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GEOLOGICAL SURVEY

GEOCHEMICAL MAP AND INTERPRETATIONS FOR THE FOSSIL RIDGE WILDERNESS STUDY AREA, GUNNISON COUNTY, 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 U.S. Geological Survey.

CONTENTS

PLATES

TABLES

STUDIES RELATED TO WILDERNESS

The Wilderness Act (Public Law 88-577, September 3, 1964) and related acts require the U.S. Geological Survey and the U.S. Bureau of Mines to survey certain areas on Federal lands to determine their mineral resource potential. Results must be made available to the public and submitted to the President and the Congress. This report presents the results of a geochemical survey of the Fossil Ridge Wilderness Study Area in the Gunnison National Forest, Gunnison County, Colorado. The Fossil Ridge Wilderness Study Area was classified as a further planning area during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979.

INTRODUCTION

Geochemical sampling was conducted during July, 1982, in and around the Fossil Ridge Wilderness Study Area, eastern Gunnison County, Colorado (see location map on Plate 1), in order to evaluate the potential for mineral deposits in the area. The study area includes 225 sq km (85.5 sq mi) within the Gunnison National Forest. Surface access is provided by highways and roads along Taylor River, Quartz Creek, Gold Creek, and Halls Gulch.

Elevations in the area sampled range from about 8400 feet to over 13,000 feet. The topography is rugged and much of the study area was affected by alpine glaciation. Tree line is at about 11,700 feet. Evergreen forests cover the higher slopes and mixed aspen, pine, and/or brush are found on the lower slopes.

Most of the streams in the eastern part of the study area drain glaciated terrain. In the western and southern parts of the study area, the drainages at lower elevations appear to be unaffected by glaciation. Beaver ponds are common throughout the study area. Underfit streams and streams draining beaver ponds in many instances have a relatively high proportion of organic matter in the stream sediments.

Proterozoic granitic and metamorphic rocks crop out over most of the study area. The oldest Proterozoic rocks are metavolcanics which are overlain by a sequence of metasediments. Various Proterozoic diorite, granodiorite, quartz monzonite, and granite intrusions post-date these volcanics and sediments. Paleozoic sandstones, carbonates, and shales overlie the crystalline basement in some parts of the study area. Small Tertiary intrusions cut the earlier crystalline and sedimentary rocks (DeWitt, Zech, and others, unpublished map).

Numerous mineralized outcrops are present in and around the proposed wilderness, and a substantial amount of gold and silver mining took place during the late 1800's and early 1900's (Kluender and McColly, 1983). Leadville-type sulfide replacement deposits in carbonate rocks, gold vein deposits, and gold placers have been mined in the study area. The most significant mining activity has been in the north-central part of the study area (around Cross Mountain and Cameron Mountain), along the northeastern boundary of the study area (near Tincup), east and south of Fairview Peak (around Green Mountain and Terrible Mountain), and in the Gold Creek drainage (Kluender and McColly, 1983). Recent exploration and small scale mining have been centered in these same areas.

SAMPLING

Both stream channels and rock outcrops were sampled in the Fossil Ridge study area to try to characterize mineralization types and potential resource areas by geochemical means. Stream-sediment samples, usually composite samples, were collected at each stream sample site. Panned concentrates were prepared at sample sites where there was an adequate amount of sample material. Panned samples were washed down to 10-20 grams or until the remaining material was predominantly heavy minerals. Rock samples were collected along ridges between drainage basins and at mineralized outcrops and old mine dumps.

SAMPLE PREPARATION AND ANALYSIS

Stream sediments were sieved for the minus-80-mesh fraction. A small number of the panned concentrates were subjected to a mineral separation scheme in which the nonmagnetic heavy fraction was retained for analysis. Most of the panned concentrates were analyzed without mineral separations being performed, because of the possibility of gold being lost (J. C. Antweiler, personal communication). Rock samples were crushed, and a split was pulverized to approximately minus-200 mesh.

