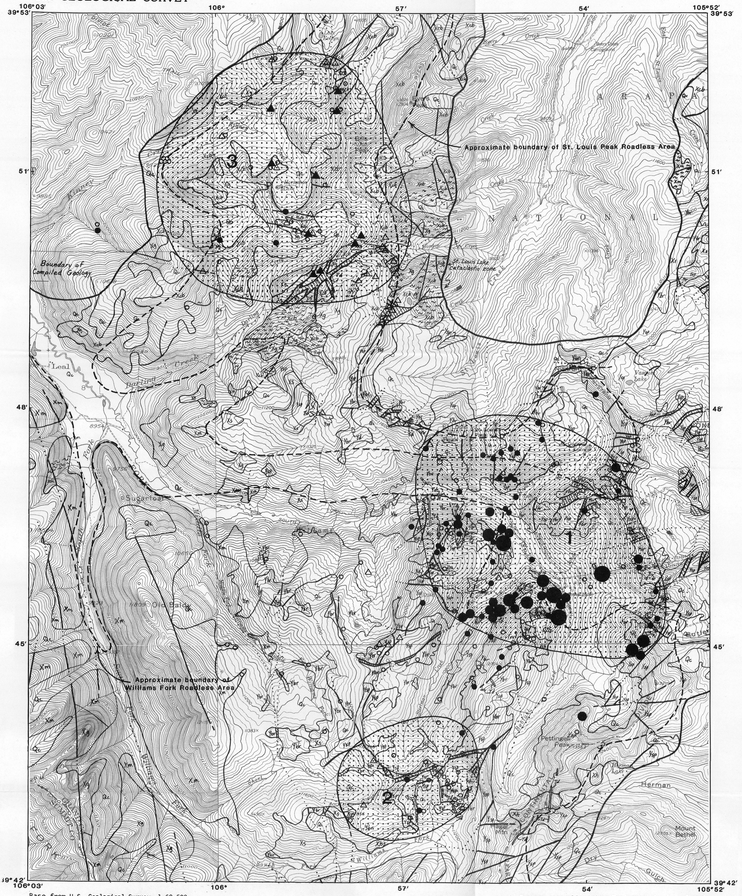
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

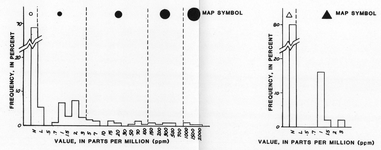
MISCELLANEOUS FIELD STUDIES
MAP MF-1588-E



Base from U.S. Geological Survey, 1:62,500
Dillon, 1929; Ute Peak, 1933; Fraser, 1957;
and Montezuma, 1958

Geology generalized from Eppinger and others (1985)

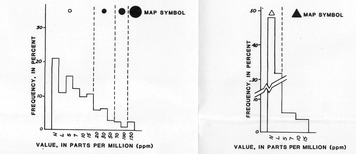
MAP A. DISTRIBUTION AND ABUNDANCE OF SILVER IN ALTERED ROCK AND SOILS



Histogram showing silver in rock samples.
Number of samples, 207.

Histogram showing silver in soil samples.
Number of samples 50.

HISTOGRAMS FOR MAP A. L, detected but below lower limit of determination (0.5 ppm); N, not detected



Histogram showing molybdenum in rock samples.
Number of samples, 207.

Histogram showing molybdenum in soil samples.
Number of samples, 50

HISTOGRAMS FOR MAP B. L, detected but below lower limit of determination (5 ppm); N, not detected.

CORRELATION OF MAP UNITS

Qc	Holocene and Pleistocene — QUATERNARY
Unconformity	
Try, Td	Oligocene(?), Paleocene(?) — TERTIARY
Unconformity	
Ysp, Ybr, Xg, Xs, Xcb, Xhs, Xh, Xm	MIDDLE PROTEROZOIC; EARLY PROTEROZOIC

DESCRIPTION OF MAP UNITS[1]

Qc SURFICIAL DEPOSITS (QUATERNARY)--Cover unit composed of undifferentiated glacial drift, alluvium, and alluvial-fan deposits, colluvium, landslide and slumped ground. Includes deposits of suspected Tertiary age reworked by periglacial processes

