UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Analytical results and sample locality map for stream-sediment and heavy-mineral-concentrate samples from the Chamisa (NM-010-021), Empedrado (NM-010-063), and La Lena (NM-010-063A) Wilderness Study Areas, Sandoval and McKinley Counties, New Mexico

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 Chamisa, Empedrado, and La Lena Wilderness Study Areas, Sandoval and McKinley Counties, New Mexico.

INTRODUCTION

In July and August, 1987, the U.S. Geological Survey conducted a reconnaissance geochemical survey of the Chamisa (NM-010-021), Empedrado (NM-010-063), and La Lena (NM-010-063A) Wilderness Study Areas, Sandoval and McKinley Counties, New Mexico.

The total area covered by the three wilderness study areas is approximately 36,027 acres (56 mi^2) and is subdivided as follows: Chamisa, 16,582 acres (26 mi^2), Empedrado 9,007 acres (14 mi^2), and La Lena 10,438 acres (16 mi^2). The combined wilderness study areas and adjacent sampled terrain are hereafter termed the "study area."

Most of the study area (fig. 1) is located in the west-central part of Sandoval County. The western tip of the Chamisa Wilderness Study Area extends into eastern McKinley County. The study area is about 45 mi northwest of Albuquerque, New Mexico. Access is from New Mexico Highway 44 via state- and county-maintained roads.

Topography of the study area consists primarily of sandstone- or lava-capped mesas cut by canyons and arroyos. Elevations range from about 5,900 to over 8,100 ft. A major drainage, the Rio Puerco, arcs along the east side of the study area. Most streams in the study area are ephemeral but Arroyo Chico, which crosses the Empedrado Wilderness Study Area, is now a perennial stream because of a constant source of water supplied by the dewatering of a uranium mine about 30 mi upstream from the study area. Vegetation ranges from tamarisk and other riparian vegetation in the bottomlands along Arroyo Chico, Torreon Wash, and Canon Guadalupe, to open grasslands at lower elevations, to pinyon-juniper forests at higher elevations, to ponderosa pine forests at the highest elevations.

The study area is in the Albuquerque 1° x 2° quadrangle; Wyant and Olson (1978) compiled the geology of the quadrangle at 1:250,000. Aspects of the geology relating to coal beds were presented by Tabet and Frost (1979a, b) and later modified by Schreiner (1988). The following description of geology of the study area is from P.J. Modreski (written commun., 1988). Nearly flat-lying Cretaceous sandstone and shale underly approximately 90 percent of the study area. Tertiary basalt flows cap the high mesa in the southwest part of the study area. A number of basalt plugs intrude the Cretaceous strata in the middle to southern parts of the study area; these volcanic plugs form prominent and picturesque, steep-sided peaks that jut from several hundred to a thousand feet or more above surrounding terrain. Dissection of the flat-lying Cretaceous strata has resulted in an abundance of vertical cliffs and prominent mesas.

