N	15	15.0	20

Table 4. Geochemical data for 297 samples of mineral spring precipitates collected at 105 localities in 9 states-Continued.

[<, less than; >, greater than; --, not analyzed; N, not detected; H, analytical interference.]

Sample	Sc ppm-S	Sr ppm-S	Ge ppm-S	V ppm-S	W ppm-S	Y ppm-S	Yb ppm-S	Zn ppm-S	Zr ppm-S
UTAH --continued									
75MS115	N	15,000.00	N	<7	N	N	N	N	N
75MS116	N	15,000.00	15	15	N	50	1.0	N	15
75MS117	N	3,000.00	30	15	N	N	N	N	70
75MS118	N	3,000.00	N	N	N	N	N	N	N
MBQ303	42	7,000.00	--	250	<100	75	--	5,000	200
WYOMING									
CD76-29	N	2,000.00	N	N	N	N	N	N	N
CD76-30	N	1,500.00	N	N	N	N	N	N	N
CD76-31A	N	2,000.00	N	<7	N	N	N	N	20
CD76-31B	10	300.00	N	70	N	20	3.0	N	150
CD76-32	N	1,000.00	N	<7	N	N	N	N	<20
CD76-33	N	1,000.00	N	N	N	N	N	N	N
CD76-28	N	5,000.00	N	7	N	N	N	N	15
CD76-34	N	1,500.00	N	10	N	20	2.0	N	30
CD76-35	N	200.00	N	10	N	N	1.5	N	100
CD76-36	N	7.00	N	N	N	N	N	N	30
CD76-37	N	2,000.00	N	<7	N	N	N	N	N
CD76-38	N	3,000.00	N	N	N	N	N	N	N
CD76-26	10	200.00	N	150	N	50	5.0	N	200
CD76-27	7	300.00	<10	100	N	30	3.0	N	300

Table 5.--Summary of geometric means, maximum and minimum values, log standard deviations, estimated range of means at the 95 percent confidence level and number of analyses used in the statistical computations for each element. [As indicated, some values are in percent (%) and some are in parts per million (ppm). Elements are listed in the general order of their abundance, as suggested by their geometric mean values.]

Elements	Geometric Mean	Maximum value	Minimum value	Standard Dev. log base *e*	Estimated Range of Geometric Mean		Number of values
					low	high	
Ca-%	9.95	40.0	0.07	1.364	8.51	11.63	297
Si-%	1.97	36.0	0.03	1.659	1.63	2.39	297
K-%	1.00	10.0	0.14	0.958	0.85	1.17	136
Fe-%	0.71	20.0	0.002	1.825	0.57	0.87	297
Na-%	0.59	20.0	0.007	1.350	0.50	0.68	294
S-%	0.57	64.1	0.01	2.019	0.42	.76	188
Al-%	0.55	20.0	0.01	1.679	0.46	0.67	297
Mg-%	0.41	3.0	0.005	1.116	0.36	0.46	297
Sr-ppm	1420	30000	7.0	1.498	1200	1690	297
Ba-ppm	583	200000	5.0	2.224	452	752	297
Mn-ppm	481	200000	3.0	2.058	380	608	297
As-ppm	355	200000	20.0	3.193	166	759	70
Ti-%	0.015	0.50	0.00002	1.871	0.012	0.019	289
Li-ppm	79.2	5000	10.0	1.274	60.5	104	86
eU-ppm	77.6	10200	2.0	2.063	61.1	98.4	291
Zn-ppm	65.7	8600	5.0	2.398	35.9	121	61
*Ce	51.5	300.0	20.00	0.692	40.0	67.1	29*
*W-ppm	50.8	10000	10.0	2.281	28.7	90.7	62*
Zr-ppm	50.7	500	2.0	1.169	42.8	60	189
La	35.4	200	4.0	0.919	28.7	43.8	74
B-ppm	26.8	1500	2.0	1.348	21.3	33.9	132
Ge	17.3	1515	2.0	1.138	13.5	22.1	84
V	15.9	300	1.0	1.207	13.4	18.8	195
Pb-ppm	14.8	1800	1.0	1.612	11.2	19.4	137
Y-ppm	12.4	1600	1.0	1.418	10.1	15.3	180
Be-ppm	6.7	500	0.1	1.529	5.5	8.2	225
Ni-ppm	6.5	150	1.0	1.200	5.4	7.8	178
*Th-ppm	6.4	56.8	1.2	0.878	5.5	7.3	164
Cr-ppm	6.3	300	0.2	1.310	5.4	7.3	271
Ga-ppm	5.9	200	1.0	1.352	4.8	7.2	169
Cu-ppm	5.8	1000	0.2	1.401	4.9	6.8	273
Sc-ppm	5.4	100	1.0	1.558	4.1	7.1	128
Co-ppm	5.1	200	1.0	1.246	4.1	6.4	115
Nb-ppm	4.4	70	2.0	0.958	3.6	5.2	109
Mo-ppm	2.8	50.0	0.7	1.227	2.2	3.7	91
Yb-ppm	1.3	50.0	0.2	1.300	1.0	1.7	107
U-ppm	0.68	61.6	0.02	2.115	0.53	0.87	285

*Elements not used in further statistical manipulations.

```
HISTOGRAM FOR VARIABLE   4 (eU ppm   )

    1 118E 00 XXXXXXXXXX
    1 968E 00 XXXXXXXXXXX
    2 818E 00 XXXXXXXXX
    3 668E 00 XXXXXXXXXXXXX
    4 518F 00 XXXXXXXXXXXXXXXXX
    5 368E 00 XXXXXXXXXX
    6 218F 00 XXXXXXXXXXXXXX
    7 068F 00 XXXXX
    7 918E 00 XXXXXX
    8 768F 00 XX
    9 618E 00
```

```
HISTOGRAM FOR VARIABLE   5 (U ppm    )

   -3 512E 00 XXXXXXXXXXXXXXXXX
   -2 712E 00
   -1 912E 00 XXXXXX
   -1 112E 00 XXXXXXXXXXX
   -3 170E-01 XXXXXXXXXXXXXXXXXXX
    4 880E-01 XXXXXXXXXXXXXXXX
    1 288E 00 XXXXXXXXXXXXX
    2 088E 00 XXXXXX
    2 888E 00 XXXXX
    3 688E 00 XX
    4 488E 00 X
```

```
HISTOGRAM FOR VARIABLE   6 (Th ppm   )

    4 [illegible] 01 XX
    [illegible] 01 XXXX
    [illegible] 00 XXXX
    1 [illegible] 00 XXXXXX
    [illegible] 00 XXXX
    [illegible] 00 XXX
    [illegible] 00 X
    [illegible] 00 X
    [illegible] 00
```

```
HISTOGRAM FOR VARIABLE   7 (T-S%

    4 165E 00 XXX
   -3 285E 00 XXX
   -2 405E 00 XXXXXXXXXXX
    1 525E 00 XXXXXXXXXXX
   -6 452E-01 XXXXXXXXXXX
    2 348E-01 XXXXXXXXXX
    1 115E 00 XXX
    1 995E 00 XXXXX
    2 875E 00 XXXX
    3 755E 00 XXX
```

```
HISTOGRAM FOR VARIABLE   8 (Al% S    )

    [illegible] 00 XXXXX
    [illegible] 00
    [illegible] 00 XXXXXXXXXXX
    1 [illegible] 00 XXXXXXXXXXXXXXX
    1 [illegible] 00 XXXXXXXXXX
    4 [illegible] 01 XXXXXXXXXXXXXXX
    [illegible] 01 XXXXXXXXXXXXXXXXXXXXXXXXXXXX
    [illegible] 00 XXXXXX
    [illegible] 00 XXXX X
    [illegible] 00 XX
    [illegible] 00 XX
```

```
HISTOGRAM FOR VARIABLE  10 (Fe% S

    5 755E 00
   -4 835E 00 X
    3 915E 00 XXXXX
    2 995E 00 XXXXXXX
   -2 075E 00 XXXXXXXX
    1 155E 00 XXXXXXXXXXXXXXXXX
    [illegible] 346E 01 XXXXXXXXXXXXXXXXXXXXXX
    6 854E 01 XXXXXXXXXXXXXXXXXXXXXXXXX X
    1 [illegible] 00 XX  XX
    [illegible] 00 X
    [illegible] 00 XX XXXXXX
```

```
HISTOGRAM FOR VARIABLE   9 (Ca% S    )

    [illegible] 00 X
    1 [illegible] 00 XX
    [illegible] 00 XX
    4 [illegible] 01 XXX
    1 [illegible] 01 XXXXX
    [illegible] 01 XXXXX
    [illegible] 00 XXX
    [illegible] 00 XXXXXXXX
    [illegible] 00 XX    XXXXXXXX X  XXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
    3 [illegible] 00 XX
    3 [illegible] 00 XXXX
```

```
HISTOGRAM FOR VARIABLE  11 (K%-S     )

    1 731E 00 XXXX
    1 761E 00 XX
    2 911E 01 XXXX
    3 211E-01 XXXXXXXXXX
    1 489E-01 XXXXX
    6 189E-01 XXXXXXXXXX
    1 089E 00 XXXXXXXX
    1 559E 00
    2 029E 00 X
    2 499E 00 X
```

```
HISTOGRAM FOR VARIABLE  13 (Na% S    )

    4 562E 00 XX
   -3 762E 00 X
   -2 962E 00 XXXX
   -2 162E 00 XXXXXXXXX
   -1 362E 00 XXXXXXXXXXXXXXXXXX
   -5 618E-01 XXXXXXXXXXXXXXXXXXXXXXXX
    2 382E-01 XXXXXXXXXXXXXXXXXXXXX
    1 038E 00 XXXXXXXXXXXXXXXXX
    1 838E 00 XX
    2 638E 00 XX
```

Figure 9.--Log distributions of values for the variables eU, U, Th, S, Al, Fe, Ca, K, and Na. Class midpoints are natural logarithms.

```
HISTOGRAM FOR VARIABLE  12 (Mg%-S     )

    -4 978E 00
    -4 338E 00 X
    -3 698E 00 XXX
     3 058E 00 XXXX
    -2 418E 00 XXXXXX
    -1 778E 00 XXXXXXXXXXX
    -1 138E 00 XXXXXXXXXXXXX
    -4 983E-01 XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
     1 417E-01 XXXXXXXXXXXXXXXXXX
     7 817E-01 XXXXXX
```

```
HISTOGRAM FOR VARIABLE  14 (Si%-S      )

    -3 152E 00 X
    -2 442E 00 XXXX
    -1 732E 00 XXXXXXXX
    -1 022E 00 XXXXXXXXXX
    -3 116E 01 XXXXXXXXXX
     3 984E 01 XXXXXXXXXXXXXXXXXXXXXXXX
     1 108E 00 XXXXXXXX
     1 818E 00 XXXXXXXXXXXX
     2 528E 00 XX
     3 238E 00 XXXXXXXXXXXXXXXXXXXXX
```

```
HISTOGRAM FOR VARIABLE  15 (Ti% S

    -1 032E 01 X
    -9 320E 00
    -8 320E 00 XX
    -7 320E 00 XXXXXXX
     6 320E 00 XXXXXX
     5 320E 00 XXXXXXXXXXXXXXXXXXXX
     4 320E 00 XXXXXXXXXXXXXXXXXXXXXX
    -3 320E 00 XXXXXXXXXXXXXXXX
    -2 320E 00 XXXXXXXXXXXXXXX XXXXX
     1 320E 00 XXXXXXX
       198E 01 X
```

```
HISTOGRAM FOR VARIABLE  16 (As ppmS

     3 596E 00 XXXXXXXXXXXX
     4 796E 00 X
     5 996E 00
     7 196E 00 XXXX
     8 396E 00 XX
     9 596E 00 X
     1 080E 01 X
     1 200E 01 XX
```

```
HISTOGRAM FOR VARIABLE  17 (B ppmS

     1 063E 00 X
     1 803E 00 XXXXXXXXXXX
     2 543E 00 X
     3 283E 00 XXXXXXXXXXXX
     4 023E 00 XXXXXXXXX
     4 763E 00 XXXXXXX
     5 503E 00 X
     6 243E 00 X
     6 983E 00
```

```
HISTOGRAM FOR VARIABLE  18 (Ba ppmS   

     2 159E 00 XX
     3 259E 00 XXXX
     4 359E 00 XXXXXXXXXXXXXXXX
     5 459E 00 XXXXXXXXXXXXXXXXXXXXXXXXXXX
     6 559E 00 XXXXXXXXXXXXXXXXXXXXXXXXXX
     7  659F 00 XXXXXXXX
     8 759E 00 XXXXX
     9 859E 00 XXX
     1 096E 01 X
     1 206E 01 XXXXXX
```

```
HISTOGRAM FOR  VARIABLE  19 (Be ppmS

     1 878E 00 XXX
    -1 028E 00
    -1 776E-01 X
     6 724E 01 XXXXXXXXXXXXXXX
     1 522E 00 XXXXXXXXXXXXXXXXXXXXXXX
     2 372E 00 XXXXXXXXXXXXXXX
     3 222E 00 XXXXXXX
     4 072E 00 XX
     4 922E 00 XXXX
     5 772E 00 X
     6 622E 00
```

```
HISTOGRAM FOR VARIABLE  20 (Ce ppmS

     3 191E 00 XX
     3 581E 00
     3 971E 00 XXXXX
     4 361E 00
     4 751E 00 XX
     5 141E 00
     5 531E 00
```

```
HISTOGRAM FOR  VARIABLE  21 (Co ppmS

     2 950E-01 XXXXXXXXXX
     8 850E 01 X
     1 475E 00 XXXXXXX
     2 065E 00 XXXXXXXXXXXXXXX
     2 655E 00 XX
     3 245E 00 XX
     3 835E 00
     4 425E 00 X
     5 015E 00 X
```

Figure 10.--Log distributions of values for the variables Mg, Si, Ti, As, B, Ba, Be, Ce, and Co. Class midpoints are natural logarithms.

```
HISTOGRAM FOR VARIABLE  22 (Cr ppmS )

     -1.244E 00 X
     -5.144E-01
      2.156E-01 XXXXXXXXXXXXXX
      9.456E-01 XXXXXXXXXXXXXXXXXXXX
      1.676E 00 XXXXXXXXXXXXXXXXX
      2.406E 00 XXXXXXXXXXXXXXXXXXXX
      3.136E 00 XXXXXXXXXXXX
      3.866E 00 XXX
      4.596E 00 XXXX
      5.326E 00
      6.056E 00
```

```
HISTOGRAM FOR  VARIABLE  23 (Cu ppmS )

     -1.184E 00 XXXXX
     -3.344E-01 XXXXXX
      5.156E-01 XXXXXXXXXXXXX
      1.366E 00 XXXXXXXXXXXXXXXXXXXX
      2.216E 00 XXXXXXXXXXXXXXXXXXXXXX X
      3.066E 00 XXXXXXXXXXXXXXXXXXXXX
      3.916E 00 XXXX
      4.766E 00 X
      5.616E 00 X
      6.466E 00
      7.316E 00
```

```
HISTOGRAM FOR VARIABLE  24 (Ga ppmS )

      2.950E-01 XXXXXXXXXXXXXXX
      8.850E-01 XXX
      1.475E 00 XXXXXXXXX
      2.065E 00 XXXXXXXXXXXXX
      2.655E 00 XXXXXXXX
      3.245E 00 XXXXXX
      3.835E 00 X
      4.425E 00 X
      5.015E 00 XX
```

```
HISTOGRAM FOR VARIABLE  34 (Ge ppmS )

      1.108E 00 XXX
      1.938E 00 XXXXX
      2.768E 00 XXXXXXXXX
      3.598E 00 XXXXXXX
      4.428E 00 XX
      5.258E 00
      6.088E 00
      6.918E 00
```

```
HISTOGRAM FOR  VARIABLE  25 (La ppmS )

      [illegible] 00
      [illegible] 00 XXXXXXX
      [illegible] 00
      [illegible] 00
      [illegible] 00 X
      [illegible] 00 XXXXXXX
      [illegible] 00 XX
      [illegible] 00 X
```

```
HISTOGRAM FOR VARIABLE  26 (Li ppmS )

      2.693E 00 XXXXXXXXXX
      3.473E 00
      4.253E 00 XXXX
      5.033E 00 XXXXXXXXXX
      5.813E 00 XXX
      6.593E 00 X
      7.373E 00
      8.153E 00 X
```

```
HISTOGRAM FOR VARIABLE  27 (Mn ppmS )

      1.649E 00 X
      2.749E 00 XXX
      3.849E 00 XXXXXXXXXXXXX
      4.949E 00 XXXX XXXXXXXXXXXXXXX
      6.049E 00 XXXXXXXXXXXXXXXXXXXXXXXXXXX
      7.149E 00 XXXXXXXXXXXXXXXX
      8.249E 00 XXXXXXXXXX
      9.349E 00 XXX
      1.045E 01 XXXX
      1.155E 01 X
      1.265E 01 X
```

```
HISTOGRAM FOR VARIABLE  28 (Mo ppmS

      1.217E-01 XXXXXXXXXXXXXX
      3.483E-01
      8.183E-01 X
      1.288E 00 XXXX
      1.758E 00 XXXXX
      2.228E 00 X
      2.698E 00 X
      3.168E 00 XXX
      3.638E 00
      4.108E 00 X
```

```
HISTOGRAM FOR VARIABLE  29 (Nb ppmS  )

      8.931E-01 XXXXXXXXXXXXXXXXXXXXXXXX
      1.293E 00
      1.693E 00 XX
      2.093E 00
      2.493E 00 XXXX
      2.893E 00 XXXXXX
      3.293E 00 X
      3.693E 00
      4.093E 00 X
```

```
HISTOGRAM FOR VARIABLE  30 (Ni ppmS

      2.800E-01 XXXXXXXXXXXX
      8.400E-01 XXXXX
      1.400E 00 XXXXXX
      1.960E 00 XXXXXX
      2.520E 00 XXXXXXXXXXXXXXXXXXXXXX
      3.080E 00 XXXX
      3.640E 00 XXXXX
      4.200E 00 X
      4.760E 00
```

Figure 11.--Log distributions of values for the variables Cr, Cu, Ga, Ge, La, Li, Mn, Mo, Nb, and Ni. Class midpoints are natural logarithms.

```
HISTOGRAM FOR VARIABLE  31 (Pb ppmS )

   4 150E-01 XXXXXXXXX
   1 245E 00
   2 075E 00 XXXXXXXX
   . 905E 00 XXXXXXXXXXXXXX
   3 735E 00 XXXXXXXX
   4 565E 00 XXX
   5 395E 00 XX
   6 225E 00 X
   7 055E 00 X
   7 885E 00
```

```
HISTOGRAM FOR VARIABLE  32 (Sc ppmS )

   2 550E-01 XXXXXXXXXXXXXXXX
   7 650E-01 X
   1 275E 00 X
   1 785E 00 XXXXXXXXXX
   2 295E 00 XXX
   2 805E 00 XXX
   3 315E 00 XX
   3.825E 00 XX
   4 335E 00 XXX
   4 845E 00 XX
```

```
HISTOGRAM FOR VARIABLE  33 (Sr   ppmS  )

   . 366E 00 X
   3 206E 00
   4 046E 00 XXX
   4 886E 00 XXXXXXXXX
   5.726E 00 XXXXXX
   6 566E 00 XXXXXXXXXXXXXXXXXXXXXX
   7 406E 00 XXXXXXXXXXXXXXXXXXXXXXX
   8 246E 00 XXXXXXXXXXXXXXXXXXXX
   9 086E 00 XXXXXXXXXXXXXXX
   9 926E 00 XXXX
```

```
HISTOGRAM FOR VARIABLE  35 (V ppmS

   2.850E-01 XXXXXX
   8 550E-01 X
   1 425E 00 XXXX
   1 995E 00 XXXXXX
   2 565E 00 XXXXXXXXXXXXXXXXXXX
   3 135E 00 XXXXXXXXXXXXXXXX
   3 705E 00 XXXXX
   4 275E 00 XXXXX
   4 845E 00 XXXXX
   5 415E 00
   5 985E 00
```

```
HISTOGRAM FOR VARIABLE  36 (W ppmS  )

   . 733E 00 XXXXXXXXXXXXXX
   3 593E 00
   4 453E 00 X
   5 313E 00 XX
   6 173E 00 X
   7 033E 00 X
   7 893E 00 X
   8 753E 00 X
   9 613E 00
```

```
HISTOGRAM FOR VARIABLE  37 (Y ppmS

   4 100E-01 XXXXXXXXXXXXXXXX
   1 230E 00
   2 050E 00 XXXXXXXXX
   2 870E 00 XXXXXXXXXXXXXXXXXXXXXXXX
   3 690E 00 XXXXXXXX
   4 510E 00 XX
   5 330E 00 XX
   6 150E 00 X
   6 970E 00 X
```

```
HISTOGRAM FOR VARIABLE  38 (Yb ppmS )

  -1 304E 00 XXXXXXXXXX
   6 944E-01
   8 444E-02 XXXXX
   5 256E 01 XXXXXXXXXXXXXXX
   1 136E 00 XXXXXX
   1 746E 00 XXX
   2 356E 00 X
   2 966E 00 X
   3 576E 00
   4 186E 00 X
```

```
HISTOGRAM FOR VARIABLE  39 (Zn ppmS

   2 074E 00 XXXXXXXXX
   3.004E 00
   3 934E 00 XX
   4 864E 00 X
   5 794E 00 XXXX
   6 724E 00 XXX
   7 654E 00 X
   8 584E 00 X
   9 514E 00
```

```
HISTOGRAM FOR VARIABLE  40 (Zr  ppmS )

   9 681E 01 XX
   1 518E 00 X
   2 068E 00 XX
   2 618E 00 XXXX
   3 168E 00 XXXXXXXXXXXXXXXX
   3 718E 00 XXXXXXX
   4 268E 00 XXXXXXXXXX
   4 818E 00 XXXXXXXXXXXXX
   5 368E 00 XXXXX
   5 918E 00 XX
   6 468E 00 X
```

Figure 12.--Log distributions of values for the variables Pb, Sc, Sr, V, W, Y, Yb, Zn, and Zr. Class midpoints are natural logarithms.

of almost pure calcite ($CaCO_3$), Ca would constitute approximately 40 percent of the sample. It would be reported as greater than 10 percent by one laboratory and greater than 20 percent by the other. Estimated maximum values used in the data matrix for statistical purposes for some samples, are order of magnitude estimates.