All sample materials were analyzed for 31 elements by a semiquantitative emission spectrographic procedure (Grimes and Marranzino, 1968). Stream sediments were also analyzed by a cold, reducing, acid leach, followed by organic extraction and atomic absorption determination of Zn, Cd, As, Sb, and Bi (Viets and others, 1984). Pulverized rock samples were subjected to a potassium pyrosulfate fusion and organic extraction (J. G. Viets, R. M. O'Leary, and J. R. Clark, unpublished data). The extracts were analyzed for Zn, Cd, As, Sb, and Bi by flame atomic absorption. Sediment and unmineralized rock samples which were reported to contain 1 ppm or greater Ag by emission spectrography were automatically analyzed for Au with a bromine-HBr leach, organic extraction, and atomic absorption procedure (Thompson and others, 1968). All mineralized rock samples and all panned concentrates were analyzed for gold with this same procedure. All of this analytical data is presented in an open-file report (Adrian and others, 1984). Uranium was not included in this study because of the recent work performed in the area by the Department of Energy (Broxton and others, 1979; Bolivar and others, 1981; Goodnight and Ludlam, 1981; Maasen, 1981).

DATA EVALUATION

Of all the trace elements determined, the suite associated with Au or Ag deposits (Cu, Ag, Au, Zn, Cd, Pb, As, Sb, Bi, Ba and Mo) generally had the largest contrasts in values (Table 1 and 2) and the most meaningful distributions in all three sample media. (The means and standard deviations for these elements are included in Tables 1 and 2 to demonstrate the variability of the data, even though the number of unqualified values in many instances is too small for these statistics to be representative.) The bulk of this report will deal with these elements. Some other trace elements proved to be indicators of pegmatites or of mafic rocks. Relatively high concentrations of La, Nb, Zr, and Th were found in stream sediments and panned concentrates from drainages where pegmatites crop out. Based on the geochemical data the significance of anomalies from pegmatites in the study area appears to be minor relative to anomalies associated with precious metal mineralization. Therefore, the distribution of La, Nb, Zr, and Th will only be discussed briefly in the next section. The concentrations of Ni, Co, and Cr in rocks and stream sediments have low contrasts (Tables 1 and 2), and the highest values of these elements are associated with mafic metavolcanic rocks. The distribution of Ni, Co, and Cr will not be discussed in this report. Other elements in the analytical data (Adrian and others, 1984), such as Be, B, V, and Sr, did not provide any information relevant to the interpretation of mineral potential.

A relatively large proportion of the rock samples collected contained high concentrations of various trace metals of the precious metals suite. In order to try to define a meaningful background population in rocks, 44 apparently unmineralized samples were examined as a separate data set. Anomalous thresholds were chosen for trace elements in rocks so as to eliminate as many of the apparently unmineralized samples as possible without breaking up significant elemental associations observed in the mineralized samples. Table 3 lists the trace elements in rock samples associated with Au and Ag deposits in the study area, their anomalous thresholds, and the percentage of those 44 samples with concentrations above the threshold for each element. Arsenic, Au, Bi, and Sb were below the detection limit in all 44 samples. Even though there was no visible alteration or mineralization in these samples, a few contained clearly anomalous concentrations of some metals.

A large proportion of the sample sites along streams were located in drainages where mineralized outcrops containing precious metals were found. Sediment samples collected in these drainages and from outside known mineralized areas were found to contain relatively high concentrations of various trace elements that would be associated with Au and Ag mineralization. Further, there is no means of presorting sediment samples by visible metal content, as was done with the rock samples. Therefore, anomaly thresholds in stream sediments for each element in the precious metal suite were established empirically so that as many low-level values as possible were eliminated without disrupting significant trace-metal associations in samples collected downstream from mineralized outcrops. Anomaly thresholds for the pegmatite suite of trace elements in stream sediments were established by the presence of obvious breaks in the histograms of the data of each of these elements. A list of stream-sediment anomaly thresholds for the precious-metal and pegmatite suites of trace elements is provided in table 4.

