UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Analytical results and sample locality map of heavy-mineral-concentrate and rock samples from the Funeral Mountains Wilderness Study Area (CDCA-143), Inyo County, California

By

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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 Funeral Mountains Wilderness Study Area (CDCA-143), Inyo County, California.

INTRODUCTION

In April 1984 the U.S. Geological Survey conducted a reconnaissance geochemical survey of the Funeral Mountains Wilderness Study Area, Inyo County, California.

The studied part of the Funeral Mountains Wilderness Study Area comprises about 21 mi^2 (55 km^2) (13,709 acres) along the southern extension of the Funeral Range in the Death Valley region of eastern California (fig. 1). The study area is located between the eastern edge of Death Valley National Monument and the California-Nevada border. Death Valley Junction, the nearest community, is approximately 7 miles to the southeast. Peripheral access to the east boundary is by California State Highway 127 and a graded gravel road through Franklin Well; access to the western boundary is by State Highway 190 and a jeep trail to Red Amphitheater (plate 1).

The Funeral Mountains are a repetitious series of fault blocks underlain predominantly by carbonate rock of Cambrian through Mississippian age. The northwest-trending range of fault-controlled mountains encloses small, narrow interior valleys and is bounded by broad, coalescing alluvial fans. The study area is characterized by rugged peaks, steep sloping ridges, and narrow drainages.

Relief within the study area is over 4,300 ft. Pyramid Peak, a dominant feature near the center of the study area, is the highest point at 6,703 ft. The surface elevation drops sharply to 2,400 ft at the southwest corner of the study area (Armstrong and others, unpublished report).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 a stream-sediment sample.

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.