Tables 6-10 list the spring sites at which precipitates contain the highest proportions of Ra (eU), U, Ba, Fe and Mn. The ranking does not show the total quantity of each metal to be found at each site. Evidence of excavations suggest past surface mining activities at the following locations: Stinking Hot Springs, Taylor Soda Spring, Doughty Springs, adit spring, Monroe Hot Springs, Sulfur Gulch springs, Baker Hot Springs, Golconda Hot Spring (not at the current spring site, but several miles to the east), Ophir Iron Spring, and Utah Hot Springs.

No attempt is made to assess the potential for any future mineral production from these sites. At certain sites, however, some surface deposits of possibly mineable Fe and Mn hydrous oxides, native sulfur and barite precipitates are present.

Based on tables 6-10 the geographic locations of sites which yield samples with high proportions of U, Ba, Fe, Mn, eU and S are plotted in figure 13. Sulfur data are not complete; only 188 samples were analyzed for sulfur. Some surface mining of sulfur has been done at Auburn Sulfur Spring (WY, 9), and of sulfurous shale and sandstone at Sulfur Gulch and Doughty Springs (CO 8, 12).

Correlation of element abundances

Before further statistical analysis, we omitted Th, Ce and W values from the computations. Th determinations by delayed neutron analysis become more undependable as the ratio of Th to U decreases as seen in samples in which there is more U than Th where the coefficient of variation of replicate analyses of Th often exceeds 30 percent and the averaged values tend to become statistically meaningless, according to H. T. Millard, Jr. (written commun., 1979). Analytical error in thorium values increases with increasing U/Th values; any use of correlation coefficients between U and Th values for the spring precipitates becomes an unreliable procedure. This is particularily true in samples with minor amounts of U and Th.

Ce and W were omitted from further statistical analysis because of their low number of valid values. As shown in table 3, only three precent of the sample analyses resulted in valid values for Ce and only seven percent resulted in valid values for tungsten. Other elements, As, La, Li, Mo, Nb, and Zn have less than twenty percent valid values. These, however, were retained, and a cutoff arbitrarily established at 10 percent. A compromise was made between optimum utilization of available data, and the projection of interpretations based on small amounts of data. The decision to use element data from as little as ten percent of the samples is perhaps justified by the lack of homogeneity of the population of precipitate samples.

Table 6.--Springs with precipitates containing the most radium and daughter products measured as equivalent uranium (eU). [Only the highest sample measurement for each spring is shown.]

Spring name (State, location number)	Measured eU (ppm)
Stinking Hot Springs (UT, 9)	10200
Taylor Soda Springs (CO, 15)	5400
Golconda Hot Spring ((NV, 6)	4500
Soda Dam Hot Springs (NM, 1)	4480
Poncha Hot Springs (CO, 17)	4000
Doughty Springs (CO, 12)	2940
Adit spring (CO, 11)	2500
LaDuke Hot Spring (MT, 14)	2500
Ouray hot springs (CO, 22)	2370
The Salt Bank springs (AZ, 16)	2380
Monroe Hot Springs (UT, 41)	2300

Table 7.--Springs with precipitates containing the most uranium. [Only the highest sample measurement for each spring is shown.]

Spring name (State, location number)	Measured uranium (ppm)
Taylor Soda Springs (CO, 15)	62
Yellow Soda Springs (CO, 14)	34
Ophir Iron Spring (CO, 23)	50
Austin springs (CO, 10)	39
Wildhorse Spring (UT, 19)	27
Sulfur Gulch springs (CO, 9)	23
Grant View Hot Springs (NV, 29)	13

Table 8.--Springs with precipitates containing the highest measured amounts of barium. [Only the highest sample measurement for each spring site is shown.]

Spring name (State, location number)	Measured barium (ppm)
*Stinking Hot Spring (UT, 9)	>100,000
Doughty Springs (CO, 12)	>100,000
Adit spring (CO, 11)	>100,000
Poncha Hot Springs (CO, 17)	100,000
Baker Hot Springs (UT, 23)	52,000
Hooper Hot Springs (UT, 12)	30,000
Kyle Hot Springs (NV, 12)	20,000
Golconda Hot Spring (NV, 6)	15,000
Ouray hot springs (CO, 22)	15,000
Manti springs (UT, 36)	10,000
Soda Dam Hot Springs (NM, 1)	10,000

*An X-ray diffractometer graph of one sample showed it to be >90% barite (50% Ba)

Table 9.--Springs with precipitates containing more than the maximum measurable amount of iron. [Only the highest sample measurement for each spring site is shown.]

Spring name (State, location number)	Measured iron (percent)
Yellow soda Spring (CO, 14)	>10
Taylor Soda Spring (CO, 15)	>10
Poncha Hot Springs (CO, 17)	>10
Ouray Hot Springs (CO, 22)	>10
Baker Hot Springs (UT, 23)	>10
Monroe Hot Springs (UT, 41)	>10
Ophir Iron Spring (CO, 23)	>10
The Salt Bank springs (Az, 16)	>10
Utah Hot Springs (UT, 10)	>10
*Spring (ID)	>10
Fayles Hot Spring (CA, 4)	>10
Bard Spring (AR, 6)	>10
Austin springs (CO, 10)	>10

*Location constitutes privileged information.

Table 10.--Springs with precipitates containing the highest measured amounts of manganese. [Only the highest sample measurement for each spring site is shown.]

Spring name (State, location number)	Measured manganese (ppm)
Doughty Springs (CO,12)	>100,000
Poncha Hot Springs (CO, 17)	>100,000
Ouray Hot Springs (CO, 22)	>100,000
Baker Hot Springs (UT, 23)	100,000
The Salt Banks springs (AZ, 16)	50,000
Soda Dam Hot Springs (NM, 1)	50,000
Hooper Hot Springs (UT, 12)	50,000
Monroe Hot Springs (UT, 41)	50,000
Golconda Hot Springs (NV, 6)	40,000
Utah Hot Springs (UT, 10)	20,000
Joseph Hot Springs (UT, 42)	20,000
Sou Hot Springs (NV, 15)	20,000
Display Spring (AR, 3)	20,000

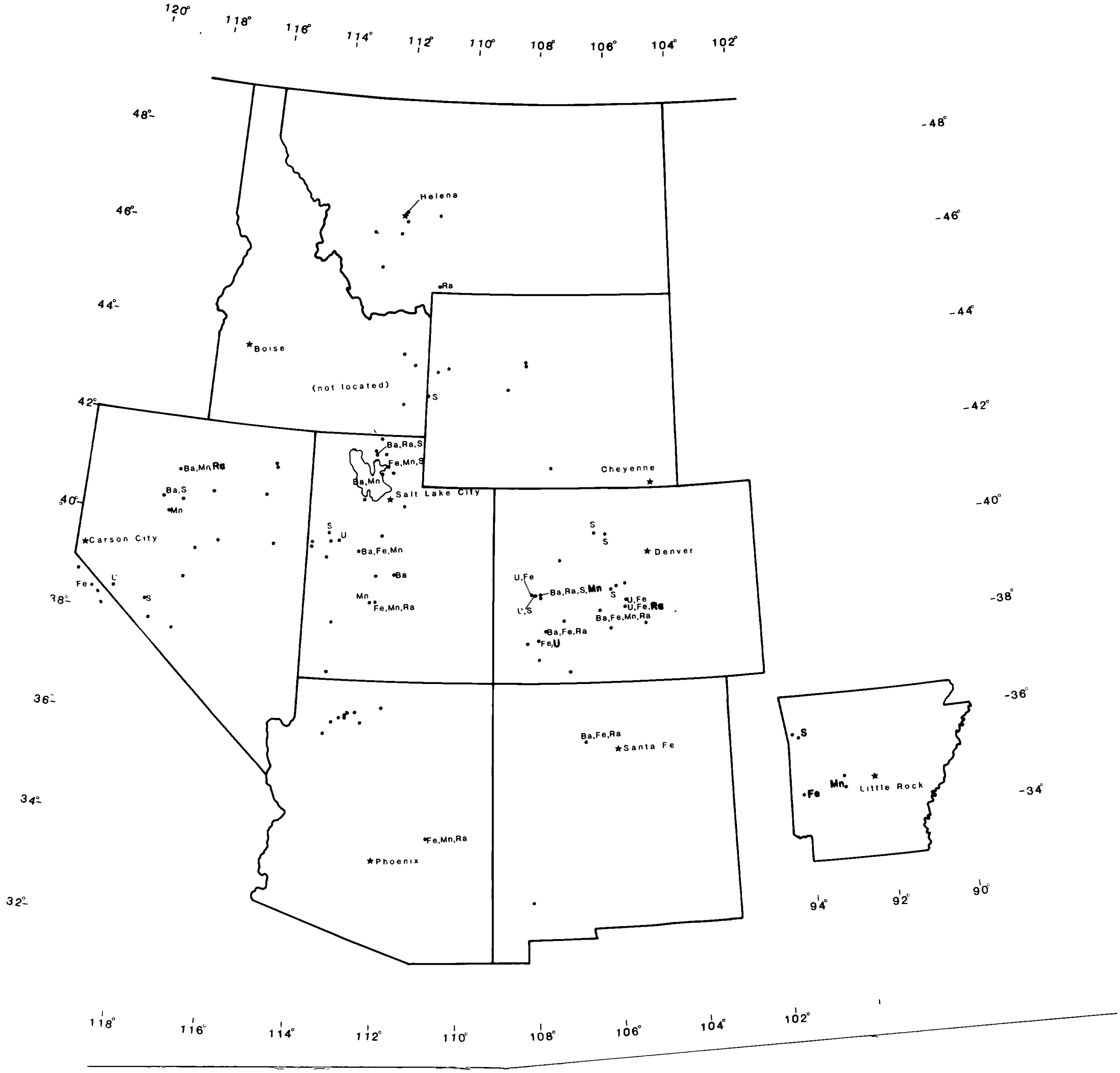

Figure 13. Location of mineral spring sites from which were collected precipitates with high values of uranium (U), barium (Ba), iron (Fe), manganese (Mn), radium (eU), and sulfur (S). Black dots are sampled mineral spring sites.

Correlation coefficients were computed for all possible pairs of the remaining 34 elements. Table 11 shows correlation coefficients of log-transformed element data in the upper half of the table with numbers of pairs in the lower half of the table. Coefficients based on different numbers of pairs of samples cannot be directly compared mathematically because the statistical significance of the coeffecent *r* is a function of the number of pairs of samples used in its computation. For 50 pairs, an *r* value of 0.200 will occur 10 to 20 percent of the time by chance using random values. For 200 pairs, an *r* value of 0.20 will occur less than 0.1 percent of the time by chance using random values (Fisher, 1948).

Computed correlation coefficients may be compared to the scatter plots of selected pairs of elements shown in figures 14-25. The shape of the correlation point clusters is an indication of the degree of actual covariation between two variables.

Extreme values have a weighted effect on the computed *r* value. A circular cluster of points in which the highest and lowest values are conspicuously scattered along the diagonal may yield a statistically significant *r* value, even though visual examination of the scatter plot leads to the conclusion that correlation is low.

A significant computed *r* value alone does not ensure that a large degree of covariation exists between two variables. The cluster of correlation points in a scatter plot should show an elongate or definitely nonspherical shape if the variables have significant covariation. Two methods can be used to reduce the possibility of being mislead by a significantly high computed *r* value in element abundance correlations. One is to convert abundances to log values, which minimized effects of extreme abundance values. The other is to rely only on values of *r* that are significant at the 1 percent or 0.1 percent levels as indicators of significant correlation between two variables. In cases of doubt, scatter plots such as figures 14-25 can be constructed, and the shapes of the point clusters evaluated. Arithmetic data were plotted by computer over logarithmic (base 10) scales for these figures.

Figure 14 is the scatter plot of correlation points of pairs of U and Th abundances. The shape of the cluster of points suggests a significant positive correlation between the two elements. Only valid values were used in the U-Th scatter plot. Similarly elongated clustering may be observed in figures 15 and 16. Grid-like spacing of correlation points is the effect of the "six-step" reporting intervals used for spectrographic analytical results. The good positive correlation between Si and Al suggests that most Si and Al is present in detrital form associated with aluminum silicates. The detrital mode for Si and Al is supported by the positive correlation between Si and Ti (fig. 16). Chemically deposited siliceous material is present as indicated by the X-ray diffraction studies of Bove and Felmlee (1982), but effects appear to be outweighed statistically by the presence of Si present as detrital silica or silicates. Vanadium in the detrital fraction appears to dominate the distribution of V as suggested by figure 17 in which V also shows good positive correlation with Al. Figure 24 illustrates the correlation between U and V in the precipitates. Considering the possible relationship of V to detrital elements in the precipitates (fig. 17), fig. 24 suggests that

Table 11.--Values of Pearson's correlation coefficient, r, for all possible pairs of variables. Based on data matrix values. The values on the diagonal are the standard deviations for each variable. Correlation coefficients are above the diagonal; numbers of pairs for each correlation are shown below the diagonal. Note: The diagonal of the correlation matrix contains the standard deviation of the variable.

	eU ppm	U ppm	T-S%	Al%-S	Ca%-S	Fe%-S	K%-S	Mg%-S	Na%-S	Si%-S
1 eU ppm	2.0631	-.0117	.0926	.0643	-.0153	.2939	-.2014	-.0696	.0787	.1056
2 U ppm	283	2.1145	.1576	.5001	-.2286	.3377	.1903	.1124	.2897	.4355
3 T-S%	185	181	2.2213	.1755	-.3328	.0786	.1897	-.2666	.2285	.1979
4 Al%-S	291	285	188	1.6793	-.3742	.4125	.7898	.2523	.4412	.7906
5 Ca%-S	291	285	188	297	1.3637	-.2091	-.3797	.4188	-.0643	-.4158
6 Fe%-S	291	285	188	297	297	1.8249	.2347	-.0448	.2725	.4217
7 K%-S	134	130	90	136	136	136	.9580	.0823	.4384	.5592
8 Mg%-S	291	285	188	297	297	297	136	1.1162	.3209	.0791
9 Na%-S	288	283	185	294	294	294	135	294	1.3502	.3487
10 Si%-S	291	285	188	297	297	297	136	297	294	1.6586
11 Ti%-S	283	277	183	289	289	289	135	289	286	289
12 As ppmS	69	68	31	70	70	70	49	70	70	70
13 B ppmS	129	126	98	132	132	132	90	132	132	132
14 Ba ppmS	291	285	188	297	297	297	136	297	294	297
15 Be ppmS	220	216	145	225	225	225	113	225	224	225
16 Co ppmS	112	110	77	115	115	115	88	115	114	115
17 Cr ppmS	266	262	178	271	271	271	134	271	268	271
18 Cu ppmS	268	262	182	273	273	273	136	273	270	273
19 Ga ppmS	166	162	109	169	169	169	126	169	168	169
20 Ge ppmS	81	79	57	83	83	83	46	83	83	83
21 La ppmS	74	72	46	74	74	74	65	74	74	74
22 Li ppmS	85	81	59	86	86	86	71	86	85	86
23 Mn ppmS	291	285	188	297	297	297	136	297	294	297
24 Mo ppmS	90	86	54	91	91	91	58	91	90	91
25 Nb ppmS	108	104	72	109	109	109	85	109	108	109
26 Ni ppmS	174	170	118	178	178	178	120	178	177	178
27 Pb ppmS	135	132	95	137	137	137	108	137	137	137
28 Sc ppmS	125	122	86	128	128	128	95	128	127	128
29 Sr ppmS	291	285	188	297	297	297	136	297	294	297
30 V ppmS	192	187	127	195	195	195	133	195	193	195
31 Y ppmS	176	174	117	180	180	180	122	180	180	180
32 Yb ppmS	105	101	80	107	107	107	73	107	107	107
33 Zn ppmS	61	61	35	61	61	61	48	61	61	61
34 Zr ppmS	185	182	115	189	189	189	132	189	189	189

Table 11.--Values of Pearson's correlation coefficient, r, for all possible pairs of variables. Based on data matrix values. The values on the diagonal are the standard deviations for each variable. Correlation coefficients are above the diagonal; numbers of pairs for each correlation are shown below the diagonal. Note: The diagonal of the correlation matrix contains the standard deviation of the variable.--continued

	Ti%-S	As ppmS	B ppmS	Ba ppmS	Be ppmS	Co ppmS	Cr ppmS	Cu ppmS	Ga ppmS	Ge ppmS
1 eU ppm	.1397	.4715	-.1435	.6064	.4786	.0613	.0035	.0034	-.0410	.1135
2 U ppm	.4240	.4071	.2004	-.0084	.2598	-.0493	.3209	.2361	.1919	.0773
3 T-S%	.2154	.1589	-.2013	.1743	-.0560	-.1588	.2012	.0923	-.0288	-.2669
4 Al%-S	.8170	.0404	.1491	.2116	-.0062	-.0529	.6649	.5004	.4489	-.0642
5 Ca%-S	-.3174	-.4173	-.2140	-.1403	.0160	-.0914	-.2357	-.2891	-.4691	.0201
6 Fe%-S	.3777	.7195	.2430	.0857	.4563	.1100	.3101	.4676	.3951	.4985
7 K%-S	.6206	.2210	.2328	.1272	-.0620	-.1061	.3218	.3559	.6339	.0715
8 Mg%-S	.1873	-.4367	-.0580	-.0957	-.2338	-.0141	.2880	.0560	-.2925	-.1260
9 Na%-S	.4001	.2527	.4350	-.0348	.0787	-.2400	.2341	.1050	.1523	-.0322
10 Si%-S	.8448	-.0299	.1672	.2240	.0127	-.0598	.6651	.5535	.5504	.0293
11 Ti%-S	1.8705	-.2190	.0554	.1958	-.0643	-.0478	.6939	.4937	.3482	-.0340
12 As ppmS	68	3.1927	.5205	.2749	.7909	.5211	-.3617	.0525	.6101	.271
13 B ppmS	132	29	1.3479	-.0406	.1313	.1089	.0204	.0920	.3755	.1910
14 Ba ppmS	289	70	132	2.2238	.2129	-.0200	.0894	-.0706	.2372	-.1908
15 Be ppmS	218	70	105	225	1.5294	.0996	-.2277	-.0670	.1595	.3999
16 Co ppmS	114	46	69	115	98	1.2463	.0970	.1465	-.0914	.4100
17 Cr ppmS	267	62	129	271	204	111	1.3103	.5477	.1518	-.0592
18 Cu ppmS	268	68	130	273	210	114	261	1.4008	.3273	.0168
19 Ga ppmS	167	54	102	169	142	102	165	165	1.3524	.0356
20 Ge ppmS	80	23	57	83	78	31	77	79	60	1.1383
21 La ppmS	74	38	41	74	66	62	73	72	70	9
22 Li ppmS	86	29	62	86	76	56	83	85	75	33
23 Mn ppmS	289	70	132	297	225	115	271	273	169	83
24 Mo ppmS	90	49	43	91	83	66	85	90	70	24
25 Nb ppmS	106	48	61	109	101	85	104	107	99	32
26 Ni ppmS	176	56	98	178	149	112	173	176	142	57
27 Pb ppmS	136	51	88	137	120	98	134	136	119	43
28 Sc ppmS	128	48	80	128	115	88	126	127	106	35
29 Sr ppmS	289	70	132	297	225	115	271	273	169	83
30 V ppmS	195	57	112	195	152	106	194	195	151	56
31 Y ppmS	178	61	101	180	160	103	173	176	143	65
32 Yb ppmS	107	9	77	107	88	55	105	106	89	45
33 Zn ppmS	60	43	25	61	59	54	58	60	52	14
34 Zr ppmS	188	61	111	189	150	103	185	187	152	59

Table 11.--Values of Pearson's correlation coefficient, r, for all possible pairs of variables. Based on data matrix values. The values on the diagonal are the standard deviations for each variable. Correlation coefficients are above the diagonal; numbers of pairs for each correlation are shown below the diagonal. Note: The diagonal of the correlation matrix contains the standard deviation of the variable.--continued

	La ppmS	Li ppmS	Mn ppmS	Mo ppmS	Nb ppmS	Ni ppmS	Pb ppmS	Sc ppmS	Sr ppmS	V ppmS
1 eU ppm	.2139	.0820	.3321	.1861	.0235	.0046	.0543	.0947	.2732	.0172
2 U ppm	-.0826	-.2751	-.0671	.0752	.1015	.0187	.2985	.0626	-.0349	.2311
3 T-S%	-.4187	.0818	-.2094	.3075	-.0941	-.0222	.1411	.3033	-.1459	.1575
4 Al%-S	-.1479	.0070	.0536	.1402	.2163	.1222	.2276	.0710	-.2250	.5502
5 Ca%-S	.3813	-.1519	.2085	-.4478	-.1361	.0517	-.3417	-.0283	.5849	-.2356
6 Fe%-S	-.0501	-.0493	.3668	.4427	.0270	.0959	.4992	-.0117	-.0366	.3604
7 K%-S	-.2251	.1586	-.1258	.5287	.4021	.0555	.5331	.3982	-.4440	.4532
8 Mg%-S	.3709	.1221	.0389	-.5692	-.2296	.2561	-.2632	-.2061	.2170	.0807
9 Na%-S	.1466	.4955	.0282	-.1513	.0401	.0670	.0001	-.0267	.1345	.1297
10 Si%-S	-.2712	-.3196	.0026	.1776	.1763	.0936	.1756	-.1633	-.2575	.5346
11 Ti%-S	-.0518	-.1656	.0471	-.0357	.0810	.1966	.1147	-.1634	-.1839	.5431
12 As ppmS	-.3088	-.0271	.1408	.7783	.0959	-.1551	.6489	.8343	.0568	.2079
13 B ppmS	.0905	.3291	-.0189	.3274	.0300	-.0755	.3465	-.0365	-.0730	.2643
14 Ba ppmS	-.1383	.1691	.3190	.4578	.3158	-.1851	.1770	.4613	.2280	.0929
15 Be ppmS	-.2563	.0478	.3279	.4182	.1618	-.1528	.2605	.2193	.2641	-.0365
16 Co ppmS	.3197	-.1891	.2826	.1571	-.1653	.5090	.1357	.1173	.0147	.2865
17 Cr ppmS	-.1011	-.2298	.0020	-.0892	.0263	.4343	.2299	-.2345	-.2089	.6225
18 Cu ppmS	-.1496	-.3984	.0520	.2883	-.0392	.3711	.3491	-.3361	-.3408	.4794
19 Ga ppmS	-.2122	-.1049	.0130	.6130	.3533	-.0499	.4732	.4084	-.4147	.3855
20 Ge ppmS	-.0033	-.0924	.2379	.4514	.0165	.2600	.3279	-.0305	.0591	.0796
21 La ppmS	.9186	.3190	.1419	-.3863	-.0081	.1267	-.1524	-.3947	.3364	-.1524
22 Li ppmS	39	1.2739	-.1397	-.1932	-.1111	-.1538	-.1654	-.1773	.0218	-.1217
23 Mn ppmS	74	86	2.0576	.4128	.1781	.1567	.1889	.1632	.3240	.0805
24 Mo ppmS	45	44	91	1.2271	.2256	-.2374	.6317	.5759	-.1979	.394
25 Nb ppmS	63	52	109	62	.9583	-.1440	.0825	.0237	-.0772	-.1022
26 Ni ppmS	67	76	178	79	99	1.1995	-.0191	-.2257	-.1473	.3433
27 Pb ppmS	65	69	137	68	92	125	1.6118	.3422	-.1867	.3836
28 Sc ppmS	63	59	128	57	83	107	98	1.5578	.1674	.2965
29 Sr ppmS	74	86	297	91	109	178	137	128	1.4983	-.2331
30 V ppmS	70	79	195	76	99	162	126	117	195	1.2067
31 Y ppmS	69	73	180	74	100	149	119	117	180	154
32 Yb ppmS	31	41	107	27	53	85	70	74	107	94
33 Zn ppmS	40	34	61	47	54	59	59	50	61	56
34 Zr ppmS	72	74	189	72	96	151	126	112	189	174

