UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Analytical results and sample locality map of heavy-mineral-concentrate samples from the Southern Inyo Mountains (CA-010-056) Wilderness Study Area, Inyo County, California

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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 Southern Inyo Mountains Wilderness Study Area, Inyo County, California.

INTRODUCTION

In July 1985 the U.S. Geological Survey conducted a reconnaissance geochemical survey of the Southern Inyo County Wilderness Study Area, Inyo County, California.

The U.S. Geological Survey was asked to study 27,240 acres (42.5 mi^2) of the Southern Inyo Mountains Wilderness Study Area (CA-010-056). Throughout this report "wilderness study area" and "study area" refer only to that acreage. The Southern Inyo Mountains Wilderness Study Area is on the western side of the southern Inyo Mountains 5 mi east of Lone Pine, in southeastern California (see fig. 1). Numerous graded dirt roads in Owens Valley provide access to the western part of the study area, leading to canyons and mines along the range front. A jeep trail, passable in four-wheel drive, runs from Swansea to the Burgess mine and provides access to the southeastern part of the study area. Access within the area is limited to narrow foot trails.

The study area is underlain by a sequence of intensely folded and faulted marine sedimentary rocks of Cambrian through Triassic age, and continental volcanic and sedimentary rocks of Triassic age. Limestone and dolomite are the most abundant rock types in the lower part of the stratigraphic sequence; shale is more abundant in the upper part. These rocks are intruded by a number of plutons and small granitic bodies of Jurassic and Cretaceous age. Faulting, folding, and metamorphism have greatly deformed the stratified rocks, especially in the proximity of the large plutons.

Elevations in the study area range from about 3,700 ft above sea level at the base of the range in Owens Valley to 11,107 ft above sea level at the summit of Mt. Inyo. The northern part of the study area is very steep and rugged with relief of up to 7,400 ft. The southeastern part of the study area is somewhat less rugged but also contains numerous steep and inaccessible canyons. The climate is arid to semiarid, and vegetation is sparse.

METHODS OF STUDY

Sample Media

Analyses of the stream-sediment samples represent the chemistry of the rock material eroded from the drainage basin upstream from each sample site. Such information is useful in identifying those basins which contain concentrations of elements that may be related to mineral deposits. 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 stream-sediment samples.

