UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Analytical results and sample locality map of stream-sediment, heavy-mineral-concentrate, and rock samples from the Mancos Mesa Wilderness Study Area (UT-060-181), San Juan County, Utah

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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 resource potential. 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 Mancos Mesa Wilderness Study Area (WSA), San Juan County, Utah.

INTRODUCTION

In May 1987, the U.S. Geological Survey conducted a reconnaissance geochemical survey of the Mancos Mesa Wilderness Study Area (UT-060-181) in southwest San Juan County, Utah (fig. 1). The 51,440 acre (80 square mile) WSA is 50 miles west of Blanding Utah, and lies just east of Lake Powell. The Glen Canyon National Recreation Area borders the west and north sides of the WSA. The east boundary is an escarpment bounding the northwest-trending Red Canyon. The south boundary is west-trending Moqui Canyon.

Access to the eastern and southern margins of the study area is by jeep roads from paved Utah State Highway 263. Access to the northern and western regions are by boat from Lake Powell and hiking. The interior of the WSA is inaccessible except by arduous climbing and hiking or by helicopter because of the vertical cliffs cut in the sandstones of the Glen Canyon Group.

Like many mesas in the Colorado Plateau physiographic province, Mancos Mesa is sparsely vegetated by desert shrubs. The mesa top has scattered blackbrush, Buffalo berry, Mormon tea, cactus, cliffrose, and Indian ricegrass and occasionally scattered pinyon and juniper. Blackbrush and sagebrush occur in canyon bottoms along with pinyon and juniper. Cottonwood and tamerisk trees are near the few springs and seeps. Altitudes range from 4,000 feet along the west boundary to nearly 6,500 feet along the escarpment forming the eastern boundary.

Mancos Mesa is on the gently dipping western flank of the north-trending Monument uplift, a regional elongate structure about 90 miles long and about 30 miles wide. The oldest rocks exposed in the WSA comprise the Upper Triassic Chinle Formation consisting of fluvial and lacustrine mudstone, siltstone, sandstone, conglomerate, and minor limestone. The Chinle Formation is overlain by the Lower Jurassic Glen Canyon Group that, in ascending order, includes the Wingate Sandstone composed dominantly of eolian sandstone, the Kayenta Formation composed of fluvial and lacustrine sandstone, siltstone, conglomeratic sandstone and minor eolian sandstone, and the Navajo Sandstone composed of eolian sandstone and thin beds of playa-lake limestone and dolostone. The Middle Jurassic Carmel Formation, which overlies the Navajo Sandstone, is the youngest formation in the WSA. Only the lower part of the Carmel is preserved where it caps a few small mesas and buttes.

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.

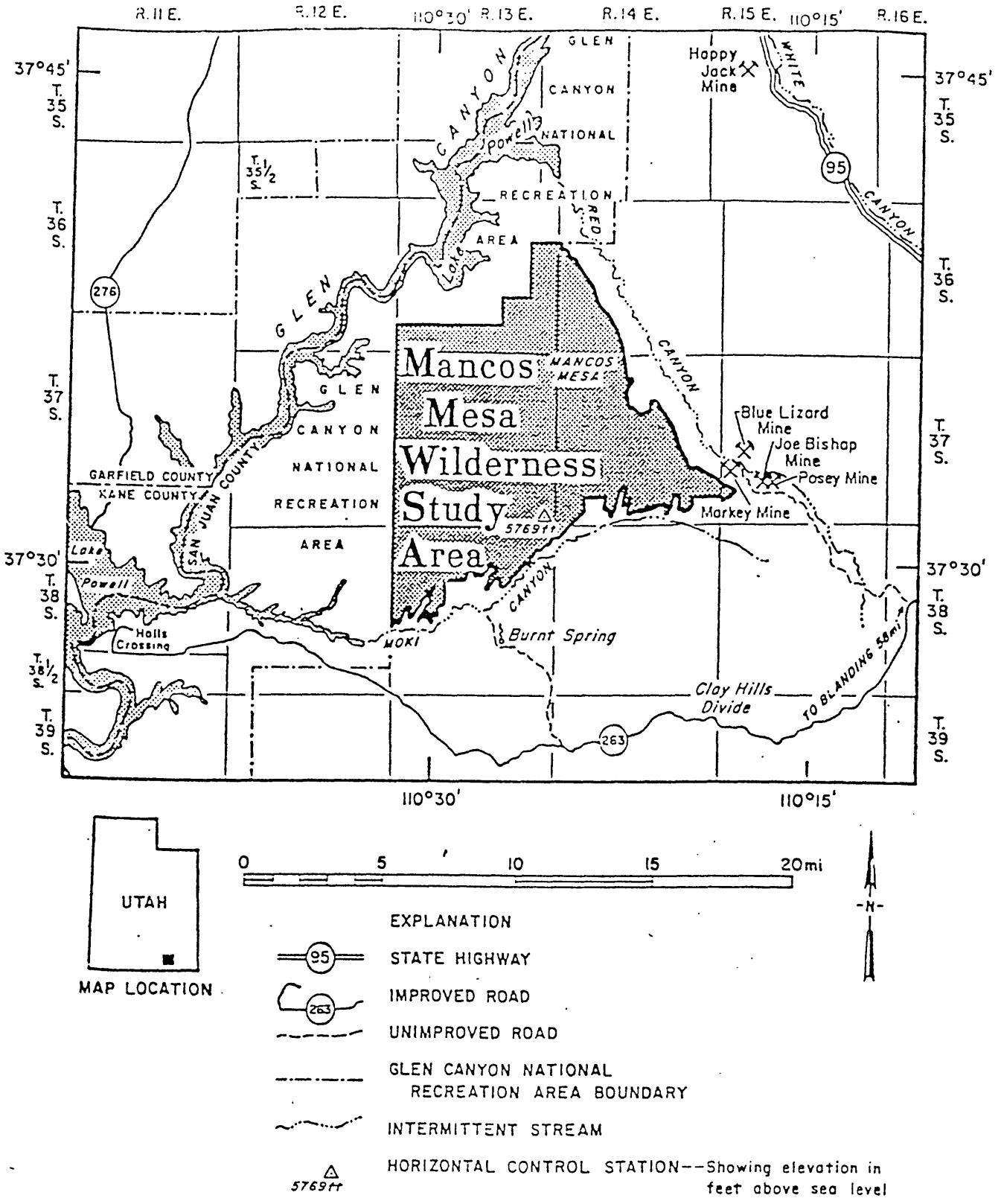

Figure 1.--Index map of the Mancos Mesa Wilderness Study Area, San Juan County, Utah.