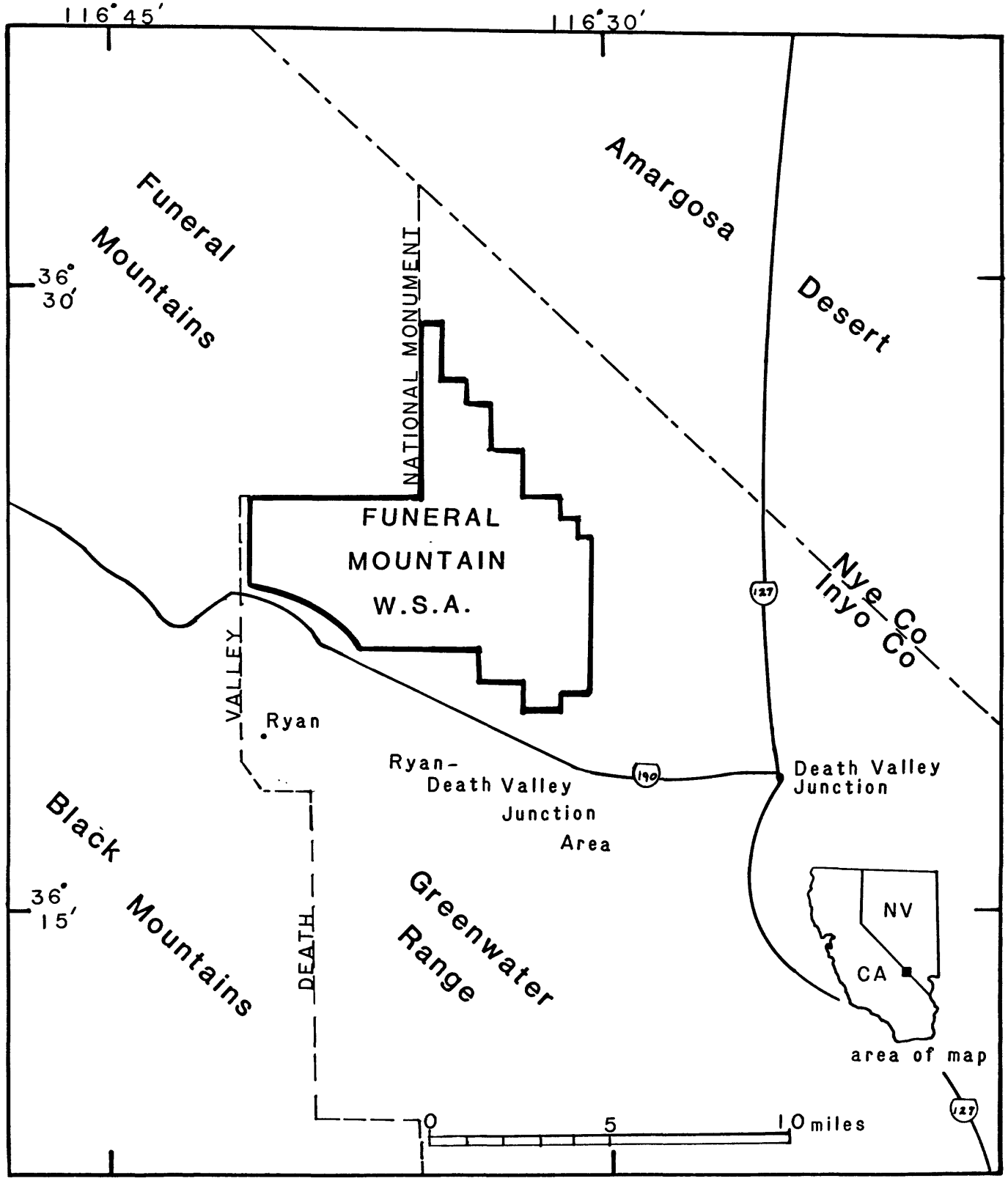

Figure 1. Location map of the Funeral Mountains Wilderness Study Area, Inyo County, California.

Sample Collection

Heavy-mineral-concentrate samples were collected at 34 sites (plate 1). Eight rock samples were collected as stream cobbles or from adjunct mine dumps. Average sampling density was about one sample site per 1.6 mi^2 for the heavy-mineral concentrates. The area of the drainage basins sampled ranged from 1 mi^2 to 3 mi^2.

Heavy-mineral-concentrate samples

Heavy-mineral-concentrate samples were collected from active alluvium 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 in the vicinity of the plotted site location. Samples were collected of unaltered 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 archival storage. 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 of the two analytical methods varies. The values in the parentheses are the limits of determination for 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. Standard concentrations are geometrically spaced over any given 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 Funeral Mountains Wilderness Study Area are listed in tables 3-4.

Chemical methods

Other analytical methods used on samples from the Funeral Mountains Wilderness Study Area are summarized in table 2. The analytical method used for determining As, Bi, Cd, Sb, and Zn is a modification and adaption 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 3-4 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; "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. 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 3-4 in place of an analytical value. Because of the formatting used in the computer program that produced tables 3-4, 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 found in table 5. The table is arranged so that column 1 contains the USGS-assigned sample numbers. A "D" indicates the rock was collected from a mine dump or prospect; "S" indicates stream cobble.

ACKNOWLEDGEMENTS

A number of our colleagues also participated in the collection, preparation, and analyses of these samples: collection, J. C. Gray, K. R. Greene, M. A. Mast, and A. D. McCollaum; preparation, T. A. Delaney and J. L. Jones; and analyses, Karan Pond.