Table 11.--Values of Pearson's correlation coefficient, r, for all possible pairs of variables. Based on data matrix values. The values on the diagonal are the standard deviations for each variable. Correlation coefficients are above the diagonal; numbers of pairs for each correlation are shown below the diagonal. Note: The diagonal of the correlation matrix contains the standard deviation of the variable.--continued

	Y ppmS	Yb ppmS	Zn ppmS	Zr ppmS
1 eU ppm	.1291	.0623	-.0443	.0345
2 U ppm	.3927	.2829	.4120	.3570
3 T-S%	.0741	-.0128	.5691	.2285
4 Al%-S	.3390	.3056	.1605	.5729
5 Ca%-S	-.1516	-.0348	-.4635	-.3637
6 Fe%-S	.3311	.5005	.5127	.2683
7 K%-S	.2595	.2303	.4024	.3935
8 Mg%-S	-.1526	-.0888	-.4096	.0177
9 Na%-S	.1181	.0435	-.2451	.2069
10 Si%-S	.3011	.2665	.1017	.4828
11 Ti%-S	.2514	.1956	.0060	.6068
12 As ppmS	.3036	.3992	.6760	-.0040
13 B ppmS	.2625	.2400	.3995	.1345
14 Ba ppmS	.1973	.0084	.1718	.1786
15 Be ppmS	.4037	.3224	.2293	-.0577
16 Co ppmS	.2068	.4522	.2702	.0123
17 Cr ppmS	.0181	.1991	.1569	.3476
18 Cu ppmS	.0309	.1672	.4649	.2145
19 Ga ppmS	.3378	.2761	.5406	.3445
20 Ge ppmS	.3846	.5398	.0256	.1138
21 La ppmS	-.0866	.0658	-.0270	.0494
22 Li ppmS	-.0679	-.2225	-.5331	-.0694
23 Mn ppmS	.1827	.2663	.1011	-.0873
24 Mo ppmS	.2535	.2370	.6560	.1259
25 Nb ppmS	.2532	.0934	-.1846	.1536
26 Ni ppmS	.0436	.0512	.1498	.1298
27 Pb ppmS	.1811	.3420	.5875	.2282
28 Sc ppmS	.2507	.0712	.5749	.1889
29 Sr ppmS	-.1191	.0614	-.3117	-.3656
30 V ppmS	.2498	.4078	.4132	.3162
31 Y ppmS	1.4178	.8488	.1688	.4692
32 Yb ppmS	101	1.3000	.4905	.3726
33 Zn ppmS	58	14	2.3976	.2534
34 Zr ppmS	153	93	54	1.1695

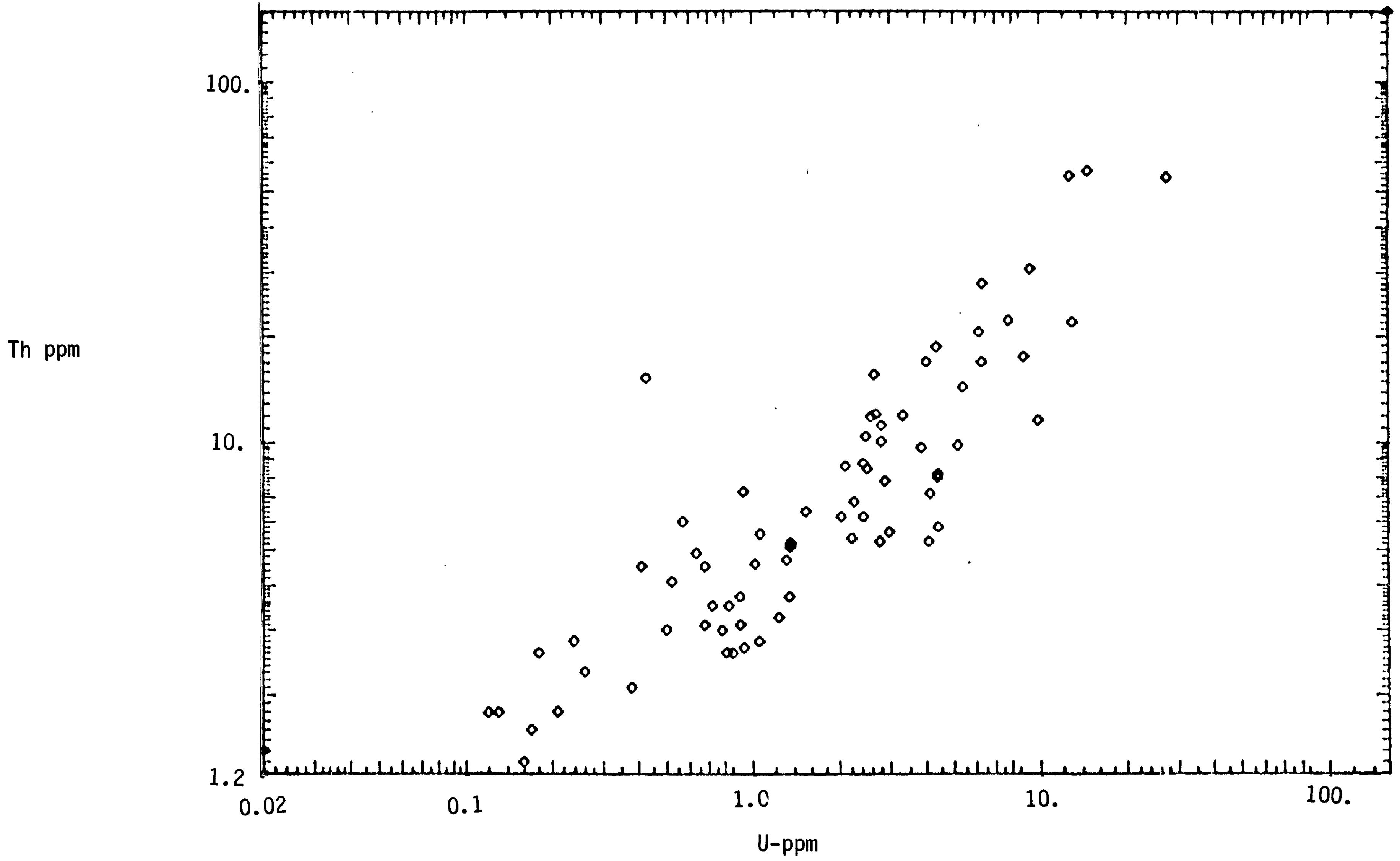

Figure 14.--Scatter plot of correlation points between abundances of uranium (U) and thorium (Th) in 88 samples of precipitated collected at mineral spring sites. Computed r=.88. Shows exceptionally good posoitive elongation of point cluster.

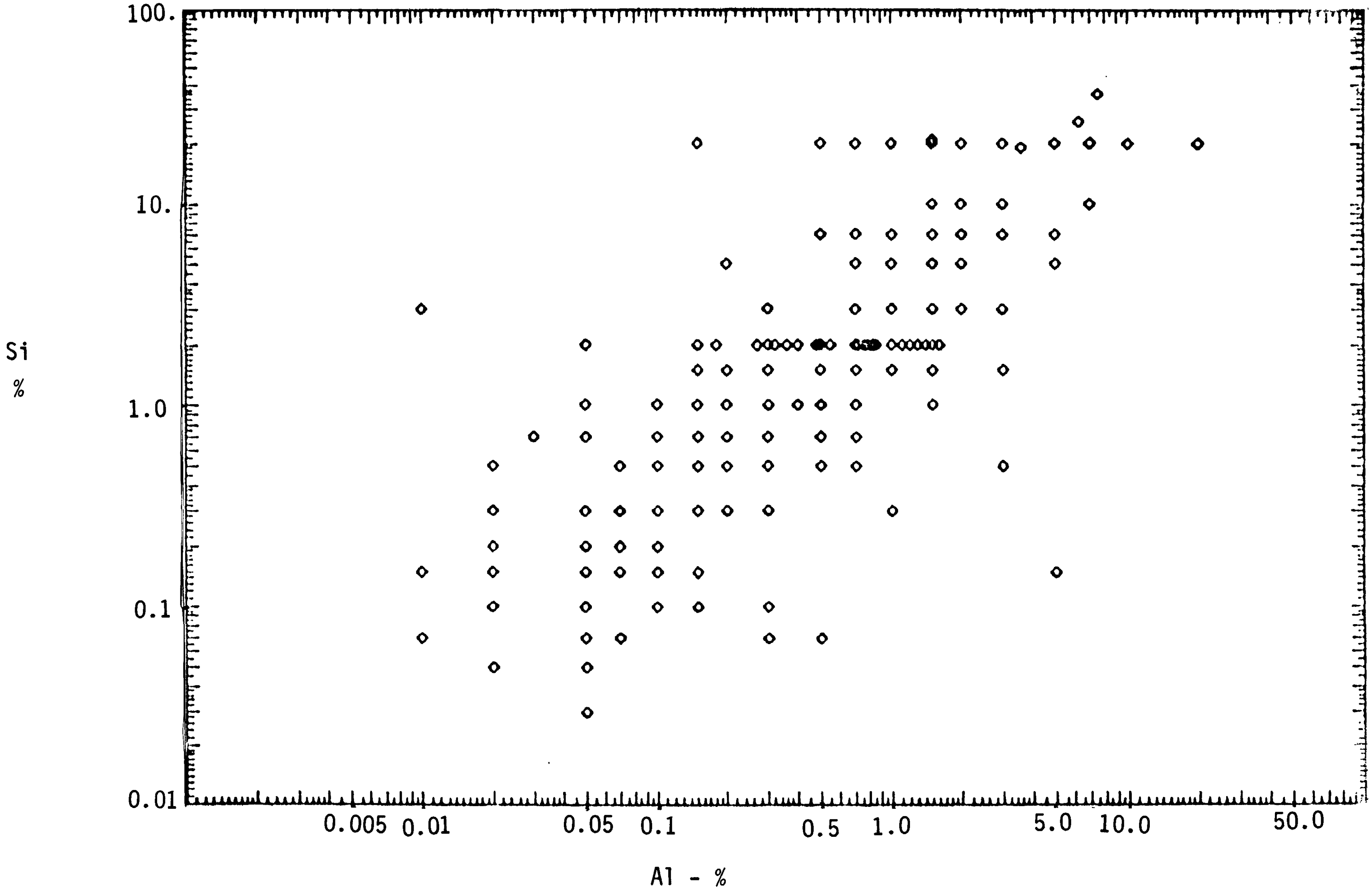

Figure 15.--Scatter plot of correlation points between abundances of silicon (Si) and aluminum (Al) in 297 samples of precipitate collected at mineral spring sites. Computed r=.64 Shows definite positive elongation. Rectangular or grid-like spacing of points is the effect of "six-step" spacing of analytical reporting intervals.

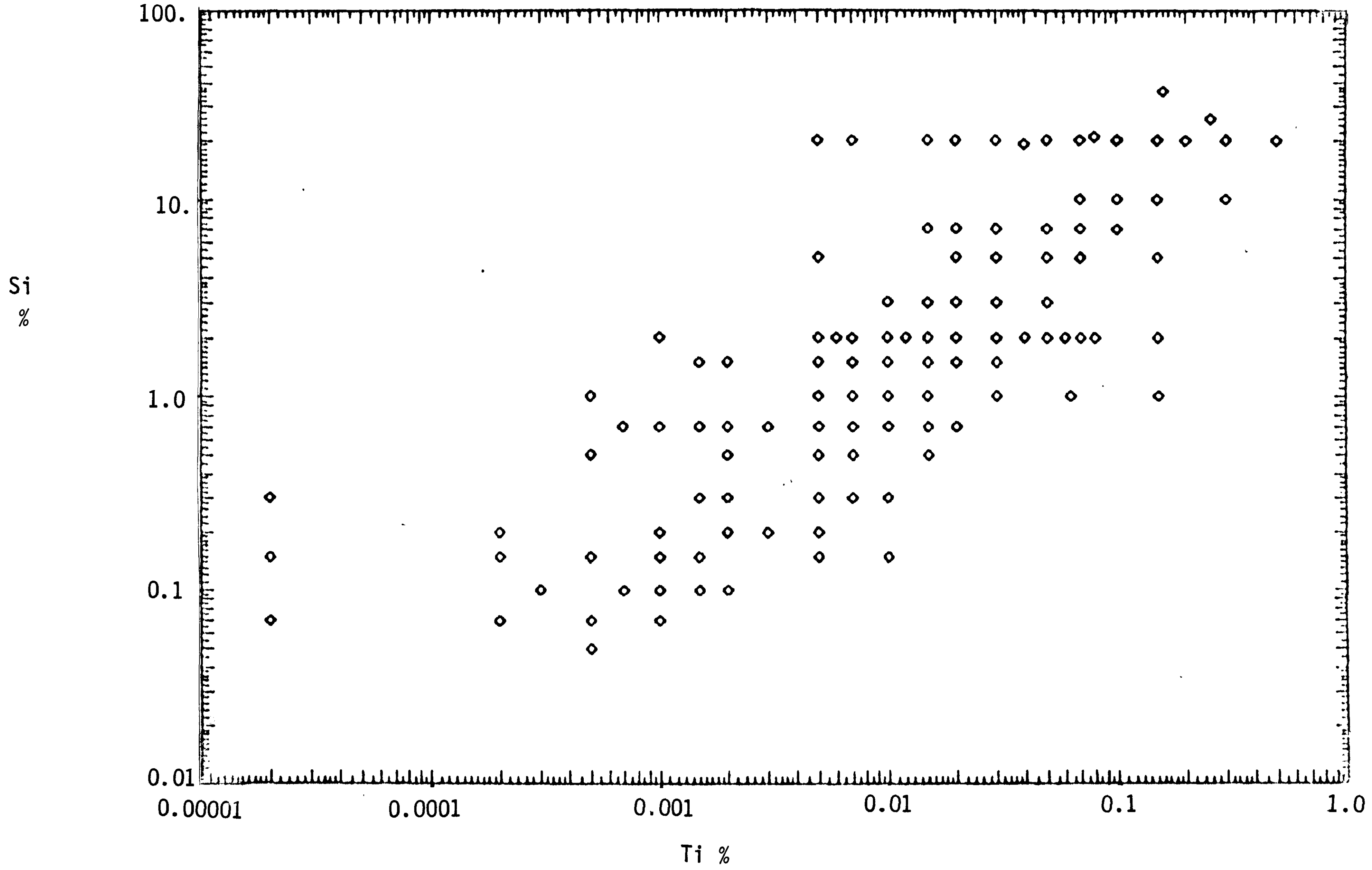

Figure 16.--Scatter plot of correlation points between abundances of titanium (Ti) and silicon (Si) in 289 samples of precipitates collected at mineral spring sited. Computed r=.72 Shows good positive elongation of point cluster.

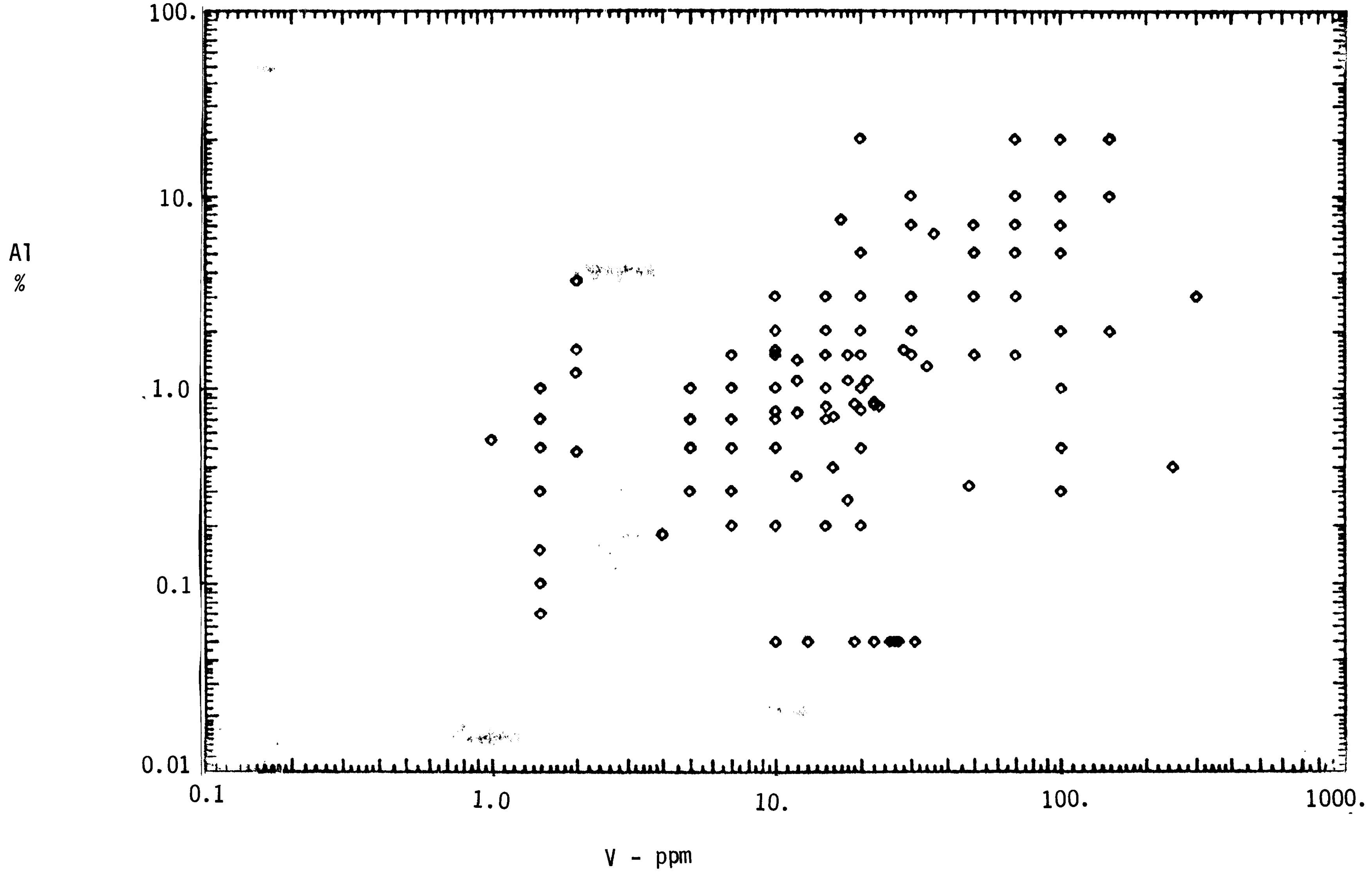

Figure 17.--Scatter plot of correlation points between abundances of vanadium (V) and aluminum (Al) in 195 samples of precipitates collected at mineral spring sites. Computed r=.57. Shows good positive elongation of point cluster.

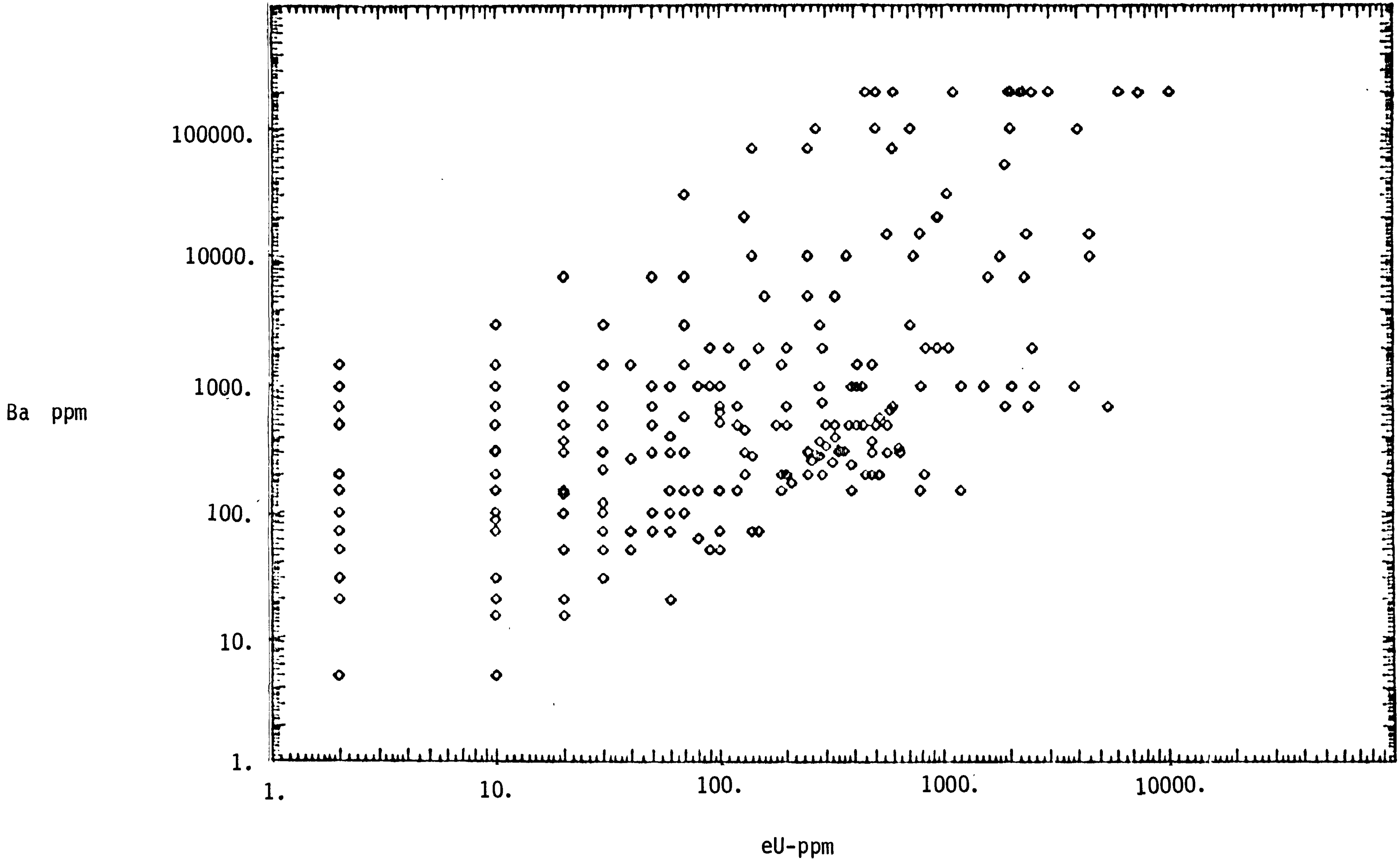

Figure 18.--Scatter plot of correlation points between abundances of radium (eU) and barium (Ba) in 291 samples of precipitates collected at mineral spring sites. Computed r=.56. Plot shows moderately good positive elongation of point cluster.