Heavy-mineral-concentrate samples provide information about the chemistry of a limited number of 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.

Analyses of unaltered or unmineralized rock samples provide background geochemical data for individual rock units. 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 36 sites within the WSA or within a mile of the escarpment forming the eastern boundary (see plate 1). Seventeen sites were sampled in Cedar Canyon, three in Forgotten Canyon, four in North Gulch, six in Moqui Canyon, and six along minor drainages to the east into Red Canyon. At all sites, both a stream-sediment sample and a heavy-mineral-concentrate sample were collected. Sampling density was about one sample site per 2.2 mi^2. The area of the drainage basins sampled ranged from 0.2 to 2 square miles. Sufficient heavy-mineral-concentrate for spectrographic analysis (5 mg) was recovered from all sites. Thirty five rock samples were collected from 27 of the sites.

Stream-sediment samples

The stream-sediment samples consisted of active alluvium collected primarily from first-order (unbranched) and second-order (below the junction of two first-order) stream as shown on USGS topographic maps (scale = 1:24,000). Each sample was composited from several localities within an area that may extend as much as 50 feet from the site plotted on the map.

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.

Rock samples

Rock samples were collected from outcrops of unmineralized rock. A description of the rock type collected at each site is given in table 6.

Sample Preparation

The stream-sediment samples were air dried, then sieved using an 80-mesh (0.17-mm) stainless-steel sieve. The portion of the sediment passing through the sieve was saved for analysis.

After air drying the samples, 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 and 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 degrees and a tilt of 10 degrees 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

Stream-sediment, heavy-mineral-concentrate, and rock samples were analyzed for 35 elements using a semiquantitative, direct-current arc emission spectrographic method (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 stream sediments, heavy-mineral concentrates, and rocks are listed in tables 3, 4, and 5, respectively.

Chemical Methods

The stream-sediment and rock samples from the study area were also analyzed by inductively coupled plasma atomic emission spectroscopy (ICP) and ultraviolet fluorimetry (UF). Arsenic (As), antimony (Sb), bismuth (Bi), cadmium (Cd), and zinc (Zn) were analyzed by ICP, and uranium (U) was analyzed by UF. In addition, the stream-sediment samples were analyzed for gold (Au) using atomic absorbance emission spectroscopy (AA). Limits of determination and references are listed in table 2.

Analytical results using these methods are listed in tables 3 and 5.

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, 1976).

DESCRIPTION OF DATA TABLES

Tables 3, 4, and 5 list the analyses for stream-sediment, heavy-mineral-concentrate, and rock samples, respectively. For the three 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 map (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, "uf" indicates ultraviolet fluorimetric analyses, and "icp" indicates inductively couple plasma 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. For emission spectrographic analyses, a "less than" symbol (<) entered in the tables in front of the lower limit of determination indicates that the element was observed but was below the lowest reporting value. For ICP and AA analyses, a "less than" symbol (<) entered in the tables in front of the lower limit of determination indicates that the element was below the lowest reporting value. If an element was observed but was above the highest reporting value, a "greater than" symbol (>) was entered in front of the upper limit of determination. If an element was not looked for in a sample, two dashes (--) are entered in the tables in place of the analytical value. Because of the formatting used in the computer program that produced the data tables, 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. Rock and stream-sediment samples were not analyzed for Ga, Ge, Na, and P.

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

[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 listed, except as noted]

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

*Determined in heavy-mineral-concentrate samples only. Limits are for heavy-mineral-concentrate samples.

TABLE 2.--Analytical methods used other than emission spectrography

[ICP = inductively coupled plasma spectroscopy; UF= ultraviolet fluorimetry; AA = atomic absorption spectroscopy]

Element determined	Sample type	Method	Lower determination limit, ppm	References
Arsenic (As)	rock/stream sediment	ICP	5	Crock and others, 1987.
Antimony (Sb)	rock/stream sediment	ICP	2	
Bismuth (Bi)	rock/stream sediment	ICP	2	
Cadmium (Cd)	rock/stream sediment	ICP	0.1	
Zinc (Zn)	rock/stream sediment	ICP	2	
Uranium (U)	rock/stream sediment	UF	0.1	Centanni and others, 1956; O'Leary and Meier, 1986.
Gold (Au)	stream sediment	AA	0.1	Thompson and others, 1968; O'Leary and Meier, 1986.

TABLE 3--ANALYTICAL RESULTS OF STREAM-SEDIMENT SAMPLES FROM THE MANCOS MESA WILDERNESS STUDY AREA, SAN JUAN COUNTY, UTAH.