Sometimes Au or sulfide mineral grains can be seen in panned concentrates, and Au was observed in five of the concentrates collected in this study. But, there were many more panned concentrates, which contained relatively high concentrations of the precious-metal suite of elements, in which no Au was visible. Therefore, preclassification of panned concentrates was not practical. In general trace-element anomaly thresholds for the precious-metal and pegmatite suites in stream sediments were also found to be effective cut-off points for qualifying the panned concentrate data. A list of anomaly thresholds for these two suites in panned concentrate is also provided in table 4.

The location of samples anomalous in the precious-metal suite of elements is shown on Plate 1. The chemical symbol for each element that is anomalous in a given sample is shown beside the sample site in Plate 1. Chemical symbols preceded by a lower case "p" indicate anomalous metals in panned concentrates. The size of the symbols indicates the relative magnitude of the anomaly. Small lettering represents values that are from 1 to 10 times greater than threshold for that element (weakly to moderately anomalous).

Medium size lettering indicates values that are 10 to 100 times threshold (moderately to strongly anomalous). Large size lettering designates values that are greater than 100 times threshold for that element (very strongly anomalous).

Emission spectrographic analysis of stream sediments provides semiquantitative estimates of the "total" trace-element content of the sample. This "total" value includes both metals in minerals as well as metals adsorbed on grain coatings and on clays. A cold "partial" leach (Viets and others, 1984) was used to determine Zn, Cd, Bi, As, and Sb in stream-sediment samples. This type of method provides determinations for that portion of metals that is adsorbed on manganese and iron oxide coatings on mineral grains in the sediment, on clays, and on organic matter. Although the background values obtained with this method are much lower than those obtained with "total" analyses, background to anomaly contrasts are substantially improved (Viets and others, 1984). Also, in drainages that contain significant amounts of weathering mineral deposits, trace-metal concentrations in the stream sediments determined by partial leaches will approach the total metal concentrations (Viets and others, 1984).

Of those metals determined only by emission spectroscopy, Ag, Cu, Mo, and Pb in stream sediments are associated with possible Au and Ag deposits in the study area, as indicated by analyses of rock samples from mineralized outcrops and old mine workings. The mean of Cu and Pb values for the stream-sediment samples (Table 2) is not unusually high for "total" analyses. Most of the sediment samples were below detection limit for Ag and Mo (Table 2).

Most of the cold leachable As concentrations for sediment samples are below detection limit (Table 2). Arsenic oxides are highly soluble in water, but their ions are readily adsorbed by ferric hydroxide. Those stream-sediment samples that are anomalous in As probably contain fragments of limonite from weathering mineralized outcrops located a short distance upstream.

Zinc, Cd, and Bi have relatively high background concentrations in the stream sediments from the study area. In unmineralized terranes, cold leachable Zn in the stream sediments would be expected to be in the low part per million range (J. G. Viets and J. R. Clark, unpublished data). The mean for leachable Zn in the stream sediments in this study area (Table 2) is about two to three times higher than the normal unmineralized range. Similarly stream sediments from unmineralized regions usually contain cold leachable concentrations of Cd and Bi that are below detection limit by the instrumental method used here (J. G. Viets and J. R. Clark, unpublished data). However, most of the sediment samples from this study area contain measurable concentrations of Cd, and half of them contain measurable Bi (Table 2). These relatively high background concentrations of Zn, Cd, and Bi in the oxide coatings in the stream sediments indicate that significant amounts of mineralized bedrock are exposed in the drainages in the study area. Further, iron and manganese oxide coatings on stream sediment particles apparently are scavenging the Zn, Cd, and Bi being transported in the drainages of the study area.

Correlation analysis was performed on the rock samples and stream-sediment samples from the study area (Tables 5 and 6). Based on the results from the rock samples, there are apparently two suites of precious metal mineralization in the study area. Silver correlates strongly with Cu, Sb, Pb, As, Zn, Cd, and Mo, but has a low correlation with Au and Bi. Gold correlates strongly with Bi and has a very low correlation with Sb, Mo, As, Pb, Zn, Cu, and Cd. The strong correlation of Au with Ca and Zr is probably the result of a host rock factor in some of the samples. These results indicate that Bi might be used as an indicator of the possible presence of Au in rock and stream sediment samples. Barium is apparently associated with Mg alteration in hydrothermal deposits in the study area (Table 5).

