UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

# Analytical results and sample locality maps of stream-sediment and heavy-mineral-concentrate samples from Dolores River Canyon Wilderness Study Area (CO-030-290), Montrose and San Miguel Counties, Colorado

By

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature. Any use of trade names is for descriptive purposes only and does not imply endorsement by the USGS.

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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 Dolores River Canyon Wilderness Study Areas, Montrose County, Colorado.

## INTRODUCTION

In May, 1986, the U.S. Geological Survey conducted a reconnaissance geochemical survey of the Dolores River Canyon Wilderness Study Area (CO-030-290) in Montrose and San Miguel Counties, Colorado.

The Dolores River Canyon comprises about 44.4 $mi^2$ (28,400 acres) in the southwest corner of Montrose County and the northwest corner of San Miguel County, Colorado and lies on the Dolores River between Slick Rock and Bedrock, Colorado (see fig. 1). Access to the study area is provided on the south by a dirt road branching off State Highway 141 approximately 14 mi east of Slick Rock. Access to the north end is by State Highway 90 at Bedrock.

The irregular area is about 11 mi across and includes the canyons of the Dolores River and its principal tributaries, Coyote Wash, Wild Steer Canyon, and Spring Creek. Elevations range from about 6,300 ft on the mesa rim down to 5,000 ft where the Dolores River crosses the northern boundary. The area consists of deeply incised meandering streams with near vertical canyon walls rising several hundred feet to the rims of relatively flat-topped mesas.

The oldest rock exposed in the area is the Hermosa Formation of Pennsylvanian age which crops out along the southern boundary, west of the river. This unit is unconformably overlain by the Triassic Chinle Formation on the north. Above this are the cliff-making Triassic Wingate Formation and a bench formed by the Kayenta Formation. Above this are steep cliffs of Navajo sandstone of late Triassic-early Jurassic age and slopes of the Jurassic Summerville Formation. The overlying basal Salt Wash member of the Morrison Formation is the major host rock for uranium and vanadium deposits in the region (Williams, 1964).

