UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Analytical results and sample locality map of heavy-mineral-concentrate and rock samples from the Greenwater Valley Wilderness Study Area (CDCA-148), Inyo County, California

By

B. M. Adrian, J. G. Frisken, Paul Briggs,

J. G. Crock, and N. M. Conklin

Open-File Report 86-581

1986

CONTENTS

ILLUSTRATIONS

TABLES

STUDIES RELATED TO WILDERNESS

Bureau of Land Management Wilderness Study Areas

The Federal Land Policy and Management Act (Public Law 94-579, October 21, 1976) requires the U.S. Geological Survey and the U.S. Bureau of Mines to conduct mineral surveys on certain areas to determine their mineral values, if any. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a geochemical survey of the Greenwater Valley Wilderness Study Area (CDCA-148), California Desert Conservation Area, Inyo County, California.

INTRODUCTION

In the spring of 1984, the U.S. Geological Survey conducted a reconnaissance geochemical survey of the Greenwater Valley Wilderness Study Area, Inyo County, California.

The U.S. Geological Survey was requested to conduct mineral surveys on 55,044 acres of the Greenwater Valley Wilderness Study Area. That part of the study area comprises about 86 mi^2 (224 km^2) east of Death Valley along the southern edge of Inyo County, California (fig. 1). The study area is on the southeastern flank of the Black Mountains along the west side of Greenwater Valley (fig. 1). Elevations within the study area range from 4,766 ft at Epaulet Peak to 2,127 ft at the eastern end of the area. The area is defined by California State Highway 178 on the south and southeast, Greenwater Valley road on the northeast, an unnamed jeep trail on the north, and on the west and southwest by the Death Valley National Monument boundary. The area can be reached by traveling 1.5 miles north from Shoshone, California, on State Highway 127 to Highway 178, then 5.8 miles west to its eastern edge. Access inside the study area is limited to two jeep roads, one in the north-central section of the area, and one from the southwest side up Rhodes Wash to the Salsberry Peak area. Throughout this report, "study area" and "wilderness study area" refer only to the area on which surveys were conducted.

The Greenwater Valley Wilderness Study Area consists of typical basin and range topography that is well represented by the tilted fault blocks of the Greenwater Range and the Black Mountains. These and adjacent mountain ranges are composed of igneous plutons, a thick sequence of marine sedimentary rocks of Precambrian through Pennsylvanian age, and Cenozoic volcanics and sediments. These rocks have been deformed by several episodes of folding, and normal faulting which presumably occurred in the Mesozoic; they were subsequently deformed by basin and range style faulting and tilting in the Cenozoic. Tertiary volcanic and volcaniclastic rocks are the dominant rock types overlain by younger unconsolidated sediments that fill the down-dropped basins between the ranges (Armstrong and others, unpublished report).

METHODS OF STUDY

Sample Media

Heavy-mineral-concentrate samples provide information about the chemistry of certain minerals in rock material eroded from the drainage basin upstream from each sample site. The selective concentration of minerals, many of which may be ore related, permits determination of some elements that are not easily detected in bulk stream-sediment samples.

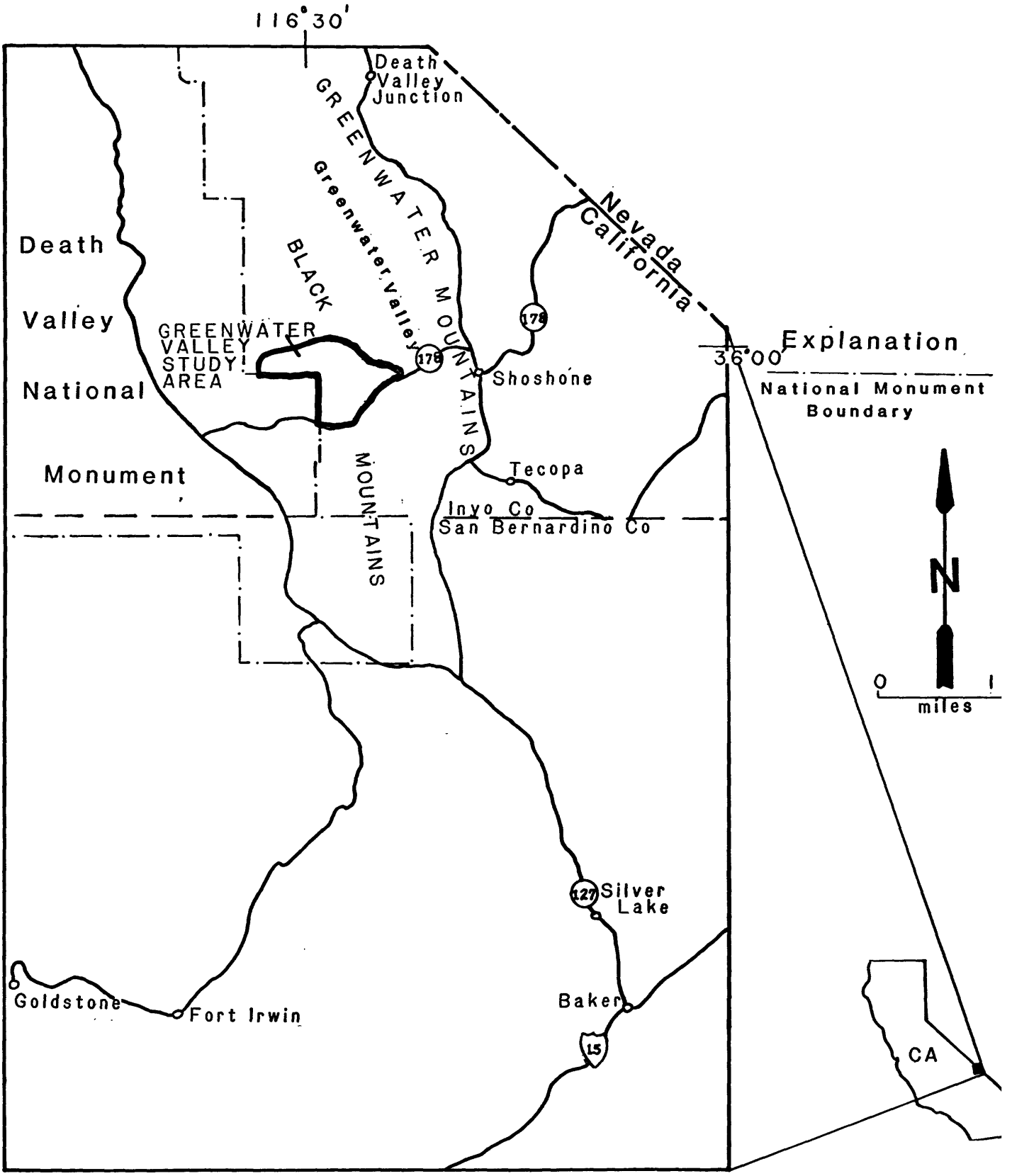

Figure 1. Location map of the Greenwater Valley Wilderness Study Area, Inyo County, California.

Analyses of unaltered or unmineralized rock samples provide background geochemical data for individual rock units. On the other hand, analyses of altered or mineralized rocks, where present, may provide useful geochemical information about the major- and trace-element assemblages associated with a mineralizing system.

Sample Collection

Heavy-mineral-concentrate samples were collected at 39 sites (plate 1). Fifteen rock samples were collected from mine dumps and prospects. The area of the drainage basins sampled ranged from .25 mi^2 to 3 mi^2 (.65 km^2 to 7.77 km^2). Table 6 lists three heavy-mineral-concentrate and nine rock samples collected in conjunction with this study. These samples are outside the map area and, consequently, do not appear on the sample locality map.

Heavy-mineral-concentrate samples

Bulk stream-sediment samples were collected primarily from first-order (unbranched) and second-order (below the junction of two first-order) streams. Each bulk sample was screened with a 2.0-mm (10-mesh) screen to remove the coarse material. The less than 2.0-mm fraction was panned until most of the quartz, feldspar, organic material, and clay-sized material were removed.

Rock samples

Rock samples were collected from mine dumps and prospects in the vicinity of the plotted site location. Samples were collected from unaltered, altered, and mineralized rocks.

Sample Preparation

After air drying, bromoform (specific gravity 2.8) was used to remove the remaining quartz and feldspar from the heavy-mineral-concentrate samples that had been panned in the field. The resultant heavy-mineral sample was separated into three fractions using a large electromagnet (in this case a modified Frantz Isodynamic Separator). The most magnetic material, primarily magnetite, was not analyzed. The second fraction, largely ferromagnesian silicates and iron oxides, was saved for analysis. The third fraction (the least magnetic material which may include the nonmagnetic ore minerals, zircon, sphene, etc.) was split using a Jones splitter. One split was hand-ground for spectrographic analysis; the other split was saved for mineralogical analysis. These magnetic separates are the same separates that would be produced by using a Frantz Isodynamic Separator set at a slope of 15° and a tilt of 10° with a current of 0.1 ampere to remove the magnetite and ilmenite, and a current of 1.0 ampere to split the remainder of the sample into paramagnetic and nonmagnetic fractions.