Try RHYOLITE DIKES (OLIGOCENE?)--Small, fine-grained, commonly silicified dikelike bodies distributed mainly along the Continental Divide north and south of Jones Pass. Locally exhibit porphyritic texture and (or) flowbanding(?) and (or) jasperoid veins

Td AUGITE DIORITE DIKES (PALEOCENE?)--Fine-grained mafic dikes locally obtaining plagioclase and augite phenocrysts. Only the larger dikes are shown

Ysp SILVER PLUME GRANITE (MIDDLE PROTEROZOIC)--Light-colored, fine- to coarse-grained, seriate porphyritic biotite-muscovite-quartz monzonite with trachytoid texture formed by microcline phenocrysts, but locally equigranular. Locally contains pegmatite. About 1.4 b.y. old

Ybr MIXED ROCKS (MIDDLE PROTEROZOIC)--Composed of Silver Plume Granite rich in inclusions of one or more of the older metamorphic rocks. Locally an intrusive breccia

Xg BOULDER CREEK GRANODIORITE (EARLY PROTEROZOIC)--Well-foliated, medium- to coarse-grained biotite-quartz monzonite to quartz diorite. Locally contains inclusions of biotite gneiss and migmatite. Foliation is parallel to that of enclosing gneisses. Locally contains pegmatites

Xs SILLIMANITE GNEISS (EARLY PROTEROZOIC)--Coarsely layered sequence of medium- to coarse-grained sillimanite-muscovite-quartz-biotite gneiss and quartz-biotite gneiss that ranges to plagioclase-quartz-biotite gneiss and quartzite. Sillimanite commonly segregated into quartz-sillimanite "eyes" oriented along foliation

Xcb CALCIUM-RICH GNEISSES (EARLY PROTEROZOIC)--Range from hornblende gneiss to calc-silicate gneiss, interlayered with biotite gneiss. Hornblende and calc-silicate gneisses range from plagioclase-quartz-hornblende gneiss through diopside-rich gneiss to marble; layering generally more conspicuous than foliation. Biotite gneiss is fine-grained, well-foliated, plagioclase-quartz-biotite gneiss; contains subordinate, fine-grained, disseminated sillimanite. Probably derived from interbedded sediments

Xhs AMPHIBOLITE AND CALC-SILICATE GNEISS (EARLY PROTEROZOIC)--Amphibolite containing numerous layers of calc-silicate gneiss, calc-silicate quartzite, felsic gneiss, and occasional layers of marble. Stratigraphic relationships are unknown, but unit is lithologically similar to the calcium-rich gneisses (Xcb)

Xh HORNBLENDE GNEISS AND AMPHIBOLITE (EARLY PROTEROZOIC)--Predominantly unlayered amphibolite containing minor amounts of hornblende gneiss, felsic gneiss, and calc-silicate gneiss. Only the largest body, near Hagar Mountain, is shown

Xm UNDIFFERENTIATED METAMORPHIC ROCKS (EARLY PROTEROZOIC)--Predominantly a biotite gneiss containing lesser amounts of sillimanite and calcium-rich gneiss. Biotite gneiss ranges from a sillimanite-quartz-muscovite-biotite gneiss to a biotite-quartz gneiss containing subordinate sillimanite and feldspar

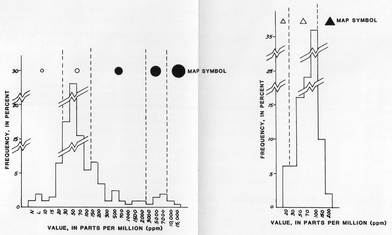
CONTACT--Approximately located

FAULT OR SHEAR ZONE--Approximately located. Zones of shattered rock and (or) abundant gouge, usually altered. Dotted where concealed. U, upthrown side; D, downthrown side

CATACLASTIC ROCK AND (OR) MYLONITE

ANOMALOUS AREAS--Discussed in text

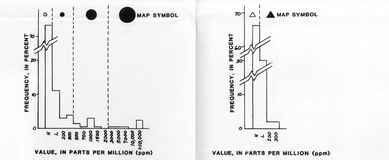
[1]The minerals in composite rock names are arranged in order of decreasing amounts; that is, a biotite-muscovite-quartz monzonite is a quartz monzonite containing more biotite than muscovite.