Large quantities of Mn and Fe precipitates in the streams can be responsible for producing false hydromorphic trace-element anomalies in sediment samples. Excessive amounts of iron and manganese oxide precipitates were not observed at any of the stream sample sites. Furthermore, there would be strong correlations between Fe and Mn and trace elements, which can be easily transported in surface and ground waters, if precipitates were producing false anomalies. Since no strong correlations exist between Fe and Mn and these trace elements, the stream sediment anomalies do not appear to be false (Table 6).

GEOCHEMICAL ANOMALIES

Precious Metal Suites

Two major areas of moderately to strongly anomalous rock samples are located within or along the margins of the proposed wilderness. One of these is located in the north-central part of the study area, between Lottis Creek and South Lottis Creek, and includes Cross Mountain and Cameron Mountain. Except for replacement bodies in carbonate rocks in the Wahl mine in Cross Mountain, the mineralization in this particular area appears to be in veins that follow northwest-striking structures, such as in the Gold Bug mine (Kluender and McColly, 1983). Gold, Ag, Bi, As, and Cu are moderately to strongly anomalous in most of those rock samples (Plate 1).

Sediments from most of the streams draining this mineralized area also contain anomalous metal concentrations. Cross Creek was sampled just upstream from an old placer operation on the south edge of Union Park. Weakly to strongly anomalous levels of Au, Ag, and associated metals were found in the minus-80-mesh fraction of the stream sediment (Plate 1). The high concentration of Cu in the panned sample probably indicates that Cu is being transported in part as incompletely weathered sulfides or gossan fragments. Cameron Creek also contains anomalous concentrations of Au and associated metals. Gold, Cd, Bi, and Mo are anomalous in the sediments of other smaller streams draining this mineralized area (Plate 1).

The second major area of moderately to strongly anomalous rock samples is located south of Fairview Peak in the vicinity of Terrible Mountain between Halls Gulch and Gold Creek. Numerous old mine dumps, prospects, and mineralized outcrops, which are located south and east of Terrible Mountain and which occupy the largest part of this metal-enriched area, were not sampled, because they were too far outside the study area. Silver is the predominant ore metal, largely occurring in partially oxidized replacement bodies in carbonate rocks. Samples FR176, 177, and 179 (Adrian and others, 1984, from the Fairview, Cleopatra, and Clifton properties, respectively) are strongly enriched in Ag, Au, and associated elements (Plate 1).

Drainages around Terrible Mountain contain evidence of the mineralization. The valley to the east of Terrible Mountain, which is drained by Halls Gulch and Jackson Gulch, is surrounded by evidence of mineralization. In addition to the deposits in Terrible Mountain, low-level anomalies of Ag, Bi, and Ba were found in rock samples from the ridge north of this valley, the mineralized Athens fault cuts diagonally across the upper end of the valley (DeWitt, Zech, and others, unpublished map) and old mining prospects are located on the east side of this valley. Stream sediments and panned concentrates collected in the valley were anomalous in Ag, Au, and other metals. New Dollar Gulch drains the west side of Terrible Mountain. Sediments in the upper end of the drainage were coated with $Al(OH)_3$ precipitate, indicating that ground water entering the stream had a pH below 4.1. This would happen if the ground water passed through a zone of weathering sulfide mineralization before it entered the stream and became diluted. The sediments in this drainage are anomalous in Ag and other associated metals (Plate 1).

Gold Creek drains a large area southwest of Fairview Peak and southeast of Fossil Ridge. The northern end of the drainage (north of Lamphier Creek and New Dollar Gulch) and the western side of the valley lie within the study area. Several old gold mines and dumps are located along the creek, outside the boundaries of the study area. There is no geochemical evidence of precious metal mineralization in this drainage north of New Dollar Gulch. Abundant geochemical indications of precious metals were found in the high ground to the west of Gold Creek and in the streams entering this creek from the west.