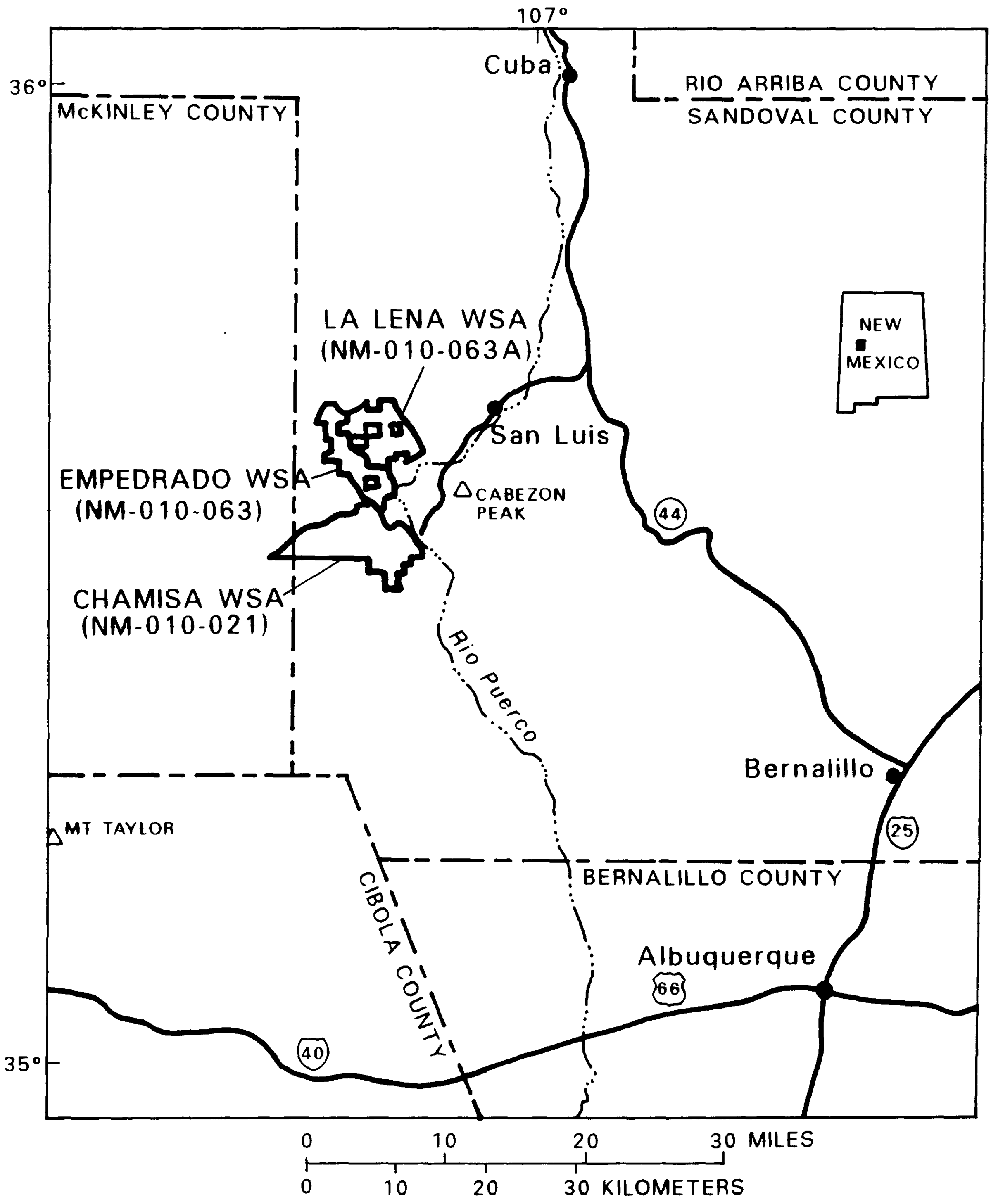

Figure 1. Index map showing location of the Chamisa, Empedrado, and La Lena Wilderness Study Areas, Sandoval and McKinley Counties, New Mexico.

The only mineral deposits that have been recognized in the study area are coal in the Cretaceous Cleary Member of the Menefee Formation and titaniferous sandstone deposits in the Cretaceous Point Lookout Sandstone and Cleary Member of the Menefee Formation (Schreiner, 1988). The small and irregular deposits of titaniferous sandstone contain titanium, zirconium, and rare earth and related elements.

METHODS OF STUDY

Sample Media

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

Sample Collection and Preparation

Heavy-mineral-concentrate and stream-sediment samples were collected at 63 sites (plate 1). Sampling density was about one sample site per 0.9 mi^2. The area of the drainage basins sampled ranged from 0.1 mi^2 to 3.5 mi^2. Samples were collected by Gary A. Nowlan.

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) streams (plate 1). The stream-sediment samples were air dried, then sieved using 80-mesh (0.17-mm) stainless-steel sieves. The portion of the sediment passing through the sieve was pulverized to approximately minus 100-mesh (0.15-mm) for analysis.

Heavy-mineral-concentrate samples

At most sites, about 20 lb of unscreened alluvium were collected. However, active alluvium from sites 088-099 (plate 1) was screened with a 10-mesh (2.0-mm) screen to obtain about 20 lb of sample after the removal of the coarse material. The samples were then panned to remove most of the quartz, feldspar, organic material, and clay-sized material. The resulting concentrate samples weighed an estimated 1-2 oz.

After the samples were oven dried at 90°C, bromoform (specific gravity 2.8) was used to remove the remaining quartz and feldspar. The resultant heavy-mineral sample was separated into two 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 may include nonmagnetic ore minerals, ferromagnesian silicates, iron and manganese oxides, and accessory minerals such as zircon, sphene, apatite, and rutile. The second fraction 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 0.2 ampere to remove the magnetite and ilmenite.

Sample Analysis

Spectrographic method

The stream-sediment and heavy-mineral-concentrate samples were analyzed using the semiquantitative, direct-current arc emission spectrographic method described by Grimes and Marranzino (1968). The elements analyzed and their 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). Emission spectrographic analyses were performed by John H. Bullock, Jr. and Olga Erlich.

Other methods

Stream-sediment samples from the study area were also analyzed by inductively coupled plasma-atomic emission spectroscopy (ICP) and ultraviolet fluorimetry. The samples were analyzed for arsenic (As), antimony (Sb), bismuth (Bi), cadmium (Cd), and zinc (Zn) using ICP and for uranium (U) using ultraviolet fluorimetry. Limits of determination, precision, and references for the methods are included in table 2. Analysts were Theodore A. Roemer and Brian A. Anderson.

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

DATA STORAGE SYSTEM

Upon completion of the analytical work, the results were entered into a U.S. Geological Survey computer data base called PLUTO. 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, VanTrump and Miesch, 1977) for computerized statistical analysis or publication.

DESCRIPTION OF DATA TABLES

The numeric part of each sample identification in tables 3-4 is the same as the corresponding sampling-site number on plate 1. 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 indicates that an element was observed but was below the lowest reporting value. For ICP analyses, a "less than" symbol (<) entered in the tables indicates that an element was below the lowest reporting value. If an element was above the highest reporting value, a "greater than" symbol (>) was entered in the tables. Because of the formatting used in the computer program that produced tables 3 and 4, some of the elements (Ca, Fe, Mg, and Ti) carry one or more nonsignificant digits to the right of the significant digits.

Some elements were not detected in any sample by emission spectrography and are omitted from tables 3-4. These elements are Ag, As, Au, Bi, Cd, Ge, Sb, Sn, Th, W, and Zn in stream-sediment samples and As, Au, Bi, Cd, Ge, Sb, Sn, Th, W, Pd, and Pt in heavy-mineral-concentrate samples. Concentrations of Bi and Sb, as determined by ICP, are all less than the lower limits of determination and thus are omitted from table 3.