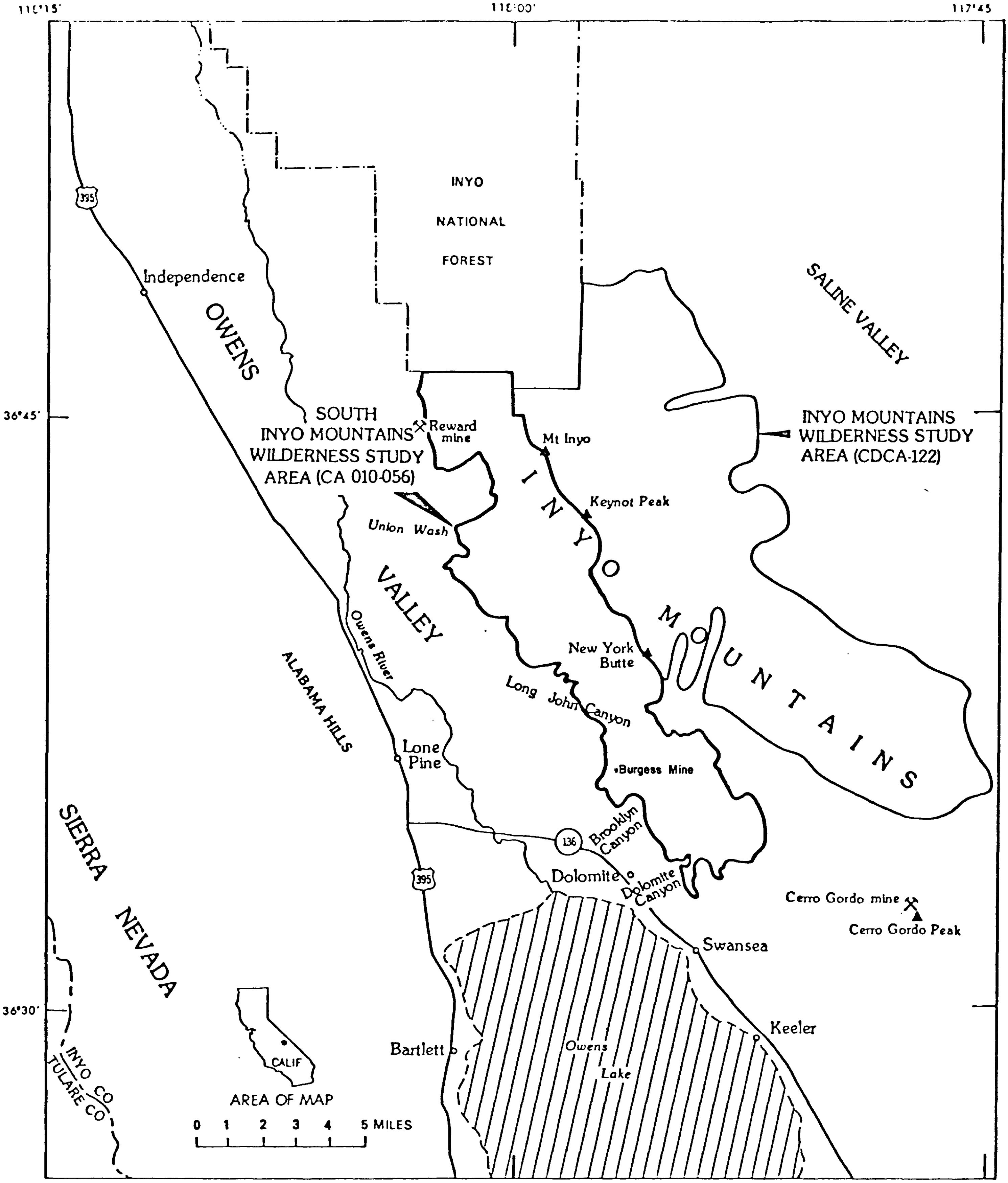

Figure 1. Location map of the Southern Inyo Mountains Wilderness Study Area, Inyo County, California.

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

Samples were collected at 53 sites (plate 1). At nearly all of those sites, both a stream-sediment sample and a heavy-mineral-concentrate sample were collected. Where suitable outcrop was available, rock samples were collected, and where water was available, water samples were collected. Average sampling density was about one sample site per 1 mi^2 for the heavy-mineral concentrates.

Heavy-mineral-concentrate samples

Heavy-mineral-concentrate samples were collected from the same active alluvium as the stream-sediment samples. 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.

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/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.

Sample Analysis

Spectrographic method

The heavy-mineral-concentrate samples were analyzed for 31 elements using semiquantitative, direct-current arc emission spectrographic methods. The analyses of heavy-mineral-concentrate samples were performed using the method of Grimes and Marranzino (1968). The elements analyzed and their lower limits of determination are listed in table 1. 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 Southern Inyo Mountains Wilderness Study Area are listed in table 2.

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

Table 2 lists the results of analyses for the samples of heavy-mineral concentrate. For the table, 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 map (plate 1). Columns in which the element headings show the letter "s" below the element symbol are emission spectrographic analyses. 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 table 2 in front of the upper limit of determination. If an element was not looked for in a sample, two dashes (--) are entered in table 2 in place of an analytical value. Because of the formatting used in the computer program that produced tables 2, 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.

REFERENCES CITED

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.

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.

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 heavy-mineral concentrates, based on a 5-mg sample

Elements	Lower determination limit	Upper determination limit
	Percent	
Iron (Fe)	0.1	50
Magnesium (Mg)	.05	20
Calcium (Ca)	.1	50
Titanium (Ti)	.005	2
	Parts per million	
Manganese (Mn)	20	10,000
Silver (Ag)	1	10,000
Arsenic (As)	500	20,000
Gold (Au)	20	1,000
Boron (B)	20	5,000
Barium (Ba)	50	10,000
Beryllium (Be)	2	2,000
Bismuth (Bi)	20	2,000
Cadmium (Cd)	50	1,000
Cobalt (Co)	10	5,000
Chromium (Cr)	20	10,000
Copper (Cu)	10	50,000
Lanthanum (La)	50	2,000
Molybdenum (Mo)	10	5,000
Niobium (Nb)	50	5,000
Nickel (Ni)	10	10,000
Lead (Pb)	20	50,000
Antimony (Sb)	200	20,000
Scandium (Sc)	10	200
Tin (Sn)	20	2,000
Strontium (Sr)	200	10,000
Vanadium (V)	20	20,000
Tungsten (W)	100	20,000
Yttrium (Y)	20	5,000
Zinc (Zn)	500	20,000
Zirconium (Zr)	20	2,000
Thorium (Th)	200	5,000