## 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 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.

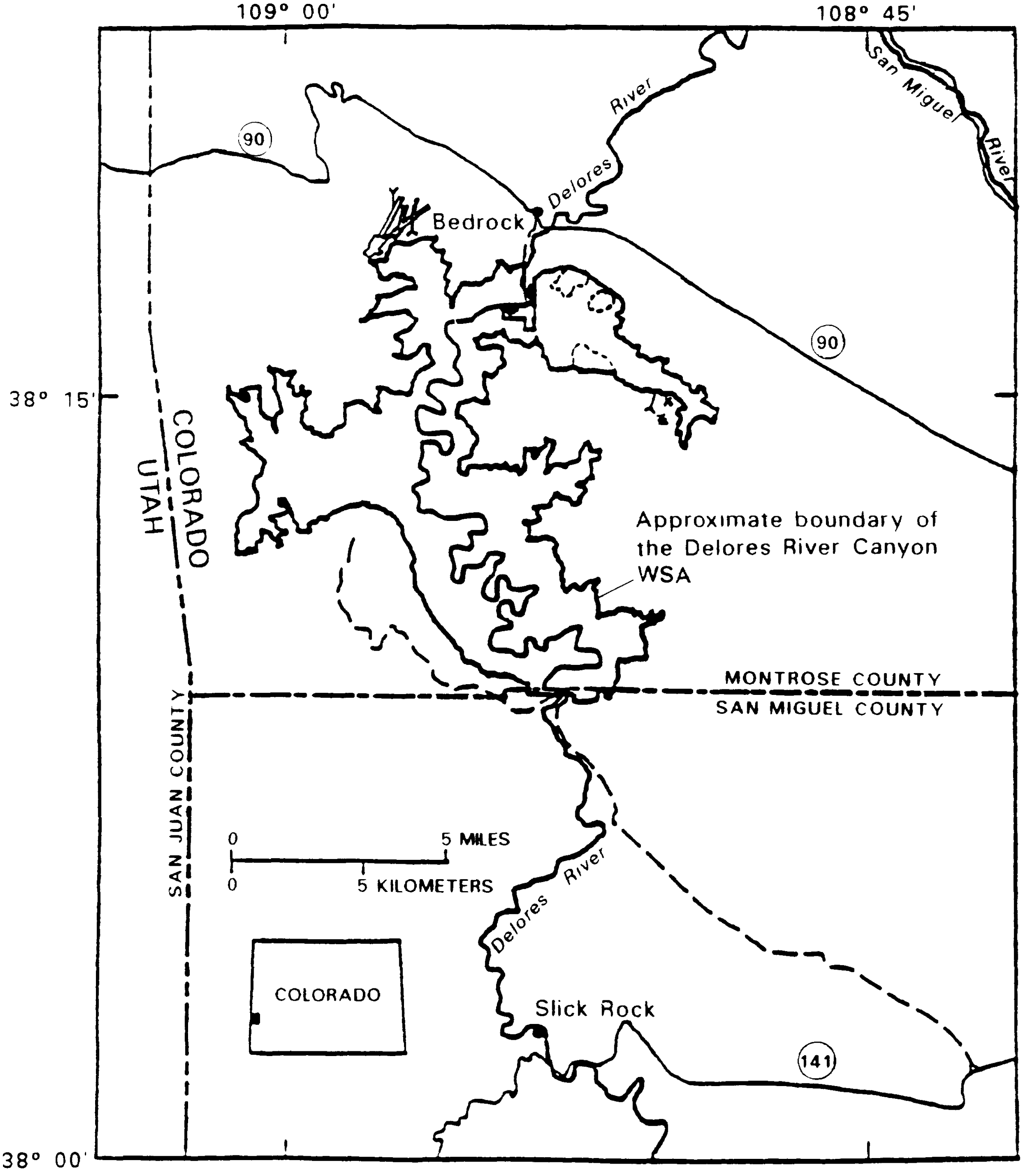


Figure 1. Index map showing location of the Dolores River Canyon Wilderness Study Area, Montrose and San Miguel Counties, Colorado.

## Sample Collection

Samples were collected at a total of 34 sites (plate 1). At all sites, both a stream-sediment sample and a heavy-mineral-concentrate sample were collected (an insufficient amount of sample DH015H was available for analysis). Sampling density was about one sample site per 1.3 $mi^2$. The area of the drainage basins sampled ranged from 0.2 to 2.0 $mi^2$.

### 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 ft 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.

## 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 the samples were air dried, 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 concentrate 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.

## Sample Analysis

### Spectrographic Method

The stream-sediment and heavy-mineral-concentrate samples were analyzed for 31 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 are listed in tables 3 and 4 for stream-sediment and heavy-mineral-concentrate samples respectively.

### Chemical Methods

The stream-sediment samples were also analyzed by inductively coupled plasma atomic emission spectroscopy (ICP), atomic absorption spectroscopy (AA), and delayed neutron analysis (DNA). These samples were analyzed by ICP for arsenic (As), antimony (Sb), bismuth (Bi), cadmium (Cd) and zinc (Zn), by AA for gold (Au) and by DNA for uranium (U) and thorium (Th). Limits of determination and references are listed in table 2.

Analytical results using these methods for stream-sediment samples are listed in table 3.

## DATA STORAGE SYSTEM

Upon completion of all analytical work, the analytical results were entered into either the Branch of Geochemistry computer data base called PLUTO or RASS (Analysis Storage System). These data bases contain 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 (Van Trump and Miesch, 1977).

## DESCRIPTION OF DATA TABLES

Tables 3 and 4 list the results of analyses for the stream-sediment and heavy-mineral concentrate samples for each of the four areas, respectively. For the 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 spectrographic analyses; "icp" indicates inductively coupled plasma-atomic emission spectroscopy; "dna" indicates delayed neutron 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 an element was observed but was below the lowest reporting value. For AA and ICP analyses, a "less than" symbol (<) entered in the tables in front of the lower limit of determination indicates that an element was below the lowest reporting value. If an element was observed but was above the highest reporting value, a "greater than" (>) was entered in the tables in front of the upper limit of determination. 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, and Ti) 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.


## ACKNOWLEDGEMENTS

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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 given for stream sediments]

| 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 | 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 |
| Lanthanum (La) | 20 | 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 | 2,000 |

## TABLE 2.--Chemical methods used

[AA = atomic absorption; ICP = inductively coupled plasma spectroscopy; DNA = delayed neutron analysis]

| Element or constituent determined | Sample type | Method | Determination limit (micrograms/ gram or ppm) | Analyst | Reference |
|---|---|---|---|---|---|
| Gold (Au) | sediments | AA | 0.1 | Kay Kennedy | Modification of Thompson and others, 1968. |
| Arsenic (As) | sediments | ICP | 5 | P.H. Briggs | Crock and others, 1983. |
| Antimony (Sb) | sediments | ICP | 2 | | |
| Zinc (Zn) | sediments | ICP | 2 | | |
| Bismuth (Bi) | sediments | ICP | 2 | | |
| Cadmium (Cd) | sediments | ICP | 0.1 | | |
| Thorium (Th) | sediments | DNA | -- | R.B. Vaughn | McKown, 1987. |
| Uranium (U) | sediments | DNA | -- | R.B. Vaughn | McKown, 1987. |

TABLE 3.--SPECTROGRAPHIC, AA, DNA, & ICP ANALYSES OF STREAM-SEDIMENT SAMPLES FROM THE DOLORES RIVER CANYON WILDERNESS STUDY AREA, MONTROSE AND SAN MIGUEL COUNTIES, COLORADO.