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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)	10	2,000
Chromium (Cr)	10	5,000
Copper (Cu)	5	20,000
Gallium (Ga)	5	500
Germanium (Ge)	10	100
Lanthanum (La)	50	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)	20	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-atomic emission spectroscopy; F = ultraviolet fluorimetry]

Element determined	Sample type	Method	Lower determination limit, ppm	Precision, percent relative standard deviation	References
Arsenic (As)	stream sediment	ICP	5	3.5-20	Crock and others, 1987.
Antimony (Sb)	stream sediment	ICP	2	6.4-11	
Bismuth (Bi)	stream sediment	ICP	2	2.2-11.9	
Cadmium (Cd)	stream sediment	ICP	.1	2.8-8.8	
Zinc (Zn)	stream sediment	ICP	2	1.4-11.9	
Uranium (U)	stream sediment	F	.1	6.9-14.2	Centanni and others, 1956; O'Leary and Meier, 1986.

TABLE 3.--Results of analyses of stream-sediment samples collected from the Chamisa, Empedrado, and La Lena Wilderness Study Areas, Sandoval County, New Mexico

[N, not detected; <, less than value shown for As-i and Cd-i, detected below value shown for others. Methods: As-i, Cd-i, and Zn-i, inductively coupled plasma spectroscopy; U-f, ultraviolet fluorimetry; others, emission spectrography. Ca, Fe, Mg, Na, P, and Ti are weight percent; other elements are ppm]

Sample	Latitude	Longitude	Ca	Fe	Mg	Na	P	Ti	As-i	B	Ba	Be	Cd-i
						Chamisa							
CHA088	35 31 48	107 11 29	1.50	2.0	1.00	.5	N	.20	<5	<10	200	N	.4
CHA089	35 31 52	107 11 27	1.00	2.0	1.00	1.0	N	.30	5	10	300	N	.3
CHA090	35 31 41	107 11 5	3.00	1.5	1.50	.2	N	.15	<5	<10	200	N	.4
CHA091	35 31 56	107 10 57	2.00	2.0	1.50	.7	N	.20	<5	<10	300	N	.4
CHA092	35 31 40	107 10 33	3.00	3.0	2.00	.5	N	.50	7	20	300	<1	.5
CHA093	35 31 55	107 10 5	2.00	1.5	1.50	.2	N	.20	6	<10	200	N	.3
CHA094	35 32 2	107 14 58	.15	2.0	.30	1.5	N	.30	<5	<10	700	N	.1
CHA095	35 32 3	107 14 57	.10	1.5	.20	1.5	N	.20	<5	N	500	N	<.1
CHA096	35 32 7	107 13 48	1.00	2.0	.70	.7	N	.30	<5	<10	500	N	.3
CHA097	35 32 24	107 13 33	.70	2.0	.70	1.0	N	.30	<5	10	500	N	.3
CHA098	35 32 39	107 13 6	.50	3.0	.70	1.5	N	.20	5	10	500	N	.2
CHA099	35 33 3	107 12 26	.70	2.0	1.00	1.0	N	.30	5	10	300	N	.3
CHA155	35 34 54	107 14 17	1.50	2.0	.50	1.5	N	.30	<5	10	500	N	.3
CHA156	35 34 48	107 14 24	.70	2.0	.50	1.5	N	.30	<5	15	1,000	N	.2
CHA179	35 34 14	107 14 55	.15	3.0	.30	2.0	N	.30	<5	N	500	N	.4
CHA180	35 30 25	107 11 21	3.00	2.0	2.00	.5	N	.20	6	15	200	N	.7
CHA181	35 30 45	107 10 13	2.00	2.0	2.00	1.0	<.2	.20	<5	10	300	N	.6
CHA182	35 31 45	107 9 31	1.50	2.0	1.50	.7	<.2	.20	6	<10	300	N	.5
CHA183	35 32 58	107 9 24	2.00	2.0	1.50	1.0	N	.20	5	<10	200	N	.6
CHA184	35 33 27	107 10 19	2.00	3.0	1.50	1.0	<.2	.30	8	10	300	N	.9
CHA185	35 34 8	107 11 51	1.50	2.0	1.00	1.0	N	.20	<5	<10	200	N	.4
CHA186	35 34 15	107 12 20	.70	2.0	1.00	1.5	N	.20	<5	10	300	N	.3
CHA187	35 34 49	107 12 3	1.00	5.0	1.50	1.5	N	.50	12	15	500	<1	.7
						Empedrado							
EMA131	35 41 25	107 15 44	.10	1.5	.30	2.0	N	.30	<5	20	1,000	N	.2
EMA132	35 41 29	107 16 18	.20	1.5	.20	1.5	N	.30	<5	<10	700	N	.2
EMA133	35 40 25	107 15 19	.15	2.0	.50	1.5	N	.70	<5	<10	300	N	.2
EMA138	35 39 38	107 15 17	.30	2.0	.30	1.5	N	.20	<5	10	700	N	.2
EMA139	35 40 3	107 17 19	.15	2.0	.50	2.0	N	.15	<5	N	500	N	.2
EMA140	35 39 7	107 15 12	.15	1.0	.20	1.5	N	.15	<5	<10	700	N	.1
EMA141	35 37 34	107 15 4	.50	3.0	.30	1.5	N	.15	<5	<10	500	N	.2
EMA142	35 37 56	107 15 37	.50	2.0	.50	2.0	N	.15	<5	10	500	N	.2
EMA143	35 38 16	107 15 35	.20	2.0	.20	2.0	N	.20	<5	<10	700	N	.1
EMA144	35 38 11	107 16 13	.70	2.0	.30	1.5	N	.30	<5	15	700	<1	.1
EMA145	35 38 51	107 16 20	.50	2.0	.30	2.0	N	.20	<5	10	1,000	N	.2
EMA146	35 37 19	107 15 5	.50	3.0	1.00	2.0	N	.30	6	20	500	N	.3
EMA147	35 36 59	107 13 36	.70	2.0	.70	1.0	N	.30	7	10	300	N	.3
EMA148	35 36 20	107 13 23	2.00	2.0	1.50	1.5	N	.50	6	15	700	N	.3
EMA149	35 36 58	107 12 27	1.50	2.0	1.50	1.0	N	.30	6	20	500	N	.3