Rock samples were crushed and then pulverized to minus 0.15 mm with ceramic plates.

Sample Analysis

Spectrographic method

The heavy-mineral-concentrate and rock samples were analyzed for 31 elements using semiquantitative, direct-current arc emission spectrographic methods. The analyses for heavy-mineral-concentrate samples were performed by analysts in the Branch of Exploration Geochemistry using the method of Grimes and Marranzino (1968); analyses for rock samples were performed by analysts in the Branch of Analytical Chemistry using the method of Myers and others (1961). The elements analyzed and their lower limits of determination are listed in table 1. For arsenic (As), gold (Au), cadmium (Cd), and thorium (Th), the lower limit of determination is different for the two analytical methods. The values in parentheses are the limits of determination for the method of Myers and others (1961). Spectrographic results were obtained by visual comparison of spectra derived from the sample against spectra obtained from standards made from pure oxides and carbonates. Element concentrations in the standards are geometrically spaced over any order of magnitude of concentration as follows: 100, 50, 20, 10, and so forth. Samples whose concentrations are estimated to fall between those values are assigned values of 70, 30, 15, and so forth. The precision of the analytical method is approximately plus or minus one reporting interval at the 83 percent confidence level and plus or minus two reporting intervals at the 96 percent confidence level (Motooka and Grimes, 1976). Values determined for the major elements (iron, magnesium, calcium, and titanium) are given in weight percent; all others are given in parts per million (micrograms/gram). Analytical data for samples from the Greenwater Valley Wilderness Study Area are listed in tables 3 and 4.

Chemical methods

Other analytical methods used on samples from the Greenwater Valley Wilderness Study Area are listed in table 2. The analytical method used for determining As, Bi, Cd, Sb, and Zn is a modification and adaptation for the inductively coupled plasma method (ICP) based on the method of O'Leary and Viets (1986).

Analytical results for heavy-mineral-concentrate and rock samples are listed in tables 3 and 4, respectively.

ROCK ANALYSIS STORAGE SYSTEM

Upon completion of all analytical work, the analytical results were entered into a computer-based file called Rock Analysis Storage System (RASS). This data base contains both descriptive geological information and analytical data. Any or all of this information may be retrieved and converted to a binary form (STATPAC) for computerized statistical analysis or publication (VanTrump and Miesch, 1977).

DESCRIPTION OF DATA TABLES

Tables 3 and 4 list the results of analyses for the samples of heavy-mineral concentrate and rock, respectively. For the two tables, the data are arranged so that column 1 contains the USGS-assigned sample numbers. These numbers correspond to the numbers shown on the site location

maps (plate 1). Columns in which the element headings show the letter "s" below the element symbol are emission spectrographic analyses; "aa" indicates atomic absorption analyses and "icp" indicates inductively coupled plasma-atomic emission spectroscopy. A letter "N" in the tables indicates that a given element was looked for but not detected at the lower limit of determination shown for that element in table 1. A letter "H" in the tables indicates that a given element was looked for but due to elemental interferences a value was not reported. If an element was observed but was below the lowest reporting value, a "less than" symbol (<) was entered in the tables in front of the lower limit of determination. If an element was observed but was above the highest reporting value, a "greater than" symbol (>) was entered in the tables in front of the upper limit of determination. If an element was not looked for in a sample, two dashes (--) are entered in tables 3 and 4 in place of an analytical value. Because of the formatting used in the computer program that produced tables 3 and 4, some of the elements listed in these tables (Fe, Mg, Ca, Ti, Ag, and Be) carry one or more nonsignificant digits to the right of the significant digits. The analysts did not determine these elements to the accuracy suggested by the extra zeros.

Descriptions of rock samples are listed in table 5.

ACKNOWLEDGMENTS

A number of our colleagues also participated in the collection, preparation, and data retrieval of these samples: collection, J. C. Gray, K. R. Greene, M. A. Mast, and A. D. McCollaum; preparation, J. C. Gray and G. L. Thurston; and data retrieval, J. L. Jones.

REFERENCES CITED

Armstrong, Augustus K., Frisken, James G., and Jachens, Robert C. (U.S. Geological Survey) and Rains, Richard L. (U.S. Bureau of Mines), 1987, Unpublished report on the Greenwater Valley Wilderness Study Area, Inyo County, California.

Crock, J. G., Lichte, F. E., and Briggs, P. H., 1983, Determination of elements in National Bureau of Standards Geological Reference Materials SRM278 Obsidian and SRM668 Basalt by Inductively Coupled Argon Plasma-Atomic Emission Spectrometry: Geostandards Newsletter, no. 7, p. 335-340.

Grimes, D. J., and Marranzino, A. P., 1968, Direct-current arc and alternating-current spark emission spectrographic field methods for the semiquantitative analysis of geologic materials: U.S. Geological Survey Circular 591, 6 p.

Koirtyohann, S. R., and Khalil, Moheb, 1976, Variables in the determination of mercury by cold vapor atomic absorption: Analytical Chemistry, 48, p. 136-139.

Motooka, J. M., and Grimes, D. J., 1976, Analytical precision of one-sixth order semiquantitative spectrographic analyses: U.S. Geological Survey Circular 738, 25 p.

Myers, A. T. , Havens, R. G., and Dunton, P. J., 1961, A spectrochemical method for the semiquantitative analyses of rocks, minerals, and ores: U.S. Geological Survey Bulletin 1084-I, p. 1207-1229.

O'Leary, R. M., and Viets, J. G., 1986, Determination of antimony, arsenic, bismuth, cadmium, copper, lead, molybdenum, silver, and zinc in geological materials by atomic absorption spectrometry using a hydrochloric acid-hydrogen peroxide digestion: Atomic Spectroscopy, 7, p. 4-8.

Thompson, C. E., Nakagawa, H. M., and Van Sickle, G. H., 1968, Rapid analysis for gold in geologic materials, in Geological Survey research 1968: U.S. Geological Survey Professional Paper 600-B, p. B130-B132.

VanTrump, George, Jr., and Miesch, A. T., 1977, The U.S. Geological Survey RASS-STATPAC system for management and statistical reduction of geochemical data: Computers and Geosciences, v. 3, p. 475-488.

TABLE 1.--Limits of determination for the spectrographic analysis of rocks based on a 10-mg sample

[The values shown are the lower limits of determination assigned by the Branch of Exploration Geochemistry, except for those values in parentheses, which are the lower values assigned by the Branch of Analytical Chemistry. The spectrographic limits of determination for heavy-mineral-concentrate samples are based on a 5-mg sample, and are therefore two reporting intervals higher than the limits given for rocks.]

Elements	Lower determination limit	Upper determination limit
	Percent	
Iron (Fe)	0.05	20
Magnesium (Mg)	.02	10
Calcium (Ca)	.05	20
Titanium (Ti)	.002	1
	Parts per million	
Manganese (Mn)	10	5,000
Silver (Ag)	0.5	5,000
Arsenic (As)	200 (700)	10,000
Gold (Au)	10 (15)	500
Boron (B)	10	2,000
Barium (Ba)	20	5,000
Beryllium (Be)	1	1,000
Bismuth (Bi)	10	1,000
Cadmium (Cd)	20 (30)	500
Cobalt (Co)	5	2,000
Chromium (Cr)	10	5,000
Copper (Cu)	5	20,000
Lanthanum (La)	20 (30)	1,000
Molybdenum (Mo)	5	2,000
Niobium (Nb)	20	2,000
Nickel (Ni)	5	5,000
Lead (Pb)	10	20,000
Antimony (Sb)	100	10,000
Scandium (Sc)	5	100
Tin (Sn)	10	1,000
Strontium (Sr)	100	5,000
Vanadium (V)	10	10,000
Tungsten (W)	50	10,000
Yttrium (Y)	10	2,000
Zinc (Zn)	200	10,000
Zirconium (Zr)	10	1,000
Thorium (Th)	100 (200)	2,000

TABLE 2.--Chemical methods used

AA = atomic absorption and ICP = inductively coupled plasma spectroscopy

Element or constituent determined	Sample Type	Method	Determination limit (micrograms/ gram or ppm)	Reference
Gold (Au)	rock	AA	.1	Modification of Thompson and others, 1968.
Mercury (Hg)	rock	AA	0.02	Koirtyohann and Khalil, 1976.
Arsenic (As)	rock	ICP	5	Crock and others, 1983, and modification of O'Leary and Viets, 1986.
Antimony (Sb)	rock	ICP	2	
Zinc (Zn)	rock	ICP	2	
Bismuth (Bi)	rock	ICP	2	
Cadmium (Cd)	rock	ICP	0.1	

TABLE 3. RESULTS OF ANALYSES OF HEAVY-MINERAL-CONCENTRATE SAMPLES FROM THE GREENWATER VALLEY WILDERNESS STUDY AREA, INYO COUNTY, CALIFORNIA

[N, not detected; <, detected but below the limit of determination shown; >, determined to be greater than the value shown.]