Table 2.--Spectrographic analyses of heavy-mineral-concentrate samples collected from the Southern Inyo Mountains BLM Wilderness Study Area, 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
IN100	36 32 31	117 52 16	.5	.30	2.0	2.00	500	<1.0	N	N	50
IN101	36 32 35	117 52 7	.7	.20	10.0	>2.00	300	7.0	N	N	50
IN102	36 35 22	117 52 28	1.0	.10	7.0	2.00	200	1.5	N	N	30
IN103	36 34 48	117 55 0	1.0	.50	10.0	>2.00	500	N	N	N	500
IN104	36 34 48	117 54 50	.7	.20	7.0	>2.00	700	N	N	N	50
IN105	36 33 50	117 56 8	.7	3.00	10.0	.15	100	1.0	N	N	150
IN106	36 35 52	117 54 35	.5	.10	1.5	1.00	100	<1.0	N	N	20
IN107	36 34 50	117 56 41	1.0	.70	2.0	.70	70	N	N	N	200
IN108	36 35 47	117 56 47	.7	7.00	15.0	.30	500	<1.0	N	N	70
IN109	36 35 44	117 56 37	.7	.20	.3	.20	50	N	N	N	100
IN110	36 36 22	117 56 20	.5	.20	1.5	.70	70	5.0	N	N	70
IN111	36 38 23	117 59 22	.3	.20	1.5	1.00	100	500.0	1,000	1,000	30
IN112	36 38 3	117 58 40	.7	1.00	7.0	2.00	200	50.0	1,000	200	50
IN113	36 38 10	117 58 32	.3	<.05	1.5	.70	70	10.0	<500	50	20
IN114	36 38 20	117 58 1	.2	.50	7.0	>2.00	300	N	N	<20	30
IN115	36 38 15	117 57 55	.7	.15	1.5	.50	70	N	N	N	30
IN116	38 38 40	117 58 50	.2	.20	3.0	>2.00	150	<1.0	N	N	50
IN117	38 39 44	117 58 7	.2	.20	7.0	1.50	200	N	N	N	30
IN118	38 39 40	117 58 6	.3	.10	5.0	2.00	200	<1.0	N	N	20
IN119	36 39 16	117 59 25	.5	.10	5.0	2.00	150	N	N	N	20
IN120	36 36 5	117 57 45	.3	5.00	7.0	.50	200	N	N	N	70
IN121	36 36 10	117 57 46	.3	5.00	7.0	.50	200	2.0	N	N	300
IN122	36 36 22	117 58 22	.5	7.00	10.0	.20	500	<1.0	N	N	20
IN123	36 36 31	117 58 58	.2	.20	3.0	.20	150	N	N	N	<20
IN124	36 37 7	117 59 32	.3	.50	3.0	1.50	150	N	N	N	20
IN125	36 37 44	117 59 20	.5	2.00	5.0	.50	500	N	N	N	50
IN200	36 32 58	117 53 20	.3	.20	3.0	2.00	150	N	N	N	30
IN201	36 34 55	117 53 40	.3	.15	2.0	.50	200	N	N	N	30
IN202	36 35 35	117 53 16	.5	.20	3.0	2.00	200	15.0	N	N	50
IN203	36 36 5	117 53 37	.3	.15	2.0	1.00	70	N	N	N	30
IN013	36 41 7	118 1 50	.5	.70	7.0	2.00	500	20.0	N	N	50
IN014	36 40 13	118 0 59	.3	.30	2.0	1.50	100	N	N	N	30
IN015	36 46 5	118 2 14	.2	.07	2.0	1.00	70	N	N	N	30
IN016	36 46 10	118 2 14	.2	.10	10.0	>2.00	500	N	N	N	20
IN017	36 45 5	118 2 15	.5	.15	3.0	.50	200	1.0	N	N	50
IN018	36 42 5	117 59 30	2.0	2.00	15.0	.20	150	N	N	N	700
IN019	36 42 10	117 59 31	5.0	1.00	10.0	>2.00	500	N	N	N	100
IN020	36 37 22	117 56 45	1.5	<.05	1.0	.70	50	N	N	N	N
IN204	36 36 7	117 53 25	.5	.20	7.0	>2.00	300	N	N	N	100
IN205	36 33 29	117 55 5	1.0	2.00	10.0	2.00	300	1.5	N	N	100
IN206	36 34 44	117 56 29	.2	7.00	7.0	.20	100	N	N	N	100
IN001	36 46 5	118 3 20	.3	.50	5.0	>2.00	200	N	N	N	50
IN002	36 45 7	118 3 5	1.0	1.00	3.0	.50	150	5.0	N	N	100
IN003	36 44 30	118 2 55	.5	.30	5.0	.50	100	2.0	N	N	50
IN004	36 44 3	118 2 36	.5	.70	3.0	1.00	150	2.0	<500	N	50