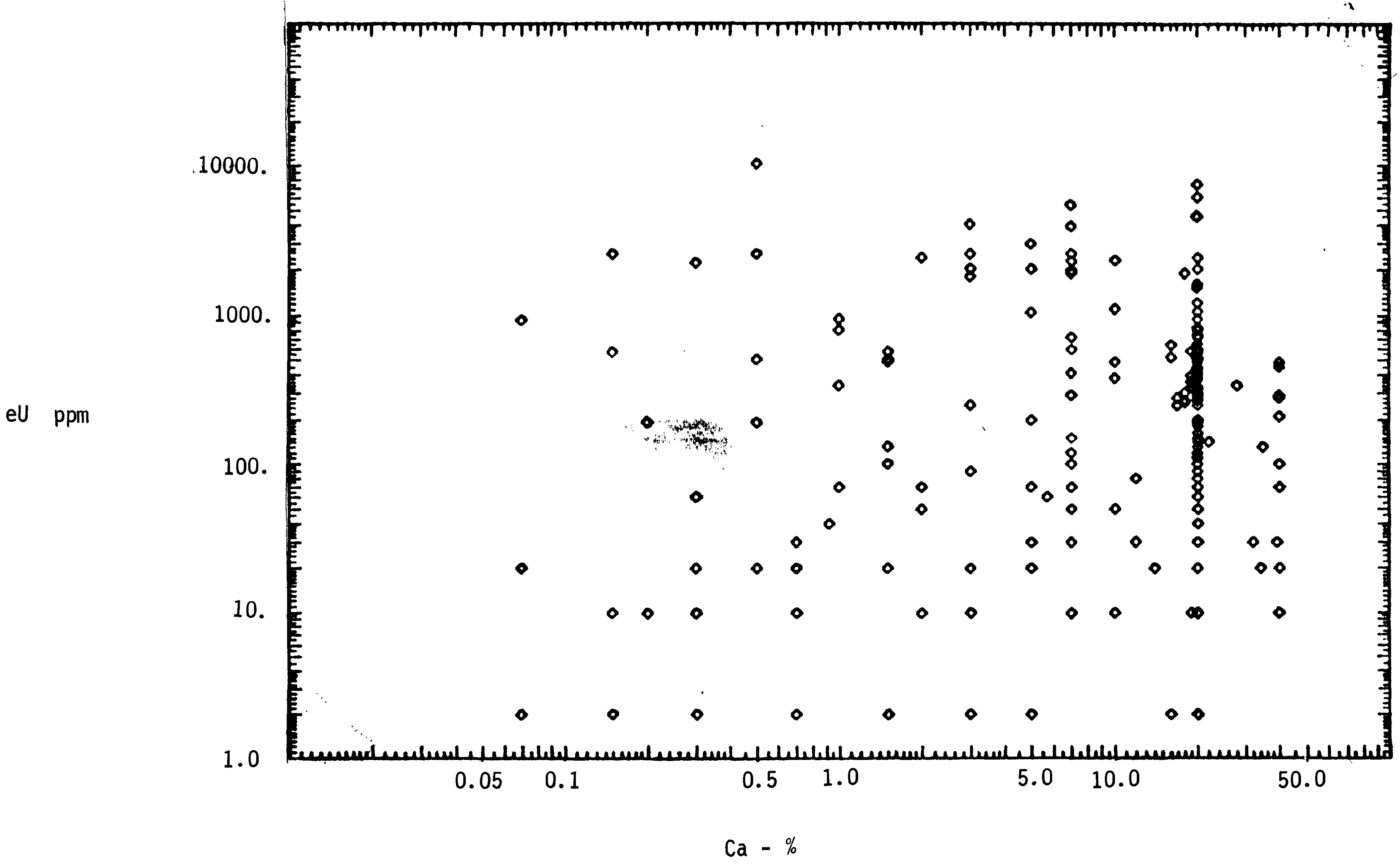

Figure 19.--Scatter plot of correlation points between abundances of calcium (Ca) and radium (eU) in 291 samples of precipitates collected at mineral spring sites. Computed r=-.17. No elongation of point cluster is apparent. Right (upper) values for Ca are constrained by analytical upper reporting limit.

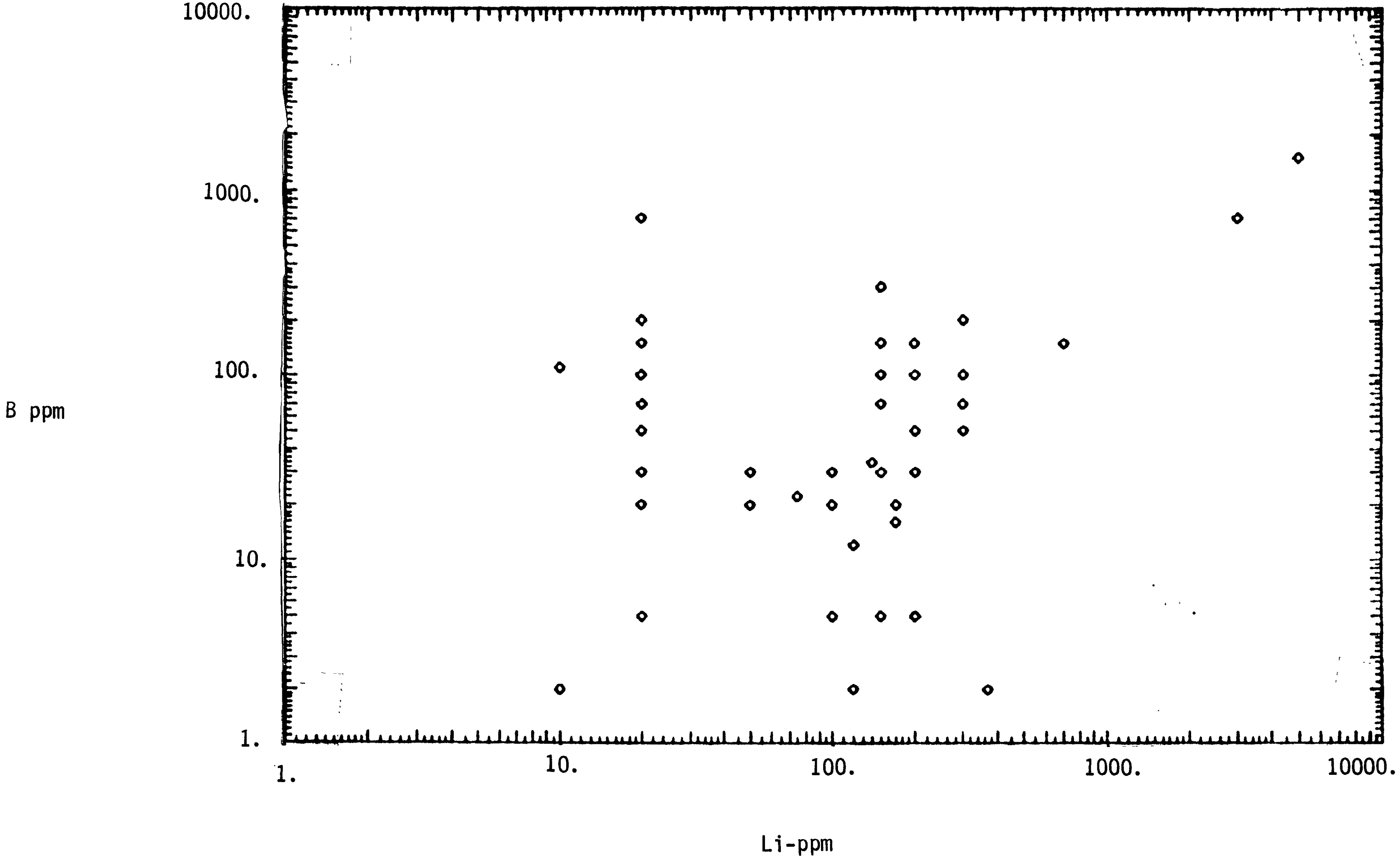

Figure 20.--Scatter plots of correlation points between abundances of lithium (Li) and boron (B) in 62 samples of precipitates collected at mineral spring sites. Computed r=.86. Note that the apparent positive elongation of the cluster depends on three or four extreme values.

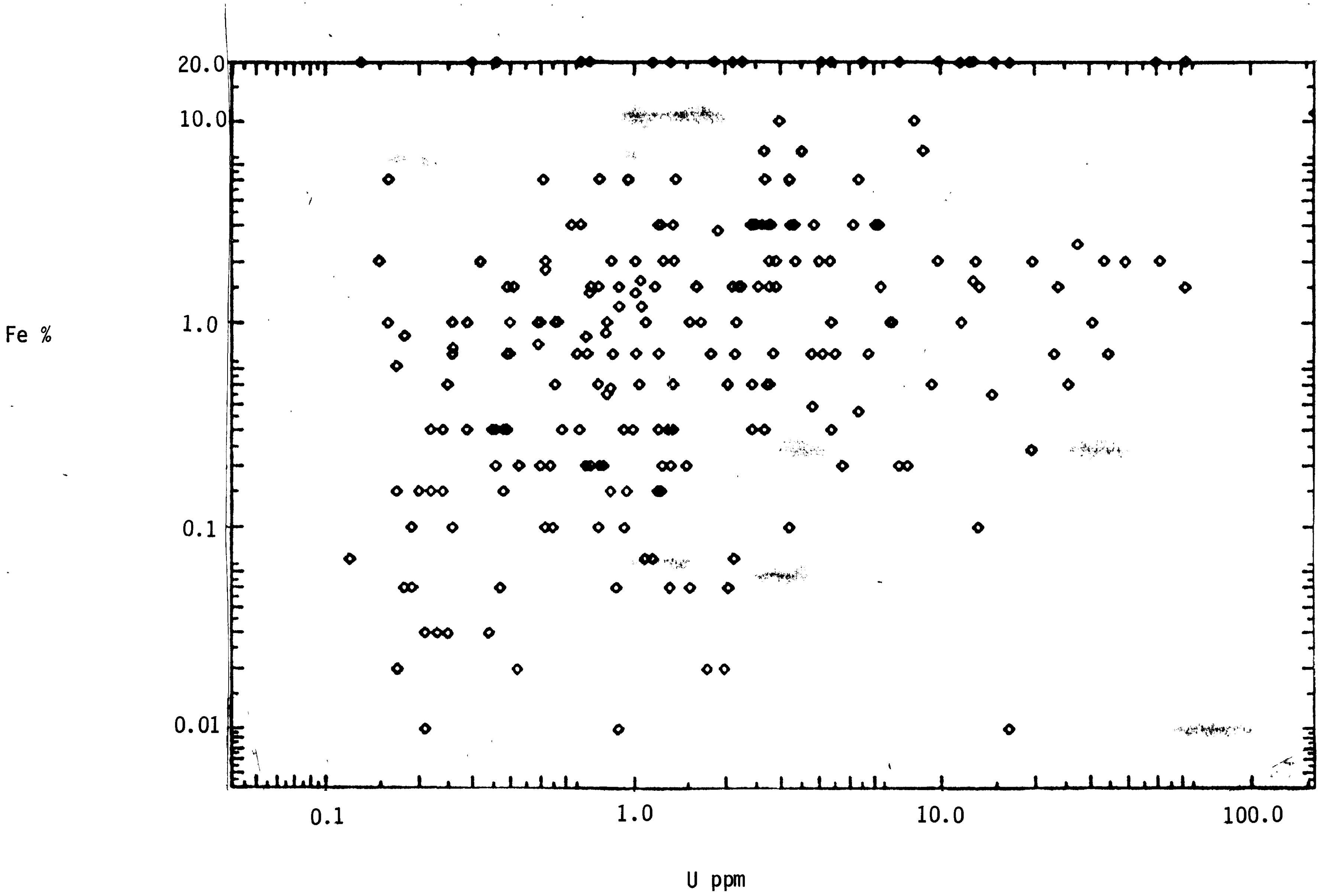

Figure 21.--Scatter plots of correlation points between uranium (U) and iron (Fe) in samples of precipitates at mineral springs. Computed r =.19

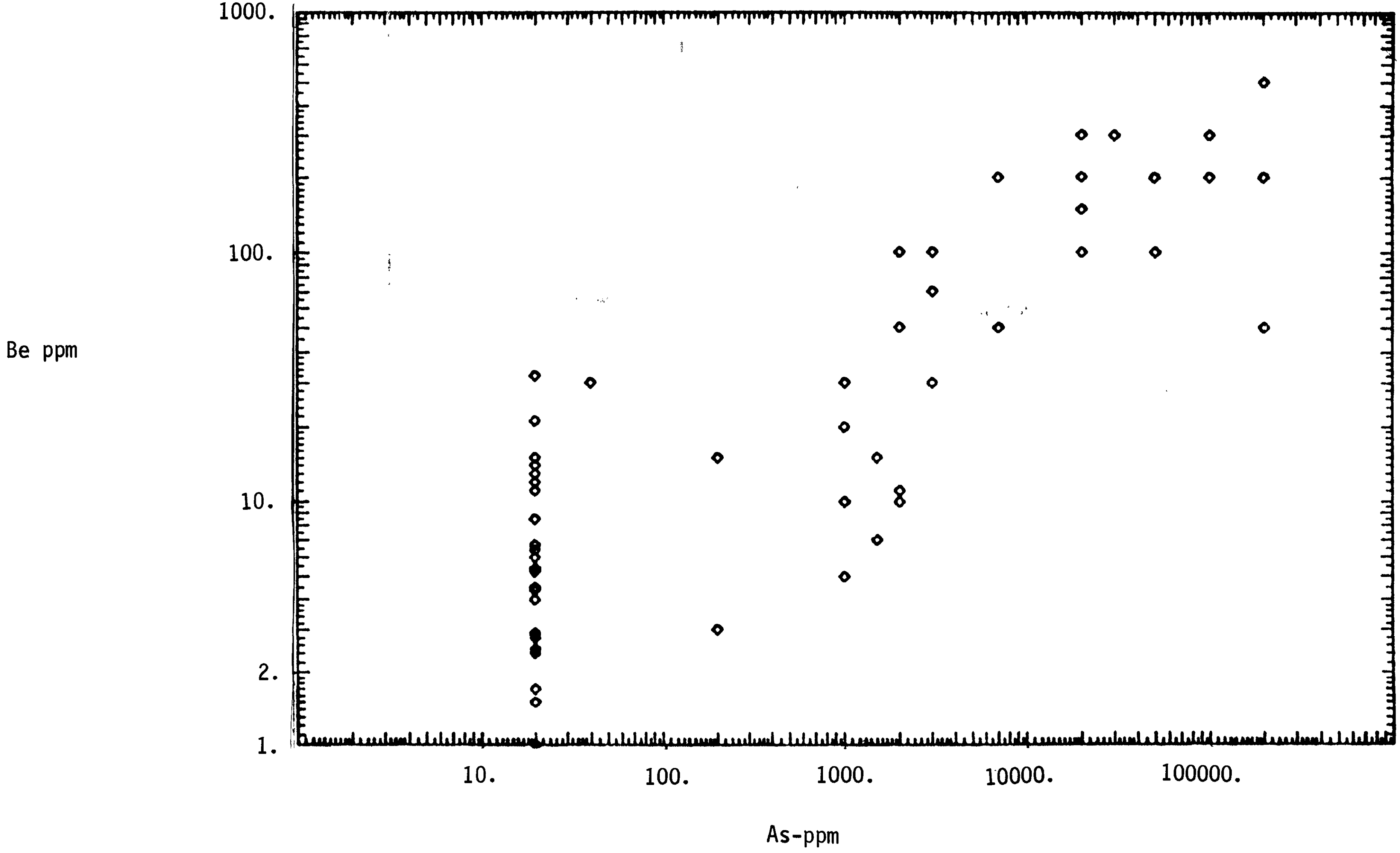

Figure 22.--Scatter plots of correlation points between abundances of arsenic (As) and beryllium (Be) in samples of precipitates collected at mineral spring sites. Computed r=.69 . Good elongation of the point cluster is apparent except in the lower left corner where reported values for As are constrained by the analytical detection limit.

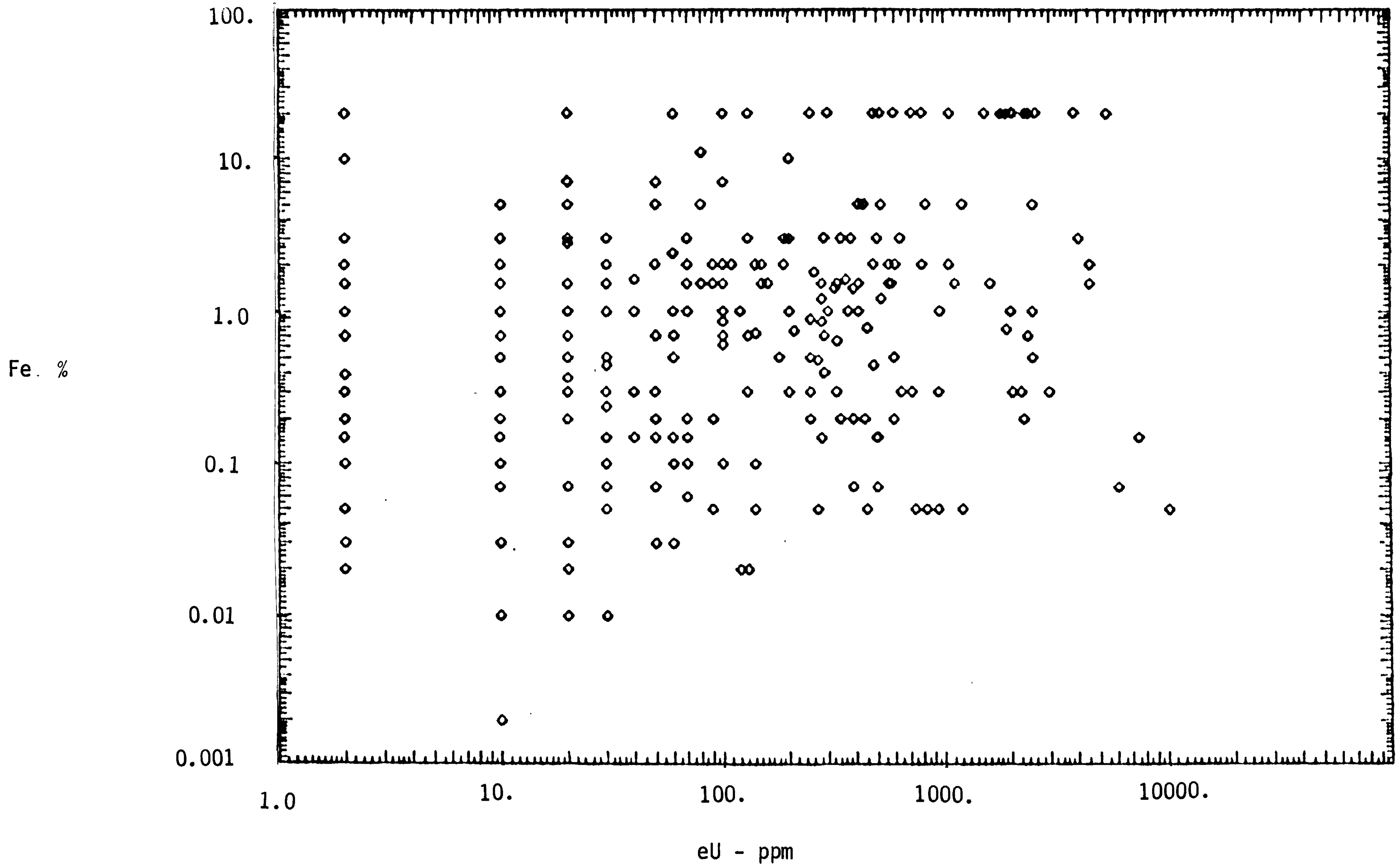

Figure 23.--Scatter plot of correlation points between abundances of radium (eU) and iron (Fe) in 291 samples of precipitates collected at mineral spring sites. Computed r=.20 shows fair positive elongation and effects of analytical reporting limit constraints.