Histogram showing lead in rock samples.
Number of samples, 207.

Histogram showing lead in soil samples.
Number of samples, 50.

HISTOGRAMS FOR MAP C. L, detected but below lower limit of determination (10 ppm); N, not detected



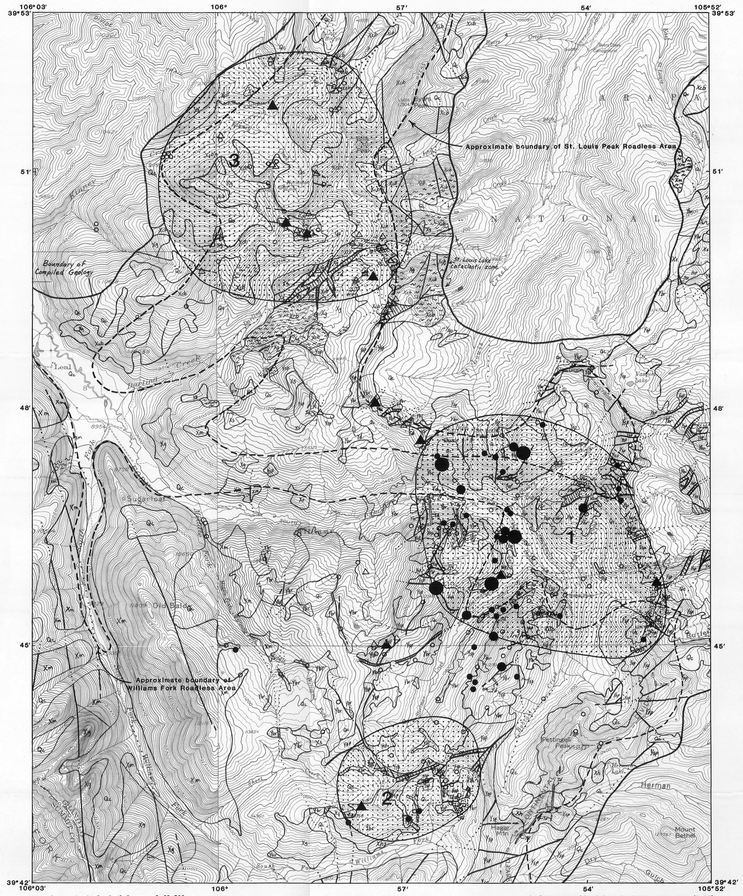
Histogram showing zinc in rock samples.
Number of samples, 207.

Histogram showing zinc in soil samples.
Number of samples, 50.

HISTOGRAMS FOR MAP D. L, detected but below lower limit of determination (200 ppm); N, not detected

SCALE 1:50 000
1 ½ 0 1 2 3 MILES
1 0 1 2 3 KILOMETERS

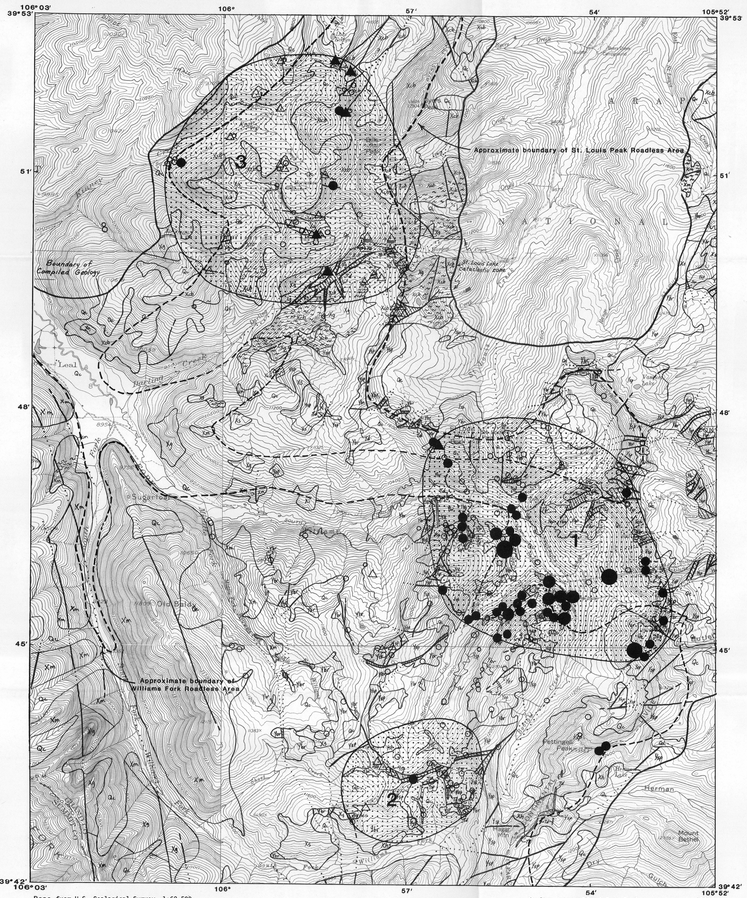
CONTOUR INTERVALS 50 AND 80 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929