[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
MM001S	37 28 6	110 30 52	.5	.20	.20	.15	30	N	N	N	20	150
MM002S	37 28 0	110 30 42	.2	.10	<.05	.03	<10	N	N	N	20	100
MM003S	37 28 54	110 28 29	.3	.20	.10	.05	30	N	N	N	10	150
MM004S	37 30 32	110 25 15	.7	.50	.20	.15	70	N	N	N	50	200
MM005S	37 31 8	110 23 55	.7	.30	.07	.10	30	N	N	N	15	100
MM006S	37 31 36	110 22 25	.7	1.50	1.50	.15	200	N	N	N	50	300
MM007S	37 31 38	110 27 3	.2	.07	<.05	.07	10	N	N	N	30	70
MM008S	37 31 47	110 27 9	.3	.20	.10	.10	30	N	N	N	30	200
MM009S	37 30 40	110 30 21	1.0	1.00	.50	.15	200	N	N	N	50	200
MM010S	37 30 13	110 30 35	.5	.20	.05	.05	50	N	N	N	20	100
MM011S	37 31 49	110 31 40	.3	.10	<.05	.07	15	N	N	N	20	100
MM012S	37 32 25	110 30 42	.3	.03	<.05	.05	<10	N	N	N	10	100
MM013S	37 32 48	110 31 34	.5	.20	.10	.10	50	N	N	N	70	200
MM014S	37 35 15	110 31 35	.2	.10	.50	.03	15	N	N	N	10	70
MM015S	37 35 40	110 29 47	.3	.20	<.05	.05	15	N	N	N	30	100
MM016S	37 35 29	110 29 16	.5	.20	.07	.10	20	N	N	N	70	150
MM017S	37 35 33	110 29 8	.3	.20	.07	.07	30	N	N	N	20	200
MM018S	37 36 32	110 29 53	.5	.20	.07	.15	20	N	N	N	50	200
MM019S	37 37 5	110 29 5	.5	.50	.15	.10	50	N	N	N	30	200
MM020S	37 36 55	110 27 58	.5	.30	.10	.10	20	N	N	N	50	300
MM021S	37 37 0	110 28 31	.3	.15	.10	.05	20	N	N	N	10	70
MM022S	37 37 42	110 26 25	1.0	.30	.10	.10	30	N	N	N	50	700
MM023S	37 37 41	110 24 50	.5	.30	.15	.07	30	N	N	N	50	200
MM024S	37 37 13	110 24 54	.3	.20	<.05	.05	15	N	N	N	30	150
MM025S	37 35 9	110 28 43	.3	.20	<.05	.07	10	N	N	N	20	150
MM026S	37 33 58	110 26 46	.2	.10	<.05	.03	10	N	N	N	30	100
MM027S	37 33 53	110 25 44	.5	.20	.05	.10	30	N	N	N	30	200
MM028S	37 33 50	110 25 12	.5	.20	.07	.10	20	N	N	N	50	150
MM029S	37 33 17	110 24 25	.2	.20	.10	.05	50	N	N	N	70	200
MM030S	37 33 35	110 24 5	.5	.20	<.05	.07	20	N	N	N	50	100
MM031S	37 33 43	110 24 24	.2	.20	.05	.10	20	N	N	N	30	200
MM032S	37 35 47	110 21 19	10.0	2.00	2.00	1.00	500	N	N	N	70	2,000
MM033S	37 35 26	110 20 37	2.0	2.00	1.00	.20	200	N	N	N	30	300
MM034S	37 34 39	110 19 55	15.0	1.00	.70	>1.00	500	N	N	N	30	2,000
MM035S	37 33 39	110 19 32	3.0	2.00	1.50	.30	300	N	N	N	50	700
MM037S	37 33 15	110 18 37	2.0	2.00	1.50	.30	200	N	N	N	50	700

TABLE 3--ANALYTICAL RESULTS OF STREAM-SEDIMENT SAMPLES FROM THE MANCOS MESA WILDERNESS STUDY AREA, SAN JUAN COUNTY, UTAH.--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	Sb-ppm s	Sc-ppm s	Sn-ppm s
MM001S	N	N	N	N	N	<5	N	N	N	N	N	N	N	N
MM002S	N	N	N	N	N	N	N	N	N	N	N	N	N	N
MM003S	N	N	N	N	N	<5	N	N	N	N	N	N	N	N
MM004S	N	N	N	N	30	5	N	N	N	N	N	N	N	N
MM005S	N	N	N	N	N	5	N	N	N	N	N	N	N	N
MM006S	<1	N	N	N	<10	5	N	N	N	<5	N	N	N	N
MM007S	N	N	N	N	10	<5	N	N	N	N	N	N	N	N
MM008S	N	N	N	N	N	<5	N	N	N	N	N	N	N	N
MM009S	<1	N	N	N	<10	7	N	N	N	5	<10	N	N	N
MM010S	N	N	N	N	N	N	N	N	N	N	N	N	N	N
MM011S	N	N	N	N	N	N	N	N	N	N	N	N	N	N
MM012S	N	N	N	N	N	<5	N	N	N	N	N	N	N	N
MM013S	N	N	N	N	10	<5	N	N	N	N	N	N	N	N
MM014S	N	N	N	N	N	N	N	N	N	N	N	N	N	N
MM015S	N	N	N	N	N	N	N	N	N	N	N	N	N	N
MM016S	N	N	N	N	N	<5	N	N	N	N	N	N	N	N
MM017S	N	N	N	N	50	<5	<20	N	N	N	N	N	N	N
MM018S	N	N	N	N	<10	N	N	N	N	N	N	N	<5	N
MM019S	N	N	N	N	N	5	N	N	N	N	N	N	N	N
MM020S	N	N	N	N	15	7	N	N	N	N	N	N	N	N
MM021S	N	N	N	N	N	<5	N	N	N	N	N	N	<5	N
MM022S	N	N	N	N	30	N	N	N	N	<5	N	N	N	N
MM023S	N	N	N	N	N	<5	N	N	N	N	N	N	N	N
MM024S	N	N	N	N	N	<5	N	N	N	N	N	N	N	N
MM025S	N	N	N	N	N	N	N	N	N	N	N	N	N	N
MM026S	N	N	N	N	N	N	N	N	N	N	N	N	N	N
MM027S	N	N	N	N	<10	<5	N	N	N	N	N	N	N	N
MM028S	N	N	N	N	10	<5	N	N	N	N	N	N	N	N
MM029S	N	N	N	N	50	<5	N	N	N	N	N	N	N	N
MM030S	N	N	N	N	N	N	N	N	N	N	N	N	N	N
MM031S	N	N	N	N	N	5	N	N	N	N	N	N	N	N
MM032S	1	N	N	15	50	70	30	N	<20	7	30	N	5	N
MM033S	<1	N	N	10	<10	10	<20	N	N	10	<10	N	<5	N
MM034S	1	N	N	15	<10	50	<20	N	30	10	20	N	5	N
MM035S	<1	N	N	5	<10	15	20	N	<20	5	15	N	<5	N
MM037S	<1	N	N	5	10	10	N	N	N	5	10	N	<5	N