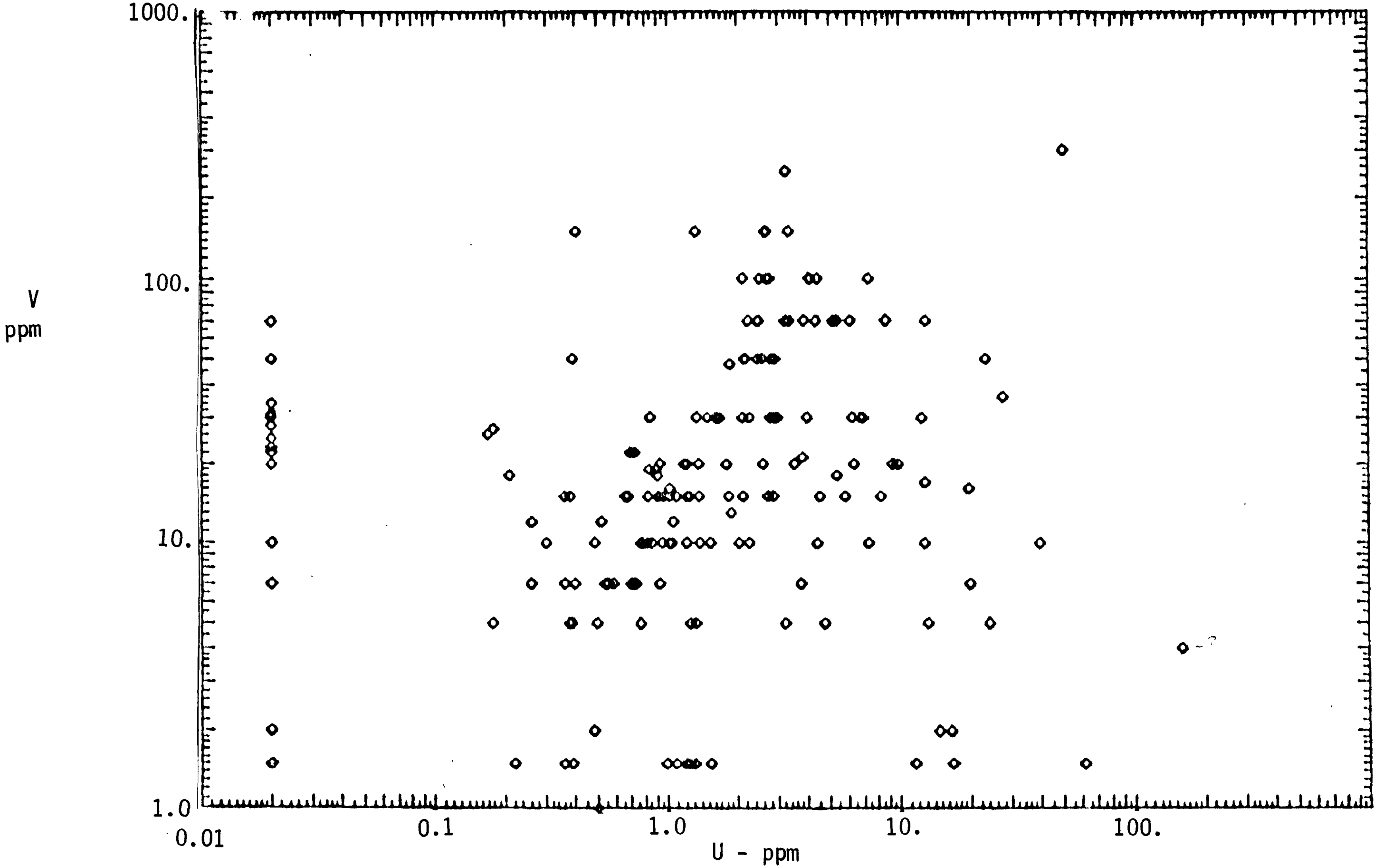

Figure 24.--Scatter plot of correlation points between abundances of uranium (U) and vanadium (V) in 187 samples of precipitate collected at mineral spring sites. Computed r =.14 . Plot shows some positive elongation of point cluster particularly in the more dense central part.

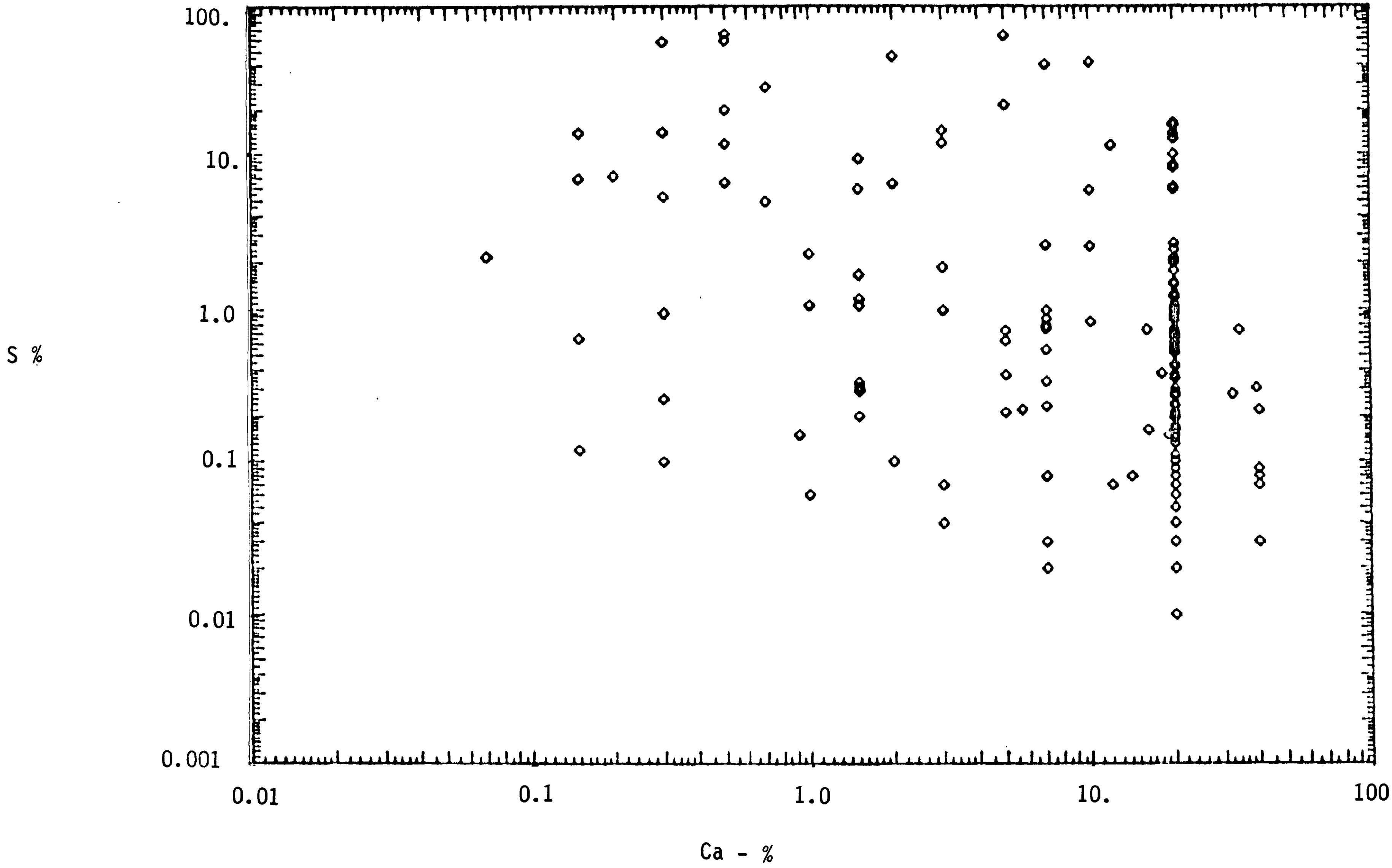

Figure 25.--Scatter plot of correlation points between abundances of calcium (Ca) and sulfur (S) in 188 samples of precipitates collected at mineral spring sites. Computed r=-.29 plot shows general negative elongation of point cluster. Vertical allignment of points is the effect of constants of the analytical reporting limits.

significant proportions of U also occur in the contaminating detrital fraction. The Ba - eU positive correlation, (fig. 18) is one of the more geochemically significant correlations in this study. The Ba - eU correlation compared with the Ca - eU correlation (fig. 19) suggests that Ra as measured by eU is chiefly related to Ba in the precipitates and not to Ca as has been suggested by some investigators. Figure 23 suggests that Ra(eU) is not exclusively coprecipitated by Ba, but is also, to a lesser extent by Fe compounds.

The positive correlation of Li to B has been suggested by computed r to be quite high. The scatter plot (fig. 20) suggests that the high computed r may be the effect of a few extreme values which exaggerate the significance of the correlation. The positive correlation of Fe and U is confirmed by figure 21. A significant positive correlation between As and Be is suggested by figure 22.

Figure 25 shows some negative correlation between Ca and S which suggests a negative relationship for these samples between the geochemical environment which produces high Ca precipitates (high CO_2) and the environment (substantial S species in spring water) which produces high S in precipitates.

To place correlation coefficients derived from different numbers of pairs on a comparable basis the computed r values were converted to standard correlation or z values. Using the same example used previously, for $n=50$ and $r=0.200$, $z=1.39$; for $n=200$ and $r=0.200$, $z=2.85$. The comparison of standard correlation coefficients, z, show a truer relationship in this instance than does a comparison of r values. The use of z (standard) correlation coefficients was introduced by Fisher (1948). The formula is: $z = \frac{\sqrt{n-3}}{2} (\ln \frac{1+r}{1-r})$. The symbol, ln, means natural logarithm; n is number of pairs.

Table 12 shows a test of the validity of the z standard correlation coefficients. All z values of 1.96-1.97 are significant at the 5 percent level, regardless of the number of pairs. Values of z significant at the 1 percent level vary more widely for small numbers of samples, but it would be safe to assume in this study that any observed z value greater than 2.64 is significant at the 1 percent level for any number of pairs.

All correlation coefficients are more reliable as the number of pairs (n) increases, as the t distribution measure in table 12 suggest. Note that the t and z values approach coincidence as n increases. Table 13 is the z correlation coefficient matrix for the 34 elements of the data matrix. Coefficients vary in magnitude from +20 (Si and Ti) to -7 (Ca and Si). As indicated in table 12, z values of ± 1.97 or higher are significant at the 5 percent level; z values of ± 2.64 or higher are significant at the 1 percent level. The highest z for U is with Al, 9.2., significant at the 0.1 percent level. If Al is an indicator of clay in the precipitates, U in the clay could be of both intrinsic (introduced in solution in spring waters) and extrinsic (detrital) origins, assuming that the clay is capable of readily adsorbing U from spring water and from precipitates on being leached from the precipitates.

Table 12.--Standard _z_ correlation coefficients at the 5% and 1% levels of significance. Student's _t_ distribution values are shown for reference.

**Degrees of freedom	_r_ (5%)	_r_ (1%)	_z_ (5%)	_z_ (1%)	_t_ (5%)	_t_ (1%)
10	.576	.708	1.96	2.64	2.23	3.17
20	.423	.537	1.97	2.62	2.09	2.85
30	.349	.449	1.96	2.60	2.04	2.75
50	.273	.354	1.96	2.59	2.01	2.68
70	.232	.302	1.96	2.59	2.00	2.65
100	.195	.254	1.97	2.58	1.99	2.63
150	.159	.208	1.96	2.58	1.97	2.60
200	.138	.181	1.96	2.58	1.97	2.60
250	.1235	.164	1.96	2.58	1.97	2.60
300	.113	.148	1.96	2.58	1.97	2.59

**Number of sample pairs minus 2, or n-2.

Table 13. Standard or Z correlation matrix constructed from the r correlation data and numbers of pairs given in Table 11.

SAMPLE	eU ppm	U ppm	T-S%	Al%-S	Ca%-S	Fe%-S	K%-S	Mg%-S	Na%-S	Si%-S
eU ppm	15.0000	-.1956	1.2527	1.0924	-.2604	5.1398	-2.3371	-1.1831	1.3306	1.7992
U ppm	-.1956	15.0000	2.1204	9.2262	-3.9070	5.9021	2.1713	1.8951	4.9911	7.8364
T-S%	1.2527	2.1204	15.0000	2.4122	-4.7060	1.0712	1.7913	-3.7162	3.1386	2.7280
Al%-S	1.0924	9.2262	2.4122	15.0000	-6.7438	7.5215	12.3489	4.4212	8.0819	18.3978
Ca%-S	-.2604	-3.9070	-4.7060	-6.7438	15.0000	-3.6396	-4.6100	7.6524	-1.0976	-7.5888
Fe%-S	5.1398	5.9021	1.0712	7.5215	-3.6396	15.0000	2.7587	-.7689	4.7692	7.7115
K%-S	-2.3371	2.1713	1.7913	12.3489	-4.6100	2.7587	15.0000	.9512	5.4028	7.2840
Mg%-S	-1.1831	1.8951	-3.7162	4.4212	7.6524	-.7689	.9512	15.0000	5.6744	1.3597
Na%-S	1.3306	4.9911	3.1386	8.0819	-1.0976	4.7692	5.4028	5.6744	15.0000	6.2081
Si%-S	1.7992	7.8364	2.7280	18.3978	-7.5888	7.7115	7.2840	1.3597	6.2081	15.0000
Ti%-S	2.3527	7.4912	2.9356	19.4100	-5.5596	6.7203	8.3407	3.2047	7.1291	20.9325
As ppmS	4.1590	3.4837	.8482	.3307	-3.6382	7.4213	1.5244	-3.8319	2.1146	-.2444
B ppmS	-1.6221	2.2529	-1.9893	1.7065	-2.4693	2.8162	2.2116	-.6596	5.2937	1.9168
Ba ppmS	11.9347	-.1408	2.3952	3.6830	-2.4221	1.4735	1.4751	-1.6464	-.5935	3.9077
Be ppmS	7.6775	3.8808	-.6684	-.0920	.2388	7.3391	-.6509	-3.5490	1.1728	.1892
Co ppmS	.6404	-.5106	-1.3774	-.5605	-.9702	1.1693	-.9815	-.1490	-2.5790	-.6332
Cr ppmS	.0564	5.3544	2.6982	13.1229	-3.9332	5.2488	3.8193	4.8520	3.8822	13.1280
Cu ppmS	.0557	3.8725	1.2381	9.0339	-4.8905	8.3303	4.2917	.9211	1.7225	10.2440
Ga ppmS	-.5241	2.4499	-.2963	6.2273	-6.5577	5.3837	8.2949	-3.8824	1.9718	7.9748
Ge ppmS	1.0070	.6751	-2.0102	-.5746	.1799	4.8947	.4697	-1.1326	-.2877	.2622
La ppmS	1.8307	-.6878	-2.9257	-1.2556	3.3839	-.4222	-1.8035	3.2816	1.2444	-2.3442
Li ppmS	.7444	-2.4940	.6137	.0633	-1.3949	-.4495	1.3190	1.1176	4.9199	-3.0175
Mn ppmS	5.8589	-1.1279	-2.8909	.9204	3.6282	6.5959	-1.4579	.6667	.4818	.0445
Mo ppmS	1.7564	.6866	2.2695	1.3238	-4.5212	4.4619	4.3637	-6.0630	-1.4218	1.6837
Nb ppmS	2411	1.0235	-.7841	2.2625	-1.4104	.2782	3.8595	-2.4064	.4115	1.8338
Ni ppmS	.0603	.2412	-.2385	1.6245	.6844	1.2721	.6004	3.4650	.8854	1.2421
Pb ppmS	.6240	3.4968	1.3625	2.6811	-4.1215	6.3466	6.0922	-3.1202	.0017	2.0540
Sc ppmS	1.0490	.6842	2.8533	.7948	-.3164	-.1310	4.0424	-2.3372	-.2970	-1.8417
Sr ppmS	4.7580	-.5858	-1.9990	-3.9256	11.4862	-.6274	-5.5034	3.7801	2.3090	-4.5170
V ppmS	.2360	3.1919	1.7685	8.5723	-3.3264	5.2279	5.5724	1.1199	1.7972	8.2652
Y ppmS	1.7070	5.4262	.7928	4.6955	-2.0323	4.5768	2.8965	-2.0460	1.5791	4.1335
Yb ppmS	.6298	2.8791	-.1126	3.2192	-.3548	5.6082	1.9616	-.9079	.4435	2.7850
Zn ppmS	-.3377	3.3361	3.6558	1.2334	-3.8217	4.3133	2.8613	-3.3140	-1.9053	.7769
Zr ppmS	.4662	4.9959	2.4616	8.8897	-5.1986	3.7516	4.7244	.2416	2.8629	7.1825

Table 13. Standard or Z correlation matrix constructed from the r correlation data and numbers of pairs given in Table 11.-continued

SAMPLE	Ti%-S	As ppmS	B ppmS	Ba ppmS	Be ppmS	Co ppmS	Cr ppmS	Cu ppmS	Ga ppmS	Ge ppmS
eU ppm	2.3527	4.1590	-1.6221	11.9347	7.6775	.6404	.0564	.0557	-.5241	1.0070
U ppm	7.4912	3.4837	2.2529	-.1408	3.8808	-.5106	5.3544	3.8725	2.4499	.6751
T-S%	2.9356	.8482	-1.9893	2.3952	-.6684	-1.3774	2.6982	1.2381	-.2963	-2.0102
Al%-S	19.4100	.3307	1.7065	3.6830	-.0920	-.5605	13.1229	9.0339	6.2273	-.5746
Ca%-S	-5.5596	-3.6382	-2.4693	-2.4221	.2388	-.9702	-3.9332	-4.8905	-6.5577	.1799
Fe%-S	6.7203	7.4213	2.8162	1.4735	7.3391	1.1693	5.2488	8.3303	5.3837	4.8947
K%-S	8.3407	1.5244	2.2116	1.4751	-.6509	-.9815	3.8193	4.2917	8.2949	.4697
Mg%-S	3.2047	-3.8319	-.6596	-1.6464	-3.5490	-.1490	4.8520	.9211	-3.8824	-1.1326
Na%-S	7.1291	2.1146	5.2937	-.5935	1.1728	-2.5790	3.8822	1.7225	1.9718	-.2877
Si%-S	20.9325	-.2444	1.9168	3.9077	.1892	-.6332	13.1280	10.2440	7.9748	.2622
Ti%-S	15.0000	-1.7947	.6298	3.3542	-.9447	-.5035	13.8990	8.8067	4.6531	-.2984
As ppmS	-1.7947	15.0000	2.9422	2.3091	8.7895	3.7895	-2.9096	.4238	5.0634	1.2468
B ppmS	.6298	2.9422	15.0000	-.4618	1.3340	.8884	.2286	1.0401	3.9288	1.4208
Ba ppmS	3.3542	2.3091	-.4618	15.0000	3.2213	-.2117	1.4675	-1.1614	3.1154	-1.7278
Be ppmS	-.9447	8.7895	1.3340	3.2213	15.0000	.9740	-3.2865	-.9649	1.8969	3.6683
Co ppmS	-.5035	3.7895	.8884	-.2117	.9740	15.0000	1.0112	1.5543	-.9118	2.3050
Cr ppmS	13.8990	-2.9096	.2286	1.4675	-3.2865	1.0112	15.0000	9.8794	1.9477	-.5101
Cu ppmS	8.8067	.4238	1.0401	-1.1614	-.9649	1.5543	9.8794	15.0000	4.3253	.1467
Ga ppmS	4.6531	5.0634	3.9288	3.1154	1.8969	-.9118	1.9477	4.3253	15.0000	.2690
Ge ppmS	-.2984	1.2468	1.4208	-1.7278	3.6683	2.3050	-.5101	.1467	.2690	15.0000
La ppmS	-.4372	-1.8886	.5592	-1.1727	-2.0811	2.5450	-.8491	-1.2519	-1.7637	-.0082
Li ppmS	-1.5224	-.1380	2.6252	1.5554	.4089	-1.3936	-2.0925	-3.8191	-.8930	-.5078
Mn ppmS	.7970	1.1598	-.2150	5.6665	5.0732	3.0742	.0334	.8553	.1678	2.1698
Mo ppmS	-.3330	7.0611	2.1497	4.6388	3.9842	1.2575	-.8103	2.7675	5.8417	2.2289
Nb ppmS	.8240	.6452	.2287	3.3668	1.6155	-1.5104	.2648	-.4000	3.6173	.0887
Ni ppmS	2.6198	-1.1383	-.7374	-2.4775	-1.8614	5.8608	6.0649	5.1255	-.5885	1.9554
Pb ppmS	1.3286	5.3581	3.3324	2.0712	2.8841	1.3304	2.6795	4.2032	5.5375	2.1536
Sc ppmS	-1.8434	8.0651	-.3202	5.5781	2.3596	1.0863	-2.6499	-3.8935	4.4016	-.1726
Sr ppmS	-3.1458	.4653	-.8304	3.9793	4.0301	.1552	-3.4706	-5.8340	-5.6852	.5292
V ppmS	8.4321	1.5500	2.8263	1.2910	-.4456	2.9914	10.0764	7.2358	4.9455	.5805
Y ppmS	3.3983	2.3871	2.6605	2.6604	5.3643	2.0977	.2354	.4060	4.1601	3.1927
Yb ppmS	2.0204	1.0355	2.1058	.0856	3.0825	3.5154	2.0378	1.7129	2.6286	3.9136
Zn ppmS	.0450	5.1970	1.9841	1.3212	1.7474	1.9788	1.1731	3.8014	4.2354	.0849
Zr ppmS	9.5732	-.0303	1.4066	2.4619	-.7003	.1227	4.8930	2.9560	4.3851	.8552

Table 13. Standard or Z correlation matrix constructed from the r correlation data and numbers of pairs given in Table 11.-continued