Sample	Latitude	Longitude	Fe-pct. s	Mg-pct. s	Ca-pct. s	Ti-pct. s	Mn-ppm s	Ag-ppm s	As-ppm s	Au-ppm s	B-ppm s	Ba-ppm s
GV013	35 59 13	116 29 47	.3	.30	2.0	.7	300	N	N	N	20	>10,000
GV014	35 59 30	116 30 27	.5	1.00	5.0	>2.0	200	N	N	N	50	>10,000
GV141	36 0 44	116 28 51	.7	.30	2.0	2.0	100	N	N	N	50	3,000
GV142	36 0 12	116 31 57	.5	.30	2.0	>2.0	150	N	N	N	30	3,000
GV143	36 0 51	116 30 10	.5	.50	3.0	>2.0	200	N	N	N	70	2,000
GV232	35 56 14	116 29 0	.5	2.00	10.0	>2.0	1,500	N	700	N	20	>10,000
GV233	35 55 48	116 27 30	5.0	2.00	5.0	>2.0	2,000	N	N	N	100	5,000
GV234	35 58 35	116 35 0	1.5	1.50	5.0	>2.0	1,500	N	N	N	100	1,500
GV235	35 58 23	116 34 35	.5	5.00	20.0	.7	1,000	N	N	N	20	>10,000
GV236	35 59 34	116 34 18	.7	1.00	5.0	2.0	300	N	N	N	50	3,000
GV237	35 58 13	116 33 22	.3	1.00	5.0	.5	300	N	N	N	20	>10,000
GV328	35 59 3	116 27 33	.7	10.00	15.0	1.0	500	N	N	N	50	5,000
GV329	35 58 57	116 27 28	.7	10.00	10.0	2.0	500	N	N	N	50	3,000
GV330	36 0 28	116 27 51	.5	1.00	3.0	2.0	150	N	N	N	30	2,000
GV331	36 2 18	116 32 0	1.0	1.00	3.0	2.0	200	N	N	N	30	5,000
GV332	36 1 45	116 31 51	.5	1.00	5.0	2.0	200	N	N	N	50	3,000
GV431	35 56 57	116 29 49	.5	2.00	5.0	>2.0	300	N	N	N	50	>10,000
GV432	35 57 28	116 25 26	1.0	1.00	3.0	2.0	200	N	N	N	70	2,000
GV433	36 0 19	116 35 20	.2	.20	3.0	.5	200	N	N	N	20	>10,000
GV435	35 59 47	116 33 55	.3	.20	7.0	.5	500	N	N	N	<20	>10,000
GV436	35 58 27	116 29 20	.5	1.00	3.0	2.0	200	N	N	N	20	>10,000
GV601	36 10 30	116 38 40	.5	.15	1.5	1.0	150	N	N	N	<20	>10,000
GV602	36 11 27	116 37 55	1.0	.70	3.0	2.0	300	N	N	N	100	5,000
GV603	36 10 26	116 36 16	.5	.50	5.0	>2.0	150	N	N	N	100	>10,000
GV604	36 10 4	116 34 35	.5	.50	3.0	>2.0	150	N	N	N	70	2,000
GV605	36 2 55	116 34 0	.7	3.00	5.0	>2.0	300	N	N	N	50	>10,000
GV606	36 2 47	116 34 14	.5	.70	5.0	>2.0	300	N	N	N	50	2,000
GV607	36 2 15	116 34 14	1.0	1.00	5.0	>2.0	300	N	N	N	70	1,000
GV608	36 1 57	116 34 58	.7	1.00	5.0	2.0	150	N	N	N	50	10,000
GV609	36 1 46	116 35 5	1.0	.50	3.0	1.0	100	N	N	N	50	1,500
GV610	36 1 30	116 35 8	.5	.30	3.0	1.5	100	N	N	N	70	1,000
GV611	36 4 15	116 32 50	.7	.50	3.0	2.0	150	N	N	N	50	1,000
GV612	36 6 0	116 33 10	.7	.50	3.0	2.0	150	N	N	N	50	1,500
GV614	36 13 10	116 37 25	.7	1.00	5.0	>2.0	200	N	N	N	70	1,000
GV615	36 8 9	116 33 40	.7	.50	3.0	>2.0	100	N	N	N	50	5,000
GV616	36 6 51	116 33 25	.5	.20	3.0	1.0	200	N	N	N	50	>10,000
GV617	35 57 6	116 29 22	.5	1.50	3.0	1.5	200	N	N	N	50	1,500
GV618	35 54 54	116 29 40	.3	.50	3.0	2.0	200	N	N	N	50	>10,000
GV619	35 54 43	116 27 3	.7	1.50	7.0	>2.0	500	N	N	N	50	2,000

TABLE 3. RESULTS OF ANALYSES OF HEAVY-MINERAL-CONCENTRATE SAMPLES FROM THE GREENWATER VALLEY WILDERNESS STUDY AREA, INYO COUNTY, CALIFORNIA--Continued

Sample	Be-ppm s	Bi-ppm s	Cd-ppm s	Co-ppm s	Cr-ppm s	Cu-ppm s	La-ppm s	Mo-ppm s	Nb-ppm s	Ni-ppm s	Pb-ppm s
GV013	5	N	N	N	N	20	<50	N	N	N	2,000
GV014	3	N	N	N	N	<10	100	N	<50	20	1,500
GV141	2	N	N	N	N	N	N	N	N	10	150
GV142	3	N	N	N	N	N	100	N	N	20	150
GV143	3	N	N	N	N	N	<50	N	N	20	<20
GV232	3	N	N	N	<20	<10	200	N	N	10	10,000
GV233	2	N	N	10	100	<10	500	N	70	30	100
GV234	3	N	N	10	150	<10	500	N	<50	30	70
GV235	<2	N	N	N	N	<10	300	N	N	N	200
GV236	3	N	N	N	N	N	150	N	N	10	50
GV237	<2	N	N	N	N	<10	150	15	N	<10	1,500
GV328	<2	N	N	N	N	N	<50	N	N	<10	100
GV329	<2	N	N	N	N	N	100	N	<50	<10	<20
GV330	5	N	N	<10	N	N	<50	N	N	<10	<20
GV331	<2	N	N	<10	<20	N	150	N	N	10	N
GV332	<2	N	N	N	N	N	150	N	N	N	N
GV431	10	N	N	<10	N	10	100	N	N	10	500
GV432	3	N	N	N	N	N	100	N	<50	10	50
GV433	N	N	N	N	N	N	<50	N	N	10	200
GV435	N	N	N	N	N	N	150	N	N	<10	700
GV436	2	N	N	N	N	N	100	N	N	15	<20
GV601	N	N	N	N	N	20	<50	N	50	N	20
GV602	3	N	N	N	N	N	150	N	50	10	<20
GV603	2	N	N	N	N	<10	150	N	100	<10	500
GV604	2	N	N	N	N	N	100	N	70	10	<20
GV605	2	N	N	N	<20	N	150	N	N	10	200
GV606	3	N	N	N	N	N	150	N	<50	10	200
GV607	2	N	N	N	20	N	150	N	N	10	20
GV608	2	N	N	N	N	N	100	N	N	<10	150
GV609	2	N	N	10	<20	N	100	N	<50	<10	100
GV610	2	N	N	N	N	N	<50	N	N	10	100
GV611	3	N	N	N	N	N	100	N	N	<10	N
GV612	3	N	N	N	N	N	100	N	N	10	70
GV614	2	N	N	<10	N	<10	150	N	50	<10	N
GV615	3	N	N	<10	N	N	<50	N	100	<10	70
GV616	3	N	N	N	N	15	<50	N	N	<10	1,000
GV617	<2	N	N	N	N	10	N	N	<50	<10	1,000
GV618	5	N	N	N	20	N	100	N	<50	<10	20
GV619	3	N	N	N	N	N	150	N	<50	<10	300

TABLE 3. RESULTS OF ANALYSES OF HEAVY-MINERAL-CONCENTRATE SAMPLES FROM THE GREENWATER VALLEY WILDERNESS STUDY AREA, INYO COUNTY, CALIFORNIA--Continued