Base from U.S. Geological Survey, 1:62,500
Dillon, 1929; Ute Peak, 1933; Fraser, 1957;
and Montezuma, 1958

Geology generalized from Eppinger and others (1985)

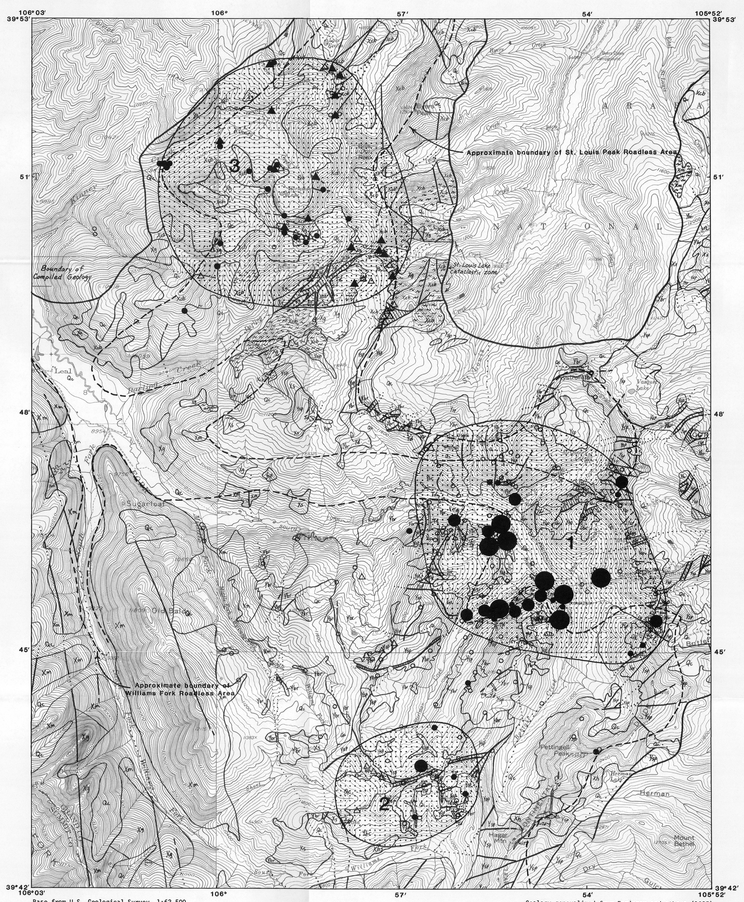
MAP B. DISTRIBUTION AND ABUNDANCE OF MOLYBDENUM IN ALTERED ROCK AND SOILS



Base from U.S. Geological Survey, 1:62,500
Dillon, 1929; Ute Peak, 1933; Fraser, 1957;
and Montezuma, 1958

Geology generalized from Eppinger and others (1985)

MAP C. DISTRIBUTION AND ABUNDANCE OF LEAD IN ALTERED ROCK AND SOILS



Base from U.S. Geological Survey, 1:62,500
Dillon, 1929; Ute Peak, 1933; Fraser, 1957;
and Montezuma, 1958

Geology generalized from Eppinger and others (1985)

MAP D. DISTRIBUTION AND ABUNDANCE OF ZINC IN ALTERED ROCK AND SOILS

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 values, if any, that may be present. 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 Williams Fork (QG114) and the St. Louis Peak (EZ361) Roadless Areas in the Arapaho National Forest, Clear Creek, Grand, and Summit Counties, Colorado. The roadless areas were classified as further planning areas during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January, 1979.