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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 Grimes and Marranzino method, except for those values in parentheses, which are the lower values assigned by the Myers and others method. 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; 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 FUNERAL MOUNTAINS 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
FM016	36 22 22	116 27 41	.5	5.0	7	2.00	200	N	N	N	70	>10,000
FM017	36 23 45	116 28 31	.5	5.0	5	>2.00	200	N	N	N	300	>10,000
FM018	36 23 8	116 29 7	.5	2.0	3	2.00	150	N	N	N	50	>10,000
FM020	36 22 54	116 29 40	.3	7.0	5	1.50	100	N	N	N	70	>10,000
FM021	36 21 34	116 30 30	.5	10.0	7	2.00	150	N	N	N	30	>10,000
FM022	36 21 2	116 31 11	.7	10.0	7	>2.00	200	N	N	N	50	>10,000
FM023	36 20 4	116 31 37	.7	7.0	7	2.00	200	N	N	N	30	3,000
FM024	36 20 1	116 28 44	.5	3.0	5	>2.00	150	N	N	N	50	>10,000
FM025	36 20 10	116 29 10	.7	.7	5	1.00	200	N	N	N	50	>10,000
FM144	36 24 20	116 38 7	1.0	5.0	30	1.00	300	N	N	N	70	5,000
FM145	36 24 12	116 38 11	.5	5.0	30	1.00	200	N	N	N	20	>10,000
FM146	36 24 38	116 41 34	.5	7.0	50	.50	100	N	N	N	50	10,000
FM147	36 23 15	116 39 37	.5	7.0	20	1.50	200	N	N	N	70	>10,000
FM148	36 22 55	116 39 1	.7	5.0	50	.50	200	N	N	N	50	>10,000
FM149	36 22 0	116 35 48	.5	15.0	20	1.00	300	N	N	N	70	1,000
FM150	36 21 47	116 33 46	.5	10.0	50	.50	500	N	N	N	20	2,000
FM151	36 21 5	116 33 23	.5	10.0	10	.70	200	N	N	N	50	1,500
FM152	36 20 18	116 32 18	1.0	3.0	3	1.00	150	N	N	N	150	>10,000
FM238	36 24 7	116 34 51	1.0	7.0	50	.15	50	N	N	N	30	10,000
FM239	36 24 13	116 33 21	.7	10.0	10	.70	150	N	N	N	500	7,000
FM240	36 24 20	116 32 31	.7	15.0	10	2.00	300	N	N	N	50	1,000
FM241	36 21 57	116 31 49	.7	10.0	20	.50	500	N	N	N	50	>10,000
FM333	36 24 46	116 38 21	.3	10.0	20	.70	100	N	N	N	50	10,000
FM334	36 24 48	116 39 59	.5	15.0	20	1.00	100	N	N	N	50	1,500
FM335	36 22 59	116 41 0	.3	15.0	20	.50	150	N	N	N	50	10,000
FM336	36 22 40	116 41 0	.5	15.0	20	2.00	200	N	N	N	100	>10,000
FM337	36 21 51	116 38 55	.7	10.0	20	.70	200	N	N	N	100	>10,000
FM338	36 21 35	116 35 2	.5	15.0	20	1.00	200	N	N	N	50	5,000
FM339	36 18 45	116 30 4	1.0	10.0	10	>2.00	300	N	N	N	100	3,000
FM340	36 21 18	116 33 37	1.0	10.0	20	1.50	300	N	N	N	50	>10,000
FM341	36 20 24	116 33 10	1.5	10.0	20	2.00	500	N	N	N	70	5,000
FM438	36 26 0	116 35 4	.7	3.0	5	>2.00	300	N	N	N	200	>10,000
FM439	36 24 57	116 34 49	1.0	7.0	50	.20	100	N	N	N	50	500
FM441	36 23 40	116 30 56	.5	7.0	7	1.00	300	N	N	N	50	>10,000