Sample	Sb-ppm s	Sc-ppm s	Sn-ppm s	Sr-ppm s	V-ppm s	W-ppm s	Y-ppm s	Zn-ppm s	Zr-ppm s	Th-ppm s
GV013	N	N	N	5,000	200	N	200	N	>2,000	N
GV014	N	30	N	500	150	N	1,000	N	>2,000	200
GV141	N	N	N	500	70	N	500	N	>2,000	N
GV142	N	30	N	500	70	N	1,000	N	>2,000	200
GV143	N	<10	N	500	70	N	1,000	N	>2,000	<200
GV232	N	<10	N	500	200	100	1,500	5,000	>2,000	N
GV233	N	30	<20	500	200	N	1,000	N	>2,000	N
GV234	N	30	N	500	100	N	1,000	N	>2,000	200
GV235	N	N	N	2,000	50	N	1,000	N	>2,000	N
GV236	N	N	N	500	70	N	700	N	>2,000	N
GV237	N	N	N	5,000	30	N	500	1,000	>2,000	N
GV328	N	N	N	500	50	N	200	N	>2,000	N
GV329	N	N	N	500	70	N	300	N	>2,000	N
GV330	N	N	N	500	50	N	500	N	>2,000	N
GV331	N	N	N	700	70	N	500	N	>2,000	N
GV332	N	N	N	1,000	50	N	500	N	>2,000	N
GV431	N	30	N	700	100	N	1,000	N	>2,000	N
GV432	N	<10	N	500	70	N	500	N	>2,000	N
GV433	N	N	N	5,000	50	N	500	N	>2,000	200
GV435	N	<10	N	7,000	50	N	1,000	N	>2,000	N
GV436	N	30	N	700	70	N	1,000	N	>2,000	<200
GV601	N	N	N	>10,000	30	N	70	N	>2,000	N
GV602	N	N	N	700	100	N	500	N	>2,000	N
GV603	N	50	N	3,000	150	N	700	N	>2,000	<200
GV604	N	30	N	500	70	N	500	N	>2,000	N
GV605	N	N	N	700	100	N	500	N	>2,000	N
GV606	N	20	N	500	150	N	700	N	>2,000	N
GV607	N	N	N	700	100	N	500	N	>2,000	N
GV608	N	N	N	700	100	N	200	N	>2,000	N
GV609	N	N	N	1,000	50	N	100	N	>2,000	N
GV610	N	N	N	700	30	N	300	N	>2,000	N
GV611	N	N	N	700	50	N	200	N	>2,000	N
GV612	N	N	N	1,000	70	N	300	N	>2,000	N
GV614	N	<10	N	700	70	N	300	N	>2,000	N
GV615	N	N	50	700	30	N	200	N	>2,000	N
GV616	N	N	N	2,000	50	N	150	N	>2,000	N
GV617	N	N	N	1,000	50	N	150	N	>2,000	N
GV618	N	N	N	5,000	70	N	300	1,000	>2,000	N
GV619	N	30	N	500	100	N	700	N	>2,000	N

TABLE 4. RESULTS OF ANALYSES OF ROCK SAMPLES FROM THE GREENWATER VALLEY WILDERNESS STUDY AREA, INYO COUNTY, CALIFORNIA

[N, not detected; <, detected but below the limit of determination shown; >, determined to be greater than the value shown.]

Sample	Latitude	Longitude	Fe-pct. s	Mg-pct. s	Ca-pct. s	Ti-pct. s	Mn-ppm s	Ag-ppm s	As-ppm s	Au-ppm s	B-ppm s	Ba-ppm s	Be-ppm s
GV011	35 59 0	116 29 44	20.0	.05	.07	N	200	N	N	N	150	<20	N
GV012	35 59 6	116 29 42	.5	.03	.10	.030	200	N	N	N	30	1,000	1.0
GV691	36 10 34	116 38 41	15.0	.20	.05	.200	100	2.0	N	N	50	2,000	N
GV694	36 10 50	116 38 10	3.0	.03	<.05	.010	30	1.5	N	N	50	>5,000	5.0
GV695	35 57 2	116 27 40	1.5	.02	N	.005	70	200.0	N	N	20	1,500	2.0
FM4-1	35 57 15	116 27 35	1.5	.02	.07	.005	70	30.0	N	N	10	500	2.0
FM4-2	35 57 15	116 27 35	1.5	.02	<.05	.005	70	30.0	N	N	N	300	1.0
FM4-3	35 57 5	116 27 30	1.5	.07	.20	.070	100	1.5	N	N	10	1,500	<1.0
FM5-1	35 52 25	116 27 10	20.0	.10	.30	.030	3,000	7.0	N	N	H	100	N
FM5-2	35 52 25	116 27 10	7.0	<.02	.15	.030	15	3.0	N	20	<10	200	N
FM6-1	35 49 55	116 27 45	>20.0	.03	<.05	.030	>5,000	3.0	N	N	30	30	N
FM6-2	35 49 55	116 27 45	20.0	.15	.07	.070	1,500	10.0	700	20	30	150	1.0
FM6-3	35 49 55	116 27 45	3.0	.20	.15	.300	>5,000	3.0	N	N	70	200	1.5
FM7-1	35 52 20	116 23 30	15.0	.05	.07	.070	700	15.0	1,500	30	N	30	N
FM7-2	35 52 20	116 23 30	15.0	.15	.30	.030	200	150.0	1,500	150	N	<20	N

TABLE 4. RESULTS OF ANALYSES OF ROCK SAMPLES FROM THE GREENWATER VALLEY WILDERNESS STUDY AREA, INYO COUNTY, CALIFORNIA--Continued

Sample	Bi-ppm s	Cd-ppm s	Co-ppm s	Cr-ppm s	Cu-ppm s	La-ppm s	Mo-ppm s	Nb-ppm s	Ni-ppm s	Pb-ppm s	Sb-ppm s	Sc-ppm s	Sn-ppm s	Sr-ppm s
GV011	20	N	10	10	>20,000	N	N	N	15	70	N	N	N	N
GV012	N	N	<5	N	70	N	N	N	<5	15	N	N	N	N
GV691	30	N	30	200	>20,000	N	20	N	20	30	N	7	N	200
GV694	30	N	<5	20	20,000	N	20	N	N	300	N	N	N	1,500
GV695	300	30	N	N	3,000	<20	50	N	N	>20,000	N	N	N	200
FM4-1	100	N	N	<10	2,000	N	N	N	N	>20,000	N	N	N	<100
FM4-2	100	70	N	<10	300	N	7	N	N	>20,000	N	N	N	<100
FM4-3	N	N	N	<10	10	70	N	<20	N	3,000	N	N	N	150
FM5-1	15	N	100	<10	>20,000	150	<10	<20	70	500	N	N	H	150
FM5-2	N	N	N	<10	70	N	N	<20	N	150	N	N	N	<100
FM6-1	N	70	300	<10	15,000	N	<10	<20	300	30	N	5	H	<100
FM6-2	30	N	70	<10	>20,000	N	50	<20	150	700	100	5	H	<100
FM6-3	N	N	700	15	>20,000	N	10	<20	700	70	N	15	N	150
FM7-1	30	N	20	<10	>20,000	N	<10	<20	30	7,000	7,000	N	N	<100
FM7-2	300	N	5	<10	>20,000	N	<10	<20	15	>20,000	>10,000	N	N	<100

TABLE 4. RESULTS OF ANALYSES OF ROCK SAMPLES FROM THE GREENWATER VALLEY WILDERNESS STUDY AREA, INYO COUNTY, CALIFORNIA--Continued

Sample	V-ppm s	W-ppm s	Y-ppm s	Zn-ppm s	Zr-ppm s	Th-ppm s	Au-ppm aa	Hg-ppm aa	As-ppm icp	Zn-ppm icp	Cd-ppm icp	Bi-ppm icp	Sb-ppm icp
GV011	<10	N	20	200	N	N	--	--	--	--	--	--	--
GV012	<10	N	N	N	50	N	--	--	--	--	--	--	--
GV691	30	N	N	N	10	N	--	--	--	--	--	--	--
GV694	500	N	N	<200	N	N	--	--	--	--	--	--	--
GV695	<10	N	N	700	N	N	--	--	--	--	--	--	--
FM4-1	N	N	N	7,000	N	N	4.0	1.80	41	4,110.0	4.9	85	15
FM4-2	10	N	N	1,000	N	N	5.0	3.90	<5	722.0	17.7	65	174
FM4-3	<10	N	10	N	150	N	<.1	.16	<5	73.0	1.0	2	6
FM5-1	15	N	30	N	N	N	1.9	.33	47	101.0	.4	13	17
FM5-2	N	N	15	N	30	N	19.0	.04	18	3.0	.2	4	16
FM6-1	N	N	10	>10,000	30	N	<.1	.34	8	14,100.0	43.2	11	37
FM6-2	<10	N	10	3,000	30	N	15.0	.32	941	2,000.0	3.5	33	63
FM6-3	70	N	30	5,000	200	N	.1	.15	28	5,390.0	10.8	74	15
FM7-1	N	N	N	700	30	N	5.4	.65	1,090	391.0	.2	14	744
FM7-2	N	N	N	1,500	N	N	5.1	590.00	350	1.6	119.0	4,450	4,450

TABLE 5. Description of rock samples

[D = mine dump or prospect]

GV 011	D	Quartz-Cu staining
012	D	Quartz veins + quartz breccia
691	D	Cu stained volcanic breccia
694	D	Cu stained volcanic breccia
695	D	Galena-quartz-Cu staining
FM 4-1	D	Galena-quartz-Cu staining
4-2	D	Quartzite
4-3	D	?
5-1	D	Cu-stained rock
5-2	D	Chert
6-1	D	?
6-2	D	?
6-3	D	?
7-1	D	?
7-2	D	?