[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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DH001S | 38 10 17 | 108 52 10 | 1.0 | .7 | 1.0 | .07 | 100 | N | N | N | 20 | 2,000 | N |
| DH002S | 38 10 45 | 108 52 45 | .5 | .5 | 1.0 | .05 | 50 | N | N | N | 50 | 500 | N |
| DH003S | 38 11 52 | 108 55 19 | .5 | .3 | .3 | .03 | 30 | N | N | N | 30 | 150 | N |
| DH004S | 38 12 47 | 108 54 34 | .7 | 1.0 | 1.5 | .07 | 70 | N | N | N | 50 | 300 | N |
| DH005S | 38 13 4 | 108 55 0 | .5 | .7 | 1.0 | .03 | 50 | N | N | N | 20 | 300 | N |
| DH006S | 38 14 3 | 108 57 9 | .7 | .5 | .5 | .05 | 50 | N | N | N | 30 | 300 | N |
| DH007S | 38 13 29 | 108 57 40 | 1.5 | .7 | 3.0 | .10 | 500 | N | N | N | 100 | 1,500 | <1 |
| DH008S | 38 13 43 | 108 58 12 | 1.0 | 1.0 | 1.5 | .07 | 150 | N | N | N | 50 | 300 | N |
| DH009S | 38 13 3 | 109 0 57 | .5 | .3 | 1.0 | .10 | 50 | N | N | N | 50 | 1,000 | N |
| DH010S | 38 13 7 | 109 0 59 | .7 | .3 | 1.0 | .05 | 50 | N | N | N | 70 | 200 | N |
| DH011S | 38 13 32 | 109 0 18 | .3 | .2 | .2 | .05 | 20 | N | N | N | 20 | 500 | N |
| DH012S | 38 16 4 | 108 55 27 | 1.0 | 1.0 | 1.5 | .20 | 150 | N | N | N | 50 | 500 | N |
| DH013S | 38 18 3 | 108 56 49 | .5 | .5 | .7 | .10 | 70 | N | N | N | 70 | 700 | N |
| DH014S | 38 17 45 | 108 56 15 | 1.0 | 1.5 | 3.0 | .15 | 200 | N | N | N | 70 | 700 | <1 |
| DH015S | 38 16 46 | 108 56 0 | 3.0 | 2.0 | 2.0 | .20 | 300 | N | N | N | 150 | 500 | 1 |
| DH016S | 38 17 8 | 108 54 32 | 1.0 | .7 | .5 | .10 | 70 | N | N | N | 30 | 150 | N |
| DH017S | 38 16 38 | 108 51 52 | 1.0 | .7 | 1.0 | .05 | 50 | N | N | N | 30 | 150 | N |
| DH018S | 38 16 34 | 108 51 55 | .7 | .3 | .7 | .07 | 30 | N | N | N | 30 | 500 | N |
| DJ001S | 38 9 57 | 108 51 48 | 1.5 | .7 | 2.0 | .15 | 100 | N | N | N | 50 | 1,000 | <1 |
| DJ002S | 38 10 18 | 108 52 35 | .7 | .5 | .2 | .10 | 50 | N | N | N | 30 | 200 | N |
| DJ003S | 38 11 28 | 108 54 2 | 1.0 | 1.0 | 2.0 | .10 | 100 | N | <200 | N | 30 | 1,000 | <1 |
| DJ004S | 38 12 7 | 108 55 51 | .7 | .7 | 1.0 | .05 | 30 | N | N | N | 30 | 200 | N |
| DJ005S | 38 13 2 | 108 54 6 | .7 | 1.0 | 2.0 | .07 | 100 | N | N | N | 30 | 700 | N |
| DJ006S | 38 13 5 | 108 54 8 | .7 | .5 | .7 | .05 | 100 | N | N | N | 50 | 1,000 | N |
| DJ007S | 38 13 49 | 109 0 0 | .3 | .2 | .5 | .02 | 20 | N | N | N | 20 | 700 | N |
| DJ008S | 38 13 42 | 108 59 37 | 1.0 | 1.0 | 2.0 | .15 | 200 | N | N | N | 100 | 700 | <1 |
| DJ009S | 38 14 3 | 108 59 37 | .7 | .5 | 1.0 | .05 | 70 | .5 | N | N | 30 | 700 | N |
| DJ010S | 38 14 58 | 108 56 44 | 1.5 | 1.0 | 1.5 | .15 | 200 | N | N | N | 70 | 300 | <1 |
| DJ011S | 38 16 32 | 108 55 57 | 1.0 | 1.0 | .7 | .10 | 50 | N | N | N | 50 | 150 | <1 |
| DJ012S | 38 18 0 | 108 56 56 | .7 | .7 | 1.0 | .05 | 70 | N | N | N | 50 | 500 | N |
| DJ013S | 38 17 0 | 108 56 29 | .7 | .7 | .5 | .05 | 50 | N | N | N | 50 | 150 | N |
| DJ014S | 38 16 45 | 108 52 42 | .5 | .5 | .7 | .07 | 50 | N | N | N | 30 | 300 | N |
| DJ015S | 38 16 47 | 108 53 10 | 1.5 | 1.0 | 2.0 | .10 | 300 | N | N | N | 50 | 300 | <1 |
| DJ016S | 38 17 43 | 108 53 46 | .7 | 1.0 | .7 | .07 | 100 | N | N | N | 70 | 500 | N |