INTRODUCTION

The U.S. Geological Survey and the U.S. Bureau of Mines conducted field studies from 1979 through 1982 to assess the mineral resource potential of the Williams Fork and St. Louis Peak Roadless Areas and the Vasquez Peak Wilderness Study Area. Included were geological, geochemical, and geophysical studies by the U.S. Geological Survey and investigation of known prospects and mines by the U.S. Bureau of Mines. The area of study is located in the Arapaho National Forest, north of Interstate Highway 70, west of U.S. Highway 40, and east of the Blue River, on the west side of the Front Range (fig. 1).

Presented here are geochemical maps showing the distribution of silver, lead, molybdenum, and zinc in altered rocks and soils. The samples included in this report were collected only in the areas in which detailed geologic mapping was performed by the authors. Roughly, those areas include the northeastern part of the Williams Fork Roadless Area, all but the northernmost part of the St. Louis Peak Roadless Area, and the corridor between these two roadless areas. Altered-rock and soil samples were not collected in the Vasquez Peak Wilderness Study Area or the northernmost St. Louis Peak Roadless Area. However, these areas were studied in stream-sediment and soil geochemical investigations by Barton and Turner (1984).

GEOLOGY

Information in this section is derived from a more detailed description of the geology of the area by Eppinger and others (1985), which is a compilation of reconnaissance and detailed geologic mapping in the study area.

The crystalline rocks in this area form the westernmost part of the Front Range uplift and have been thrust westward over the eastern edge of the generally synclinal basin of Mesozoic sedimentary rocks underlying the Blue River valley. The eastern part of the area has been included in the Front Range mineral belt since the discovery of the Henderson ore body at Red Mountain in 1964. The Urad and Henderson deposits, less than two miles east of the Williams Fork Roadless Area are recognized as one of the largest accumulations of molybdenum ore in the world (Wallace and others, 1978).

Bedrock in the area is generally Proterozoic metamorphic and igneous rocks, although Mesozoic sedimentary rocks are exposed along the west side of the Williams Fork Roadless Area and near Bottle Peak in the northernmost part of the St. Louis Peak Roadless Area. The metamorphic rocks range from sillimanite and biotite gneisses to calcic hornblende and calc-silicate gneisses. The Proterozoic igneous rocks are of two types and ages: Boulder Creek Granodiorite of the 1.7 billion year age group and Silver Plume Granite, a quartz monzonite of the 1.4 billion year age group. Sparse Tertiary(?) dikes of augite diorite and rhyolite cut the Proterozoic rocks in the central and eastern parts of the contiguous areas of study, but these are generally too small to be shown at this scale.

A complex mesh of faults, fractures, and shear zones ranging in age from Proterozoic to Cenozoic segments the rock units. In the north, northeast-trending faults predominate. To the west, the Williams Range thrust, and parallel faults to the east of it, trend northwesterly. The Berthoud Pass fault zone, on the eastern edge of the study area, trends northeasterly, converging to the southwest with the Williams Range fault system. The triangular area within these three domains, particularly the area bounded by the Middle Fork Williams Fork River on the west, Bobtail Creek on the east, and the Williams Fork River on the north, is a wedge between the three structural domains. Although not shown at this scale, faults, fractures, and shear zones within the triangle are more numerous than elsewhere, trends are more erratic and often curved, and through-going structures are not evident.

Cover on bedrock is extensive and ranges from a periglacially deformed, deep regolith on the gentler slopes flanking ridgetops, through a variety of glacial deposits on valley walls and floors, to broad alluvial plains on the lower valley bottoms. In all, these cover units limit bedrock exposures to 30 percent or less.