SAMPLE	La ppmS	Li ppmS	Mn ppmS	Mo ppmS	Nb ppmS	Ni ppmS	Pb ppmS	Sc ppmS	Sr ppmS	V ppmS
eU ppm	1.8307	.7444	5.8589	1.7564	.2411	.0603	.6240	1.0490	4.7580	.2360
U ppm	-.6878	-2.4940	-1.1279	.6866	1.0235	.2412	3.4968	.6842	-.5858	3.1919
T-S%	-2.9257	.6137	-2.8909	2.2695	-.7841	-.2385	1.3625	2.8533	-1.9990	1.7685
Al%-S	-1.2556	.0633	.9204	1.3238	2.2625	1.6245	2.6811	.7948	-3.9256	8.5723
Ca%-S	3.3839	-1.3949	3.6282	-4.5212	-1.4104	.6844	-4.1215	-.3164	11.4862	-3.3264
Fe%-S	-.4222	-.4495	6.5959	4.4619	.2782	1.2721	6.3466	-.1310	-.6274	5.2279
K%-S	-1.8035	1.3190	-1.4579	4.3637	3.8595	.6004	6.0922	4.0424	-5.5034	5.5724
Mg%-S	3.2816	1.1176	.6667	-6.0630	-2.4064	3.4650	-3.1202	-2.3372	3.7801	1.1199
Na%-S	1.2444	4.9199	.4818	-1.4218	.4115	.8854	.0017	-.2970	2.3090	1.7972
Si%-S	-2.3442	-3.0175	.0445	1.6837	1.8338	1.2421	2.0540	-1.8417	-4.5170	8.2652
Ti%-S	-.4372	-1.5224	.7970	-.3330	.8240	2.6198	1.3286	-1.8434	-3.1458	8.4321
As ppmS	-1.8886	-.1380	1.1598	7.0611	.6452	-1.1383	5.3581	8.0651	.4653	1.5500
B ppmS	.5592	2.6252	-.2150	2.1497	.2287	-.7374	3.3324	-.3202	-.8304	2.8263
Ba ppmS	-1.1727	1.5554	5.6665	4.6388	3.3668	-2.4775	2.0712	5.5781	3.9793	1.2910
Be ppmS	-2.0811	.4089	5.0732	3.9842	1.6155	-1.8614	2.8841	2.3596	4.0301	-.4456
Co ppmS	2.5450	-1.3936	3.0742	1.2575	-1.5104	5.8608	1.3304	1.0863	.1552	2.9914
Cr ppmS	-.8491	-2.0925	.0334	-.8103	.2648	6.0649	2.6795	-2.6499	-3.4706	10.0764
Cu ppmS	-1.2519	-3.8191	.8553	2.7675	-.4000	5.1255	4.2032	-3.8935	-5.8340	7.2358
Ga ppmS	-1.7637	-.8930	.1678	5.8417	3.6173	-.5885	5.5375	4.4016	-5.6852	4.9455
Ge ppmS	-.0082	-.5078	2.1698	2.2289	.0887	1.9554	2.1536	-.1726	.5292	.5805
La ppmS	15.0000	1.9832	1.2040	-2.6402	-.0631	1.0191	-1.2097	-3.2329	2.9493	-1.2576
Li ppmS	1.9832	15.0000	-1.2816	-1.2525	-.7812	-1.3243	-1.3562	-1.3413	.1988	-1.0664
Mn ppmS	1.2040	-1.2816	15.0000	4.1178	1.8533	2.0904	2.2136	1.8413	5.7625	1.1171
Mo ppmS	-2.6402	-1.2525	4.1178	15.0000	1.7632	-2.1097	6.0002	4.8230	-1.8810	3.5606
Nb ppmS	-.0631	-.7812	1.8533	1.7632	15.0000	-1.4211	.7803	.2122	-.7967	-1.0050
Ni ppmS	1.0191	-1.3243	2.0904	-2.1097	-1.4211	15.0000	-.2110	-2.3424	-1.9633	4.5127
Pb ppmS	-1.2097	-1.3562	2.2136	6.0002	.7803	-.2110	15.0000	3.4759	-2.1874	4.4840
Sc ppmS	-3.2329	-1.3413	1.8413	4.8230	.2122	-2.3424	3.4759	15.0000	1.8896	3.2639
Sr ppmS	2.9493	.1988	5.7625	-1.8810	-.7967	-1.9633	-2.1874	1.8896	15.0000	-3.2900
V ppmS	-1.2576	-1.0664	1.1171	3.5606	-1.0050	4.5127	4.4840	3.2639	-3.2900	15.0000
Y ppmS	-.7055	-.5694	2.4585	2.1840	2.5487	.5271	1.9726	2.7346	-1.5918	3.1360
Yb ppmS	.3485	-1.3949	2.7833	1.1834	.6625	.4644	2.9167	.6005	.6266	4.1306
Zn ppmS	-.1640	-3.3097	.7725	5.2121	-1.3333	1.1293	5.0424	4.4890	-2.4558	3.1996
Zr ppmS	.4107	-.5859	-1.1939	1.0513	1.4926	1.5880	2.5760	1.9961	-5.2285	4.2821

Table 13. Standard or Z correlation matrix constructed from the r correlation data and numbers of pairs given in Table 11.-continued

SAMPLE	Y ppmS	Yb ppmS	Zn ppmS	Zr ppmS
eU ppm	1.7070	.6298	-.3377	.4662
U ppm	5.4262	2.8791	3.3361	4.9959
T-S%	.7928	-.1126	3.6558	2.4616
Al%-S	4.6955	3.2192	1.2334	8.8897
Ca%-S	-2.0323	-.3548	-3.8217	-5.1986
Fe%-S	4.5768	5.6082	4.3133	3.7516
K%-S	2.8965	1.9616	2.8613	4.7244
Mg%-S	-2.0460	-.9079	-3.3140	.2416
Na%-S	1.5791	.4435	-1.9053	2.8629
Si%-S	4.1335	2.7850	.7769	7.1825
Ti%-S	3.3983	2.0204	.0450	9.5732
As ppmS	2.3871	1.0355	5.1970	-.0303
B ppmS	2.6605	2.1058	1.9841	1.4066
Ba ppmS	2.6604	.0856	1.3212	2.4619
Be ppmS	5.3643	3.0825	1.7474	-.7003
Co ppmS	2.0977	3.5154	1.9788	.1227
Cr ppmS	.2354	2.0378	1.1731	4.8930
Cu ppmS	.4060	1.7129	3.8014	2.9560
Ga ppmS	4.1601	2.6286	4.2354	4.3851
Ge ppmS	3.1927	3.9136	.0849	.8552
La ppmS	-.7055	.3485	-.1640	.4107
Li ppmS	-.5694	-1.3949	-3.3097	-.5859
Mn ppmS	2.4585	2.7833	.7725	-1.1939
Mo ppmS	2.1840	1.1834	5.2121	1.0513
Nb ppmS	2.5487	.6625	-1.3333	1.4926
Ni ppmS	.5271	.4644	1.1293	1.5880
Pb ppmS	1.9726	2.9167	5.0424	2.5760
Sc ppmS	2.7346	.6005	4.4890	1.9961
Sr ppmS	-1.5918	.6266	-2.4558	-5.2285
V ppmS	3.1360	4.1306	3.1996	4.2821
Y ppmS	15.0000	12.3938	1.2642	6.2347
Yb ppmS	12.3938	15.0000	1.7799	3.7137
Zn ppmS	1.2642	1.7799	15.0000	1.8499
Zr ppmS	6.2347	3.7137	1.8499	15.0000

Factor analysis

Factor analysis of a symmetrical z correlation matrix was computed. Seven factors which account for 65 percent of the covariance in the correlation matrix were selected. The factors account for 65 percent of the variation.

Table 14 shows the varimax factor loadings and the interpreted designations of the seven factors based on interpretations of geochemical causes and effects. Causes are geochemical or geologic processes. Effects are the results of variation in operating level (intensity) of the processes. For example, if the loss of CO_2 from spring water at spring sites is the main cause of the precipitation of $CaCO_3$ (an effect), then the rate of carbonate precipitation would depend on the rate of the loss of CO_2 as a gas.

For all factors, the initial composition of the spring waters or diluted hydrothermal brines is a critical variable. For example: An increase in pH of the waters at the spring site will not result in precipitation of iron hydroxides unless there is an optimum amount of dissolved iron in the waters. Composition of the spring waters is discussed in a companion report (Felmlee and Cadigan, 1982).

Cause and effect interpretations of the factors are outlined as follows:

Factor 1. Silica and silicate contamination and precipitation (versus calcium carbonate precipitation).

Assumed causes:

- Contamination of spring sites by detrital rock fragments, sand and clay due to soil wash, talus accumulation and wind.
- Temperature decrease of spring water due to loss of heat near and on the surface and dilution by cool water.
- Loss of dissolved and entrained carbon dioxide due to loss of gas and fluid pressure near and at the surface, with accompanying precipitation of aragonite and calcite.

Positive effects:

- Deposition of detrital minerals proceeds at a rapid rate at the spring site compared with rate of accumulation of precipitates, primarily calcium carbonate.
- Deposition of siliceous material by precipitation from cooling supersaturated spring water at a high rate relative to precipitation rate of carbonates.

Negative effects:

- Deposition of calcium carbonate by precipitation from solution proceeds at a rapid rate compared with deposition of detrital silica and silicates, and precipitation of siliceous material.

Affected elements: See Factor 1, table 14.

Factor 2. Carbonate travertine precipitation (versus native sulfur precipitation).

Table 14.--Reordered varimax factor loadings for seven factors, with tentative interpretations of geochemical factors. Primary loadings for each factor are marked with an asterisk (*); secondary loadings are in parentheses.

Element	Factor 1 Silica & silicate precipitation & contamination vs - (calcite) precipitation	Factor 2 Carbonate travertine precipitation vs - native sulfur precipitation	Factor 3** Radium coprecipitation	Factor 4 Evaporite precipitation	Factor 5 Hydrous limonite precipitation and coprecipitated elements including U	Factor 6 Rare earth metals deposited detrital contamination	Factor 7 Metal carbonate adsorption and precipitation	Communality
Ti	.974*	-.070	+.110	.051	-.037	.137	-.080	.99
Al	.952*	-.042	+.056	.151	-.044	.206	+.101	.99
Si	.936*	-.207	+.098	.038	.046	.145	-.017	.95
Cr	.826*	+.034	-.020	-.215	-.038	-.100	-.049	.74
Cu	.626*	-.158	-.098	(-.292)	(.246)	-.229	+.100	.64
V	.547*	.082	-.059	(-.255)	-.011	.050	(+.369)	.51
K	.463*	-.056	-.191	.211	-.208	(.253)	(+.439)	.60
Zr	.450*	-.127	-.065	.003	-.025	(.427)	+.064	.41
U	.437*	-.041	+.003	.169	(.294)	.147	+.090	.34
Ca	(-.320)	.693*	+.147	-.055	-.119	-.047	-.184	.66
Mg	(.295)	.673*	-.067	.115	-.156	-.136	-.173	.63
Sr	(-.246)	.555*	(+.511)	.129	-.010	-.052	-.069	.65
La	-.026	.381*	-.014	.019	.076	-.023	-.116	.17
S	.168	-.359*	+.094	.067	-.153	-.070	+.105	.21
eU	.066	-.050	+.796*	.016	.144	-.030	-.022	.66
Ba	.120	-.147	+.730*	.035	(-.260)	.181	+.168	.70
Mn	.023	(.288)	+.542*	-.216	.188	.059	+.150	.49
Na	(.432)	(.264)	+.008	.610*	.132	-.041	+.071	.65
Li	-.069	.082	-.032	.530*	.015	-.053	-.026	.30
B	.081	.103	-.231	.334*	(.312)	.055	(+.299)	.37
Ni	(.273)	.282	-.137	-.438*	.109	-.168	+.019	.41
Co	-.005	.227	-.016	-.458*	.203	.013	+.223	.35
Fe	(.419)	-.045	(+.260)	.010	.610*	-.101	(+.281)	.70
Be	-.115	-.063	(+.479)	.157	.527*	.122	+.204	.61
Ge	.041	.085	-.013	-.122	.472*	.177	+.042	.28
Y	.131	.012	+.059	-.053	(.318)	.760*	+.100	.71
Yb	.112	.150	-.017	-.207	(.374)	.636*	+.080	.63
Nb	.029	-.154	+.119	.104	-.087	.370*	-.003	.19
Sc	-.132	.023	+.207	.028	(-.324)	.228	+.646*	.64
As	-.092	-.122	+.227	.151	(.330)	-.055	+.629*	.61
Mo	-.011	(-.304)	+.193	-.083	.093	.047	+.571*	.47
Pb	.144	-.122	-.005	-.064	.190	.022	+.563*	.39
Zn	.063	-.168	-.033	-.224	.091	.085	+.539*	.39
Ga	(.280)	(-.279)	-.076	.098	.026	(.266)	+.484*	.48

**With minerals barite, and "romanechite" (Bove and Felmlee, 1981), and other hydrous oxides of Fe and Mn. (Romanechite, according to Dana (1932) is a mixture of hollandite, a manganate of Mn, Ba, and ferric Fe, and an unidentified mineral.)

Assumed causes:

- Loss of dissolved and entrained carbon dioxide due to loss of gas and fluid pressure near and at the surface with accompanying precipitation of Ca, Mg, Sr, Mn complex carbonates or other carbonates.
- Presence of significant amounts of sulfur species in the dilute hydrothermal brines and their oxidation on or near the surface.

Positive effects:

- Deposition of calcium and other carbonates from solution due to loss of carbon dioxide proceeds at a relatively rapid rate.

Negative effect:

- Deposition of native sulfur and sulfates, due to oxidation of sulfur species near and at the surface, at a relatively rapid rate in competition with carbonates.

Affected elements: See Factor 2, table 14.

Factor 3. Radium coprecipitation with barium (barite?) and manganese-barium and iron hydrous oxides.

Assumed causes:

- Decrease in temperature of hot hydrothermal spring water at near the surface.
- Loss of dissolved carbon dioxide at or near the surface due to decreasing gas and fluid pressure.
- Possible increase in pH due to loss of carbon dioxide or precipitation of sulfates.
- Formation of sulfate ion as a result of oxidation of sulfur species in spring water.

Positive effects:

- Precipitation of barite and coprecipitation of Ra.
- Precipitation of Mn, Ba, Fe oxy-hydroxides and coprecipitation of Ra.[1]
- Coprecipitation of other metals with Mn and Fe.
- Precipitation of Sr salts.

Negative effects: None indicated.

Affected elements: See Factor 3, table 14.

Factor 4. Evaporite precipitation vs heavy metal precipitation.

Assumed causes:

- Evaporation of diluted hydrothermal spring brines on the surface or on poorly drained precipitate surfaces.

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[1] "Romanechite"--reported by Bove and Felmlee (1982)--indicated by Dana (1932) to be a mixture of hollandite and an unidentified mineral.

Positive effects:

- Precipitation of Na, Li, and B salts from supersaturated spring water at seeps and in surface evaporation pans.

Negative effects:

- Precipitation of heavy metals from supersaturated spring waters.

Affected elements: See Factor 4, table 14.

Factor 5. Hydrous limonite precipitation and coprecipitated elements including U.

Assumed causes:

- Increase of pH due to loss of carbon dioxide from slowly flowing spring waters.
- Presence of ferrous iron and other metallic compounds in solution in diluted brines; no potential for other floculating precipitate.
- Little or no sulfur species present.

Positive effects:

- Precipitation of a limonitic slime or gel on surface of spring pool, as in water at orifice of conduit.
- Coprecipitation or adsorption of elements by hydrous limonite which acts as a coagulated slime.
- Limonite adsorbs U.

Negative effects:

- Increase in sulfur species would decrease pH.
- Increase in speed of discharge would prevent filtering effect of limonite.
- Precipitation of limonite is in competition with precipitation of calcite and barite.

Affected elements: See Factor 5, table 14.

Factor 6. Rare earth fraction of detrital contamination.

Assumed causes:

- Contamination of spring chemical precipitates by detrital minerals containing rare earth elements.

Positive effects:

- Increase in abundances of rare earth elements in samples collected at spring sites.

Negative effects:

- Decrease in contamination would result in decreased amounts of rare earth elements.

Affected elements: See Factor 6, table 14.

Factor 7. Metal carbonate adsorption and precipitation (?).

Assumed causes:

- Loss of carbon dioxide at or near suface of a dilute hydrothermal brine.
- Adsorbtive properties of unidentified precipitated minerals and limonite.

Positive effects:

- Precipitates of soft mud-like precipitates containing Sc, As, Mo, Pb, Zn, and Ga possibly as carbonates or hydrous oxides.
- Precipitation of hydrous limonite and coprecipitation or adsorption of other minerals.

Affected elements: See Factor 7, table 14.

The causes of precipitation of metal compounds are summarized as:

(1) Decrease in temperature of the spring water. The temperature gradient from the orifice outward is a function of the speed and volume of flow. Precipitation may occur 100-500 meters along a drainage channel containing fast-moving spring water; or, precipitation may be complete within a few meters of the orfice in a collecting pool into which spring water is flowing at a slow rate. At Beowawe (NV,11) water from the geyser loses some of its silica content in the air almost over the orifices, so that the siliceous materials form deposits resembling snow drifts on the rocks. In instances of fast moving water, such as at Monte Neva (NV 18) the concentration of the radioactive precipitates increased with distance from the orifice; in a collecting pool precipitates may form a heterogeneous mixture. The samples collected from such pools may yield a mixture of precipitates from the spring such as aragonite, calcite, sulfur, barite, etc. Samples from along a ditch may yield more segregated precipitates.

(2) Loss of carbon dioxide from the spring. This was established by Friedman (1970) as the major cause of the precipitation of calcium carbonate. Some occurrences in the field, such as in collecting pools, suggest that calcium carbonate (aragonite) may be precipitated in microcrystalline or cryptocrystalline forms, then be transported to an adjacent site where it undergoes recrystallization to calcite and is bonded to a travertine apron. Other poorly soluble carbonates will also precipitate.

(3) Oxidation or other chemical reactions of a dilute hydrothermal brine that is rich in sulfur species can yield a variety of sulfate or sulfide precipitates, and native sulfur. Gases detectable by odor are H_2S, and SO_2 (resulting from oxidation of the native sulfur, presumably).

(4) Oxidation of non-sulfurous spring water combined with decreasing temperature tends to precipitate poorly soluble metal oxides or hydrous oxides.

The most common environment is one in which all or any of the first four environments are combined. Commonly, a hot diluted hydrothermal metal-rich brine containing both high concentrations of carbon dioxide and sulfur species (such as HS^-) will reach the surface environment. Many chemical reactions occur at or near the surface and wide variety of precipitates are deposited at or near the spring site. Some precipitates are unstable and additional reactions proceed in the direction of stable compounds. Gases, including carbon dioxide and sulfur gases and energy in the form of steam are lost to the atmosphere. Chemical changes involving oxidation and reduction occur, but oxidation is dominant. Precipitation brings about changes in the diluted brines usually from acid to alkaline which in turn results in new precipitates of metal hydroxides. Surface environments influence the precipitates by providing contaminating compounds in the form of detrital silicates and other mineral material, by providing cool, surface or near surface aerated water to further dilute the hydrothermal brines, and by providing conditions in which brines can be evaporated to dryness.

The seven factors which result from mathmatical analysis of the covariances of the 34 elements appear to reflect both independent and interdependent covarying geochemical effects.
Correlation of the element loadings of all possible pairs of factors produced the following values of *r*:

Factors	1	2	3	4	5	6	7
1	1						
2	-.312	1					
3	-.323	-.006	1				
4	-.027	-.048	.033				
5	-.105	-.069	.003	-.108	1		
6	.005	-.273	-.062	.010	.041	1	
7	-.169	-.514	-.038	-.061	.082	.096	1

(Significant values of *r*: at the 5% level, ±.340; at 1% level, ±.436).

Of the 21 correlations, 14 approach zero (<.10), 3 suggest weak negative correlations between factors 1 and 2, 1 and 3, and 2 and 6. There is one highly significant correlation, a negative one between factors 2 and 7.

The negative correlations suggest competition among the processes which is highest between (calcite) travertine deposition and other metal carbonate deposition. As the proportions of highly positively loaded elements under factor 2 increase, the proportions of highly positively loaded elements under factor 7 decrease.

From the element data available, the form the metals in factor 7 are deposited cannot be determined. Carbonates, oxides, sulfates or sulfides are possible.

Deposition of S under factor 2 has a significantly high negative loading, which indicates that it too is in competition with travertine deposition. The list of communalities in table 14 shows La and S to be the two elements whose covariance is least explained by the factors. In the case of S, only two thirds of the samples were analyzed for S. Many of the samples not analyzed were collected from sulfurous springs. This bias may account for the low communality for S.

Factor scores were computed for each sample after the method of Steiner (1965), and are listed in table 15. A score of approximately zero suggests average effects of any one factor on any one sample. Negative scores suggest

Table 15.--Sample factor scores. [Factor scores for seven factors obtained by converting the data values to standard scores and multiplying by the primary and secondary loadings for each factor (table 14). The combined score for each factor for each sample measures the relative effect of each factor on each sample. After the method of Steiner (1965).]

Sample	Factor 1 Silica precipitation and silicate contamination	Factor 2 Carbonate travertine precipitation	Factor 3 Radium Coprecipitation	Factor 4 Evaporite precipitation	Factor 5 Hydrothermal iron precipitation	Factor 6 Rare earth metals precipitation	Factor 7 Base metals precipitation
ARIZONA							
CF2	-1.0457	.5496	-2.4149	.0398	-.4409	-.0047	-.5477
CF9	2.7923	.6144	-1.4915	-.5161	.0167	-.0060	-.6098
CF11	-2.6084	-.0464	-3.4601	-.0057	-.1126	.0	-.5477
CF10	3.1345	.5678	-2.4858	.3343	.3890	.3774	-.2369
CF12	-2.4117	-.1001	-3.6213	.0398	-.3272	-.0047	-.6544
CF13	-6.2363	-.3921	-3.5287	-.6154	-1.0252	.0	-.5489
CF14	-4.6166	-1.3556	-4.1574	-.7462	-.7627	.0	-.4078
CF6	-6.7702	-2.9816	-4.0366	.0076	-.7181	.0	-.5518
CF7	-6.6662	-2.8164	-4.5830	-2.0000	-.7240	.0	-.4865
CF8	-7.1559	-2.3012	-4.4866	-1.7189	-1.0502	.0	-.5489
CF4	-2.2237	-.6122	-2.2822	.4482	-.3054	-.1912	-.1008
CF15	2.0150	-.2589	-2.5012	-.0584	.1623	-.0358	-.0754
CF16	5.6570	.4882	-1.2535	.5783	-.5527	1.2863	-.3448
CD76-2	3.5641	-2.1271	-.0487	-3.5090	2.3635	-.3093	2.0750
CD76-3	8.4188	1.1313	-.8754	-.7144	.7147	1.4300	3.1352
CD76-4	9.4307	-.3245	-1.4996	-1.0360	1.8798	1.7875	3.8503
CD76-5B	10.7386	-.3599	3.2700	-1.9084	4.3709	1.3188	4.7169
CD76-6B	3.6448	1.2497	2.4673	1.4701	5.5383	2.3444	5.2466
CD76-7	2.8576	1.7598	2.1495	-.8299	3.7399	.2091	1.6005
CD76-8	2.9455	2.0733	-.9539	-.3506	.5155	-.7920	-.8632
CD76-9B	.6334	.7337	3.7809	-1.7650	4.9046	2.3444	6.3916
CD76-10	-.6685	2.1153	1.0079	.1516	1.2923	-.9401	-.2386
ARKANSAS							
CD77-91	7.9023	-4.0322	-1.1332	-.7036	.9630	.1469	.0459
CD77-92	9.1726	-.9370	.0556	-1.7842	.7360	1.6698	1.5134
CD77-93	5.3985	-.0834	.4029	-.7173	.5265	.3565	-.9930
CD77-64	6.6503	-1.8740	-1.0752	-.8481	.1892	.6097	.3530
CD77-65	9.3093	-2.5031	-.2973	-1.7954	.9332	1.1534	1.9348
CD77-66	9.2479	-2.2194	-.1731	-1.0241	.8021	1.6697	1.5310
CD77-67	10.0492	-2.8001	-.4887	-2.5204	1.0878	1.7748	2.2162
CD77-68	7.0635	-4.3244	-1.1598	-1.2106	1.4008	.7385	.2632
CD77-69	8.6653	-1.3763	.6675	-2.8619	1.2735	.8615	1.1017
CD77-70	8.6424	-3.8433	-2.8705	-2.0919	.5868	.3833	.9862
CD77-72	6.7052	-2.8574	-1.1062	.3809	1.2113	-.1904	.1403
CALIFORNIA							
79KF-46	-6.0661	1.7592	1.7799	-1.9312	-.4973	-1.8933	-4.6215
79KF-47	-4.9263	2.0883	1.1728	-1.0218	-.0337	-2.2275	-3.5722
79KF-48	-6.0585	1.8675	.4617	-.8081	-1.9026	-3.3432	-5.0406
79KF-50	-5.4771	1.5801	1.2724	-1.8856	.0495	-1.7906	-4.5564
CD77-18	4.1387	2.2153	1.8035	.5862	.3384	-1.7045	-.0174