TABLE 3.--SPECTROGRAPHIC, AA, DNA, & ICP ANALYSES OF STREAM-SEDIMENT SAMPLES FROM THE DOLORES RIVER CANYON WILDERNESS STUDY AREA, MONTROSE AND SAN MIGUEL COUNTIES, COLORADO.--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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DH001S | N | N | N | 150 | <5 | N | N | N | <5 | N | N | N | N | 100 |
| DH002S | N | N | N | N | <5 | N | N | N | N | N | N | N | N | N |
| DH003S | N | N | N | N | 5 | N | N | N | N | <10 | N | N | N | N |
| DH004S | N | N | N | N | <5 | N | N | N | <5 | N | N | N | N | <100 |
| DH005S | N | N | N | N | <5 | N | N | N | N | N | N | N | N | N |
| DH006S | N | N | N | N | <5 | N | N | N | <5 | <10 | N | N | N | N |
| DH007S | N | N | N | 30 | 5 | N | N | N | N | 10 | N | N | N | 200 |
| DH008S | N | N | N | N | <5 | N | N | N | <5 | N | N | N | N | N |
| DH009S | N | N | N | N | N | N | N | N | N | N | N | N | N | N |
| DH010S | N | N | N | N | <5 | N | N | N | <5 | N | N | N | N | N |
| DH011S | N | N | N | N | N | N | N | N | N | N | N | N | N | N |
| DH012S | N | N | <5 | 10 | 5 | N | N | N | 150 | <10 | N | <5 | N | N |
| DH013S | N | N | N | N | 5 | N | N | N | N | N | N | N | N | N |
| DH014S | N | N | <5 | 10 | 5 | N | N | N | 5 | <10 | N | <5 | N | <100 |
| DH015S | N | N | 5 | 10 | 10 | N | N | N | 10 | 20 | N | 5 | N | N |
| DH016S | N | N | N | N | <5 | N | N | N | <5 | <10 | N | N | N | N |
| DH017S | N | N | N | N | <5 | N | N | N | <5 | N | N | N | N | N |
| DH018S | N | N | N | N | <5 | N | N | N | N | N | N | N | N | N |
| DJ001S | N | N | N | N | 20 | N | N | N | 5 | <10 | N | N | N | <100 |
| DJ002S | N | N | N | N | <5 | N | N | N | <5 | <10 | N | N | N | N |
| DJ003S | N | N | N | N | <5 | N | N | N | 5 | <10 | N | <5 | N | 150 |
| DJ004S | N | N | N | N | <5 | N | N | N | <5 | 30 | N | N | N | N |
| DJ005S | N | N | N | N | <5 | N | N | N | N | <10 | N | N | N | <100 |
| DJ006S | N | N | N | N | <5 | N | N | N | <5 | N | N | N | N | 100 |
| DJ007S | N | N | N | N | N | N | N | N | N | N | N | N | N | N |
| DJ008S | N | N | N | 20 | 5 | N | N | N | <5 | <10 | N | N | N | 150 |
| DJ009S | N | N | N | 10 | N | N | N | N | N | N | N | N | N | N |
| DJ010S | N | N | <5 | 10 | 7 | <20 | N | N | 5 | 10 | N | <5 | N | N |
| DJ011S | N | N | N | <10 | <5 | N | N | N | 5 | N | N | N | N | N |
| DJ012S | N | N | N | N | <5 | N | N | N | <5 | <10 | N | N | N | N |
| DJ013S | N | N | N | N | <5 | N | N | N | <5 | N | N | N | N | N |
| DJ014S | N | N | N | N | <5 | N | N | N | N | N | N | N | N | N |
| DJ015S | N | N | <5 | N | 5 | <20 | N | N | 5 | <10 | N | <5 | N | <100 |
| DJ016S | N | N | N | N | <5 | N | N | N | 5 | N | N | N | N | N |