TABLE 3.--Results of analyses of stream-sediment samples collected from the Chamisa, Empedrado, and La Lena Wilderness Study Areas, Sandoval County, New Mexico--Continued

Sample	Co	Cr	Cu	Ga	La	Mn	Mo	Nb	Ni	Pb	Sc	Sr	U-f	V	Y	Zn-i	Zr
								Chamisa--Continued									
CHA088	N	<10	<5	5	N	50	N	N	<5	N	N	N	.60	30	N	30	200
CHA089	N	10	7	15	N	70	N	N	<5	<10	N	N	.50	50	N	36	100
CHA090	N	10	<5	5	N	70	N	N	<5	<10	N	N	.65	30	<10	23	100
CHA091	N	10	5	10	N	100	N	N	5	<10	N	N	.70	50	<10	29	150
CHA092	N	20	15	20	<50	150	<5	<20	15	10	5	100	.90	100	10	42	300
CHA093	N	10	5	5	<50	100	N	N	<5	<10	N	N	.70	50	<10	27	500
CHA094	<10	<10	7	15	N	150	N	N	<5	<10	5	N	.65	50	<10	32	1,000
CHA095	N	N	5	10	N	70	N	N	<5	<10	N	N	.50	30	<10	29	500
CHA096	<10	10	7	7	N	200	N	N	<5	<10	N	N	.70	70	<10	35	300
CHA097	<10	10	7	10	N	200	N	<20	<5	<10	<5	<100	.45	70	<10	39	300
CHA098	<10	10	7	15	N	150	N	N	5	10	<5	N	.60	70	<10	40	200
CHA099	N	30	7	10	N	200	N	N	5	10	<5	N	.60	70	<10	38	300
CHA155	10	10	10	15	N	300	N	N	7	10	N	N	.85	70	N	39	150
CHA156	10	<10	7	20	N	200	N	<20	5	10	<5	<100	.90	100	10	35	500
CHA179	N	15	7	50	N	100	N	N	<5	10	N	N	.75	50	<10	32	100
CHA180	N	10	7	10	N	100	N	N	7	10	N	<100	.90	50	<10	41	100
CHA181	N	15	7	20	N	70	N	N	10	<10	<5	<100	.80	70	10	33	200
CHA182	N	15	7	20	N	50	N	N	5	<10	<5	N	.85	70	<10	30	200
CHA183	N	10	5	15	N	50	N	N	<5	<10	N	N	.65	50	N	33	200
CHA184	<10	20	10	30	N	100	N	N	7	15	<5	N	.90	70	<10	53	100
CHA185	N	<10	7	10	N	100	N	N	<5	<10	N	N	.80	70	N	43	150
CHA186	N	10	7	20	N	100	<5	N	<5	<10	N	N	.75	50	<10	37	150
CHA187	10	20	20	30	N	150	N	<20	10	15	5	N	1.30	100	10	64	150
								Empedrado--Continued									
EMA131	50	<10	10	30	N	500	N	<20	<5	10	N	N	1.10	50	10	42	1,000
EMA132	<10	20	7	15	N	200	N	<20	<5	N	N	N	.45	50	<10	31	300
EMA133	10	20	20	20	N	150	N	N	<5	15	N	N	1.10	70	<10	55	100
EMA138	N	10	10	15	N	500	N	N	5	<10	N	<100	.70	50	N	43	70
EMA139	N	20	10	50	N	100	N	N	<5	15	N	N	.70	30	15	38	30
EMA140	N	N	<5	5	N	200	N	N	<5	N	N	N	.55	20	N	34	200
EMA141	N	10	7	20	N	150	N	N	5	<10	N	N	.70	50	<10	35	300
EMA142	N	50	<5	10	N	200	N	N	<5	<10	N	N	.65	30	N	30	200
EMA143	<10	20	5	30	<50	150	N	N	<5	10	N	N	.65	50	<10	34	150
EMA144	<10	15	10	15	N	200	N	<20	5	<10	N	100	.75	70	10	36	50
EMA145	<10	70	10	20	N	200	N	N	5	<10	N	<100	.70	70	<10	42	200
EMA146	<10	10	10	30	N	300	N	N	<5	10	N	<100	1.10	70	10	48	300
EMA147	<10	10	7	20	N	100	N	N	5	<10	N	N	.65	70	N	35	150
EMA148	10	15	7	20	<50	200	N	<20	10	<10	<5	100	.70	100	10	34	500
EMA149	N	10	10	10	<50	200	N	<20	<5	10	N	100	.65	100	10	39	200

TABLE 3.--Results of analyses of stream-sediment samples collected from the Chamisa. Empedrado. and La Lena Wilderness Study Areas, Sandoval County, New Mexico--Continued