TABLE 3--ANALYTICAL RESULTS OF STREAM-SEDIMENT SAMPLES FROM THE MANCOS MESA WILDERNESS STUDY AREA, SAN JUAN COUNTY, UTAH.--Continued

Sample	Sr-ppm s	V-ppm s	W-ppm s	Y-ppm s	Zn-ppm s	Zr-ppm s	Th-ppm s	As-ppm icp	Bi-ppm icp	Cd-ppm icp	Sb-ppm icp	Zn-ppm icp	Au-ppm aa	U-ppm uf
MM001S	N	10	N	N	N	300	N	<5	<2	<.1	<2	4	<.05	.10
MM002S	N	<10	N	N	N	70	N	<5	<2	<.1	<2	3	<.05	.20
MM003S	N	<10	N	N	N	200	N	<5	<2	<.1	<2	5	<.05	.35
MM004S	N	15	N	N	N	300	N	<5	<2	<.1	<2	3	<.05	.10
MM005S	N	<10	N	N	N	100	N	<5	<2	<.1	<2	4	<.05	.20
MM006S	<100	15	N	N	N	300	N	<5	<2	<.1	<2	3	<.05	.30
MM007S	N	<10	N	N	N	500	N	<5	<2	<.1	<2	3	<.05	.25
MM008S	N	10	N	<10	N	1,000	N	<5	<2	<.1	<2	3	<.05	.10
MM009S	<100	20	N	<10	N	500	N	<5	<2	<.1	<2	7	<.05	.40
MM010S	N	<10	N	N	N	30	N	<5	<2	<.1	<2	3	<.05	.20
MM011S	N	<10	N	N	N	100	N	<5	<2	.3	<2	4	<.05	.10
MM012S	N	<10	N	N	N	200	N	<5	<2	<.1	<2	2	<.05	.10
MM013S	N	<10	N	N	N	700	N	<5	<2	<.1	<2	3	<.05	.20
MM014S	N	<10	N	N	N	15	N	<5	<2	<.1	<2	3	<.05	.10
MM015S	N	<10	N	N	N	1,000	N	<5	<2	<.1	<2	3	<.05	.15
MM016S	N	<10	N	N	N	>1,000	N	<5	<2	<.1	<2	3	<.05	<.05
MM017S	N	10	N	N	N	150	N	<5	<2	<.1	<2	3	<.05	.15
MM018S	N	10	N	<10	N	>1,000	N	<5	<2	<.1	<2	3	<.05	.30
MM019S	N	<10	N	N	N	200	N	<5	<2	<.1	<2	5	<.05	.10
MM020S	N	10	N	N	N	>1,000	N	<5	<2	<.1	<2	3	<.05	.20
MM021S	N	<10	N	N	N	>1,000	N	<5	<2	<.1	<2	3	<.05	.20
MM022S	N	10	N	N	N	>1,000	N	<5	<2	<.1	<2	3	<.05	.20
MM023S	N	10	N	N	N	100	N	<5	<2	<.1	<2	5	<.05	.15
MM024S	N	<10	N	N	N	200	N	<5	<2	<.1	<2	3	<.05	.10
MM025S	N	<10	N	N	N	70	N	<5	<2	<.1	<2	3	<.05	.20
MM026S	N	<10	N	N	N	500	N	<5	<2	<.1	<2	3	<.05	.15
MM027S	N	<10	N	<10	N	>1,000	N	<5	<2	<.1	<2	3	<.05	.30
MM028S	N	10	N	N	N	1,000	N	<5	<2	<.1	<2	3	<.05	.15
MM029S	N	<10	N	N	N	100	N	<5	<2	<.1	<2	3	<.05	.10
MM030S	N	<10	N	N	N	1,000	N	<5	<2	<.1	<2	3	<.05	.20
MM031S	N	<10	N	N	N	100	N	<5	<2	<.1	<2	3	<.05	.15
MM032S	300	100	N	20	N	>1,000	N	<5	<2	1.1	<2	62	<.05	3.10
MM033S	100	30	N	10	N	200	N	<5	<2	.2	<2	11	<.05	.75
MM034S	150	150	N	50	<200	1,000	N	<5	<2	1.3	<2	62	<.05	2.30
MM035S	150	100	N	15	N	500	N	<5	<2	.4	<2	20	<.05	.80
MM037S	100	50	N	10	N	500	N	<5	<2	.5	<2	16	<.05	.55

TABLE 4--ANALYTICAL RESULTS OF HEAVY-MINERAL-CONCENTRATE SAMPLES FROM THE MANCOS MESA WILDERNESS STUDY AREA, SAN JUAN COUNTY, UTAH.