TABLE 3.--SPECTROGRAPHIC, AA, DNA, & ICP ANALYSES OF STREAM-SEDIMENT SAMPLES FROM THE DOLORES RIVER CANYON WILDERNESS STUDY AREA, MONTROSE AND SAN MIGUEL COUNTIES, COLORADO.--Continued

| Sample | V-ppm s | W-ppm s | Y-ppm s | Zn-ppm s | Zr-ppm s | Th-ppm s | Au-ppm aa | As-ppm icp | Bi-ppm icp | Cd-ppm icp | Sb-ppm icp | Zn-ppm icp | Th-ppm dna | U-ppm dna |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DH001S | 30 | N | N | N | 1,000 | N | <.1 | <5 | <2 | .3 | <2 | 11 | <7.00 | 5.780 |
| DH002S | 15 | N | <10 | N | 200 | N | <.1 | <5 | <2 | .1 | <2 | 7 | 3.40 | 1.600 |
| DH003S | <10 | N | N | N | 100 | N | <.1 | <5 | <2 | .2 | <2 | 11 | 2.40 | 1.150 |
| DH004S | 10 | N | N | N | 150 | N | <.1 | <5 | <2 | .1 | <2 | 10 | 2.90 | .942 |
| DH005S | 10 | N | N | N | 300 | N | <.1 | <5 | <2 | .2 | <2 | 8 | 1.70 | .965 |
| DH006S | 10 | N | N | N | 150 | N | <.1 | <5 | <2 | .1 | <2 | 8 | 1.70 | .949 |
| DH007S | 30 | N | <10 | N | 500 | N | <.1 | <5 | <2 | .1 | <2 | 8 | 3.00 | 1.900 |
| DH008S | 10 | N | N | N | 200 | N | <.1 | <5 | <2 | .2 | <2 | 10 | 2.20 | 1.180 |
| DH009S | 10 | N | N | N | 200 | N | <.1 | <5 | <2 | .1 | <2 | 6 | 2.00 | 1.530 |
| DH010S | 10 | N | N | N | 200 | N | <.1 | <5 | <2 | .1 | <2 | 5 | 3.00 | 1.110 |
| DH011S | <10 | N | N | N | 150 | N | <.1 | <5 | <2 | .1 | <2 | 5 | <1.40 | .896 |
| DH012S | 15 | N | N | N | 700 | N | <.1 | <5 | <2 | .2 | <2 | 7 | 3.61 | 1.370 |
| DH013S | 20 | N | N | N | 300 | N | <.1 | <5 | <2 | .2 | <2 | 11 | <2.10 | 3.700 |
| DH014S | 20 | N | 15 | N | 500 | N | <.1 | <5 | <2 | .1 | <2 | 7 | 3.20 | 1.480 |
| DH015S | 20 | N | 10 | N | 300 | N | <.1 | <5 | <2 | .3 | <2 | 19 | 6.83 | 2.550 |
| DH016S | 15 | N | N | N | 150 | N | <.1 | <5 | <2 | .1 | <2 | 8 | 4.55 | 1.540 |
| DH017S | 10 | N | N | N | 100 | N | <.1 | <5 | <2 | .1 | <2 | 8 | 3.30 | 1.290 |
| DH018S | 15 | N | N | N | 300 | N | <.1 | <5 | <2 | .3 | <2 | 8 | <2.30 | 2.860 |
| DJ001S | 100 | N | N | N | 300 | N | <.1 | <5 | <2 | 1.2 | <2 | 17 | <6.20 | 24.600 |
| DJ002S | 10 | N | N | N | 300 | N | <.1 | <5 | <2 | .1 | <2 | 8 | 2.50 | .888 |
| DJ003S | 20 | N | N | N | 100 | N | <.1 | <5 | <2 | .1 | <2 | 9 | <4.10 | 2.880 |
| DJ004S | <10 | N | N | N | 200 | N | <.1 | <5 | <2 | .1 | <2 | 11 | 2.10 | 1.040 |
| DJ005S | 15 | N | N | N | 300 | N | <.1 | <5 | <2 | .1 | <2 | 8 | 2.00 | 1.090 |
| DJ006S | 10 | N | N | N | 300 | N | <.1 | <5 | <2 | .1 | <2 | 8 | 2.80 | 1.500 |
| DJ007S | <10 | N | N | N | 100 | N | <.1 | <5 | <2 | .2 | <2 | 5 | 1.80 | 1.110 |
| DJ008S | 15 | N | 10 | N | 300 | N | <.1 | <5 | <2 | .2 | <2 | 9 | 3.60 | 1.680 |
| DJ009S | 10 | N | N | N | 500 | N | <.1 | <5 | <2 | .1 | <2 | 6 | 2.10 | 1.170 |
| DJ010S | 20 | N | 10 | N | 500 | N | <.1 | <5 | <2 | .2 | <2 | 12 | 4.45 | 1.470 |
| DJ011S | 15 | N | N | N | 150 | N | <.1 | <5 | <2 | .2 | <2 | 9 | 5.07 | 1.150 |
| DJ012S | 15 | N | N | N | 200 | N | <.1 | <5 | <2 | .2 | <2 | 9 | 3.30 | 1.540 |
| DJ013S | 10 | N | N | N | 500 | N | <.1 | <5 | <2 | .2 | <2 | 9 | 4.26 | 1.580 |
| DJ014S | <10 | N | N | N | 100 | N | <.1 | <5 | <2 | <.1 | <2 | 5 | 2.50 | 1.060 |
| DJ015S | 20 | N | <10 | N | 150 | N | <.1 | <5 | <2 | .2 | <2 | 8 | 3.30 | 1.430 |
| DJ016S | 10 | N | N | N | 100 | N | <.1 | <5 | <2 | <.1 | <2 | 7 | 2.30 | 1.260 |