Sample	Latitude	Longitude	Ca	Fe	Mg	Na	P	Ti	As-i	B	Ba	Be	Cd-i
						Empedrado--Continued							
EMA150	35 36 20	107 12 36	1.00	3.0	1.00	1.5	N	.20	5	10	700	N	.4
EMA151	35 36 26	107 12 19	.20	2.0	.50	2.0	N	.50	<5	10	300	N	.2
EMA152	35 35 43	107 12 24	1.00	3.0	1.50	2.0	N	.30	6	15	500	N	.4
EMA153	35 36 2	107 11 38	.70	2.0	1.50	1.5	N	.20	6	10	300	N	.3
						La Lena							
LLA127	35 42 1	107 10 44	.20	2.0	.30	2.0	N	.20	<5	N	700	N	.2
LLA128	35 41 46	107 11 25	.15	1.0	.15	1.0	N	.30	<5	N	500	N	<.1
LLA129	35 41 24	107 12 50	.30	2.0	.20	2.0	N	.50	<5	N	1,000	N	<.1
LLA130	35 41 5	107 13 21	.10	1.5	.20	2.0	N	.20	<5	N	700	N	<.1
LLA134	35 40 34	107 14 42	.20	1.5	.30	1.5	N	.30	<5	<10	1,000	N	.2
LLA135	35 39 27	107 13 11	.30	1.5	.50	2.0	N	.30	<5	10	1,500	N	.2
LLA136	35 39 24	107 13 10	.50	1.0	.50	1.5	N	.30	<5	10	1,000	N	<.1
LLA137	35 39 18	107 13 38	.30	2.0	.30	2.0	N	.20	<5	N	1,000	N	.3
LLA154	35 38 11	107 10 4	.70	3.0	.50	2.0	N	.30	<5	10	700	N	.2
LLA188	35 37 58	107 13 29	.50	2.0	.70	1.5	N	.20	8	10	500	N	.5
LLA189	35 38 23	107 13 56	.30	5.0	1.00	2.0	N	.30	13	20	300	<1	.7
LLA190	35 39 29	107 14 51	.50	3.0	.50	1.5	N	.50	<5	15	5,000	N	.6
LLA191	35 40 16	107 14 11	.20	2.0	.30	2.0	N	.30	<5	10	700	<1	.4
LLA192	35 39 56	107 14 9	.50	2.0	.50	2.0	N	.50	<5	10	700	N	.5
LLA193	35 37 56	107 11 11	.70	2.0	.70	1.5	N	.30	5	10	500	<1	.5
LLA194	35 37 49	107 11 12	2.00	3.0	1.50	1.0	N	.50	6	15	500	N	.6
LLA195	35 37 44	107 9 39	.50	2.0	1.00	.7	N	.20	<5	<10	300	N	.4
LLA196	35 38 59	107 8 38	.30	2.0	1.00	2.0	N	.20	5	10	500	N	.4
LLA197	35 39 15	107 8 37	.30	2.0	1.00	1.0	N	.20	7	10	300	N	.5
LLA198	35 39 48	107 9 0	.50	2.0	.50	2.0	N	.30	<5	10	500	N	.3
LLA199	35 40 11	107 9 32	.30	1.5	.30	2.0	N	.20	<5	<10	700	N	.3

TABLE 3.--Results of analyses of stream-sediment samples collected from the Chamisa, Empedrado, and La Lena Wilderness Study Areas, Sandoval County, New Mexico--Continued

Sample	Co	Cr	Cu	Ga	La	Mn	Mo	Nb	Ni	Pb	Sc	Sr	U-f	V	Y	Zn-i	Zr
								Empedrado--Continued									
EMA150	N	15	7	20	N	150	N	N	<5	10	N	N	.60	50	N	38	150
EMA151	N	15	7	15	N	200	N	<20	<5	<10	N	N	.80	30	N	33	500
EMA152	10	20	15	50	N	150	N	N	5	15	N	N	1.20	70	<10	42	100
EMA153	N	15	5	10	N	150	N	N	<5	10	N	N	.75	50	<10	36	200
								La Lena--Continued									
LLA127	N	10	5	20	N	300	N	N	<5	<10	N	N	.75	30	N	39	100
LLA128	N	<10	<5	15	N	150	N	<20	N	N	N	N	.65	30	N	20	300
LLA129	<10	10	5	50	N	200	N	<20	<5	<10	N	N	.65	50	<10	31	500
LLA130	N	<10	<5	20	N	150	N	N	<5	<10	N	N	.65	50	50	29	200
LLA134	<10	<10	7	15	N	200	N	N	<5	<10	N	<100	.65	30	<10	35	150
LLA135	N	10	10	20	N	300	N	N	<5	10	N	N	.70	50	<10	37	200
LLA136	N	<10	7	30	N	200	N	<20	5	<10	N	<100	.60	70	<10	29	200
LLA137	N	<10	15	50	N	200	N	N	<5	20	N	N	.75	30	N	43	200
LLA154	<10	10	5	50	N	150	N	<20	5	10	N	N	.55	70	<10	32	200
LLA188	<10	<10	10	30	N	200	N	N	<5	10	N	N	.70	70	<10	49	100
LLA189	10	20	20	50	<50	200	N	<20	10	20	7	<100	1.10	100	10	69	150
LLA190	<10	70	15	20	<50	500	N	N	5	10	5	100	.90	70	30	48	1,000
LLA191	<10	<10	10	20	N	200	N	N	<5	10	<5	<100	.55	50	<10	42	150
LLA192	10	10	15	20	N	300	N	<20	<5	15	<5	100	.60	70	<10	51	200
LLA193	<10	10	10	15	N	150	N	N	5	<10	<5	<100	.65	70	N	45	70
LLA194	10	20	15	30	N	200	N	<20	10	<10	5	<100	.60	100	20	44	500
LLA195	N	20	7	15	N	70	N	N	<5	<10	N	N	.50	50	N	41	100
LLA196	N	<10	7	20	N	150	N	N	<5	10	N	N	.70	50	N	44	70
LLA197	N	10	7	15	N	100	N	N	<5	<10	N	N	.75	30	N	44	70
LLA198	<10	<10	5	20	N	150	N	N	<5	N	<5	<100	.55	50	<10	32	100
LLA199	<10	<10	7	20	N	200	N	N	<5	10	N	<100	.65	50	<10	35	100