Rock samples from the heads of the Lamphier Creek, Mill Gulch, and Boulder Gulch drainages and one rock sample from the middle of the Comanche Gulch drainage revealed Ag, Cd, Bi, Pb, and Ba anomalies (Plate 1). The most prominent of these anomalies is located in the cirque wall southwest of Boulder Lake. A small andesite plug that intruded carbonate sedimentary rocks is surrounded by alteration and small amounts of sulfide mineralization. The center of this plug is apparently slightly enriched but not anomalous in Zn, relative to other igneous rocks in the study area. The margin of the intrusion is altered and heavily stained with limonite. Some of the fractures in this margin are lightly stained with malachite, and small malachite-rich rock fragments are present in the float along the contact. A sample from the altered edge of the andesite is enriched in Bi and Au. The sedimentary rocks around this plug are altered, and a sample of silicified limestone collected there contained anomalous concentrations of Cd, Ag, and associated metals.

Trace element anomalies in stream sediments collected near the heads of Lamphier Creek, Mill Gulch, and Boulder Gulch generally reflect the anomalies found in nearby rock samples, with the exception that Mo was found in Lamphier Creek and Mill Gulch but not in the nearby rocks. The upper end of the Comanche Gulch drainage is too steep and dry for appreciable stream sediments to collect. A large flowing spring, located near some old mine adits, contributes most of the total flow of the creek. A stream-sediment sample, taken at the outlet of the spring, was enriched in Ag and associated metals (Plate 1). The high trace element concentrations in the panned concentrate from that site indicate that fragments of incompletely weathered mineralization are being washed out of the mountainside.

In addition to the trace metals found in sediment samples upstream, Cu and Au were found to be anomalous downslope in most of the stream sediments near the mouths of Boulder Gulch, Comanche Gulch, and two nearby, small, unnamed tributaries to Gold Creek. Anomalous chalcophile trace metals were present, probably as gossan fragments or partially weathered sulfides, in panned concentrates collected near the mouths of Boulder Gulch and Comanche Gulch. These observations indicate the apparent existence of a second area of mineralization in the lower forested slopes between Gold Creek and the ridge to the west.

Along the southern edge of the study area, small Cu, Cd, Pb, and Sn stream-sediment anomalies were found in the drainages of Alder Creek and upper Willow Creek. Low grade copper mineralization apparently crops out between these two streams.

A low level Cd and Zn anomaly was found on Fossil Ridge between the head of Crystal Creek and the head of the East Fork of Alder Creek. Also, some old mining prospects are located near the head of the East Fork of Alder Creek. This mineralization is reflected in the Cd, Pb, and Zn stream-sediment anomaly found in the upper end of that drainage. No evidence of old mining activity was observed along the northern side of Fossil Ridge. However, sediments from the headwaters that drain the northern side of Fossil Ridge above Crystal Creek are anomalous in Ag, As, and associated metals (Plate 1).

Another local area of low-grade bedrock anomalies was found along the north-trending ridge between the drainages of Crystal Creek and South Lottis Creek. Some rock samples from that area are enriched in Ag, As, and other trace metals. Anomalous levels of Ag and many other trace elements were found in sediments and concentrates from the streams draining this ridge (Plate 1).

Stream-sediment analyses indicate another local area of mineralization along the eastern edge of the study area. All but one of the stream channels draining the eastern side of the north-trending ridge in that area contain anomalous metal values. A few old mining prospects are located along the eastern side of this ridge. Gold, Ag, Cd, and Zn are anomalous in the sediments of most of these streams. Porcupine Gulch and West Willow Creek present particularly strong anomalies (Plate 1). A porphyry molybdenum prospect, which is located just to the south of West Willow Creek, was being drilled by a mining company while the area was being sampled. Anomalous Ag was found at two sample sites along the top of the ridge and in the sediment of one of the streams draining the west side of the ridge (Plate 1).