TABLE 6.--Latitudes and longitudes of samples not appearing on plate 1

[C--heavy-mineral concentrate; R--rock]

Sample	Latitude	Longitude
GV601C	36 10 30	116 38 40
GV602C	36 11 27	116 37 55
GV614C	36 13 10	116 37 25
GV691R	36 10 34	116 38 41
GV694R	36 10 50	116 38 10
FM5-1R	35 52 25	116 27 10
FM5-2R	35 52 25	116 27 10
FM6-1R	35 49 55	116 27 45
FM6-2R	35 49 55	116 27 45
FM6-3R	35 49 55	116 27 45
FM7-1R	35 52 20	116 23 30
FM7-2R	35 52 20	116 23 30

CONTENTS

ILLUSTRATIONS

TABLES

STUDIES RELATED TO WILDERNESS

Bureau of Land Management Wilderness Study Areas

The Federal Land Policy and Management Act (Public Law 94-579, October 21, 1976) requires the U.S. Geological Survey and the U.S. Bureau of Mines to conduct mineral surveys on certain areas to determine their mineral values, if any. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a geochemical survey of the Greenwater Valley Wilderness Study Area (CDCA-148), California Desert Conservation Area, Inyo County, California.

INTRODUCTION

In the spring of 1984, the U.S. Geological Survey conducted a reconnaissance geochemical survey of the Greenwater Valley Wilderness Study Area, Inyo County, California.

The U.S. Geological Survey was requested to conduct mineral surveys on 55,044 acres of the Greenwater Valley Wilderness Study Area. That part of the study area comprises about 86 mi^2 (224 km^2) east of Death Valley along the southern edge of Inyo County, California (fig. 1). The study area is on the southeastern flank of the Black Mountains along the west side of Greenwater Valley (fig. 1). Elevations within the study area range from 4,766 ft at Epaulet Peak to 2,127 ft at the eastern end of the area. The area is defined by California State Highway 178 on the south and southeast, Greenwater Valley road on the northeast, an unnamed jeep trail on the north, and on the west and southwest by the Death Valley National Monument boundary. The area can be reached by traveling 1.5 miles north from Shoshone, California, on State Highway 127 to Highway 178, then 5.8 miles west to its eastern edge. Access inside the study area is limited to two jeep roads, one in the north-central section of the area, and one from the southwest side up Rhodes Wash to the Salsberry Peak area. Throughout this report, "study area" and "wilderness study area" refer only to the area on which surveys were conducted.

The Greenwater Valley Wilderness Study Area consists of typical basin and range topography that is well represented by the tilted fault blocks of the Greenwater Range and the Black Mountains. These and adjacent mountain ranges are composed of igneous plutons, a thick sequence of marine sedimentary rocks of Precambrian through Pennsylvanian age, and Cenozoic volcanics and sediments. These rocks have been deformed by several episodes of folding, and normal faulting which presumably occurred in the Mesozoic; they were subsequently deformed by basin and range style faulting and tilting in the Cenozoic. Tertiary volcanic and volcaniclastic rocks are the dominant rock types overlain by younger unconsolidated sediments that fill the down-dropped basins between the ranges (Armstrong and others, unpublished report).

METHODS OF STUDY

Sample Media

Heavy-mineral-concentrate samples provide information about the chemistry of certain minerals in rock material eroded from the drainage basin upstream from each sample site. The selective concentration of minerals, many of which may be ore related, permits determination of some elements that are not easily detected in bulk stream-sediment samples.

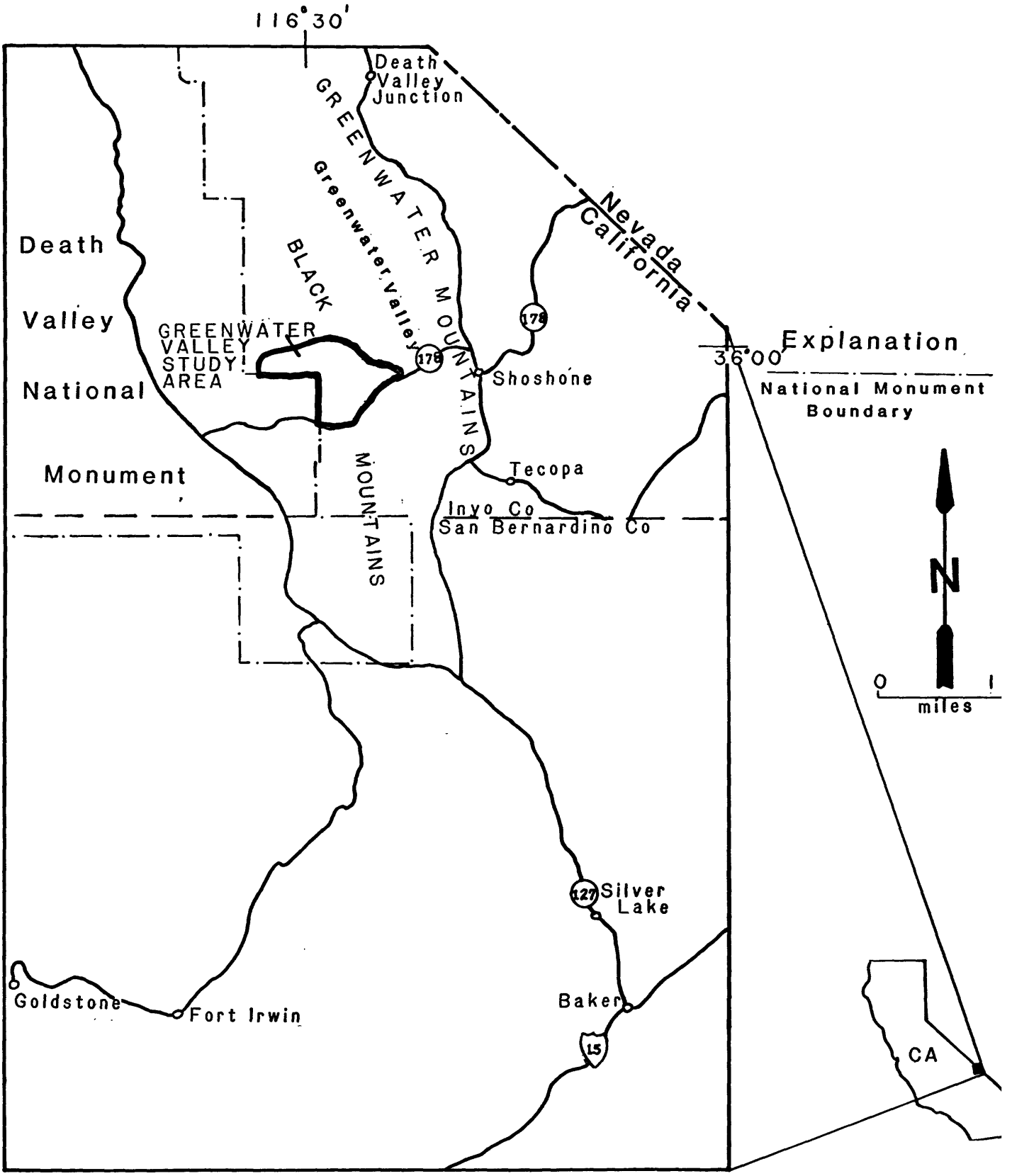

Figure 1. Location map of the Greenwater Valley Wilderness Study Area, Inyo County, California.

Analyses of unaltered or unmineralized rock samples provide background geochemical data for individual rock units. On the other hand, analyses of altered or mineralized rocks, where present, may provide useful geochemical information about the major- and trace-element assemblages associated with a mineralizing system.

Sample Collection

Heavy-mineral-concentrate samples were collected at 39 sites (plate 1). Fifteen rock samples were collected from mine dumps and prospects. The area of the drainage basins sampled ranged from .25 mi^2 to 3 mi^2 (.65 km^2 to 7.77 km^2). Table 6 lists three heavy-mineral-concentrate and nine rock samples collected in conjunction with this study. These samples are outside the map area and, consequently, do not appear on the sample locality map.

Heavy-mineral-concentrate samples

Bulk stream-sediment samples were collected primarily from first-order (unbranched) and second-order (below the junction of two first-order) streams. Each bulk sample was screened with a 2.0-mm (10-mesh) screen to remove the coarse material. The less than 2.0-mm fraction was panned until most of the quartz, feldspar, organic material, and clay-sized material were removed.

Rock samples

Rock samples were collected from mine dumps and prospects in the vicinity of the plotted site location. Samples were collected from unaltered, altered, and mineralized rocks.

Sample Preparation

After air drying, bromoform (specific gravity 2.8) was used to remove the remaining quartz and feldspar from the heavy-mineral-concentrate samples that had been panned in the field. The resultant heavy-mineral sample was separated into three fractions using a large electromagnet (in this case a modified Frantz Isodynamic Separator). The most magnetic material, primarily magnetite, was not analyzed. The second fraction, largely ferromagnesian silicates and iron oxides, was saved for analysis. The third fraction (the least magnetic material which may include the nonmagnetic ore minerals, zircon, sphene, etc.) was split using a Jones splitter. One split was hand-ground for spectrographic analysis; the other split was saved for mineralogical analysis. These magnetic separates are the same separates that would be produced by using a Frantz Isodynamic Separator set at a slope of 15° and a tilt of 10° with a current of 0.1 ampere to remove the magnetite and ilmenite, and a current of 1.0 ampere to split the remainder of the sample into paramagnetic and nonmagnetic fractions.

Rock samples were crushed and then pulverized to minus 0.15 mm with ceramic plates.