TABLE 4.--Results of analyses of heavy-mineral-concentrate samples collected from the Chamisa, Empedrado, and La Lena Wilderness Study Areas, Sandoval County, New Mexico

[N, not detected; <, detected below value shown; >, greater than value shown. Analyses by emission spectrography, Ca, Fe, Mg, Na, P, and Ti are weight percent; other elements are ppm]

Sample	Latitude	Longitude	Ca	Fe	Mg	Na	P	Ti	Ag	B	Ba	Be	Co	Cr
						Chamisa								
CHH088	35 31 48	107 11 29	1.50	15	2.0	N	N	.7	N	20	>10,000	N	20	150
CHH089	35 31 52	107 11 27	.30	15	.7	N	N	.2	N	<20	>10,000	N	<20	30
CHH090	35 31 41	107 11 5	2.00	15	.7	N	<.5	2.0	N	50	>10,000	N	<20	100
CHH091	35 31 56	107 10 57	1.50	15	5.0	N	N	2.0	N	70	>10,000	N	50	3,000
CHH092	35 31 40	107 10 33	2.00	20	1.5	N	.5	>2.0	N	300	3,000	<2	<20	200
CHH093	35 31 55	107 10 5	.30	15	.5	N	<.5	2.0	N	150	>10,000	<2	<20	1,000
CHH094	35 32 2	107 14 58	.20	20	1.0	N	N	>2.0	N	70	7,000	N	70	2,000
CHH095	35 32 3	107 14 57	.20	15	1.0	N	N	>2.0	N	100	2,000	N	30	1,500
CHH096	35 32 7	107 13 48	.70	20	3.0	N	N	1.0	N	20	>10,000	N	70	700
CHH097	35 32 24	107 13 33	1.00	20	5.0	N	N	>2.0	N	150	>10,000	N	100	2,000
CHH098	35 32 39	107 13 6	1.50	15	3.0	N	N	2.0	N	30	>10,000	N	70	200
CHH099	35 33 3	107 12 26	.20	20	.7	N	N	2.0	N	20	>10,000	N	50	1,500
CHH155	35 34 54	107 14 17	.70	20	2.0	N	N	2.0	N	70	10,000	<2	50	100
CHH156	35 34 48	107 14 24	.50	20	1.5	.7	N	1.5	N	70	7,000	N	70	300
CHH179	35 34 14	107 14 55	.30	15	1.5	<.5	N	2.0	N	50	5,000	N	50	200
CHH180	35 30 25	107 11 21	5.00	15	2.0	N	1.0	2.0	N	300	7,000	<2	<20	300
CHH181	35 30 45	107 10 13	3.00	7	3.0	N	.7	>2.0	N	500	1,000	<2	N	1,000
CHH182	35 31 45	107 9 31	.50	15	1.0	N	N	>2.0	N	500	10,000	<2	<20	700
CHH183	35 32 58	107 9 24	2.00	20	2.0	N	N	1.5	N	300	7,000	<2	20	500
CHH184	35 33 27	107 10 19	5.00	15	3.0	N	1.0	1.5	N	200	700	N	20	300
CHH185	35 34 8	107 11 51	1.00	15	2.0	.7	N	.5	<1	30	3,000	N	30	200
CHH186	35 34 15	107 12 20	1.00	20	2.0	<.5	N	1.5	N	150	5,000	N	50	150
CHH187	35 34 49	107 12 3	1.00	20	2.0	.5	N	.7	N	50	1,500	N	70	100
						Empedrado								
EMH131	35 41 25	107 15 44	.10	10	.5	N	N	1.5	N	150	>10,000	2	20	1,500
EMH132	35 41 29	107 16 18	<.10	10	.5	N	N	2.0	N	100	>10,000	<2	20	700
EMH133	35 40 25	107 15 19	.70	10	.7	N	.5	>2.0	N	500	7,000	3	50	2,000
EMH138	35 39 38	107 15 17	.15	10	.3	N	N	1.0	N	70	>10,000	N	20	100
EMH139	35 40 3	107 17 19	<.10	10	.3	N	N	2.0	N	150	>10,000	<2	<20	1,500
EMH140	35 39 7	107 15 12	.20	15	.7	N	N	>2.0	N	200	>10,000	<2	20	1,500
EMH141	35 37 34	107 15 4	.50	20	.5	N	N	1.5	N	70	>10,000	N	30	300
EMH142	35 37 56	107 15 37	.50	15	1.0	N	N	1.5	N	50	>10,000	<2	30	500
EMH143	35 38 16	107 15 35	.15	20	.3	N	N	>2.0	N	200	>10,000	2	50	1,000
EMH144	35 38 11	107 16 13	.50	20	2.0	<.5	N	1.0	N	30	>10,000	<2	100	300
EMH145	35 38 51	107 16 20	.30	30	.7	N	N	.7	N	100	>10,000	<2	50	150
EMH146	35 37 19	107 15 5	.50	15	1.0	N	<.5	2.0	N	70	7,000	<2	30	700
EMH147	35 36 59	107 13 36	.70	20	1.0	<.5	N	.7	<1	50	5,000	<2	50	30
EMH148	35 36 20	107 13 23	.70	20	2.0	<.5	N	.7	<1	50	>10,000	N	70	700
EMH149	35 36 58	107 12 27	.30	20	.7	N	N	1.0	N	70	>10,000	N	30	150