A few low-level elemental anomalies in stream-sediments were found which could not be correlated with known areas of mineralization in the bedrock. One of these is the minor W anomaly in the Crystal Creek drainage. A soil sample from the small dry channel of a tributary on the west side of Crystal Creek is slightly enriched in As and Zn. Gold and tin were found in panned concentrates from Five Mile Creek, a tributary to Taylor River. A few minor Zn, Cd, and Ag anomalies, found in the Beaver Creek drainage, are probably associated with small veins of mineralization. Lead enrichment in panned concentrates from near the mouths of Beaver Creek and Summerville Creek is apparently due to lead contained in zircons.

Pegmatites

Lanthanum, Nb, Y, Zr, and Th anomalies, which were detected in stream sediment and panned concentrate samples, apparently result from pegmatites cropping out in some of the drainages in the study area. At most of the sample sites where these elements were found to be anomalous, large quantities of muscovite, occurring in many places as small books, were present in the stream sediment. Based on observations made during sampling, the large areal extent of these anomalies is due to numerous small pegmatites cropping out over a wide area, rather than the presence of a few very large pegmatites. Although these anomalies do not have contrasts nearly as high as the trace metal anomalies associated with Au and Ag mineralization, the locations of these anomalies are worth noting.

The largest of these anomalies, spatially, is an area drained by Beaver Creek, One Mile Creek (not shown on Plate 1), Three Mile Creek, and Five Mile Creek. The anomaly at the mouth of Summerville Creek indicates a La, Y, Zr, Th-rich pegmatite in that drainage. Crystal Creek contains minor anomalies of Th, La, and Nb. Thorium anomalies are indicated in the Alder Creek drainage, and the Willow Creek drainage produced one high Th value and one high Zr value. Thorium was also found in Bear Creek, south of Lottis Creek, and Halls Gulch. Lanthanum, Nb, and Y were found in the northeastern corner of the study area and in the Brush Creek-South Lottis Creek drainage.

CONCLUSIONS

Abundant geochemical indications of potentially large precious metal deposits were found in and around the Fossil Ridge Wilderness Study Area. Even though geochemically anomalous areas can be identified, the areal extent of pegmatites is probably small. Nickel, Co, and Cr are geochemically associated with mafic rocks in the study area. The mineral resource potential of the Fossil Ridge Wilderness study area is evaluated by DeWitt, Clark, and Kluender (1984).

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Table 1.--Summary of chemical analyses for 66 rock samples from the Fossil Ridge Wilderness Study Area, Gunnison County, Colorado. [Minimum and maximum in parts per million unless indicated otherwise]

Variable	No. of Unqualified Values[1]	Minimum	Maximum	Mean[2]	Standard Deviation[2]	Geometric Mean[2]	Geometric Deviation[2]
S-Fe%	64	<0.05	20	3.1	4.5	1.3	3.8
S-Mg%	64	<0.02	10	1.9	3.1	0.5	5.2
S-Ca%	52	<0.05	20	4.2	6.6	0.9	6.9
S-Ti%	62	<0.002	1	0.14	0.17	0.06	4.0
S-Mn	65	<10	1,500	367	361	225	2.9
S-Ag	15	<0.5	5,000	410	1,281	9.6	20.0
S-B	51	<10	200	38	40	26	2.3
S-Ba	48	<20	>2,000	524	435	335	3.0
S-Be	39	<1	50	3	7.8	1.8	2.0
S-Co	36	<5	70	15	16	10	2.3
S-Cr	18	<10	300	95	114	37	4.4
S-Cu	31	<5	15,000	1,265	3,092	56	14.0
S-La	22	<20	100	68	20	65	1.3
S-Mo	8	<5	70	20	22	13	2.5
S-Nb	9	<20	30	22	4.4	22	1.2
S-Ni	46	<5	70	12	16	8	2.1
S-Pb	51	<10	>5,000	245	971	45	3.4
S-Sc	32	<5	70	11	12	9.2	1.9
S-Sr	29	<100	1,500	331	344	220	2.4
S-V	55	<10	300	41	48	26	2.5
S-Y	54	<10	70	29	19	24	2.0
S-Zr	47	<10	300	112	81	83	2.4
AA-Au	10	<0.05	190	43	77	2.4	20.0
AA-As	13	<5	1,200	180	332	42	6.5
AA-Zn	54	<5	75,000	2,037	10,522	53	7.5
AA-Cd	11	<0.2	200	49	77	4.3	16.0
AA-Bi	13	<1	650	68	178	7.7	8.3
AA-Sb	7	<2	18,000	3,050	6,659	128	24.0