TABLE 4.--SPECTROGRAPHIC ANALYSES OF HEAVY-MINERAL-CONCENTRATE SAMPLES FROM THE DOLORES RIVER CANYON WILDERNESS STUDY AREA, MONTROSE AND SAN MIGUEL COUNTIES, COLORADO.

[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 |
|---|---|---|---|---|---|---|---|---|---|---|
| DH001H | 38 10 17 | 108 52 10 | 2.0 | .10 | .15 | .30 | 150 | <1 | N | N |
| DH002H | 38 10 45 | 108 52 45 | .5 | .10 | .15 | .50 | 150 | N | N | N |
| DH003H | 38 11 52 | 108 55 19 | 1.5 | .70 | .70 | >2.00 | 300 | N | N | N |
| DH004H | 38 12 47 | 108 54 34 | 1.0 | .50 | 1.00 | .50 | 100 | N | N | N |
| DH005H | 38 13 4 | 108 55 0 | .2 | .15 | .30 | 1.00 | 50 | N | N | N |
| DH006H | 38 14 3 | 108 57 9 | 1.0 | .70 | 1.00 | 2.00 | 300 | N | N | N |
| DH007H | 38 13 29 | 108 57 40 | .7 | <.05 | .20 | .20 | 30 | N | N | N |
| DH008H | 38 13 43 | 108 58 12 | 1.0 | 1.00 | 1.00 | 2.00 | 500 | N | N | N |
| DH009H | 38 13 3 | 109 0 57 | .5 | .05 | .15 | .50 | 50 | N | N | N |
| DH010H | 38 13 7 | 109 0 59 | .7 | .07 | .30 | 1.50 | 50 | N | N | N |
| DH011H | 38 13 32 | 109 0 18 | .5 | .20 | .30 | 2.00 | 70 | N | N | N |
| DH012H | 38 16 4 | 108 55 27 | .2 | .07 | .20 | .30 | 20 | N | N | N |
| DH013H | 38 18 3 | 108 56 49 | 1.5 | .05 | <.10 | .70 | 50 | 100 | N | N |
| DH014H | 38 17 45 | 108 56 15 | 1.5 | .50 | .50 | 2.00 | 150 | N | N | N |
| DH016H | 38 17 8 | 108 54 32 | 1.0 | .30 | .30 | >2.00 | 100 | N | N | N |
| DH017H | 38 16 38 | 108 51 52 | .3 | .50 | .50 | >2.00 | 70 | N | N | N |
| DH018H | 38 16 34 | 108 51 55 | 2.0 | .20 | .30 | .50 | 300 | N | N | N |
| DJ001H | 38 9 57 | 108 51 48 | .7 | .05 | .10 | .30 | 50 | 20 | N | N |
| DJ002H | 38 10 18 | 108 52 35 | 5.0 | .20 | .30 | >2.00 | 200 | N | N | N |
| DJ003H | 38 11 28 | 108 54 2 | .3 | .10 | .20 | .50 | 50 | 10 | N | N |
| DJ004H | 38 12 7 | 108 55 51 | 1.5 | .30 | .30 | >2.00 | 200 | N | N | N |
| DJ005H | 38 13 2 | 108 54 6 | .7 | .15 | .20 | 1.50 | 50 | N | N | N |
| DJ006H | 38 13 5 | 108 54 8 | .3 | .07 | .10 | .70 | 30 | <1 | N | N |
| DJ007H | 38 13 49 | 109 0 0 | .5 | <.05 | <.10 | .15 | 30 | N | N | N |
| DJ008H | 38 13 42 | 108 59 37 | 1.0 | .20 | .20 | 1.00 | 100 | N | N | N |
| DJ009H | 38 14 3 | 108 59 37 | .3 | .05 | .10 | .30 | 30 | N | N | N |
| DJ010H | 38 14 58 | 108 56 44 | 2.0 | .20 | .30 | >2.00 | 150 | <1 | N | 20 |
| DJ011H | 38 16 32 | 108 55 57 | 1.5 | 1.00 | 1.50 | >2.00 | 200 | N | N | N |
| DJ012H | 38 18 0 | 108 56 56 | 1.0 | .15 | .20 | 2.00 | 70 | N | N | N |
| DJ013H | 38 17 0 | 108 56 29 | .5 | .30 | .50 | .30 | 70 | 1 | N | N |
| DJ014H | 38 16 45 | 108 52 42 | .2 | .15 | .30 | >2.00 | 30 | N | N | N |
| DJ015H | 38 16 47 | 108 53 10 | .7 | .20 | .50 | .30 | 150 | N | N | N |
| DJ016H | 38 17 43 | 108 53 46 | 3.0 | .50 | .70 | >2.00 | 300 | N | N | N |