TABLE 4.--Results of analyses of heavy-mineral-concentrate samples collected from the Chamisa, Empedrado, and La Lena Wilderness Study Areas, Sandoval County, New Mexico--Continued

Sample	Cu	Ga	La	Mn	Mo	Nb	Ni	Pb	Sc	Sr	V	Y	Zn	Zr
						Chamisa--Continued								
CHH088	100	15	<100	1,500	<10	N	150	30	N	10,000	70	70	N	>2,000
CHH089	100	10	N	500	10	N	70	50	N	7,000	50	20	N	1,000
CHH090	30	10	200	1,000	30	<50	70	30	N	5,000	70	200	N	>2,000
CHH091	70	15	150	1,000	<10	<50	500	<20	<10	2,000	100	200	N	>2,000
CHH092	70	15	1,000	1,500	20	50	50	20	15	<200	100	1,000	N	>2,000
CHH093	70	10	2,000	1,500	20	N	30	50	30	200	70	1,500	N	>2,000
CHH094	70	15	1,000	3,000	N	<50	70	20	50	N	200	1,000	N	>2,000
CHH095	50	10	500	2,000	N	<50	70	20	15	N	150	500	N	>2,000
CHH096	100	100	300	1,500	N	<50	500	30	<10	1,000	150	150	N	>2,000
CHH097	70	70	500	3,000	N	<50	300	20	30	200	200	1,000	N	>2,000
CHH098	100	100	150	2,000	N	<50	200	<20	<10	<200	200	200	N	>2,000
CHH099	70	50	200	2,000	N	<50	70	20	20	500	200	200	N	>2,000
CHH155	150	70	100	5,000	N	50	70	30	10	<200	200	200	<500	>2,000
CHH156	100	50	150	3,000	N	<50	100	70	<10	N	200	150	N	>2,000
CHH179	50	20	<100	2,000	N	<50	150	30	N	N	150	100	N	>2,000
CHH180	100	30	700	2,000	15	<50	70	70	15	<200	150	1,000	N	>2,000
CHH181	N	10	1,000	2,000	N	<50	20	<20	15	N	100	700	N	>2,000
CHH182	100	50	1,500	1,500	30	<50	50	150	20	<200	100	1,000	N	>2,000
CHH183	50	100	1,000	2,000	15	<50	70	20	15	<200	150	700	N	>2,000
CHH184	50	50	200	1,000	20	<50	70	30	N	<200	100	300	N	>2,000
CHH185	70	100	<100	1,000	<10	N	100	70	N	N	100	70	N	>2,000
CHH186	100	70	<100	1,000	N	<50	100	100	N	N	200	150	N	>2,000
CHH187	100	100	<100	1,500	N	N	100	100	N	N	200	100	N	>2,000
						Empedrado--Continued								
EMH131	50	30	700	3,000	N	N	20	20	20	200	100	1,500	N	>2,000
EMH132	70	20	150	2,000	N	N	20	<20	10	200	100	700	N	>2,000
EMH133	150	50	700	2,000	N	50	30	70	70	<200	200	1,000	N	>2,000
EMH138	50	30	100	3,000	N	N	10	30	<10	5,000	100	100	N	>2,000
EMH139	70	20	300	1,500	N	<50	<10	50	15	200	70	1,000	N	>2,000
EMH140	70	50	150	5,000	N	<50	30	500	20	500	200	700	N	>2,000
EMH141	200	150	200	1,500	N	<50	100	70	10	10,000	150	150	N	>2,000
EMH142	70	70	200	3,000	N	N	150	50	<10	700	100	150	N	>2,000
EMH143	100	100	300	2,000	N	<50	50	70	20	10,000	150	700	N	>2,000
EMH144	70	100	<100	5,000	N	<50	200	30	N	500	200	50	N	>2,000
EMH145	70	150	150	7,000	N	<50	50	50	<10	3,000	200	200	N	>2,000
EMH146	150	70	500	1,500	N	<50	50	70	15	<200	100	700	N	>2,000
EMH147	200	70	N	2,000	<10	<50	70	70	N	N	200	50	N	>2,000
EMH148	200	50	150	5,000	<10	N	150	70	N	700	150	100	N	>2,000
EMH149	300	70	100	1,000	N	N	100	70	N	<200	150	150	N	>2,000

TABLE 4.--Results of analyses of heavy-mineral-concentrate samples collected from the Chamisa, Empedrado, and La Lena Wilderness Study Areas, Sandoval County, New Mexico--Continued