[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
MM001M	37 28 6	110 30 52	.15	.07	.2	>2.0	<20	N	N	N	N	>10,000
MM002M	37 28 0	110 30 42	<.10	<.05	N	>2.0	N	N	N	N	70	10,000
MM003M	37 28 54	110 28 29	.30	.15	.5	>2.0	20	N	N	N	30	>10,000
MM004M	37 30 32	110 25 15	.20	.10	<.1	>2.0	20	N	N	N	<20	>10,000
MM005M	37 31 8	110 23 55	.30	3.00	5.0	>2.0	500	N	N	N	30	>10,000
MM006M	37 31 36	110 22 25	.20	.20	1.0	>2.0	50	N	N	N	<20	>10,000
MM007M	37 31 38	110 27 3	.15	.05	N	>2.0	<20	N	N	N	20	>10,000
MM008M	37 31 47	110 27 9	<.10	.05	N	>2.0	N	N	N	N	<20	>10,000
MM009M	37 30 40	110 30 21	.15	.07	.3	>2.0	<20	N	N	N	N	7,000
MM010M	37 30 13	110 30 35	.10	.15	.1	>2.0	20	N	N	N	50	1,000
MM011M	37 31 49	110 31 40	.20	.10	.2	>2.0	<20	N	N	N	100	7,000
MM012M	37 32 25	110 30 42	<.10	<.05	N	1.5	N	N	N	N	<20	3,000
MM013M	37 32 48	110 31 34	<.10	<.05	N	2.0	N	N	N	N	30	1,000
MM014M	37 35 15	110 31 35	.10	.15	.1	>2.0	<20	N	N	N	30	>10,000
MM015M	37 35 40	110 29 47	.20	.30	.3	>2.0	20	N	N	N	150	>10,000
MM016M	37 35 29	110 29 16	<.10	<.05	N	2.0	<20	N	N	N	20	10,000
MM017M	37 35 33	110 29 8	.10	.05	N	2.0	N	N	N	N	<20	10,000
MM018M	37 36 32	110 29 53	.10	.05	N	.7	N	N	N	N	<20	>10,000
MM019M	37 37 5	110 29 5	.10	.07	<.1	>2.0	<20	N	N	N	N	>10,000
MM020M	37 36 55	110 27 58	<.10	.10	<.1	>2.0	<20	N	N	N	20	>10,000
MM021M	37 37 0	110 28 31	<.10	1.00	1.5	2.0	300	N	N	N	N	>10,000
MM022M	37 37 42	110 26 25	.10	.07	N	>2.0	<20	N	N	N	30	>10,000
MM023M	37 37 41	110 24 50	<.10	.10	<.1	2.0	<20	N	N	N	20	>10,000
MM024M	37 37 13	110 24 54	.15	.07	N	>2.0	<20	N	N	N	<20	10,000
MM025M	37 35 9	110 28 43	.20	.30	.3	>2.0	200	N	N	N	15	10,000
MM026M	37 33 58	110 26 46	<.10	<.05	N	1.5	N	N	N	N	20	7,000
MM027M	37 33 53	110 25 44	.15	.07	<.1	>2.0	<20	N	N	N	<20	10,000
MM028M	37 33 50	110 25 12	.10	.05	N	>2.0	<20	N	N	N	<20	>10,000
MM029M	37 33 17	110 24 25	<.10	<.05	N	2.0	N	N	N	N	<20	>10,000
MM030M	37 33 35	110 24 5	.10	.50	.3	2.0	30	N	N	N	N	>10,000
MM031M	37 33 43	110 24 24	.10	.05	N	2.0	<20	N	N	N	20	5,000
MM032M	37 35 47	110 21 19	.70	.20	1.5	1.5	200	N	N	N	30	>10,000
MM033M	37 35 26	110 20 37	.70	.50	5.0	2.0	500	2	N	20	50	>10,000
MM034M	37 34 39	110 19 55	1.00	.15	1.0	1.0	100	N	N	N	N	>10,000
MM035M	37 33 39	110 19 32	.20	.30	3.0	2.0	300	N	N	N	<20	>10,000
MM037M	37 33 15	110 18 37	.15	.30	5.0	2.0	300	N	N	N	<20	>10,000

TABLE 4--ANALYTICAL RESULTS OF HEAVY-MINERAL-CONCENTRATE SAMPLES FROM THE MANCOS MESA WILDERNESS STUDY AREA, SAN JUAN COUNTY, UTAH.--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	Sb-ppm S	Sc-ppm S	Sn-ppm S
MM001H	<2	N	N	N	N	N	N	N	N	N	30	N	100	N
MM002H	N	N	N	N	N	N	N	N	N	N	<20	N	30	N
MM003H	N	N	N	N	<20	<10	N	N	N	N	<20	N	50	N
MM004H	<2	N	N	N	<20	N	N	N	N	N	<20	N	100	N
MM005H	N	N	N	N	<20	N	N	N	N	N	<20	N	10	N
MM006H	N	N	N	N	N	N	N	N	N	N	50	N	15	N
MM007H	N	N	N	N	N	N	N	N	N	N	<20	N	150	N
MM008H	<2	N	N	N	N	N	N	N	N	N	N	N	100	N
MM009H	N	N	N	N	N	<10	N	N	N	N	<20	N	150	N
MM010H	<2	N	N	N	N	<10	N	N	N	N	<20	N	30	N
MM011H	<2	N	N	N	N	<10	N	N	N	N	<20	N	100	N
MM012H	N	N	N	N	N	N	N	N	N	N	<20	N	10	N
MM013H	N	N	N	N	N	N	N	N	N	N	<20	N	50	N
MM014H	N	N	N	N	N	<10	N	N	N	N	<20	N	15	N
MM015H	<2	N	N	N	<20	<10	N	N	N	N	20	N	70	N
MM016H	N	N	N	N	<20	N	N	N	N	N	<20	N	50	N
MM017H	N	N	N	N	<20	N	N	N	N	N	N	N	50	N
MM018H	N	N	N	N	<20	N	N	N	N	N	<20	N	10	N
MM019H	N	N	N	N	N	N	N	N	N	N	20	N	70	N
MM020H	N	N	N	N	<20	N	N	N	<50	N	<20	N	50	N
MM021H	N	N	N	N	N	N	N	N	N	N	<20	N	15	N
MM022H	N	N	N	N	<20	N	N	N	N	N	<20	N	70	N
MM023H	N	N	N	N	<20	N	N	N	N	N	<20	N	20	N
MM024H	N	N	N	N	<20	N	N	N	N	N	N	N	70	N
MM025H	N	N	N	N	30	N	N	N	N	<10	<20	N	50	N
MM026H	N	N	N	N	N	N	N	N	N	N	<20	N	30	N
MM027H	N	N	N	N	N	<10	N	N	N	N	<20	N	70	N
MM028H	<2	N	N	N	N	N	N	N	N	N	<20	N	100	N
MM029H	N	N	N	N	N	N	N	N	N	N	<20	N	50	N
MM030H	N	N	N	N	N	N	N	N	N	N	20	N	50	N
MM031H	N	N	N	N	N	N	N	N	N	N	20	N	70	N
MM032H	<2	N	N	N	<20	15	150	N	<50	N	100	N	<10	70
MM033H	N	N	N	N	N	N	150	N	<50	N	20	N	N	N
MM034H	<2	N	N	N	N	100	200	N	N	N	<20	N	N	N
MM035H	<2	N	N	N	N	10	150	50	<50	N	200	N	<10	70
MM037H	<2	N	N	N	N	<10	100	N	<50	N	20	N	<10	50