SAMPLING MEDIA

Sample media were selected to give indication of types of mineralization and local intensity of mineralization. A total of 207 rock and 50 soil samples were collected from fault zones, fractures, shear zones, alteration zones, and prospects encountered during the detailed geologic mapping phase of the mineral resource assessment studies. Known mineralization (prospects) and possible leakage halos from concealed mineralization (faults, shear zones, and fractures) were sampled, as were sporadic zones of alteration in bedrock. The resulting distribution of sample sites reflects the irregular occurrences of the geologic features sampled. These samples were selected to characterize deviations from the norm rather than to establish normal background levels of concentration.

The "soil" samples were generally composite samples taken across fault or shear zones and in most cases are simply unconsolidated gouge.

ANALYTICAL METHODS

Samples were crushed and pulverized to approximately minus-150 mesh. Precaution was taken to minimize the potential for contamination by running liberal amounts of quartz through the pulverizing equipment between each sample. A 10 milligram split was then used for emission spectrographic analysis for silver, molybdenum, lead, and zinc; and 27 other elements by the semiquantitative spectrographic method of Grimes and Marranzino (1968).

Details on analysis, detection limits, and sample coordinates are presented in Eppinger and others (1983), and are also entered in the U.S. Geological Survey computerized Rock Analysis Storage System (RASS) (VanTrump, and Miesch, 1977).

RESULTS

The term anomalous, as used in the following discussion, refers to values found to deviate substantially from the upper limit of background values. It is based on inspection of histograms, percentiles, and average crustal abundances for elements given by Levinson (1980).

Rock and soil samples having anomalous values for silver, lead, molybdenum, and zinc are spatially clustered in three areas: (1) an area centered near the head of the Williams Fork River and extending into both the Williams Fork and St. Louis Peak Roadless Areas, (2) an area in the Williams Fork Roadless Area centered near the head of the South Fork Williams Fork River, and (3) an area centered near Horseshoe Lake in the St. Louis Peak Roadless Area.

Area 1 has the highest values for the four metals and encompasses much of the structurally complex triangular area described above. The radius of this anomalous zone is approximately 1.5 miles and has a center near the junctions of Bobtail, Steelman, and McQueary Creeks. The terrane is predominantly Silver Plume Granite, often exhibiting blotchy alteration patterns. Alteration minerals are chlorite, clay, sericite, and quartz. Sporadic Tertiary(?) augite diorite dikes and, to a lesser degree, Tertiary(?) rhyolite dikes occur in the area. Faults, fractures, and shear zones are more numerous in this area than elsewhere; numerous prospect pits and small adits in the area generally follow mineralized veins or fault zones. Thus, this area is more densely sampled than other areas. Lead values range from just detectable at 10 parts per million (ppm) to 15,000 ppm (1.5 percent). All sites with lead values greater than or equal to 1000 ppm (which corresponds approximately to the 92nd percentile) occur in this area. Zinc in excess of 10,000 ppm (1 percent) occurs at five sites. Molybdenum values of 20 ppm or greater occur at 37 sites, 12 of which have molybdenum values ranging from 70 to 150 ppm. Silver values greater than 100 ppm occur at 21 sites; four of those sites have values of 1000 ppm or greater. Anomalous values for copper, arsenic, and antimony also occur in this area. Ore-related minerals observed in outcrop and prospect dumps include galena, sphalerite, pyrite, chalcopyrite, arsenopyrite, and fluorite. Iron oxide pseudomorphs after pyrite are common. Secondary copper minerals were rarely observed.

Area 2 is a smaller, less intense, anomalous zone in the Williams Fork Roadless Area and is centered near the heads of the South Fork Williams Fork River, Bobtail Creek, and Steelman Creek. Silver Plume Granite is the major rock unit in the area; the area contains lesser amounts of hornblende gneiss and augite diorite dikes. Rhyolite float, presumably from a small dike, occurs at one spot within the anomalous zone. Shear zones are numerous. Out of a total of approximately 30 sites within this zone, four sites have a silver value of 1 ppm, four sites have molybdenum values ranging from 10 to 50 ppm, four sites have zinc values ranging from just detectable at 200 ppm to 500 ppm, and a single site has a lead value of 150 ppm. Two sites anomalous for arsenic and two sites containing anomalous copper values also occur in this zone. Chalcopyrite, pyrite, fluorite, and a secondary copper mineral were observed in one prospect; however, ore-related minerals are generally rare and prospects are few.