Sample	Latitude	Longitude	Ca	Fe	Mg	Na	P	Ti	Ag	B	Ba	Be	Co	Cr
						Empedrado--Continued								
EMH150	35 36 20	107 12 36	1.00	20	1.0	.7	N	.7	N	30	>10,000	N	30	30
EMH151	35 36 26	107 12 19	.20	20	.7	N	N	>2.0	N	200	>10,000	N	50	2,000
EMH152	35 35 43	107 12 24	.50	15	1.0	N	N	2.0	N	100	10,000	N	30	700
EMH153	35 36 2	107 11 38	.50	20	1.0	N	N	>2.0	N	100	>10,000	<2	50	500
						La Lena								
LLH127	35 42 1	107 10 44	.30	20	.7	<.5	N	.7	N	50	>10,000	<2	50	100
LLH128	35 41 46	107 11 25	<.10	20	.5	N	N	>2.0	N	70	3,000	2	30	1,000
LLH129	35 41 24	107 12 50	.20	20	.7	N	N	2.0	N	150	>10,000	<2	30	700
LLH130	35 41 5	107 13 21	.30	15	.7	N	<.5	>2.0	N	300	>10,000	<2	100	500
LLH134	35 40 34	107 14 42	.20	15	.3	N	N	>2.0	N	150	10,000	<2	50	1,000
LLH135	35 39 27	107 13 11	.10	10	.2	N	N	2.0	N	30	>10,000	N	<20	150
LLH136	35 39 24	107 13 10	.15	20	.7	N	N	2.0	N	70	>10,000	<2	30	500
LLH137	35 39 18	107 13 38	.20	30	.5	N	N	2.0	N	100	>10,000	2	70	1,000
LLH154	35 38 11	107 10 4	.20	20	.3	N	N	2.0	N	100	10,000	<2	30	500
LLH188	35 37 58	107 13 29	.70	20	1.0	N	N	2.0	N	150	2,000	N	50	1,000
LLH189	35 38 23	107 13 56	.50	20	.7	<.5	N	.7	<1	70	3,000	N	70	50
LLH190	35 39 29	107 14 51	.10	15	.5	N	N	>2.0	N	30	>10,000	N	30	700
LLH191	35 40 16	107 14 11	.30	20	.5	N	N	.7	N	50	>10,000	<2	50	300
LLH192	35 39 56	107 14 9	.30	20	.5	N	N	2.0	N	300	>10,000	<2	50	500
LLH193	35 37 56	107 11 11	.70	15	.7	N	<.5	>2.0	N	300	7,000	2	30	1,000
LLH194	35 37 49	107 11 12	.20	20	.5	N	N	.2	1	<20	>10,000	N	20	20
LLH195	35 37 44	107 9 39	.30	30	.7	N	N	.2	1	20	>10,000	N	30	20
LLH196	35 38 59	107 8 38	.50	20	1.0	N	N	.5	<1	30	3,000	N	50	100
LLH197	35 39 15	107 8 37	.50	20	.7	N	N	.5	<1	30	5,000	N	20	300
LLH198	35 39 48	107 9 0	.50	20	1.0	N	N	1.0	N	200	7,000	<2	50	700
LLH199	35 40 11	107 9 32	.30	30	.5	N	N	.7	N	100	>10,000	2	50	100

TABLE 4.--Results of analyses of heavy-mineral-concentrate samples collected from the Chamisa, Empedrado, and La Lena Wilderness Study Areas, Sandoval County, New Mexico--Continued

Sample	Cu	Ga	La	Mn	Mo	Nb	Ni	Pb	Sc	Sr	V	Y	Zn	Zr
						Empedrado--Continued								
EMH150	300	30	N	1,500	N	N	150	70	N	3,000	200	50	N	>2,000
EMH151	150	30	1,000	7,000	N	50	15	30	20	200	200	1,000	N	>2,000
EMH152	200	50	200	1,000	N	<50	50	100	10	<200	150	500	N	>2,000
EMH153	300	30	700	5,000	N	50	70	70	15	700	300	500	N	>2,000
						La Lena--Continued								
LLH127	70	200	150	7,000	N	<50	50	70	15	<200	200	150	N	>2,000
LLH128	100	70	700	5,000	N	<50	30	70	30	N	200	1,000	N	>2,000
LLH129	70	100	500	7,000	N	N	30	70	20	200	150	1,000	N	>2,000
LLH130	70	50	300	5,000	N	50	30	100	15	<200	150	500	N	>2,000
LLH134	70	50	500	3,000	N	50	15	20	30	<200	150	1,000	N	>2,000
LLH135	30	20	200	2,000	N	N	<10	30	N	7,000	100	200	N	>2,000
LLH136	50	70	500	5,000	N	N	15	20	15	300	150	500	N	>2,000
LLH137	70	100	300	7,000	N	<50	50	<20	15	300	200	150	N	>2,000
LLH154	100	50	300	3,000	N	<50	20	30	10	N	200	300	N	>2,000
LLH188	150	50	500	1,500	N	<50	100	150	10	N	150	700	N	>2,000
LLH189	100	70	<100	1,500	<10	<50	70	70	N	N	150	70	N	>2,000
LLH190	50	30	500	3,000	N	<50	15	30	<10	1,500	200	500	500	>2,000
LLH191	50	70	100	5,000	N	50	50	20	N	500	150	200	N	>2,000
LLH192	70	50	150	5,000	N	<50	50	50	<10	<200	150	200	N	>2,000
LLH193	100	30	700	1,500	N	<50	70	20	20	<200	100	1,000	<500	>2,000
LLH194	150	100	N	1,000	<10	N	100	70	N	700	70	20	<500	2,000
LLH195	200	150	N	500	10	N	200	70	N	N	100	30	<500	2,000
LLH196	150	100	N	1,000	<10	<50	150	70	N	N	100	100	<500	>2,000
LLH197	150	30	150	700	<10	<50	100	100	N	N	70	150	N	>2,000
LLH198	70	50	1,000	2,000	N	<50	70	50	15	<200	200	500	N	>2,000
LLH199	70	100	100	5,000	N	<50	70	30	<10	300	200	150	<500	>2,000