TABLE 4--ANALYTICAL RESULTS OF HEAVY-MINERAL-CONCENTRATE SAMPLES FROM THE MANCOS MESA WILDERNESS STUDY AREA, SAN JUAN COUNTY, UTAH.--Continued

Sample	Sr-ppm s	Y-ppm s	W-ppm s	Y-ppm s	Zn-ppm s	Zr-ppm s	Ga-ppm s	Ge-ppm s	Na-pct. s	P-pct. s	Th-ppm s	Pt-ppm s	Pd-ppm s
MM001M	<200	150	N	1,500	N	>2,000	70	N	N	N	N	N	N
MM002M	<200	70	N	1,000	N	>2,000	N	N	N	N	N	N	N
MM003M	200	200	N	1,000	N	>2,000	70	N	N	.5	N	N	N
MM004M	<200	100	N	1,500	N	>2,000	<10	N	N	N	N	N	N
MM005M	7,000	100	N	1,000	N	>2,000	30	N	N	N	N	N	N
MM006M	>10,000	200	N	1,000	N	>2,000	50	N	N	N	N	N	N
MM007M	<200	100	N	1,500	N	>2,000	N	N	N	N	N	N	N
MM008M	200	70	N	1,500	N	>2,000	N	N	N	N	N	N	N
MM009M	N	150	N	2,000	N	>2,000	100	N	N	<.5	N	N	N
MM010M	N	100	N	700	N	>2,000	50	N	N	<.5	N	N	N
MM011M	N	150	N	1,500	N	>2,000	70	N	N	<.5	N	N	N
MM012M	<200	20	N	500	N	>2,000	N	N	N	N	N	N	N
MM013M	<200	50	N	1,500	N	>2,000	N	N	N	N	N	N	N
MM014M	500	50	N	1,000	N	>2,000	70	N	N	N	N	N	N
MM015M	200	100	N	1,500	N	>2,000	100	N	N	N	N	N	N
MM016M	<200	50	N	1,000	N	>2,000	10	N	N	N	N	N	N
MM017M	N	50	N	1,500	N	>2,000	<10	N	N	N	N	N	N
MM018M	200	30	N	500	N	>2,000	N	N	N	<.5	N	N	N
MM019M	<200	100	N	1,500	N	>2,000	100	N	N	N	N	N	N
MM020M	300	70	N	1,000	N	>2,000	<10	N	N	N	N	N	N
MM021M	300	70	N	700	N	>2,000	30	N	N	N	N	N	N
MM022M	200	70	N	1,000	N	>2,000	<10	N	N	N	N	N	N
MM023M	500	30	N	700	N	>2,000	10	N	N	N	N	N	N
MM024M	N	70	N	1,000	N	>2,000	N	N	N	N	N	N	N
MM025M	300	70	N	1,000	N	>2,000	50	N	N	N	N	N	N
MM026M	N	30	N	1,000	N	>2,000	N	N	N	N	N	N	N
MM027M	N	100	N	1,500	N	>2,000	100	N	N	N	N	N	N
MM028M	N	100	N	1,500	N	>2,000	100	N	N	N	N	N	N
MM029M	<200	50	N	1,000	N	>2,000	N	N	N	N	N	N	N
MM030M	N	70	N	1,500	N	>2,000	100	N	N	N	N	N	N
MM031M	N	50	N	1,500	N	>2,000	150	N	N	N	N	N	N
MM032M	>10,000	50	N	700	N	>2,000	N	N	N	.7	N	N	N
MM033M	>10,000	100	N	500	N	>2,000	70	N	<.5	.7	N	N	N
MM034M	>10,000	50	N	500	N	>2,000	20	N	N	.5	N	N	N
MM035M	>10,000	50	N	500	N	>2,000	N	N	<.5	1.0	N	N	N
MM037M	>10,000	70	N	700	N	>2,000	N	N	.5	1.0	N	N	N