TABLE 4.--SPECTROGRAPHIC ANALYSES OF HEAVY-MINERAL-CONCENTRATE SAMPLES FROM THE DOLORES RIVER CANYON WILDERNESS STUDY AREA, MONTROSE AND SAN MIGUEL COUNTIES, COLORADO.--Continued

| Sample | B-ppm s | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| DH001H | 200 | >10,000 | N | N | <50 | N | 700 | 200 | 50 | 10 | N |
| DH002H | 100 | >10,000 | N | N | N | N | 50 | N | N | N | N |
| DH003H | 300 | >10,000 | N | N | N | N | 300 | N | 50 | N | <50 |
| DH004H | 200 | >10,000 | N | N | N | N | 300 | N | <50 | N | N |
| DH005H | 30 | >10,000 | N | N | N | N | 100 | N | 50 | N | N |
| DH006H | 200 | >10,000 | <2 | N | N | N | 200 | N | 50 | N | <50 |
| DH007H | 20 | >10,000 | N | N | N | N | 100 | N | N | N | N |
| DH008H | 150 | >10,000 | N | N | N | N | 150 | N | <50 | N | N |
| DH009H | 100 | >10,000 | N | N | N | N | 30 | N | 50 | N | N |
| DH010H | 150 | >10,000 | N | N | N | N | 70 | N | 70 | N | <50 |
| DH011H | 100 | >10,000 | N | N | N | N | 100 | N | <50 | N | 50 |
| DH012H | 50 | >10,000 | N | N | N | N | 50 | N | 70 | N | <50 |
| DH013H | 200 | >10,000 | N | N | N | N | 200 | 300 | 70 | N | N |
| DH014H | 150 | >10,000 | N | N | N | N | 200 | N | 200 | N | N |
| DH016H | 150 | >10,000 | 2 | N | N | N | 200 | N | 150 | N | <50 |
| DH017H | 30 | >10,000 | N | N | N | N | 70 | N | 200 | N | 50 |
| DH018H | 300 | >10,000 | N | N | <50 | N | 300 | N | N | 30 | N |
| DJ001H | 100 | >10,000 | N | N | 50 | N | 150 | 300 | 50 | N | N |
| DJ002H | 500 | >10,000 | 2 | N | N | N | 200 | N | 100 | N | N |
| DJ003H | 50 | >10,000 | N | N | N | N | 50 | 10 | <50 | N | N |
| DJ004H | 500 | >10,000 | 2 | N | N | N | 1,000 | N | 50 | N | <50 |
| DJ005H | 300 | >10,000 | N | N | N | N | 70 | N | 50 | N | <50 |
| DJ006H | 150 | >10,000 | N | N | N | N | 100 | N | 50 | N | N |
| DJ007H | 70 | >10,000 | N | N | N | N | 150 | <10 | N | N | N |
| DJ008H | 200 | >10,000 | <2 | N | N | N | 200 | N | <50 | N | N |
| DJ009H | 150 | >10,000 | N | N | N | N | 20 | N | N | N | N |
| DJ010H | 50 | >10,000 | <2 | N | N | N | 200 | N | 70 | N | N |
| DJ011H | 200 | >10,000 | <2 | N | N | N | 150 | N | 300 | N | 50 |
| DJ012H | 150 | >10,000 | N | N | N | N | 150 | 20 | <50 | N | <50 |
| DJ013H | 50 | >10,000 | N | N | N | N | 150 | 30 | 50 | N | N |
| DJ014H | 20 | >10,000 | N | N | 50 | N | 70 | N | <50 | N | N |
| DJ015H | 150 | >10,000 | N | N | N | N | 100 | N | <50 | N | N |
| DJ016H | 1,000 | >10,000 | 3 | N | N | N | 500 | N | 150 | N | <50 |