TABLE 2.-- Continued

Sample	Ba-ppm s	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
IN100	7,000	<2	N	N	N	N	20	200	20	50	N
IN101	>10,000	<2	N	N	N	<20	<10	500	N	70	N
IN102	>10,000	<2	N	N	N	<20	<10	300	100	50	20
IN103	>10,000	<2	N	N	N	20	<10	700	N	200	N
IN104	>10,000	<2	N	N	N	<20	10	300	N	70	N
IN105	500	2	N	N	N	150	N	50	N	N	N
IN106	10,000	<2	N	N	N	N	20	100	N	<50	10
IN107	700	2	<20	N	N	200	<10	100	N	<50	10
IN108	5,000	<2	N	N	N	20	10	200	<10	70	N
IN109	5,000	5	N	N	N	150	N	N	N	N	N
IN110	10,000	3	N	N	N	100	<10	100	100	<50	N
IN111	>10,000	<2	N	N	10	N	30	100	200	<50	N
IN112	5,000	<2	N	N	N	20	30	500	200	100	N
IN113	5,000	<2	N	N	N	N	10	100	1,000	N	10
IN114	5,000	<2	N	N	N	N	N	500	50	200	N
IN115	700	<2	N	N	N	N	N	100	N	N	N
IN116	>10,000	<2	N	N	N	N	30	200	70	150	N
IN117	300	<2	N	N	N	N	N	200	N	N	N
IN118	5,000	<2	N	N	N	N	N	300	50	70	N
IN119	3,000	N	N	N	N	N	N	150	50	N	N
IN120	200	<2	N	N	N	N	<10	50	20	<50	N
IN121	100	<2	N	N	N	N	N	N	N	<50	N
IN122	50	<2	N	N	N	20	N	N	N	N	N
IN123	300	2	N	N	N	N	N	50	N	100	N
IN124	300	2	N	N	N	N	N	150	N	70	N
IN125	200	2	N	N	N	<20	<10	50	N	N	N
IN200	7,000	<2	N	N	N	N	N	150	N	<50	30
IN201	10,000	<2	N	N	N	N	<10	70	300	N	N
IN202	10,000	<2	N	N	N	20	N	300	N	70	10
IN203	1,000	<2	N	N	N	N	N	100	N	<50	N
IN013	5,000	<2	N	N	N	30	700	300	500	70	N
IN014	500	<2	N	N	N	N	10	100	N	50	N
IN015	1,000	<2	N	N	N	N	N	200	N	50	N
IN016	700	<2	N	N	20	N	<10	1,000	N	150	N
IN017	500	<2	N	N	N	N	20	200	N	N	N
IN018	>10,000	<2	N	N	20	50	<10	50	N	N	20
IN019	>10,000	<2	N	N	30	N	N	700	N	200	30
IN020	700	N	N	N	N	N	N	150	N	N	N
IN204	10,000	<2	N	N	N	<20	<10	700	<10	100	10
IN205	2,000	<2	N	N	N	100	20	100	N	50	20
IN206	500	<2	<20	N	N	<20	N	N	N	N	N
IN001	700	<2	N	N	N	N	N	1,000	N	100	N
IN002	1,000	<2	30	N	10	20	30	100	N	<50	20
IN003	10,000	<2	70	N	N	<20	20	200	20	N	N
IN004	10,000	<2	N	N	N	<20	50	200	30	<50	10