Sample Analysis

Spectrographic method

The heavy-mineral-concentrate and rock samples were analyzed for 31 elements using semiquantitative, direct-current arc emission spectrographic methods. The analyses for heavy-mineral-concentrate samples were performed by analysts in the Branch of Exploration Geochemistry using the method of Grimes and Marranzino (1968); analyses for rock samples were performed by analysts in the Branch of Analytical Chemistry using the method of Myers and others (1961). The elements analyzed and their lower limits of determination are listed in table 1. For arsenic (As), gold (Au), cadmium (Cd), and thorium (Th), the lower limit of determination is different for the two analytical methods. The values in parentheses are the limits of determination for the method of Myers and others (1961). Spectrographic results were obtained by visual comparison of spectra derived from the sample against spectra obtained from standards made from pure oxides and carbonates. Element concentrations in the standards are geometrically spaced over any order of magnitude of concentration as follows: 100, 50, 20, 10, and so forth. Samples whose concentrations are estimated to fall between those values are assigned values of 70, 30, 15, and so forth. The precision of the analytical method is approximately plus or minus one reporting interval at the 83 percent confidence level and plus or minus two reporting intervals at the 96 percent confidence level (Motooka and Grimes, 1976). Values determined for the major elements (iron, magnesium, calcium, and titanium) are given in weight percent; all others are given in parts per million (micrograms/gram). Analytical data for samples from the Greenwater Valley Wilderness Study Area are listed in tables 3 and 4.

Chemical methods

Other analytical methods used on samples from the Greenwater Valley Wilderness Study Area are listed in table 2. The analytical method used for determining As, Bi, Cd, Sb, and Zn is a modification and adaptation for the inductively coupled plasma method (ICP) based on the method of O'Leary and Viets (1986).

Analytical results for heavy-mineral-concentrate and rock samples are listed in tables 3 and 4, respectively.

ROCK ANALYSIS STORAGE SYSTEM

Upon completion of all analytical work, the analytical results were entered into a computer-based file called Rock Analysis Storage System (RASS). This data base contains both descriptive geological information and analytical data. Any or all of this information may be retrieved and converted to a binary form (STATPAC) for computerized statistical analysis or publication (VanTrump and Miesch, 1977).

DESCRIPTION OF DATA TABLES

Tables 3 and 4 list the results of analyses for the samples of heavy-mineral concentrate and rock, respectively. For the two tables, the data are arranged so that column 1 contains the USGS-assigned sample numbers. These numbers correspond to the numbers shown on the site location

maps (plate 1). Columns in which the element headings show the letter "s" below the element symbol are emission spectrographic analyses; "aa" indicates atomic absorption analyses and "icp" indicates inductively coupled plasma-atomic emission spectroscopy. A letter "N" in the tables indicates that a given element was looked for but not detected at the lower limit of determination shown for that element in table 1. A letter "H" in the tables indicates that a given element was looked for but due to elemental interferences a value was not reported. If an element was observed but was below the lowest reporting value, a "less than" symbol (<) was entered in the tables in front of the lower limit of determination. If an element was observed but was above the highest reporting value, a "greater than" symbol (>) was entered in the tables in front of the upper limit of determination. If an element was not looked for in a sample, two dashes (--) are entered in tables 3 and 4 in place of an analytical value. Because of the formatting used in the computer program that produced tables 3 and 4, some of the elements listed in these tables (Fe, Mg, Ca, Ti, Ag, and Be) carry one or more nonsignificant digits to the right of the significant digits. The analysts did not determine these elements to the accuracy suggested by the extra zeros.

Descriptions of rock samples are listed in table 5.

ACKNOWLEDGMENTS

A number of our colleagues also participated in the collection, preparation, and data retrieval of these samples: collection, J. C. Gray, K. R. Greene, M. A. Mast, and A. D. McCollaum; preparation, J. C. Gray and G. L. Thurston; and data retrieval, J. L. Jones.

REFERENCES CITED

Armstrong, Augustus K., Frisken, James G., and Jachens, Robert C. (U.S. Geological Survey) and Rains, Richard L. (U.S. Bureau of Mines), 1987, Unpublished report on the Greenwater Valley Wilderness Study Area, Inyo County, California.

Crock, J. G., Lichte, F. E., and Briggs, P. H., 1983, Determination of elements in National Bureau of Standards Geological Reference Materials SRM278 Obsidian and SRM668 Basalt by Inductively Coupled Argon Plasma-Atomic Emission Spectrometry: Geostandards Newsletter, no. 7, p. 335-340.

Grimes, D. J., and Marranzino, A. P., 1968, Direct-current arc and alternating-current spark emission spectrographic field methods for the semiquantitative analysis of geologic materials: U.S. Geological Survey Circular 591, 6 p.

Koirtyohann, S. R., and Khalil, Moheb, 1976, Variables in the determination of mercury by cold vapor atomic absorption: Analytical Chemistry, 48, p. 136-139.

Motooka, J. M., and Grimes, D. J., 1976, Analytical precision of one-sixth order semiquantitative spectrographic analyses: U.S. Geological Survey Circular 738, 25 p.

Myers, A. T. , Havens, R. G., and Dunton, P. J., 1961, A spectrochemical method for the semiquantitative analyses of rocks, minerals, and ores: U.S. Geological Survey Bulletin 1084-I, p. 1207-1229.

O'Leary, R. M., and Viets, J. G., 1986, Determination of antimony, arsenic, bismuth, cadmium, copper, lead, molybdenum, silver, and zinc in geological materials by atomic absorption spectrometry using a hydrochloric acid-hydrogen peroxide digestion: Atomic Spectroscopy, 7, p. 4-8.

Thompson, C. E., Nakagawa, H. M., and Van Sickle, G. H., 1968, Rapid analysis for gold in geologic materials, in Geological Survey research 1968: U.S. Geological Survey Professional Paper 600-B, p. B130-B132.

VanTrump, George, Jr., and Miesch, A. T., 1977, The U.S. Geological Survey RASS-STATPAC system for management and statistical reduction of geochemical data: Computers and Geosciences, v. 3, p. 475-488.

TABLE 1.--Limits of determination for the spectrographic analysis of rocks based on a 10-mg sample

[The values shown are the lower limits of determination assigned by the Branch of Exploration Geochemistry, except for those values in parentheses, which are the lower values assigned by the Branch of Analytical Chemistry. The spectrographic limits of determination for heavy-mineral-concentrate samples are based on a 5-mg sample, and are therefore two reporting intervals higher than the limits given for rocks.]

Elements	Lower determination limit	Upper determination limit
	Percent	
Iron (Fe)	0.05	20
Magnesium (Mg)	.02	10
Calcium (Ca)	.05	20
Titanium (Ti)	.002	1
	Parts per million	
Manganese (Mn)	10	5,000
Silver (Ag)	0.5	5,000
Arsenic (As)	200 (700)	10,000
Gold (Au)	10 (15)	500
Boron (B)	10	2,000
Barium (Ba)	20	5,000
Beryllium (Be)	1	1,000
Bismuth (Bi)	10	1,000
Cadmium (Cd)	20 (30)	500
Cobalt (Co)	5	2,000
Chromium (Cr)	10	5,000
Copper (Cu)	5	20,000
Lanthanum (La)	20 (30)	1,000
Molybdenum (Mo)	5	2,000
Niobium (Nb)	20	2,000
Nickel (Ni)	5	5,000
Lead (Pb)	10	20,000
Antimony (Sb)	100	10,000
Scandium (Sc)	5	100
Tin (Sn)	10	1,000
Strontium (Sr)	100	5,000
Vanadium (V)	10	10,000
Tungsten (W)	50	10,000
Yttrium (Y)	10	2,000
Zinc (Zn)	200	10,000
Zirconium (Zr)	10	1,000
Thorium (Th)	100 (200)	2,000

TABLE 2.--Chemical methods used

AA = atomic absorption and ICP = inductively coupled plasma spectroscopy

Element or constituent determined	Sample Type	Method	Determination limit (micrograms/ gram or ppm)	Reference
Gold (Au)	rock	AA	.1	Modification of Thompson and others, 1968.
Mercury (Hg)	rock	AA	0.02	Koirtyohann and Khalil, 1976.
Arsenic (As)	rock	ICP	5	Crock and others, 1983, and modification of O'Leary and Viets, 1986.
Antimony (Sb)	rock	ICP	2	
Zinc (Zn)	rock	ICP	2	
Bismuth (Bi)	rock	ICP	2	
Cadmium (Cd)	rock	ICP	0.1	

TABLE 3. RESULTS OF ANALYSES OF HEAVY-MINERAL-CONCENTRATE SAMPLES FROM THE GREENWATER VALLEY WILDERNESS STUDY AREA, INYO COUNTY, CALIFORNIA

[N, not detected; <, detected but below the limit of determination shown; >, determined to be greater than the value shown.]