TABLE 4.--SPECTROGRAPHIC ANALYSES OF HEAVY-MINERAL-CONCENTRATE SAMPLES FROM THE DOLORES RIVER CANYON WILDERNESS STUDY AREA, MONTROSE AND SAN MIGUEL COUNTIES, COLORADO.--Continued

| Sample | Ni-ppm s | Pb-ppm s | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DH001H | N | 100 | N | 10 | N | 10,000 | 100 | N | 100 | N | >2,000 | N |
| DH002H | N | 70 | N | <10 | N | 3,000 | 50 | N | 200 | N | >2,000 | N |
| DH003H | N | <20 | N | 15 | N | 500 | 70 | N | 300 | N | >2,000 | N |
| DH004H | N | N | N | 10 | N | 2,000 | 50 | N | 200 | N | >2,000 | N |
| DH005H | N | 50 | N | N | N | 10,000 | 30 | N | 300 | N | >2,000 | N |
| DH006H | <10 | 30 | N | 15 | N | 2,000 | 70 | N | 300 | N | >2,000 | N |
| DH007H | N | 70 | N | N | N | 7,000 | 20 | N | 20 | N | >2,000 | N |
| DH008H | N | 200 | N | 50 | N | 5,000 | 50 | N | 500 | N | >2,000 | N |
| DH009H | N | <20 | N | <10 | N | 10,000 | 20 | N | 150 | N | >2,000 | N |
| DH010H | N | N | N | <10 | N | 3,000 | 30 | N | 150 | N | >2,000 | N |
| DH011H | N | N | N | N | N | 1,000 | 30 | N | 500 | N | >2,000 | N |
| DH012H | N | N | N | <10 | N | 10,000 | 30 | N | 50 | N | >2,000 | N |
| DH013H | N | 150 | N | 15 | N | 3,000 | 100 | N | 500 | N | >2,000 | N |
| DH014H | N | <20 | N | 30 | N | 3,000 | 70 | N | 700 | N | >2,000 | N |
| DH016H | N | <20 | N | 10 | N | 1,000 | 70 | N | 1,000 | N | >2,000 | N |
| DH017H | N | N | N | N | N | 3,000 | 30 | N | 70 | N | >2,000 | N |
| DH018H | N | 500 | N | <10 | N | 5,000 | 300 | N | 70 | N | >2,000 | N |
| DJ001H | N | 500 | N | 10 | N | 5,000 | 500 | N | 150 | N | >2,000 | N |
| DJ002H | <10 | 70 | N | 200 | <20 | 200 | 150 | N | 1,000 | N | >2,000 | N |
| DJ003H | N | 50 | N | <10 | N | 10,000 | 70 | N | 150 | N | >2,000 | N |
| DJ004H | <10 | 20 | N | 20 | N | 700 | 70 | N | 700 | N | >2,000 | N |
| DJ005H | <10 | <20 | N | 15 | N | 10,000 | 50 | N | 300 | N | >2,000 | N |
| DJ006H | N | <20 | N | 10 | N | 7,000 | 20 | N | 150 | N | >2,000 | N |
| DJ007H | N | N | N | <10 | N | 7,000 | 20 | N | 30 | N | >2,000 | N |
| DJ008H | N | 20 | N | 30 | N | 1,500 | 50 | N | 700 | N | >2,000 | N |
| DJ009H | N | 30 | N | <10 | N | 5,000 | <20 | N | 70 | N | >2,000 | N |
| DJ010H | N | <20 | N | 20 | N | 1,000 | 50 | N | 700 | N | >2,000 | N |
| DJ011H | <10 | <20 | N | 10 | N | 5,000 | 100 | N | 300 | N | >2,000 | N |
| DJ012H | <10 | 50 | N | 10 | N | 5,000 | 50 | N | 500 | N | >2,000 | N |
| DJ013H | <10 | <20 | N | <10 | N | >10,000 | 20 | N | 70 | N | >2,000 | N |
| DJ014H | N | N | N | N | 200 | 2,000 | 50 | N | 700 | N | >2,000 | N |
| DJ015H | N | N | N | N | N | 10,000 | 20 | N | 70 | N | >2,000 | N |
| DJ016H | N | 20 | N | 70 | 100 | 1,000 | 150 | N | 1,000 | N | >2,000 | N |