TABLE 5--ANALYTICAL RESULTS OF ROCK SAMPLES FROM THE MANCOS MESA WILDERNESS STUDY AREA, SAN JUAN COUNTY, UTAH.
[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
MM001R	37 28 6	110 30 52	.30	.20	.10	.070	20	N	N	N	50	100
MM003R	37 28 54	110 28 29	.50	7.00	7.00	.010	150	N	N	N	20	<20
MM004R	37 30 32	110 25 15	.50	3.00	5.00	.050	200	N	N	N	100	700
MM005R	37 31 8	110 23 55	.50	5.00	5.00	.030	200	N	N	N	30	50
MM006R	37 31 36	110 22 25	1.00	5.00	10.00	.050	300	N	N	N	50	200
MM007R	37 31 38	110 27 3	.20	.20	.05	.020	20	N	N	N	30	100
MM008R	37 31 47	110 27 9	.50	7.00	5.00	.010	700	N	N	N	10	50
MM009R	37 30 40	110 30 21	.10	.10	<.05	.020	10	N	N	N	30	50
MM011R	37 31 49	110 31 40	.50	3.00	1.00	.070	500	N	N	N	30	100
MM012R	37 32 25	110 30 42	.20	.20	10.00	.005	150	N	N	N	100	30
MM013R	37 32 48	110 31 34	.30	.20	<.05	.070	15	N	N	N	20	150
MM014R	37 35 15	110 31 35	2.00	.50	<.05	.500	<10	N	N	N	70	150
MM015R	37 35 40	110 29 47	.15	1.00	.20	.010	70	N	N	N	10	5,000
MM017R	37 35 33	110 29 8	.07	10.00	10.00	<.002	300	N	N	N	<10	20
MM018R	37 36 32	110 29 53	.50	7.00	10.00	.070	700	N	N	N	10	70
MM019R	37 37 5	110 29 5	.50	1.50	.30	.070	100	N	N	N	30	70
MM022R	37 37 42	110 26 25	.70	10.00	15.00	.020	1,000	N	N	N	30	300
MM024R	37 37 13	110 24 54	.70	.70	.20	.150	50	N	N	N	70	100
MM025R	37 35 9	110 28 43	.30	.30	.50	.030	50	N	N	N	10	100
MM026R	37 33 58	110 26 46	.20	.20	.05	.020	<10	N	N	N	10	150
MM030R	37 33 35	110 24 5	.30	.10	<.05	.050	10	N	N	N	70	100
MM032R	37 35 47	110 21 19	10.00	5.00	15.00	.150	>5,000	N	N	N	<10	5,000
MM033R	37 35 26	110 20 37	7.00	2.00	1.00	.200	200	N	N	N	20	1,000
MM034R	37 34 39	110 19 55	10.00	.50	1.50	.150	300	N	N	N	20	150
MM034X	37 34 39	110 19 55	>20.00	.20	.20	.020	700	N	N	N	30	5,000
MM035R	37 33 39	110 19 32	5.00	2.00	10.00	.500	2,000	N	N	N	30	>5,000
MM036A	37 32 30	110 17 5	7.00	.05	.50	.007	100	N	200	N	<10	1,000
MM036B	37 32 30	110 17 5	.30	.07	<.05	.100	1,000	1.5	N	N	10	100
MM036C	37 32 30	110 17 5	15.00	.20	<.05	1.000	500	1.0	N	N	10	200
MM036D	37 32 30	110 17 5	.50	.02	.70	.070	70	N	N	N	<10	50
MM036E	37 32 30	110 17 5	.20	.05	<.05	1.000	700	<.5	N	N	<10	100
MM036F	37 32 30	110 17 5	.50	.02	<.05	.100	<10	30.0	N	N	10	<20
MM036G	37 32 30	110 17 5	5.00	.10	<.05	.700	70	10.0	N	N	<10	70
MM036I	37 32 30	110 17 5	.20	<.02	<.05	<.002	<10	2.0	N	N	10	N
MM037R	37 33 15	110 18 37	3.00	7.00	7.00	.200	500	N	N	N	30	300

TABLE 5--ANALYTICAL RESULTS OF ROCK SAMPLES FROM THE MANCOS MESA WILDERNESS STUDY AREA, SAN JUAN COUNTY, UTAH.--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	Sb-ppm s	Sc-ppm s
MM001R	N	N	N	N	15	7	N	N	N	<5	N	N	N
MM003R	N	N	N	<5	N	7	N	N	N	N	N	N	N
MM004R	N	N	N	N	N	20	N	N	N	5	N	N	<5
MM005R	N	N	N	N	N	7	N	N	N	<5	N	N	N
MM006R	N	N	N	<5	N	15	N	N	N	5	N	N	N
MM007R	N	N	N	N	N	<5	N	N	N	<5	N	N	N
MM008R	N	N	N	N	N	7	N	N	N	N	<10	N	N
MM009R	N	N	N	N	N	<5	N	N	N	N	N	N	N
MM011R	N	N	N	<5	N	<5	N	N	N	N	N	N	N
MM012R	N	N	N	N	N	5	N	N	N	N	N	N	N
MM013R	N	N	N	N	N	N	N	N	N	N	N	N	N
MM014R	3	N	N	<5	N	10	N	<5	<20	N	N	N	7
MM015R	N	N	N	N	N	<5	N	N	N	N	N	N	N
MM017R	N	N	N	N	N	<5	N	N	N	N	N	N	N
MM018R	N	N	N	<5	N	5	N	N	N	N	<10	N	N
MM019R	N	N	N	N	N	<5	N	N	N	<5	N	N	N
MM022R	N	N	N	N	N	7	N	N	N	<5	10	N	N
MM024R	<1	N	N	N	N	5	N	N	N	<5	N	N	N
MM025R	N	N	N	N	N	<5	N	N	N	N	N	N	N
MM026R	N	N	N	N	N	7	N	N	N	N	N	N	N
MM030R	N	N	N	N	N	<5	N	N	N	N	N	N	N
MM032R	N	N	N	15	<10	10	<20	N	N	20	15	N	5
MM033R	<1	N	N	7	10	7	<20	N	N	10	<10	N	5
MM034R	N	N	N	<5	N	10	N	100	N	10	10	N	N
MM034X	10	N	N	50	N	10	N	20	N	70	30	N	<5
MM035R	<1	N	N	10	<10	15	20	N	N	15	<10	N	5
MM036A	1	N	N	100	<10	30	N	<5	N	50	N	N	N
MM036B	3	N	N	500	N	2,000	N	N	N	50	N	N	N
MM036C	15	N	N	150	<10	20,000	<20	N	<20	150	10	N	5
MM036D	1	N	N	20	N	>20,000	N	N	N	20	N	N	N
MM036E	<1	N	N	150	N	10,000	N	N	N	50	N	N	N
MM036F	1	N	N	N	N	>20,000	N	20	N	N	20	N	N
MM036G	2	N	N	50	<10	>20,000	70	10	<20	20	50	N	<5
MM036I	N	N	N	N	N	20,000	N	N	N	N	<10	N	N
MM037R	1	N	N	10	10	15	<20	N	N	10	20	N	5