Table 15.--Sample factor scores.--continued

Sample	Factor 1 Silica precipitation and silicate contamination	Factor 2 Carbonate travertine precipitation	Factor 3 Radium Coprecipitation	Factor 4 Evaporite precipitation	Factor 5 Hydrothermal iron precipitation	Factor 6 Rare earth metals precipitation	Factor 7 Base metals precipitation
CD77-19	2.7319	.1662	1.7489	-1.2681	2.4201	-1.1742	3.2079
CD77-20	-1.1717	.7426	1.0513	.2507	.1941	-1.4231	-.0473
CD77-21	9.5859	-.3670	.9125	.0563	1.4021	.7381	2.0401
79KF-53	-2.9877	.9390	-.4264	-3.5048	-2.1873	-2.3479	-3.8218
CD77-26	-8.4156	2.0465	-.5733	.3547	-.3220	-.9787	-2.2022
CD77-27	-1.8200	2.7301	-.7715	.8966	.1181	-.6484	-1.7283
CD77-26	9.0947	1.0266	.9221	.0731	1.0128	1.9234	1.4999
79KF-25	-5.8026	2.8002	-2.5750	-.6649	-3.7598	-3.5926	-5.3240
				COLORADO			
CD76-24	1.9350	-5.6641	-1.6611	-.6515	-.4253	-.5389	-1.0242
CD76-25A	-1.2881	1.6479	1.7284	.4134	.2496	-.5302	-1.0149
CD76-25B	5.3357	-4.6573	-1.6448	-.0805	-.4585	.6585	.5443
CD76-T1	.9842	.2280	-1.6344	-.9284	.7673	.0	.0595
CD76-T6	6.9899	-4.1827	-1.4344	1.2754	.5526	2.5994	1.6113
CD76-T7	10.4085	-1.8196	-.0729	-1.3130	1.3807	2.6766	2.5205
CD76-T8	8.7326	.5655	-1.6618	-1.0264	.8734	1.9484	1.8325
CD76-T5	4.1931	.7197	-.2175	.2552	.1900	.4131	.7816
CD76-T3	-.2838	.1538	-1.2933	1.4226	-1.1520	-2.4386	-1.1478
CD76-T4	7.7471	-.0625	-.5650	.9992	1.1494	2.1819	.9937
CD5903	6.2498	1.7816	.2356	.6704	.7201	.2028	.0824
CD5906	4.7133	-.4153	-.2136	-.3007	2.3789	2.3724	.9848
CD5911	-.0070	.7703	-.8593	-.2238	-.5073	.1396	.0593
CD5913	7.3851	.5688	-1.0070	-.4987	.5474	.3800	1.3167
CD5929	7.5393	-.3815	-1.5744	.0172	.7819	.4919	1.5298
CD5930	.4820	-4.6768	-4.1677	.3738	.7132	-.2656	-.0445
CD5994	4.7004	1.0602	.5725	-.1976	1.1244	1.6411	1.1161
CD5834	7.1811	-2.4261	-1.8159	-.7943	.1704	.9260	3.3765
CD5868	-3.0018	-2.9982	-3.9258	4.1495	-.7445	-.0931	-.3864
CD5889	1.4194	2.2162	.1848	1.1401	-.2418	-.6548	.4545
CD5892	-1.3144	.8202	-2.0537	.9967	-1.8200	-1.1699	.4570
CD5993	-2.9089	-2.4659	-2.1915	4.9688	-.9659	.2912	.2845
CD6172	-4.9632	2.0422	-.5736	.3787	-1.7706	.1841	.8865
CD6173	-4.7359	2.1159	-1.8224	.5549	-1.7872	.0	.2265
CD6177	3.6790	1.0584	.8522	1.0076	2.0838	.4791	3.0454
CD6173	-3.4893	2.9390	-.5789	.9428	-1.1913	.0	-.0273
CD6179	-.7422	1.3023	.3974	1.6134	1.8595	-.8393	-.3269
CD6182	-1.0079	.8303	-.6874	1.4527	1.0880	-.1912	-.1865
CD6183	-2.3890	1.6975	-.3632	2.1309	1.2741	.0	.9827
CD6189	-1.5870	2.0161	.7044	1.6509	1.8473	.0	.4781

Table 15.--Sample factor scores.--continued

Sample	Factor 1 Silica precipitation and silicate contamination	Factor 2 Carbonate travertine precipitation	Factor 3 Radium Coprecipitation	Factor 4 Evaporite precipitation	Factor 5 Hydrothermal iron precipitation	Factor 6 Rare earth metals precipitation	Factor 7 Base metals precipitation
CD6191A	-1.0441	1.7060	.3529	1.5852	1.1353	-.1912	-.3354
CD5979	5.5628	-4.2538	2.1275	-.5939	-1.4883	.2201	.4488
CD5991	5.6898	-2.9449	1.4928	-.3215	-3.1855	.2740	.9425
CD5992	5.7684	-2.5382	-.0641	-1.1792	-.0042	.1489	1.4316
80KF-6	4.7287	-3.9009	2.8299	-.4490	-.1859	.7504	.6952
CD 6216	7.0822	-5.5205	-.6789	.1114	2.1399	1.4314	2.6193
CD 6217	-1.1686	-1.7854	3.2352	-.6689	-2.1454	1.4538	.4798
75MS 31	-1.6765	-2.6339	5.6337	-.9467	2.9906	.4303	4.4405
75 MS33	-1.9426	-.9544	3.7808	-.2532	-1.6430	.4477	.9116
75 MS34	-.5788	.7455	4.0617	-.2123	-1.5144	.2830	.8430
CD5982	4.1461	1.2156	3.9107	1.6762	.1296	1.1446	1.6614
CD5983	3.2420	.4583	4.1937	1.4537	.2396	1.3378	1.8274
CD5985	-5.3304	-4.0696	1.5988	.0633	-2.0497	-1.2687	-1.0185
CD5986	-3.9140	.9904	1.8071	-.2669	-3.4769	-1.0370	.2508
CD5987	-2.9594	1.9305	1.9004	.4914	-3.9652	-1.8997	.0390
CD5988	-7.1812	.9973	2.8982	.6296	-2.4489	-.9210	.7929
CD5989	-6.4649	1.7818	2.2404	.3651	-2.6759	.0	-.0677
CD5990	-2.9553	-3.3073	-.8046	.1497	-2.0806	-1.0370	-.7028
CD5995	-7.6810	1.0939	3.0909	.3989	-2.5106	.0	.6565
CD6107	-7.7908	.9156	3.5156	.3989	-2.9336	-.6654	.6565
CD6108	-6.8458	.8680	3.8028	.4809	-2.3322	.5377	-.1208
CD6208	-6.7517	1.3074	-.1622	.7817	-3.4276	-.9787	.0584
CD6209	-6.3804	1.3074	.8639	.7817	-3.6519	-1.0370	.2265
80KF-5	-3.5826	.7895	1.1592	1.1005	-1.3262	.4611	-.0354
75MS-36	4.0799	-2.6097	-5.2138	-1.2665	.5282	.0	-.1944
75 MS1	2.0192	.2958	2.1761	.8587	4.1824	2.3980	.7918
75 MS2	-.3670	1.3898	.5774	.2718	1.3635	-.3716	.1602
75 MS3	-3.3279	1.7972	-.0392	.8359	.3261	.0	-.0533
75 MS4	.5962	1.5580	2.0115	.6551	3.0953	1.3945	.2539
75 MS5	-3.9193	1.0092	.0976	.0806	.8051	-.4553	.0534
80KF-1	.3521	1.8323	.3696	1.1279	1.5005	.0991	-.8423
80KF-2	-4.4030	1.4558	-.9327	.8327	-.2219	-.9787	-.0015
75 MS11	-.2665	-.2123	3.0477	.8455	3.8878	.4314	1.5458
75 MS12	1.3728	-.1911	-1.3887	4.0874	.2817	.6360	1.6981
75 MS13	-1.3794	1.4654	1.8815	.3783	1.6141	-.3393	.3641
75 MS14	2.8089	.5601	3.1114	2.4596	3.8117	.2867	1.7642
75 MS16	-.1703	.8972	1.8471	.9866	3.0911	-.1209	1.2769
75 MS17	.3345	.2444	3.3846	.9222	3.7519	.0756	1.6723
75-MS-15	3.5044	1.4582	3.3821	1.2264	3.9854	.3967	1.9593
CD80-3	-3.2931	-.5077	2.9565	.3538	2.9868	.0556	-.6530
CD80-4	-1.9881	-.0517	3.1520	.5362	3.4131	-.1261	-.1649
80KF-3	.7269	1.5126	1.5483	.5391	.9572	-1.4833	-1.4731
75 MS25	.2554	-1.8718	5.8724	-.1588	3.3485	4.8764	2.5842
75 MS26	-4.8820	-.3128	-.4288	-1.1117	-.4922	.4557	-.1098
75 MS27	.2889	-.8205	5.8609	.0876	1.3428	4.3952	2.7033

Table 15.--Sample factor scores.--continued

Sample	Factor 1 Silica precipitation and silicate contamination	Factor 2 Carbonate travertine precipitation	Factor 3 Radium Coprecipitation	Factor 4 Evaporite precipitation	Factor 5 Hydrothermal iron precipitation	Factor 6 Rare earth metals precipitation	Factor 7 Base metals precipitation
CD80-1	.6345	-1.8856	5.6707	.0055	3.4264	4.3992	2.2921
80KF-4	.5082	-.5039	2.4073	1.1068	1.1812	2.1626	1.2359
75 MS29	-4.1098	1.5779	-1.0263	-.4854	-.6296	.0	-.2387
75 MS20	-3.9995	-.1965	.9132	-1.1117	-.7666	-.1315	-.1235
75 MS21	-3.9032	.3465	.4393	-.3022	-.2624	-.1315	-.1859
75 MS22	-4.3724	.6940	-.7660	-.4854	-.9712	.0	-.1944
75 MS19	-5.5074	1.0611	-.4240	-.2035	-.1128	.0	-.1320
75 MS 30	-4.4177	-1.5841	4.4558	-.5833	2.2411	.7840	3.2359
75-MS-12	-4.2897	-.3961	5.4058	-1.1813	.0727	.4772	.9074
CD80-2	-3.2061	-1.9768	5.4373	-.1423	1.9623	-.1159	3.5372
75-MS-12	.6566	-4.8113	-2.8176	-3.1975	1.9444	-.3845	.9411
75-MS-12	4.8383	-7.9647	-3.5566	-3.0125	2.7417	-1.2794	3.0760
75-MS-11	-4.7761	.4411	-1.4921	-.6154	-.1304	.0	-.1320
75-MS-12	-3.4601	.7385	-.2664	.5549	.3522	.0	.0534
75-MS-12	-3.2929	-3.0098	-1.5880	-.0212	-.7317	.0	-.3011
IDAHO							
CD76-41	-2.8659	.6221	-.5350	-.3360	-2.2800	.0	-.6740
CD76-42	-7.3034	.7921	-1.6602	.7817	-1.8960	.0	-.4078
CD76-43	8.8348	-1.3321	-.6051	1.3293	1.4755	4.4899	1.3286
CD76-39	-9.2241	-.3620	-2.4761	1.1327	.1539	.0	-.6057
CD76-40	-6.2949	.0031	-1.7667	1.0144	-.5818	.0	-.4262
CD76-44	-6.9594	-.3846	-1.4896	-.5853	-.1042	-.9210	.3531
CD76-45	-7.0375	-.8456	-2.9633	.0857	-.6175	-.3007	.0534
CD76-46A	-6.5012	1.7654	.7787	.2131	-.5763	.0	-.2127
CD76-46B	8.5164	-.1689	1.4553	-.5919	3.2553	1.4984	2.5420
MONTANA							
CD78R-12	10.2468	.1879	-.7661	.3448	1.3122	1.6037	3.6289
CD78R-19	9.3803	-1.0752	-1.3250	-.4030	.2845	.6615	2.9059
CD78R-4	-2.2393	-1.3662	.9800	-.6523	1.9374	.0	.2759
CD78R-5	5.1605	.7198	.2571	-.7030	-.2643	-.9071	.9632
CD78R-[illegible]	-8.7773	-.2005	.0399	-.7986	-.7382	.0	-.1944
CD78R-9	-5.3447	.3915	.7971	-.7685	-.9359	.0	-.1320
CD78R-10	-6.6068	-.2823	-.9896	-.3943	-.7230	.0	-.2387
CD78R-13	1.1980	-2.6093	-2.7031	.4531	.6516	.6379	2.6304
CD78R-14	-4.6883	-1.0793	-.3771	-1.2485	.1471	-.0311	.1610
CD78R-15	-8.5901	-1.9998	-1.7266	-.9975	-.5935	.0	-.0015
CD78R-16	-6.7800	-2.0184	-3.4864	-.7298	-.8015	.0	-.1320
CD78R-17	-1.9149	-3.7355	-.1201	-.9018	2.0122	-1.2914	.8756
CD78R-18	-6.8551	-1.0885	-1.6193	-1.1420	-.0744	.0	.0534
CD78R-20	-2.8872	-.8332	-2.4093	-.9420	-.9828	.0	-.6116
CD78R-1	-4.6520	-.6068	-1.9042	-.4854	-.0993	-.1159	-.1944

Table 15.--Sample factor scores.--continued

Sample	Factor 1 Silica precipitation and silicate contamination	Factor 2 Carbonate travertine precipitation	Factor 3 Radium Coprecipitation	Factor 4 Evaporite precipitation	Factor 5 Hydrothermal iron precipitation	Factor 6 Rare earth metals precipitation	Factor 7 Base metals precipitation
CD73R-2	-6.7003	-.3319	-1.5298	-.4854	-.1172	.0	-.1320
CD73R-3	9.7975	.5940	2.4511	-2.8422	-.3173	.8283	1.6734
NEVADA							
CD77-54	-3.9698	1.0598	.9666	-.1198	-.9121	-.5925	-.3011
CD77-55	-3.1908	.6122	-.0898	.2941	-1.7767	.0	-.4078
CD77-53	1.3586	-4.8229	-4.6290	.6485	-.0805	.4218	.5077
CD77-3	-2.5492	1.2271	3.2166	-.4735	-.9460	-1.8669	-.1345
CD77-4	2.6881	.8084	.4268	-.1337	-.7594	-.8824	-1.1322
CD77-5	9.3254	-1.5559	1.1270	-.9652	1.2716	2.2833	2.1291
CD77-6	-.0752	.7066	3.6737	.0488	-.5325	-.9123	-.3527
CD77-7	-.8044	1.7550	.0314	1.0389	-1.1728	-1.8638	-.7999
80KF-50	-4.5139	.9248	-1.9557	-.5111	-1.9594	-.1159	-.0015
CD77-1	-.0984	-3.9186	-3.4632	1.3069	-.0840	-.3078	-.1843
CD77-2	6.4748	-2.9717	-1.4352	.8632	.7633	2.0518	1.7022
CD77-12	6.2086	-.9429	-.4545	.6608	.0996	-1.4206	.6529
CD77-13	6.5151	-.6858	-.0574	.8737	.0429	-1.0995	1.6317
CD77-14	4.4004	-2.4678	-1.4078	.9728	-2.0290	-2.0420	-.2569
CD77-15	-2.2727	-6.0906	.4962	.3785	-2.0701	-2.4299	-1.7373
CD77-16	8.6384	-2.9617	.1865	2.2391	-1.5339	-.4286	2.2991
CD77-17	7.7827	-2.9029	.9581	1.7827	-1.8272	-.3715	1.9696
CD77-8	-4.9228	1.4748	.1192	-.8132	-1.5061	-.9787	-.2387
CD77-9	-.6617	1.3793	.0912	.2371	-1.9733	-1.4811	-.5937
CD77-10	-4.9614	1.6509	-.2468	.6562	-1.6428	-1.3263	-1.3289
CD77-11	5.3006	.2522	-.6115	-1.4630	-.6167	-1.1793	.5777
KF1	-7.2537	1.2339	-.8186	-.2445	-1.1060	-.9787	-.8535
KF2	-3.1803	.8736	1.2163	-.4627	-.9039	-.2054	-.3315
CD77-46	-7.6908	-.0740	-1.8312	-1.1518	-1.8481	.0	-.5489
CD77-47	-8.4621	-.8406	-2.0560	-1.1601	-1.0136	.0	-.1944
CD77-48	-1.3749	.8563	-.7163	-.3557	-.2901	-.6869	-1.1802
CD77-49	2.6333	1.3450	1.1356	-.1259	-.4508	-.3512	-1.1528
CD77-50	-6.1416	.2482	-1.8334	-.7462	-2.4276	-.0047	-.5489
CD77-51	4.2171	-2.5231	-1.3759	-.5721	-.4124	-.7524	.5311
CD77-52	-5.1384	-.7539	-2.1565	-.7298	-.7054	.0	-.2387
CD73R-21	-6.2395	-.6067	-.5430	-.2044	-1.6750	.0	-.4078
CD73R-22	-4.7642	.8172	-.3798	-.5775	-1.5120	.0	-.3560
CD73R-23	-8.8774	-.8372	-2.6562	.3656	-1.4770	.0	-.4078
CD80-59	-4.7215	-.1726	-.0962	-.7986	-.8769	.0	-.4078
CD77-43	-1.3197	1.4629	-.3720	1.0021	-.5640	-.6859	-1.0508

Table 15.--Sample factor scores.--continued

Sample	Factor 1 Silica precipitation and silicate contamination	Factor 2 Carbonate travertine precipitation	Factor 3 Radium Coprecipitation	Factor 4 Evaporite precipitation	Factor 5 Hydrothermal iron precipitation	Factor 6 Rare earth metals precipitation	Factor 7 Base metals precipitation
CD77-44	.8151	-.0336	-1.6842	.7468	-1.4088	-1.9344	-.2432
CD77-45	3.4903	.6601	-.4581	-.1764	-.3001	-1.9344	.6949
CD77-41	-8.0852	.8337	-1.4615	.3989	-2.2321	.0	-.3011
CD77-42	.2734	.6802	-.7216	.0883	.0095	-.3345	.7737
CD77-40	1.2082	-3.7535	-3.1945	-.0925	.4428	.2501	1.7785
CD77-24	9.3644	-1.1404	-.4261	.2508	.6768	1.4958	1.4352
CD77-32	2.8130	-.7112	-2.5073	2.0872	-.3657	-1.5575	-.2330
CD77-33	7.4148	-1.0866	-.6446	2.3748	1.4038	.8533	2.2891
CD77-34	5.5541	-.0543	-1.0280	.9263	1.5891	.0706	1.9324
CD77-35	-.8899	.2557	-2.1848	-.3457	-.6107	-.9787	-.1058
CD77-36	-1.7283	.5487	-1.3401	-.9103	-.9211	-.9787	.1859
CD77-39	11.6066	.1509	-1.0233	-1.7057	1.4134	2.1430	3.4514
CD77-37	-1.0796	.5388	-1.2149	1.0100	-.6630	-1.5949	-.4700
CD77-38	4.9613	.3589	-1.4042	1.6691	.8801	-1.1926	-.0304
			NEW MEXICO				
75MS-40	.5695	.2867	4.0975	-.1393	1.3683	.7181	.9086
CD76-16	-7.3751	.2417	-1.0175	.0651	-1.9128	-.3007	-.0533
			UTAH				
CD76-13	3.4364	1.4855	-.2325	.9490	.3029	.3205	-.2644
CD76-14	-.7919	.0502	-.9197	.3826	-.3610	-.5925	-.3037
CD76-12	1.2816	1.0621	-.3879	1.2942	-.3923	-.3154	-.5468
CD76-16	.8558	1.3739	-2.1730	1.9089	-.0641	-.0978	-1.2955
CD76-15	.6538	1.0862	-.7066	-.0414	-.0855	-.3393	-.1946
75-MS-10	-4.6227	.8624	3.6555	.3016	-1.8823	-.1912	-.3560
75-MS-10	2.4032	1.2602	2.7339	-.2584	-.9860	-.7505	-.3868
75-MS-10	4.2220	1.9623	2.5423	.2937	-.5857	-.0543	.4037
CD76-11B	-3.8978	-3.6857	2.9729	.1243	-2.0602	.0	-.3049
CD76-19	6.4191	.6529	.7033	.2603	.5746	.3047	-.3605
80KF-51	-3.1228	-.3556	-2.4161	-.9382	-.3184	-.5603	-.1428
CD80-72	-4.1680	-.3082	3.7670	-.1758	-2.2150	-1.3180	-.4891
75-MS-10	-2.8253	.5954	2.9848	.7956	.9484	.0	.7462
75-MS-10	-3.6245	-.5167	1.8644	.5549	.5382	.0	.3012
CD76-20B	-3.0835	-.6247	3.2296	.6073	1.5471	.0	.9351
75-MS-10	1.0453	.5883	2.2849	.3382	.8635	.0452	-.2410
75-MS-10	5.6195	.4604	3.9217	.5577	.2376	-.2370	2.2828
CD76-21	-.5342	.8218	1.5486	-.1927	-.0175	.0	.3325
CD76-22	-.1567	1.1952	-.7049	-.7962	.1186	-.5925	-.3289
75-MS-10	-4.2556	.2231	-2.8898	-.3943	-1.3995	.0	-.3011