TABLE 3. RESULTS OF ANALYSES OF HEAVY-MINERAL-CONCENTRATE SAMPLES FROM THE FUNERAL MOUNTAINS 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
FM016	3	N	N	N	<20	N	200	N	N	10	N
FM017	2	N	N	N	N	N	150	N	50	15	1,500
FM018	3	N	N	N	N	N	N	N	N	20	300
FM020	3	N	N	N	N	N	<50	N	N	15	N
FM021	5	N	N	N	N	N	100	N	N	15	30
FM022	5	N	N	N	20	N	150	N	N	15	<20
FM023	5	N	N	N	<20	N	100	N	N	15	N
FM024	5	N	N	N	N	N	100	N	N	30	<20
FM025	N	N	N	N	<20	<10	150	N	N	15	N
FM144	N	N	N	N	<20	N	300	N	N	10	20
FM145	N	N	N	N	N	<10	100	N	N	<10	100
FM146	N	N	N	N	N	N	200	N	N	N	50
FM147	N	N	N	N	N	<10	100	N	N	<10	<20
FM148	N	N	N	N	N	N	<50	N	N	<10	50
FM149	N	N	N	N	N	N	100	N	N	<10	200
FM150	N	N	N	N	N	N	<50	N	N	<10	N
FM151	2	N	N	N	N	N	<50	N	N	<10	N
FM152	3	N	N	N	N	N	150	N	N	20	300
FM238	N	N	N	N	N	N	300	N	N	10	<20
FM239	N	N	100	N	N	N	100	N	N	10	2,000
FM240	2	N	N	N	N	N	<50	N	N	10	20
FM241	N	N	N	N	N	N	150	N	N	<10	50
FM333	N	N	N	N	N	N	200	N	N	<10	20
FM334	N	N	N	N	N	<10	100	N	N	10	50
FM335	N	N	N	N	N	N	<50	N	N	N	N
FM336	N	N	N	N	<20	N	200	N	N	<10	3,000
FM337	N	N	N	N	N	300	150	N	N	10	20,000
FM338	N	N	N	N	N	N	<50	N	N	10	100
FM339	2	N	N	N	50	N	100	N	<50	15	70
FM340	N	N	N	N	N	N	100	N	N	10	20
FM341	<2	N	N	N	<20	N	200	N	N	10	150
FM438	7	N	N	N	30	N	150	N	N	20	<20
FM439	N	N	N	N	<20	N	500	N	N	<10	<20
FM441	2	N	N	N	N	N	150	N	N	15	<20

TABLE 3. RESULTS OF ANALYSES OF HEAVY-MINERAL-CONCENTRATE SAMPLES FROM THE FUNERAL MOUNTAINS 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
FM016	N	N	N	1,000	70	N	500	N	>2,000	N
FM017	N	20	200	1,500	500	N	500	N	>2,000	N
FM018	N	N	N	>10,000	100	N	500	N	>2,000	N
FM020	N	N	N	1,000	50	N	500	N	>2,000	N
FM021	N	<10	100	<200	50	N	500	N	>2,000	N
FM022	N	30	50	<200	100	N	700	N	>2,000	N
FM023	N	30	150	N	70	N	500	N	>2,000	N
FM024	N	50	N	<200	100	N	1,000	N	>2,000	N
FM025	N	N	N	5,000	70	N	200	N	>2,000	N
FM144	N	N	N	1,000	50	N	500	N	>2,000	N
FM145	N	N	N	1,000	70	N	200	N	>2,000	N
FM146	N	N	N	700	50	N	300	N	>2,000	N
FM147	N	N	N	2,000	50	N	200	N	>2,000	N
FM148	N	N	N	2,000	30	N	100	500	>2,000	N
FM149	N	N	N	<200	50	N	150	N	>2,000	N
FM150	N	N	N	1,000	30	N	150	N	>2,000	N
FM151	N	N	150	500	30	N	300	N	>2,000	N
FM152	N	<10	N	1,000	150	N	700	1,000	>2,000	<200
FM238	N	N	N	700	30	N	500	N	>2,000	N
FM239	N	N	N	<200	70	N	200	>20,000	>2,000	N
FM240	N	N	N	N	50	N	300	N	>2,000	N
FM241	N	N	N	700	50	N	150	N	>2,000	N
FM333	N	N	N	500	30	N	500	N	>2,000	N
FM334	N	N	N	500	30	N	300	N	>2,000	N
FM335	N	N	N	700	30	N	70	N	>2,000	N
FM336	N	<10	N	1,500	70	N	200	N	>2,000	<200
FM337	N	N	N	500	30	N	300	N	>2,000	N
FM338	N	N	N	<200	50	N	150	N	>2,000	N
FM339	N	N	N	<200	70	N	700	N	>2,000	N
FM340	N	N	N	700	50	N	200	N	>2,000	N
FM341	N	<10	N	500	100	N	300	N	>2,000	N
FM438	N	30	N	1,000	150	N	1,000	N	>2,000	N
FM439	N	N	N	700	50	N	700	N	>2,000	N
FM441	N	N	N	1,000	70	N	300	N	>2,000	200