Sample	Latitude	Longitude	Fe-pct. s	Mg-pct. s	Ca-pct. s	Ti-pct. s	Mn-ppm s	Ag-ppm s	As-ppm s	Au-ppm s	B-ppm s	Ba-ppm s
GV013	35 59 13	116 29 47	.3	.30	2.0	.7	300	N	N	N	20	>10,000
GV014	35 59 30	116 30 27	.5	1.00	5.0	>2.0	200	N	N	N	50	>10,000
GV141	36 0 44	116 28 51	.7	.30	2.0	2.0	100	N	N	N	50	3,000
GV142	36 0 12	116 31 57	.5	.30	2.0	>2.0	150	N	N	N	30	3,000
GV143	36 0 51	116 30 10	.5	.50	3.0	>2.0	200	N	N	N	70	2,000
GV232	35 56 14	116 29 0	.5	2.00	10.0	>2.0	1,500	N	700	N	20	>10,000
GV233	35 55 48	116 27 30	5.0	2.00	5.0	>2.0	2,000	N	N	N	100	5,000
GV234	35 58 35	116 35 0	1.5	1.50	5.0	>2.0	1,500	N	N	N	100	1,500
GV235	35 58 23	116 34 35	.5	5.00	20.0	.7	1,000	N	N	N	20	>10,000
GV236	35 59 34	116 34 18	.7	1.00	5.0	2.0	300	N	N	N	50	3,000
GV237	35 58 13	116 33 22	.3	1.00	5.0	.5	300	N	N	N	20	>10,000
GV328	35 59 3	116 27 33	.7	10.00	15.0	1.0	500	N	N	N	50	5,000
GV329	35 58 57	116 27 28	.7	10.00	10.0	2.0	500	N	N	N	50	3,000
GV330	36 0 28	116 27 51	.5	1.00	3.0	2.0	150	N	N	N	30	2,000
GV331	36 2 18	116 32 0	1.0	1.00	3.0	2.0	200	N	N	N	30	5,000
GV332	36 1 45	116 31 51	.5	1.00	5.0	2.0	200	N	N	N	50	3,000
GV431	35 56 57	116 29 49	.5	2.00	5.0	>2.0	300	N	N	N	50	>10,000
GV432	35 57 28	116 25 26	1.0	1.00	3.0	2.0	200	N	N	N	70	2,000
GV433	36 0 19	116 35 20	.2	.20	3.0	.5	200	N	N	N	20	>10,000
GV435	35 59 47	116 33 55	.3	.20	7.0	.5	500	N	N	N	<20	>10,000
GV436	35 58 27	116 29 20	.5	1.00	3.0	2.0	200	N	N	N	20	>10,000
GV601	36 10 30	116 38 40	.5	.15	1.5	1.0	150	N	N	N	<20	>10,000
GV602	36 11 27	116 37 55	1.0	.70	3.0	2.0	300	N	N	N	100	5,000
GV603	36 10 26	116 36 16	.5	.50	5.0	>2.0	150	N	N	N	100	>10,000
GV604	36 10 4	116 34 35	.5	.50	3.0	>2.0	150	N	N	N	70	2,000
GV605	36 2 55	116 34 0	.7	3.00	5.0	>2.0	300	N	N	N	50	>10,000
GV606	36 2 47	116 34 14	.5	.70	5.0	>2.0	300	N	N	N	50	2,000
GV607	36 2 15	116 34 14	1.0	1.00	5.0	>2.0	300	N	N	N	70	1,000
GV608	36 1 57	116 34 58	.7	1.00	5.0	2.0	150	N	N	N	50	10,000
GV609	36 1 46	116 35 5	1.0	.50	3.0	1.0	100	N	N	N	50	1,500
GV610	36 1 30	116 35 8	.5	.30	3.0	1.5	100	N	N	N	70	1,000
GV611	36 4 15	116 32 50	.7	.50	3.0	2.0	150	N	N	N	50	1,000
GV612	36 6 0	116 33 10	.7	.50	3.0	2.0	150	N	N	N	50	1,500
GV614	36 13 10	116 37 25	.7	1.00	5.0	>2.0	200	N	N	N	70	1,000
GV615	36 8 9	116 33 40	.7	.50	3.0	>2.0	100	N	N	N	50	5,000
GV616	36 6 51	116 33 25	.5	.20	3.0	1.0	200	N	N	N	50	>10,000
GV617	35 57 6	116 29 22	.5	1.50	3.0	1.5	200	N	N	N	50	1,500
GV618	35 54 54	116 29 40	.3	.50	3.0	2.0	200	N	N	N	50	>10,000
GV619	35 54 43	116 27 3	.7	1.50	7.0	>2.0	500	N	N	N	50	2,000

TABLE 3. RESULTS OF ANALYSES OF HEAVY-MINERAL-CONCENTRATE SAMPLES FROM THE GREENWATER VALLEY WILDERNESS STUDY AREA, INYO COUNTY, CALIFORNIA--Continued

Sample	Be-ppm s	Bi-ppm s	Cd-ppm s	Co-ppm s	Cr-ppm s	Cu-ppm s	La-ppm s	Mo-ppm s	Nb-ppm s	Ni-ppm s	Pb-ppm s
GV013	5	N	N	N	N	20	<50	N	N	N	2,000
GV014	3	N	N	N	N	<10	100	N	<50	20	1,500
GV141	2	N	N	N	N	N	N	N	N	10	150
GV142	3	N	N	N	N	N	100	N	N	20	150
GV143	3	N	N	N	N	N	<50	N	N	20	<20
GV232	3	N	N	N	<20	<10	200	N	N	10	10,000
GV233	2	N	N	10	100	<10	500	N	70	30	100
GV234	3	N	N	10	150	<10	500	N	<50	30	70
GV235	<2	N	N	N	N	<10	300	N	N	N	200
GV236	3	N	N	N	N	N	150	N	N	10	50
GV237	<2	N	N	N	N	<10	150	15	N	<10	1,500
GV328	<2	N	N	N	N	N	<50	N	N	<10	100
GV329	<2	N	N	N	N	N	100	N	<50	<10	<20
GV330	5	N	N	<10	N	N	<50	N	N	<10	<20
GV331	<2	N	N	<10	<20	N	150	N	N	10	N
GV332	<2	N	N	N	N	N	150	N	N	N	N
GV431	10	N	N	<10	N	10	100	N	N	10	500
GV432	3	N	N	N	N	N	100	N	<50	10	50
GV433	N	N	N	N	N	N	<50	N	N	10	200
GV435	N	N	N	N	N	N	150	N	N	<10	700
GV436	2	N	N	N	N	N	100	N	N	15	<20
GV601	N	N	N	N	N	20	<50	N	50	N	20
GV602	3	N	N	N	N	N	150	N	50	10	<20
GV603	2	N	N	N	N	<10	150	N	100	<10	500
GV604	2	N	N	N	N	N	100	N	70	10	<20
GV605	2	N	N	N	<20	N	150	N	N	10	200
GV606	3	N	N	N	N	N	150	N	<50	10	200
GV607	2	N	N	N	20	N	150	N	N	10	20
GV608	2	N	N	N	N	N	100	N	N	<10	150
GV609	2	N	N	10	<20	N	100	N	<50	<10	100
GV610	2	N	N	N	N	N	<50	N	N	10	100
GV611	3	N	N	N	N	N	100	N	N	<10	N
GV612	3	N	N	N	N	N	100	N	N	10	70
GV614	2	N	N	<10	N	<10	150	N	50	<10	N
GV615	3	N	N	<10	N	N	<50	N	100	<10	70
GV616	3	N	N	N	N	15	<50	N	N	<10	1,000
GV617	<2	N	N	N	N	10	N	N	<50	<10	1,000
GV618	5	N	N	N	20	N	100	N	<50	<10	20
GV619	3	N	N	N	N	N	150	N	<50	<10	300

TABLE 3. RESULTS OF ANALYSES OF HEAVY-MINERAL-CONCENTRATE SAMPLES FROM THE GREENWATER VALLEY WILDERNESS STUDY AREA, INYO COUNTY, CALIFORNIA--Continued