Table 15.--Sample factor scores.--continued

Sample	Factor 1 Silica precipitation and silicate contamination	Factor 2 Carbonate travertine precipitation	Factor 3 Radium Coprecipitation	Factor 4 Evaporite precipitation	Factor 5 Hydrothermal iron precipitation	Factor 6 Rare earth metals precipitation	Factor 7 Base metals precipitation
CD77-56	-7.4473	-1.5022	-3.2046	-.1198	-1.1381	.0	-.5489
CD77-57	-3.3567	.8328	-.1737	1.6035	.0822	.0	.1602
CD77-58	-.2565	.3598	-.4650	1.4420	.4498	-.1912	.0474
CD77-59	-7.4391	-1.2826	-3.2078	.1496	-1.3042	.0	-.4865
CD77-60	3.5480	1.5183	1.5979	-.1223	-.1133	-2.1327	.4119
CD77-61	-2.5022	1.2351	1.6391	1.0820	.6632	-.3476	-.3005
CD77-62	2.8454	1.2098	.6542	.1708	-.4838	-1.9344	-.2367
CD77-63	-3.0594	.6790	-.6333	.9204	-.2066	.0	.0534
MBQ-339	1.8390	2.1805	1.4349	.3341	.8055	-.1762	-3.3190
MBQ-783	1.5214	2.7563	1.0004	.2463	.3039	-.3821	-4.0805
MBQ-784	-4.3996	2.4977	-3.3319	.0123	-3.3640	-3.5038	-4.2026
MBQ-785	.6173	2.8395	.5707	.4875	-.9349	-2.0477	-4.5877
MBQ-786	.8072	2.6190	.8647	.5088	.3361	-.6867	-4.2490
MBQ-787	.7384	2.3581	1.0237	.0996	.2603	-.6393	-4.2722
MBQ-788	.3321	2.4754	.7422	-.1554	-.2564	-.6053	-3.9063
MBQ-789	-2.8901	2.3878	.5698	.8855	-.4817	-2.3947	-4.3122
MBQ-790	-1.4400	2.5940	.1977	-.1048	-.5906	-2.1353	-3.4530
MBQ-791	2.1088	2.0712	.6399	.0388	.4862	-.2942	-2.8041
MBQ-792	-2.5172	3.0341	.9501	1.4179	.1228	-1.2280	-4.3663
MBQ-793	2.5557	2.0633	.6965	.5637	.2475	-.0320	-3.0934
MBQ-794	1.5730	3.0129	.6682	-.1099	.0784	-.5538	-3.2197
MBQ-841	.8323	2.4284	.4150	.3514	-.7557	-.5938	-4.1069
MBQ-842	.4790	2.0104	-.2334	.1523	-1.8015	-1.7728	-3.5021
MBQ-837	1.5839	2.6128	.4589	.5156	-.3257	-.4926	-2.9808
MBQ-838	.9974	2.7800	.5263	-.4575	-2.2062	-1.8007	-3.2900
MBQ-839	2.3864	2.1663	.8605	.0499	-.2504	-.0519	-2.8915
MBQ-840	1.0736	2.8299	.9640	.2121	.0422	-.7258	-2.3191
MBQ-350	9.2925	-1.6734	-1.0605	.5915	1.5727	3.7174	-1.2836
MBQ-759	2.9676	-.0470	-1.0302	.9929	1.2133	2.3955	-3.4686
MBQ-760	9.4502	.2447	-.2503	-.5468	2.2552	2.6756	-.3686
MBQ-761	.1340	2.0687	-.6882	-1.5745	1.5662	1.8514	-2.7810
MBQ-346	-4.1178	2.1467	-2.1567	-1.8330	-3.3170	-2.5355	-5.2446
MBQ-347	-1.8275	2.0999	-.8541	-2.1310	.0553	-2.5916	-3.5486
MBQ-763	-.8575	1.2606	-1.6928	.0400	.8304	3.7066	-5.3854
MBQ-344	4.6324	.4682	-2.6675	-.5936	-.3081	.2546	-3.7425
75-MS-10	-.4788	.2334	2.7034	.2096	.9497	.2020	.7062
75-MS-11	-1.5461	1.0334	-1.8853	-.5371	-.2528	.0	.1602
75-MS-11	.5069	1.6084	4.2303	.7468	1.2942	.0829	.7688
MBQ-340	-.5904	1.9856	4.8642	-.9230	-.5611	.3960	-1.9361
MBQ-345	2.5039	1.8574	-2.9810	-.6621	-1.1999	-.0661	-1.8064
CD76-23B	-6.0231	1.0099	1.3474	-.3022	-1.7074	.0	-.4078
CD76-23B	-.8257	1.2381	1.2643	.5458	-1.0276	-.0047	-.4853
75-MS-11	3.9874	1.4588	1.6007	.6087	-.3321	-.0867	.3201
75-MS-11	-.7756	-.1531	4.5692	.1273	2.8754	.7613	2.0991
75-MS-11	-6.0781	-.6617	1.4457	-.4854	-.2467	.0	.3641

Table 15.--Sample factor scores.--continued

Sample	Factor 1 Silica precipitation and silicate contamination	Factor 2 Carbonate travertine precipitation	Factor 3 Radium Coprecipitation	Factor 4 Evaporite precipitation	Factor 5 Hydrothermal iron precipitation	Factor 6 Rare earth metals precipitation	Factor 7 Base metals precipitation
75-MS-11	-5.3604	1.0690	.1735	1.1403	-.4630	.0	-.6057
75-MS-11	-.5564	1.9608	3.0305	.4211	.8559	.0756	.6680
75-MS-11	3.4805	.3911	-.1479	1.4453	.7171	.4113	.6616
75-MS-11	-6.4177	.1692	-1.4693	.0806	-.9886	.0	-.4865
MBQ-303	5.2832	.9341	1.5087	-2.9858	1.3033	1.6454	6.8493
WYOMING							
CD76-29	-7.9573	.2045	-1.6888	-.0212	-.6882	.0	-.3560
CD76-30	-5.6754	-.1330	-3.1530	-.4788	-.5550	.0	-.3011
CD76-31A	-2.0209	.4225	-2.3576	1.2221	-1.4132	-.3393	-.9890
CD76-31B	9.7951	.9389	-2.0117	-.6059	-.0986	1.7457	1.6206
CD76-32	-2.4949	1.1014	.3036	-.1569	-.5997	-1.2113	-.6618
CD76-33	-3.5045	.3774	-1.9101	-.0212	-.3878	.0	-.1944
CD76-28	-.0679	.9060	.5617	-.0991	-.4609	-.4444	-.5803
CD76-34	.2379	.2379	1.1822	-.2446	.2855	.3049	-.2718
CD76-35	2.9449	-3.2488	-2.2973	-.3602	-.7698	.6038	-1.5053
CD76-36	-1.3962	-7.9187	-4.5682	-.9998	-1.3534	-.1912	-.4865
CD76-37	-5.2340	-.0559	-1.9106	.5449	-1.4117	.0	-1.4504
CD76-38	-6.3019	.6895	-1.0927	.4461	-1.6593	.0	-1.1669
CD76-26	12.0967	-1.4160	-1.3081	-1.0432	1.7472	2.9121	2.7030
CD76-27	10.5914	-1.3500	-1.2635	-.7593	.8994	2.4798	1.9814

less than average effects; positive scores suggest higher than average effects. Factor 1 scores are generally a measure of detrital contamination of the sample. Effects of silica precipitation appear to be minor. High negative scores generally indicate a relatively high proportion of calcium and strontium deposited.

High scores for factor 3 suggest relatively high radium precipitation. The scores show the relative effects of each factor on each sample. The reason for a particularly high score for a particular sample can only be determined by referring to the sample data in table 4. The value of the computed scores is that they make it possible to identify the unusual samples more easily than would be possible by inspecting individual element abundances in the sample data (table 14). The scores also identify unusual springs.

The range of scores for each factor is a function of the variance of occurrence of the elements with high loadings (table 14) for each factor.

CARBON ISOTOPE DATA

To understand the role of carbon dioxide in the formation of the springs, we would first summarize our results up to this point. The data which have resulted from our study of radioactive mineral springs and precipitates suggests conclusions which may be summarized as follows:

1. Radioactivity at mineral spring sites is due principally to the presence of Ra-226 and Rn-222.
2. Ra-226 is concentrated by coprecipitation chiefly with barite and to a lesser extent with Mn-Ba-Fe hydrous oxides.
3. Precipitation of minerals from spring waters at or near spring sites results from oxidation of sulfur species, and loss of carbon dioxide, and loss of heat.
4. Radioactive mineral springs are surface manifestations of deep-source hydrothermal systems.
5. The springs flow as the result of subsurface gas and fluid pressures. They are not artesian.
6. The spring waters flow laterally and upward along established conduits (joints, faults, unconformities, etc.). They do not represent aquifer flow but may contain water contributed by aquifers.
7. The principal entrained and dissolved gas in the springs is probably carbon dioxide (CO_2). It is also the chief source of gas pressure in the spring system.
8. Other entrained or dissolved gases in the springs are radon, gaseous sulfur species, oxygen, methane, helium and nitrogen.

Barnes, Irwin, and White (1978) made a study of the carbon isotopes of the CO_2 in gas charged springs. They also studied the occurrence world-wide of such springs. One of their conclusions was that "CO_2 discharge is chiefly in the orogenic areas of the earth's surface along or near major crustal plate boundaries. It is along these plates that resistance is expressed as seismic energy and anomalous temperatures." They also found that high thermal gradients coincide with abundant CO_2 discharge, but, more than high temperature is required to generate CO_2 from limestones.

Based on the interpretations of C^{13}/C^{12} carbon isotope ratio studies by Craig, Boato, and White (1956), Barnes and others, (1978) came to the conclusion that the CO_2 in the springs comes from three major sources: metamorphosed organic material; metamorphosed marine carbonate rocks; and, the earth's mantle. Barnes, Irwin and White (1978) found that the hydrothermal spring water from great depths bearing CO_2 of apparently deep origins was basically water of meteoric origin. They expected more magmatic and connate water.

The interpretive limits assigned to the C^{13}/C^{12} isotope ratios (used by Barnes and others, 1978) are as follows: (A) 0.0 permil -- marine carbonate the standard; (B) -4.7 to -8.0 permil -- CO_2 of mantle origin; (C) -8.0 to -20 permil -- CO_2 originating from organic-carbon-bearing rock undergoing metamorphism; (D) +5.0 to -5.0 permil -- CO_2 originating from the metamorphosis of marine carbonate rocks. However, limits listed under (B) could represent a mixture of gases from (D) and (C), or dissolution of fresh water carbonates. The (B) interpretation should be used with the qualification of "possibly" mantle.

We collected samples for C^{13}/C^{12} carbon isotope ratios from selected springs. The spring sampled, the ratio obtained, and the interpreted source are shown in table 16. These results suggest that according to Barnes and others (1978) and Craig, and others (1956) most of the sampled springs could be discharging CO_2 from the earth's mantle and from zones of metamorphism or it could be a mixture of (D) and (C). This raised the question of the special relationship between the mantle and metamorphic zone environments. We were also forced to keep in mind that for some sampled springs large quantities of Ra-226 and Rn-222 and Ra-228 and Rn-220 far out of equilibrium were also being discharged at large rates (Cadigan and Felmlee, 1979) which is compatible with zones of metamorphism.

A SEISMIC MODEL

A simplified model which ties the numerous parts of the radioactive mineral spring and CO_2 discharge puzzle together is one proposed by Newton and Perkins (1981), and discussed by Derra (1981). Newton and Perkins were seeking an explanation for the almost consistent evidence in old metamorphic granulite terranes of extreme seismic pressures of about 8000 times standard barometric pressure (8 Kbar). The model which best satisfies the requirements for such a concentration of force or seismic energy is overthrust faulting at depth by one plate segment over another, and sandwiching of a significant quantity of the sediment overlying the overridden plate between the plates.

The model is illustrated in figure 26. We have added a stage of hydrothermal system origin and other processes to Newton and Perkins' original scheme as shown in Derra (1981).

The adapted model shows a rupturing of the crust which would allow for the increased degassing of the mantle, or the CO_2-fluid pressures could even have facilitated the rupture and overthrusting. The crust is thickened, thus satisfying the requirements of Barnes, Irwin and White (1978) for an orogenic area. The zone of metamorphism would provide the heat energy and degree of metamorphism required for metamorphic sources of CO_2. Mantle material would be intruded into crustal and associated sediments in the zone of metamorphism.

Table 16.--Radioactive mineral springs: C^{13}/C^{12} Ratios in HCO_3 - CO_3 - CO_2

Spring	C^{13}/C^{12}	Class
Austin	-4.4 permil	B
Ouray	-6.2	B
Doughty (bath)	-3.6	D
Doughty (alum)	-11.2	C
Poncha	-6.2	B
Taylor	1.7	D
Guffey	-5.4	B
Doughty (bubble)	-5.5	B
Utah	-5.6	B
Golconda	-5.8	B
Monte Neva	-3.7	D
Fales	-3.7	D
Stinking Hot	-16.65	C
Baker	-4.4	B
Wildhorse	-10.00	C
Stinking Cold	-18.9	C
Monroe	-4.6	B
Wilson	-4.7	B

C^{13}/C^{12} source interpretation scheme:

B--Mantle or combination of B and D
C--Zone of metamorphism of organic carbon-bearing rocks
D--Zone of metamorphism of marine carbonate rocks

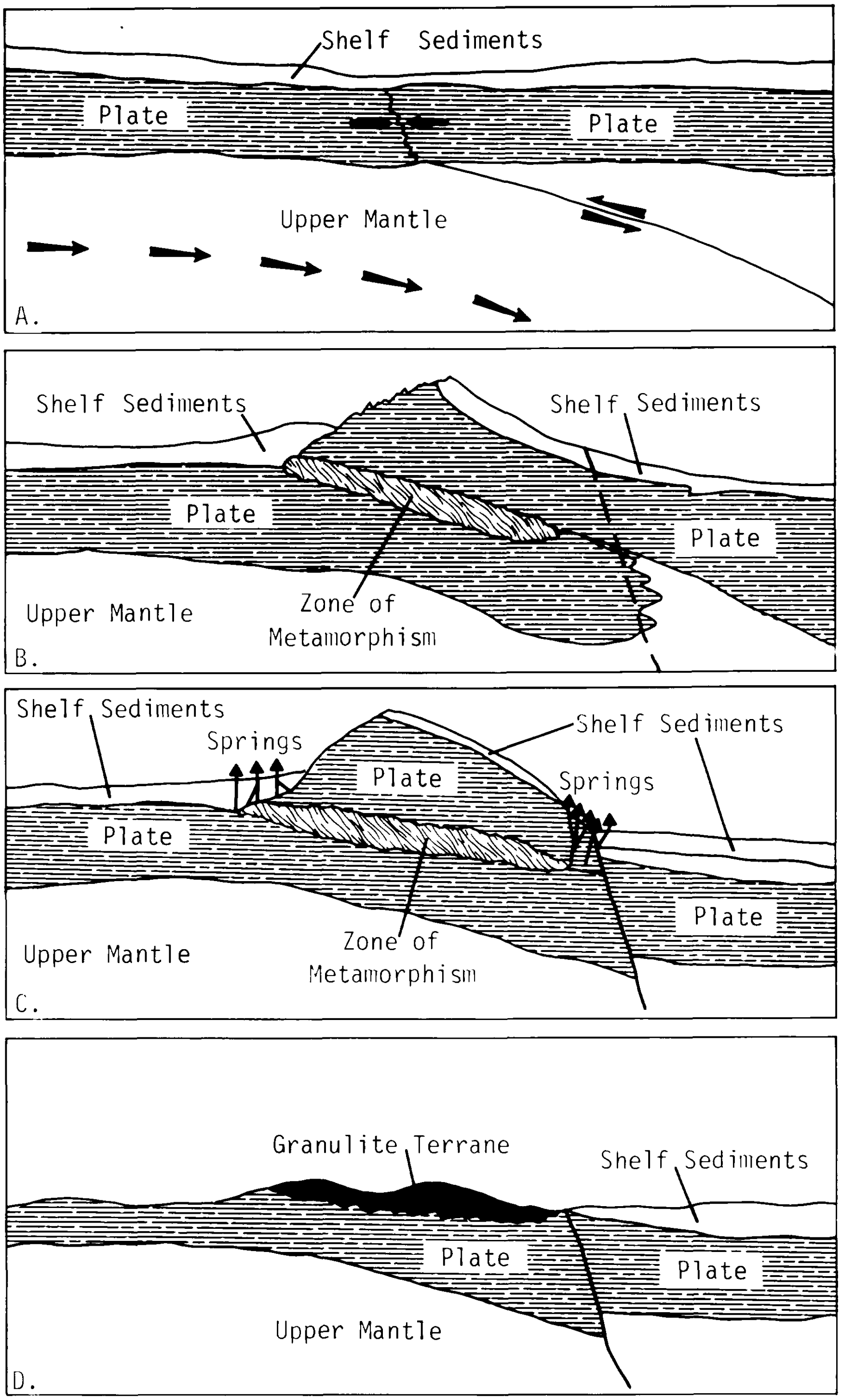

Figure 26.--Diagrammatic sketch of the relationship of radioactive mineral springs to tectonic activity in an orogenic area of the earth's crust. Modified from Derra (1981). A. Subcontinental crustal plates meet. B. On continued compression one plate rides up over the other and sedimentary rocks on the lower plate are trapped under the upper plate and subject to extreme heat and pressure. C. Thickened crust results; metamorphism continues in sandwiched sediments; hydrothermal systems develop in fractures above the zone of metamorphism; hot springs develop on the surface with connections to the zone. D. Subsequent erosion exposes old metamorphism zone now represented by granulite-type rocks, a potential area for uranium exploration.

Fractures and faults resulting directly from the overthrusting would allow ground water of meteoric origin to be drawn into the zone of metamorphism and literally blown upward in a manner similar to the operation of a coffee percolator. The upward moving water would be charged with CO_2, steam, and chemical ions. Pressures required for upward movement of the solutions through establish conduits (1-2 Kbar?) due to a levering effect, would be much less than the downward static pressure of the rock column.

For simplicity, complicated details of potential magmatic intrusion generated by the overthrusting and intrusion of mantle material into the crust are omitted from the representation of the model. Such intrusives could also generate hydrothermal cells at various depths by direct contact with groundwater, or by formation of hydrothermally active contact metamorphic zones, or by other complex indirect means.

In the zone of metamorphism, organic-carbon-rich and methane-bearing sediments would contain U, S, and connate waters in addition to geochemically unstable minerals. The U-238 in the sediments, and possibly introduced from the crustal plates and the mantle and Th-232 from similar sources would be mobilized and concentrated in a reduced state in acid-brine solutions, but would be limited in movement by the extent of the acid solution, or reducing environment. Limestones reacting to the acid environment would form CO_2. Other reacting rocks would yield mobile solutions of ferrous iron or Mn oxide ions. Ra, Rn, and sulfur species liberated in the zone would move freely with the upward streaming hydrothermal waters of higher pH fed by deeply circulating meteoric waters. The released Rn moving as a dissolved gas would be even more mobile than the relatively soluble Ra salts which would account for the usually order of magnitude higher rate of discharge of Rn from the springs, in spite of the much shorter half-life of the Rn.

SUMMARY

The concentration of springs in continental orogenic or volcanic zones suggests than that most radioactive mineral springs have similar tectonic origins. Radioactive precipitates may be characteristic of continental mineral springs only. Deep ocean springs may carry only contributions from mantle-derived rocks. Variation in precipitates formed from the springs suggest that many geochemical variables affect the chemistry at the spring sites. The primary variable is the type of source rocks which supply the mineral content. The second in importance is probably the geochemical environment of the spring conduit system.

Factor analysis of the chemical analytical data from the spring precipitates gives us some insight into the geological and geochemical processes operating at the spring sites. Seven factors are identified and interpreted as follows: (1) Detrital silicate contamination and silica precipitation; (2) Carbonate travertine precipitation; (3) Ra coprecipitation with barite, and Mn-Ba-Fe oxy-hydroxides; (4) Evaporite precipitation; (5) Hydrous limonite precipitation and coprecipitation of U and other elements; (6) Rare earth metals deposited by detrital contamination; and (7) Metal carbonates adsorption and precipitation.

Factor scores in table 15 identify the samples of precipitates that are affected positively or negatively by the seven processes.

The precipitates at a mineral spring site reflect the type of source from which elements composing the precipitates were derived. The element groups most likely derived from deep sources, such as zones of metamorphism, are represented by factors 2, 3, 5 and 7. High-uranium-bearing sources are most likely represented by factors (3) and (5), but are not restricted to springs dominated by these factors.

Anomalous amounts of Ra and Rn in hot spring waters which produce almost no precipitates would also be indicative of high-uranium-bearing sources associated with zones of metamorphism (Cadigan and Felmlee, 1979). Data on high-radium-bearing spring waters is presented in a companion report by Felmlee and Cadigan (1982).

Springs producing precipitates which have high abundances of the elements identified with factors 3 and 5 can be identified from the factor scores in table 15. Any of the factor scores of 3.0 or higher may be considered anomalous. Highest for factor 3 are as follows:

Spring	Factor score
Poncha Hot Springs (CO, 17)	5.9
Ouray hot springs (CO, 22)	5.4
Baker Hot Springs (UT, 23)	4.9
Monroe Hot Springs (UT, 41)	4.6
Doughty Springs (CO, 12)	4.2

Highest scores for factor (5) are found at the following springs:

Spring	Factor score
Salt Bank (AZ, 16)	5.5
Yellow Soda Spring (CO, 14)	4.2
Taylor Soda Spring (CO, 15)	4.0
Poncha Hot Springs (CO, 17)	3.4
Ophir Iron Spring (CO, 23)	2.7

All of the above listed 9 springs with high scores for factors 3 and 5 are among the springs with the most radioactive precipitates. An additional 13 springs with highly radioactive precipitates based on high eU values >500 ppm are listed below:

Stinking Hot Springs (UT, 9)
Wilson Health Springs (UT, 18)
Monte Neva Hot Springs (NV, 18)
Utah Hot Springs (UT, 10)
Hooper Hot Springs (UT, 12)
Adit spring (CO, 11)
Simms flowing well (AR, 1)
Alhambra Hot Springs (MT, 3)
La Duke Hot Springs (MT, 14)
Golconda Hot Springs (NV, 6)
Kyle Hot Springs (NV, 12)
Soda Dam Hot Springs (NM, 1)
Auburn Sulfur Spring (WY, 9)
Stinking springs (UT, 36)

All of these radioactive springs are assumed to rise from orogenic zones of metamorphism and mantle intrusion or from related contact metamorphic zones involving hydrothermally active radioactive igneous or metamorphic source rocks. In a contact metamorphic zone involving igneous intrusion of sedimentary rocks, the intrusive body would probably have been generated by similar crustal plate overthrusting.

Relationships of mineral spring precipitate radioactivity to U resources, as suggested by the model illustrated by figure 26 places the U source in the zone of metamorphism or at the acid-alkaline brine interface in the hydrothermal conduit system between the spring site and the source rock.

U deposits which would fit the tectonic model of Newton and Perkins (1981) could include the types described by Grauch (1978) and Nash, Granger, and Adams (1981) associated with granulite geologic terrane with a history of metamorphism, hydrothermal activity, and subsequent uncovering by erosion as in fig. 26 "D".

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