Lower level anomalous values for silver, lead, molybdenum, and zinc occur in area 3, in the central part of the St. Louis Peak Roadless Area. Centered near Horseshoe Lake, this anomalous area has a radius of approximately 2 miles. The terrane is predominately a calcic sequence of metamorphic rocks and lesser amounts of Boulder Creek Granodiorite. Generally, alteration was not observed in bedrock; however, blocks of gossan, presumably derived from massive pyrite bodies, were commonly observed in float on till. Approximately 60 sample sites occur in this area, where silver values in rock and soil range from 1 to 3 ppm at 13 sites. A lead value of 150 ppm occurs at 8 sites. Four soil-sample sites have molybdenum values of 5 to 15 ppm. Zinc values near the detection limit of 200 ppm occur in more than 50 percent of the samples within the area. Anomalous beryllium and copper values also occur at several sites.

SUMMARY

Anomalous geochemical values for silver, lead, and zinc in altered rocks and for molybdenum in altered rocks and soils occur near the junctions of Bobtail, Steelman, and McQueary Creeks. Known silver-rich, lead-zinc vein-type deposits occur in the area, as evidenced by past prospecting and mining activity. These geochemical data, along with visual evidence of ore-related minerals, the pervasive, but blotchy alteration in bedrock, and the fact that 70 percent or more of the area is covered by surficial deposits, suggest the possibility of additional, but concealed, vein-type Ag-Pb-Zn deposits.

Similar, though less intense geochemical evidence and limited prospecting activity near the head of the South Fork Williams Fork River suggest that the same concealed vein-type deposits may occur in this area.

The large molybdenum ore deposits at Red Mountain occur less than two miles east of the Williams Fork Roadless Area, and these deposits are surrounded by vein-type deposits similar to those described above. This anomalous metal assemblage, the alteration in bedrock, the occurrence of fluorite and other ore-related minerals, the sporadic recognition of small rhyolite bodies, and the geochemical presence of molybdenum in altered rocks and soils are all features that would be expected to occur above deposits similar to the molybdenite stockwork deposits at Red Mountain.

Low-level geochemical anomalies for Ag, Mo, Pb, Zn, Cu, and Be occur in rocks and soils in the central part of the St. Louis Peak Roadless Area. Some pods and small masses of gossan contain geochemically anomalous amounts of silver, lead, zinc, and copper. Abundant surficial cover in the area obscures most of the bedrock from direct observation. Concealed massive-sulfide mineralization may occur in this area, as suggested by the low-level geochemical anomalies, the occurrence of gossan blocks in float, and the favorable terrane of calcic metamorphic rocks intruded by granitic rocks.

REFERENCES

Barton, H. N., and Turner, R. L., 1984, Geochemical data for the Vasquez Peak Wilderness Study Area and the Williams Fork and St. Louis Peak Roadless Areas, Clear Creek, Grand, and Summit Counties, Colorado: U.S. Geological Survey Open-File Report 84-505.

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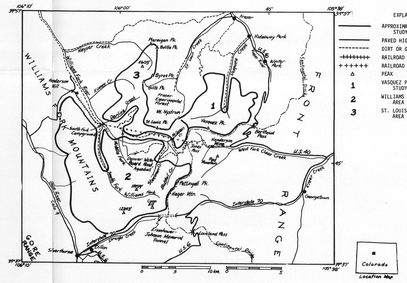

Figure 1.--Location of the Vasquez Peak Wilderness Study Area and the Williams Fork and St. Louis Peak Roadless Areas, Colorado

MAPS SHOWING ANOMALY PATTERNS FOR SILVER, MOLYBDENUM, LEAD, AND ZINC IN ALTERED ROCKS AND SOILS, WILLIAMS FORK AND ST. LOUIS PEAK ROADLESS AREAS, CLEAR CREEK, GRAND, AND SUMMIT COUNTIES, COLORADO

By
R. G. Eppinger, P. K. Theobald, H. N. Barton, and R. R. Carlson

1985

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