Sample	Sb-ppm s	Sc-ppm s	Sn-ppm s	Sr-ppm s	V-ppm s	W-ppm s	Y-ppm s	Zn-ppm s	Zr-ppm s	Th-ppm s
GV013	N	N	N	5,000	200	N	200	N	>2,000	N
GV014	N	30	N	500	150	N	1,000	N	>2,000	200
GV141	N	N	N	500	70	N	500	N	>2,000	N
GV142	N	30	N	500	70	N	1,000	N	>2,000	200
GV143	N	<10	N	500	70	N	1,000	N	>2,000	<200
GV232	N	<10	N	500	200	100	1,500	5,000	>2,000	N
GV233	N	30	<20	500	200	N	1,000	N	>2,000	N
GV234	N	30	N	500	100	N	1,000	N	>2,000	200
GV235	N	N	N	2,000	50	N	1,000	N	>2,000	N
GV236	N	N	N	500	70	N	700	N	>2,000	N
GV237	N	N	N	5,000	30	N	500	1,000	>2,000	N
GV328	N	N	N	500	50	N	200	N	>2,000	N
GV329	N	N	N	500	70	N	300	N	>2,000	N
GV330	N	N	N	500	50	N	500	N	>2,000	N
GV331	N	N	N	700	70	N	500	N	>2,000	N
GV332	N	N	N	1,000	50	N	500	N	>2,000	N
GV431	N	30	N	700	100	N	1,000	N	>2,000	N
GV432	N	<10	N	500	70	N	500	N	>2,000	N
GV433	N	N	N	5,000	50	N	500	N	>2,000	200
GV435	N	<10	N	7,000	50	N	1,000	N	>2,000	N
GV436	N	30	N	700	70	N	1,000	N	>2,000	<200
GV601	N	N	N	>10,000	30	N	70	N	>2,000	N
GV602	N	N	N	700	100	N	500	N	>2,000	N
GV603	N	50	N	3,000	150	N	700	N	>2,000	<200
GV604	N	30	N	500	70	N	500	N	>2,000	N
GV605	N	N	N	700	100	N	500	N	>2,000	N
GV606	N	20	N	500	150	N	700	N	>2,000	N
GV607	N	N	N	700	100	N	500	N	>2,000	N
GV608	N	N	N	700	100	N	200	N	>2,000	N
GV609	N	N	N	1,000	50	N	100	N	>2,000	N
GV610	N	N	N	700	30	N	300	N	>2,000	N
GV611	N	N	N	700	50	N	200	N	>2,000	N
GV612	N	N	N	1,000	70	N	300	N	>2,000	N
GV614	N	<10	N	700	70	N	300	N	>2,000	N
GV615	N	N	50	700	30	N	200	N	>2,000	N
GV616	N	N	N	2,000	50	N	150	N	>2,000	N
GV617	N	N	N	1,000	50	N	150	N	>2,000	N
GV618	N	N	N	5,000	70	N	300	1,000	>2,000	N
GV619	N	30	N	500	100	N	700	N	>2,000	N

TABLE 4. RESULTS OF ANALYSES OF ROCK SAMPLES FROM THE GREENWATER VALLEY WILDERNESS STUDY AREA, INYO COUNTY, CALIFORNIA

[N, not detected; <, detected but below the limit of determination shown; >, determined to be greater than the value shown.]

Sample	Latitude	Longitude	Fe-pct. s	Mg-pct. s	Ca-pct. s	Ti-pct. s	Mn-ppm s	Ag-ppm s	As-ppm s	Au-ppm s	B-ppm s	Ba-ppm s	Be-ppm s
GV011	35 59 0	116 29 44	20.0	.05	.07	N	200	N	N	N	150	<20	N
GV012	35 59 6	116 29 42	.5	.03	.10	.030	200	N	N	N	30	1,000	1.0
GV691	36 10 34	116 38 41	15.0	.20	.05	.200	100	2.0	N	N	50	2,000	N
GV694	36 10 50	116 38 10	3.0	.03	<.05	.010	30	1.5	N	N	50	>5,000	5.0
GV695	35 57 2	116 27 40	1.5	.02	N	.005	70	200.0	N	N	20	1,500	2.0
FM4-1	35 57 15	116 27 35	1.5	.02	.07	.005	70	30.0	N	N	10	500	2.0
FM4-2	35 57 15	116 27 35	1.5	.02	<.05	.005	70	30.0	N	N	N	300	1.0
FM4-3	35 57 5	116 27 30	1.5	.07	.20	.070	100	1.5	N	N	10	1,500	<1.0
FM5-1	35 52 25	116 27 10	20.0	.10	.30	.030	3,000	7.0	N	N	H	100	N
FM5-2	35 52 25	116 27 10	7.0	<.02	.15	.030	15	3.0	N	20	<10	200	N
FM6-1	35 49 55	116 27 45	>20.0	.03	<.05	.030	>5,000	3.0	N	N	30	30	N
FM6-2	35 49 55	116 27 45	20.0	.15	.07	.070	1,500	10.0	700	20	30	150	1.0
FM6-3	35 49 55	116 27 45	3.0	.20	.15	.300	>5,000	3.0	N	N	70	200	1.5
FM7-1	35 52 20	116 23 30	15.0	.05	.07	.070	700	15.0	1,500	30	N	30	N
FM7-2	35 52 20	116 23 30	15.0	.15	.30	.030	200	150.0	1,500	150	N	<20	N

TABLE 4. RESULTS OF ANALYSES OF ROCK SAMPLES FROM THE GREENWATER VALLEY WILDERNESS STUDY AREA, INYO COUNTY, CALIFORNIA--Continued

Sample	Bi-ppm s	Cd-ppm s	Co-ppm s	Cr-ppm s	Cu-ppm s	La-ppm s	Mo-ppm s	Nb-ppm s	Ni-ppm s	Pb-ppm s	Sb-ppm s	Sc-ppm s	Sn-ppm s	Sr-ppm s
GV011	20	N	10	10	>20,000	N	N	N	15	70	N	N	N	N
GV012	N	N	<5	N	70	N	N	N	<5	15	N	N	N	N
GV691	30	N	30	200	>20,000	N	20	N	20	30	N	7	N	200
GV694	30	N	<5	20	20,000	N	20	N	N	300	N	N	N	1,500
GV695	300	30	N	N	3,000	<20	50	N	N	>20,000	N	N	N	200
FM4-1	100	N	N	<10	2,000	N	N	N	N	>20,000	N	N	N	<100
FM4-2	100	70	N	<10	300	N	7	N	N	>20,000	N	N	N	<100
FM4-3	N	N	N	<10	10	70	N	<20	N	3,000	N	N	N	150
FM5-1	15	N	100	<10	>20,000	150	<10	<20	70	500	N	N	H	150
FM5-2	N	N	N	<10	70	N	N	<20	N	150	N	N	N	<100
FM6-1	N	70	300	<10	15,000	N	<10	<20	300	30	N	5	H	<100
FM6-2	30	N	70	<10	>20,000	N	50	<20	150	700	100	5	H	<100
FM6-3	N	N	700	15	>20,000	N	10	<20	700	70	N	15	N	150
FM7-1	30	N	20	<10	>20,000	N	<10	<20	30	7,000	7,000	N	N	<100
FM7-2	300	N	5	<10	>20,000	N	<10	<20	15	>20,000	>10,000	N	N	<100

TABLE 4. RESULTS OF ANALYSES OF ROCK SAMPLES FROM THE GREENWATER VALLEY WILDERNESS STUDY AREA, INYO COUNTY, CALIFORNIA--Continued

Sample	V-ppm s	W-ppm s	Y-ppm s	Zn-ppm s	Zr-ppm s	Th-ppm s	Au-ppm aa	Hg-ppm aa	As-ppm icp	Zn-ppm icp	Cd-ppm icp	Bi-ppm icp	Sb-ppm icp
GV011	<10	N	20	200	N	N	--	--	--	--	--	--	--
GV012	<10	N	N	N	50	N	--	--	--	--	--	--	--
GV691	30	N	N	N	10	N	--	--	--	--	--	--	--
GV694	500	N	N	<200	N	N	--	--	--	--	--	--	--
GV695	<10	N	N	700	N	N	--	--	--	--	--	--	--
FM4-1	N	N	N	7,000	N	N	4.0	1.80	41	4,110.0	4.9	85	15
FM4-2	10	N	N	1,000	N	N	5.0	3.90	<5	722.0	17.7	65	174
FM4-3	<10	N	10	N	150	N	<.1	.16	<5	73.0	1.0	2	6
FM5-1	15	N	30	N	N	N	1.9	.33	47	101.0	.4	13	17
FM5-2	N	N	15	N	30	N	19.0	.04	18	3.0	.2	4	16
FM6-1	N	N	10	>10,000	30	N	<.1	.34	8	14,100.0	43.2	11	37
FM6-2	<10	N	10	3,000	30	N	15.0	.32	941	2,000.0	3.5	33	63
FM6-3	70	N	30	5,000	200	N	.1	.15	28	5,390.0	10.8	74	15
FM7-1	N	N	N	700	30	N	5.4	.65	1,090	391.0	.2	14	744
FM7-2	N	N	N	1,500	N	N	5.1	590.00	350	1.6	119.0	4,450	4,450

TABLE 5. Description of rock samples

[D = mine dump or prospect]

GV 011	D	Quartz-Cu staining
012	D	Quartz veins + quartz breccia
691	D	Cu stained volcanic breccia
694	D	Cu stained volcanic breccia
695	D	Galena-quartz-Cu staining
FM 4-1	D	Galena-quartz-Cu staining
4-2	D	Quartzite
4-3	D	?
5-1	D	Cu-stained rock
5-2	D	Chert
6-1	D	?
6-2	D	?
6-3	D	?
7-1	D	?
7-2	D	?

TABLE 6.--Latitudes and longitudes of samples not appearing on plate 1

[C--heavy-mineral concentrate; R--rock]

Sample	Latitude	Longitude
GV601C	36 10 30	116 38 40
GV602C	36 11 27	116 37 55
GV614C	36 13 10	116 37 25
GV691R	36 10 34	116 38 41
GV694R	36 10 50	116 38 10
FM5-1R	35 52 25	116 27 10
FM5-2R	35 52 25	116 27 10
FM6-1R	35 49 55	116 27 45
FM6-2R	35 49 55	116 27 45
FM6-3R	35 49 55	116 27 45
FM7-1R	35 52 20	116 23 30
FM7-2R	35 52 20	116 23 30