TABLE 4. RESULTS OF ANALYSES OF ROCK SAMPLES FROM THE FUNERAL MOUNTAINS 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
FM017	36 23 45	116 28 31	.05	10.00	20.00	.010	30	N	N	N	N	N	N
FM018	36 23 8	116 29 7	2.00	2.00	7.00	.200	1,000	N	N	N	50	1,500	1.0
FM022	36 21 2	116 31 11	20.00	.70	1.50	.010	200	N	1,000	N	150	50	1.5
FM2-1	36 23 35	116 33 15	.20	3.00	3.00	<.002	30	N	N	N	N	<20	N
FM2-2	36 23 35	116 33 15	.30	3.00	10.00	.030	70	N	N	N	<10	70	N
FM2-3	36 23 35	116 33 15	.15	.70	1.50	.003	150	N	N	N	<10	30	N
FM3-1	36 25 0	116 35 0	3.00	.07	.07	.010	<10	N	N	N	15	30	<1.0
FM3-3	36 25 0	116 35 0	7.00	.10	.50	.005	70	N	N	N	<10	70	N

TABLE 4. RESULTS OF ANALYSES OF ROCK SAMPLES FROM THE FUNERAL MOUNTAINS 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
FM017	N	N	N	N	N	N	N	N	N	N	N	N	N	200
FM018	N	N	10	N	<5	<20	N	N	5	20	N	5	N	1,000
FM022	N	N	15	30	20	N	5	N	50	70	N	N	N	N
FM2-1	N	N	N	<10	7	N	N	N	<5	15	N	N	N	<100
FM2-2	N	N	N	15	7	N	N	N	5	30	N	N	N	<100
FM2-3	N	N	7	<10	7	N	N	N	7	N	N	N	N	<100
FM3-1	N	N	<5	<10	7	N	N	N	7	<10	N	<5	N	<100
FM3-3	N	N	<5	<10	70	N	N	N	10	10	N	N	N	<100

TABLE 4. RESULTS OF ANALYSES OF ROCK SAMPLES FROM THE FUNERAL MOUNTAINS 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
FM017	N	N	N	N	N	N	--	--	--	--	--	--	--
FM018	50	N	<10	N	70	N	--	--	--	--	--	--	--
FM022	100	N	N	200	10	N	--	--	--	--	--	--	--
FM2-1	<10	N	<10	N	10	N	<.1	.03	<5	20	.2	<2	42
FM2-2	15	N	<10	N	50	N	<.1	.05	11	17	.3	<2	34
FM2-3	<10	N	N	N	15	N	<.1	.02	<5	12	<.1	<2	18
FM3-1	15	N	N	N	30	N	<.1	.02	39	5	<.1	<2	55
FM3-3	<10	N	<10	N	15	N	<.1	.03	6	3	.4	<2	44

TABLE 5.--Description of rock samples

[D = mine dump or prospect; S = stream cobble]

FM 017	S	Black dolostone
018	S	Meta sandstone
022	S	Altered limonitic breccia
2-1	D	Limonitic dolomite
2-2	D	Limonitic dolomite
2-3	D	Quartzite
3-1	D	Quartzite
3-3	D	Quartzite