TABLE 3.--ANALYTICAL RESULTS OF ROCK SAMPLES FROM THE RANCOS BESA WILDERNESS STUDY AREA, SAN JUAN COUNTY, UTAH.--Continued

Sample	Sn-ppm s	Sr-ppm s	V-ppm s	W-ppm s	Y-ppm s	Zn-ppm s	Zr-ppm s	Th-ppm s	As-ppm icp	Bi-ppm icp	Cd-ppm icp	Sb-ppm icp	Zn-ppm icp	U-ppm uf
MM001R	N	N	<10	N	N	N	100	N	<5	<2	<.1	<2	4	.30
MM003R	N	N	<10	N	<10	N	<10	N	<5	<2	.2	<2	<2	.60
MM004R	N	200	15	N	N	N	20	N	<5	<2	.2	<2	4	.40
MM005R	N	100	<10	N	N	N	20	N	<5	<2	.1	<2	5	.25
MM006R	N	200	20	N	N	N	15	N	<5	<2	.1	<2	5	.20
MM007R	N	N	<10	N	N	N	150	N	<5	<2	<.1	<2	4	.30
MM008R	N	<100	<10	N	N	N	20	N	<5	<2	.2	<2	4	.80
MM009R	N	N	<10	N	N	N	15	N	<5	<2	<.1	<2	4	.30
MM011R	N	N	15	N	N	N	100	N	<5	<2	.2	<2	10	.30
MM012R	N	200	10	N	N	N	<10	N	<5	<2	.1	<2	2	.40
MM013R	N	N	N	N	N	N	70	N	<5	<2	<.1	<2	<2	.10
MM014R	N	N	30	N	15	N	500	N	<5	<2	<.1	<2	<2	.35
MM015R	N	N	10	N	N	N	50	N	<5	<2	<.1	<2	5	.45
MM017R	N	1,000	<10	N	N	N	N	N	<5	<2	.1	<2	<2	1.10
MM018R	N	<100	30	N	<10	N	70	N	<5	<2	.3	<2	<2	.30
MM019R	N	N	<10	N	N	N	100	N	<5	<2	<.1	<2	4	.20
MM022R	N	300	<10	N	<10	N	100	N	<5	<2	.3	<2	<2	.50
MM024R	N	N	10	N	N	N	500	N	<5	<2	.1	<2	5	.40
MM025R	N	N	<10	N	N	N	100	N	<5	<2	<.1	<2	3	<.05
MM026R	N	N	<10	N	N	N	<10	N	<5	<2	<.1	<2	3	.20
MM030R	N	N	<10	N	N	N	70	N	<5	<2	<.1	<2	3	.25
MM032R	N	500	30	N	30	N	20	N	<5	<2	.4	<2	45	.80
MM033R	N	<100	30	N	10	N	150	N	<5	<2	.7	<2	43	.55
MM034R	N	<100	15	N	<10	N	150	N	20	<2	.5	<2	9	.30
MM034X	N	200	70	N	30	200	N	N	31	<2	.3	<2	32	1.60
MM035R	N	500	20	N	20	N	1,000	N	<5	<2	.6	<2	32	.55
MM036A	N	100	<10	N	<10	1,000	100	N	380	<2	1.0	<2	1,000	27.00
MM036B	N	N	70	N	20	N	200	N	<5	<2	.5	<2	66	87.00
MM036C	N	N	200	N	200	<200	1,000	N	7	<2	1.4	<2	280	900.00
MM036D	N	N	15	N	15	N	30	N	<5	<2	.3	<2	190	44.00
MM036E	N	N	15	N	20	N	200	N	<5	<2	.7	<2	190	36.00
MM036F	N	N	70	N	<10	N	50	N	8	<2	<.1	<2	220	680.00
MM036G	N	N	70	N	15	N	150	N	110	<2	<.1	<2	65	670.00
MM036I	N	N	<10	N	N	N	30	N	8	<2	<.1	<2	8	210.00
MM037R	N	100	50	N	15	N	150	N	<5	<2	.5	<2	22	.55

TABLE 6 DESCRIPTION OF ROCK SAMPLES

[JK= kayenta formation, JW = wingate formation; Trc = chinle formation; Trcs = shinarump member of chinle formation]

MM001R.....Redish, laminated fine gr ss
MM003R.....Light gray chety ss
MM004R.....Float, reddish fine gr ss and chert ss
MM005R.....Float, light green gray silic ss
MM006R.....Green & pink silic ss
MM007R.....Red fine gr ss (JK)
MM008R.....Tan gray fine gr ss (JK)
MM009R.....Gray to grayish red fine gr ss
MM012R.....Red cross bedded ss & chert
MM013R.....Red cross bedded ss & chert
MM014R.....Black rock (volcanic?)
MM015R.....White fine gr ss (JK)
MM017R.....Red ss & chert (JK)
MM018R.....Gray, red fine gr ss (JK)
MM019R.....Red ss (JW)
MM022R.....Light gray ss
MM024R.....Red ss (JW)
MM025R.....Red limy med gr ss w qtz veins
MM026R.....Red ss (JK)
MM030R.....Pink ss (JK)
MM032R.....Ss w dark green concretion
MM033R.....Green silicified ss
MM034R.....Varicolored shale,yellow brown,(basal Trc)
MM034X..... " w magnetite
MM035R.....Dark green ss(Trc)
MM036A.....Black yellow ss (Trcs)
MM036B.....Iron manganese stain ss (Trcs)
MM036C.....Black yellow ss (Trcs)
MM036D.....Azurite on ss (Trcs)
MM036E.....Azurite on ss (Trcs)
MM036F.....Malachite on ss (Trcs)
MM036G.....Malachite on ss (Trcs)
MM036I.....Petrified wood (Trcs)
MM037R.....Brown ss & mudstone