[1] Number of sample values within analytical working range. Values below detection limit and above upper limit of working range were excluded from statistical calculations.

[2] Where the number of unqualified values is less than 40, these statistics are strongly influenced by anomalous samples. They are included for demonstrative purposes.

Table 2.--Summary of chemical analyses for 130 stream-sediment samples from the Fossil Ridge Wilderness Study Area, Gunnison County, Colorado. [Minimum and maximum in parts per million unless indicated otherwise]

Variable	No. of Unqualified Values[1]	Minimum	Maximum	Mean[2]	Standard Deviation[2]	Geometric Mean[2]	Geometric Deviation[2]
S-Fe%	130	0.7	7	2.6	1.3	2.3	1.5
S-Mn	130	100	2,000	684	357	592	1.8
S-Ag	25	<0.5	2	0.8	0.4	0.76	1.6
S-B	130	10	500	112	117	69	2.7
S-Ba	130	30	2,000	499	224	454	1.6
S-Be	123	<1	5	1.7	1	1.5	1.5
S-Co	130	5	50	13	7.4	12	1.7
S-Cr	120	<10	200	61	57	39	2.6
S-Cu	127	<5	500	25	51	16	2.2
S-La	94	<20	1,000	162	194	107	2.3
S-Mo	13	<5	50	12	12	8.9	1.9
S-Nb	41	<20	100	25	13	23	1.4
S-Ni	129	<5	100	16	14	13	1.7
S-Pb	130	15	200	58	35	50	1.7
S-Sc	125	<5	30	11	6.3	10	1.6
S-Sn	2	<10	70	--	--	--	--
S-Sr	122	<100	700	180	121	152	1.7
S-V	130	20	200	67	36	59	1.7
S-W	1	<50	50	--	--	--	--
S-Y	129	<10	300	67	63	48	2.2
S-Zr	130	30	1,000	289	222	219	2.1
S-Th	2	<100	100	--	--	--	--
AA-Au	2	<0.05	0.9	--	--	--	--
AA-As	5	<5	25	9	8.9	6.9	2.1
AA-Zn	130	<5	600	65	71	49	2.0
AA-Cd	120	<0.1	7	0.4	0.7	0.2	2.4
AA-Bi	65	<1	24	1.6	2.9	1.2	1.6
AA-Sb	2	<2	6	--	--	--	--

[1] Number of sample values within analytical working range. Values below detection limit and above upper limit of working range were excluded from statistical calculations.

[2] Where the number of unqualified values is less than 70, these statistics are strongly influenced by anomalous samples. They are included for demonstrative purposes.

Table 3.--Trace-element anomaly thresholds in rock samples associated with Au and Ag deposits.

Element	Threshold (ppm)	Percent visibly unmineralized samples at or above threshold
Ag	0.5	9
As (AA)	5	0
Au (AA)	0.05	0
Ba	1,000	16
Bi (AA)	1	0
Cd (AA)	0.2	7
Cu	100*	0
Mo	10	0
Pb	100**	11
Sb (AA)	2	0
Zn (AA)	100**	9

* 30 ppm in carbonate rocks

** 50 ppm in carbonate rocks

Table 4.--Trace-element anomaly thresholds in stream-sediment samples and panned concentrates.