TABLE 2.-- Continued

Sample	Pb-ppm s	Sb-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
IN100	500	N	N	200	200	N	300	N	>2,000	500
IN101	200	N	N	5,000	150	N	300	N	>2,000	300
IN102	5,000	N	N	10,000	150	N	200	N	>2,000	N
IN103	300	N	30	1,000	200	N	300	N	>2,000	<200
IN104	1,000	N	N	500	200	N	500	N	>2,000	200
IN105	200	N	N	300	150	300	30	N	>2,000	N
IN106	150	N	N	200	100	N	500	N	>2,000	300
IN107	100	N	N	200	200	N	70	N	>2,000	<200
IN108	500	N	70	500	200	N	200	N	>2,000	<200
IN109	N	N	N	100	150	N	20	N	>2,000	N
IN110	700	N	N	2,000	100	N	100	N	>2,000	N
IN111	30,000	<200	500	500	200	1,000	300	N	>2,000	700
IN112	50,000	<200	500	500	500	1,000	500	N	>2,000	300
IN113	10,000	N	N	200	150	1,500	700	<500	>2,000	300
IN114	1,000	N	20	N	150	200	500	N	>2,000	200
IN115	200	N	N	300	50	100	100	N	>2,000	N
IN116	7,000	N	N	700	150	150	300	N	>2,000	1,500
IN117	150	N	N	200	100	N	300	N	>2,000	<200
IN118	500	N	N	200	100	N	500	N	>2,000	200
IN119	200	N	N	200	100	N	700	N	>2,000	N
IN120	500	N	1,000	N	100	5,000	20	N	>2,000	N
IN121	150	N	50	N	70	2,000	30	N	>2,000	N
IN122	500	N	N	N	50	150	50	N	>2,000	N
IN123	500	N	1,000	N	20	<100	700	N	>2,000	700
IN124	100	N	150	N	50	<100	700	N	>2,000	500
IN125	30	N	N	200	50	N	30	N	>2,000	N
IN200	200	N	100	200	150	N	200	N	>2,000	300
IN201	1,000	N	N	300	300	N	70	N	>2,000	200
IN202	20	N	N	300	150	N	200	N	>2,000	200
IN203	200	N	N	200	50	N	100	N	>2,000	200
IN013	20,000	N	30	200	200	<100	200	N	>2,000	500
IN014	200	N	N	300	150	N	100	N	>2,000	<200
IN015	20	N	N	500	50	N	100	N	>2,000	1,000
IN016	30	N	N	300	200	N	300	N	>2,000	2,000
IN017	5,000	N	N	500	1,000	N	150	500	>2,000	<200
IN018	50	N	N	700	70	N	50	N	2,000	N
IN019	300	N	30	1,000	300	N	300	N	<5,000	1,500
IN020	150	N	N	N	50	N	100	N	<2,000	<200
IN204	500	N	N	700	150	150	300	N	>2,000	<200
IN205	500	N	N	1,000	200	N	150	1,000	>2,000	N
IN206	<20	N	N	N	30	N	N	N	>2,000	N
IN001	20	N	N	500	150	N	500	N	>2,000	300
IN002	1,500	N	N	500	150	N	100	N	>2,000	1,000
IN003	1,000	N	N	700	150	<100	1,000	N	>2,000	N
IN004	2,000	N	N	500	500	100	150	N	>2,000	<200

TABLE 2.--Continued

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
IN005	36 43 20	118 1 40	.7	1.00	10.0	.70	200	1.0	N	N	500
IN006	36 42 37	118 0 45	.7	2.00	10.0	.50	500	N	N	N	2,000
IN007	36 42 20	118 0 30	3.0	1.50	7.0	1.00	200	3.0	<500	N	500
IN008	36 41 37	117 58 10	1.0	2.00	20.0	.30	300	N	N	N	50
IN009	36 41 40	117 58 15	1.0	2.00	10.0	.30	200	N	N	N	500
IN010	36 40 8	117 59 50	.7	2.00	10.0	.50	300	N	N	N	300
IN011	36 40 22	118 1 10	1.0	1.00	10.0	2.00	1,000	7.0	500	N	70
IN012	36 41 31	118 1 18	.3	.30	10.0	1.50	200	N	N	N	30

Sample	Ba-ppm s	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
IN005	10,000	<2	50	N	100	70	<10	150	15	<50	10
IN006	10,000	2	70	N	N	100	20	150	20	<50	30
IN007	>10,000	<2	N	N	100	70	10	150	50	<50	50
IN008	100	<2	N	N	N	100	N	50	10	N	15
IN009	200	<2	N	N	20	70	N	N	N	N	20
IN010	5,000	<2	N	N	N	70	<10	50	N	N	10
IN011	500	<2	30	N	15	20	500	500	200	100	10
IN012	>10,000	<2	N	N	N	N	N	200	N	N	<10

Sample	Pb-ppm s	Sb-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
IN005	500	N	N	700	150	300	150	N	>2,000	300
IN006	200	N	N	700	150	1,500	70	<500	>2,000	N
IN007	500	N	N	1,000	150	N	150	N	>2,000	N
IN008	20	N	N	200	100	N	70	N	>2,000	N
IN009	<20	N	N	200	100	N	50	N	700	N
IN010	70	N	30	300	100	N	100	N	2,000	N
IN011	>50,000	1,000	<20	500	3,000	1,000	300	1,000	>2,000	1,000
IN012	200	N	N	3,000	70	N	200	N	>2,000	300