Element	Threshold (ppm)	
	Sediments	Concentrates
Ag	0.5	1.0
As (AA)	5	--
Au (AA)	0.05	Detectable***
Bi (AA)	2	--
Cd (AA)	0.3	--
Cu	50*	50
Mo	7	10
Pb	100**	100
Sb (AA)	2	--
Sn	10	20
W	50	100
Zn (AA)	75**	--
Zn (spec)	--	500
La	200	1000
Nb	100	150
Y	150	1000
Zr	1000	1000
Th	100	200

* 30 ppm in carbonate-rich sediments

** 50 ppm in carbonate-rich sediments

*** Detection limit depended on the amount of sample.

Table 5. -- Correlation matrix of selected elements for the 66 rock samples from the Fossil Ridge Wilderness Study Area. Correlation coefficients are presented in the lower left half of the table, and the number of correlated pairs for each pair of elements is shown in the upper right half of the table. (Underlined correlation coefficients are statistically significant at the 95-percent confidence level.)

	S-Fe	S-Mg	S-Ca	S-Mn	S-Ag	S-Ba	S-Co	S-Cu	S-Mo	S-Ni	S-Pb	S-Y	S-Zr	AA-Au	AA-As	AA-Zn	AA-Cd	AA-Bi	AA-Sb
S-Fe	--	64	52	64	15	48	36	31	8	45	51	54	47	10	13	54	11	13	7
S-Mg	-.10	--	52	64	15	48	36	31	8	45	51	54	47	10	13	54	11	13	7
S-Ca	-.42	.72	--	52	7	42	30	24	3	34	44	44	40	4	7	44	6	10	3
S-Mn	.39	.44	.12	--	15	48	36	31	8	45	51	54	47	10	13	54	11	13	7
S-Ag	.18	-.38	-.01	-.17	--	9	11	11	7	11	12	14	9	9	10	15	9	8	7
S-Ba	.12	.44	.10	.32	.66	--	32	25	4	38	42	45	43	6	8	41	4	11	3
S-Co	.68	.39	-.02	.26	-.21	-.14	--	24	7	30	33	35	31	8	10	35	8	12	6
S-Cu	.60	-.49	-.12	-.37	.62	-.42	.23	--	7	28	27	29	24	10	10	28	9	12	7
S-Mo	.16	-.67	-.40	-.63	.67	-.86	-.10	.73	--	7	7	7	5	6	7	8	6	4	5
S-Ni	.61	.48	.00	-.28	.27	.17	.65	.18	-.39	--	37	41	38	9	10	40	8	11	6
S-Pb	.08	-.34	-.01	.04	.60	.11	-.10	.34	.29	-.27	--	47	41	8	11	46	9	12	5
S-Y	.42	.18	-.27	.38	-.15	.44	.20	-.52	-.76	.22	-.12	--	42	9	12	49	10	13	7
S-Zr	.30	.26	.26	.28	-.34	.26	.37	.10	-.16	.33	.01	.00	--	5	8	40	5	9	3
AA-Au	.42	-.34	.84	.08	.16	.32	.39	.24	-.15	.56	.03	.40	.74	--	8	9	7	7	6
AA-As	.50	-.83	-.24	-.68	.48	-.85	.06	.70	.92	-.16	.38	-.70	-.34	.07	--	12	8	6	7
AA-Zn	.40	-.21	-.02	-.05	.73	-.21	.02	.74	.75	.26	.57	-.26	.17	-.33	.56	--	11	11	7
AA-Cd	.06	-.62	-.78	-.47	.71	.14	-.54	.30	.43	.14	.86	-.29	-.54	-.40	.11	.91	--	5	7
AA-Bi	.56	-.73	.03	-.19	.05	-.65	.35	.57	.22	.02	.28	-.40	-.26	.69	.56	.14	-.86	--	5
AA-Sb	-.43	-.43	-.61	-.72	.84	.68	-.77	.56	.78	-.06	.64	-.69	-.86	-.63	.37	.73	.85	-.81	--

Table 6.--Selected correlation coefficients for all stream-sediment samples from the Fossil Ridge Wilderness Study Area

	AA-Zn (leachable)	AA-Cd (leachable)	S-Cu
S-Mn	.30	0	.18
S-Fe	0	0	.38