APPENDIX I

APPENDIX I

MINERAL INVESTIGATION OF THE SANGRE DE CRISTO WILDERNESS STUDY AREA, ALAMOSA, CUSTER, FREMONT, HUERFANO, AND SAGUACHE COUNTIES, COLORADO

By

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INTRODUCTION

In May through September, 1982, the Bureau of Mines, as part of a joint effort with the Geological Survey, completed a mineral investigation of the Sangre de Cristo Wilderness Study Area (WSA) that was begun in 1979 and recessed after one month.

Location, size, and geographic setting

The Sangre de Cristo WSA covers approximately 221,000 acres (350 mi^2) of the San Isabel and Rio Grande National Forests in south-central Colorado. The WSA is in Alamosa, Custer, Fremont, Huerfano, and Saguache Counties, and adjacent to Costilla County (fig. 1).

The WSA includes most of the northwest-trending Sangre de Cristo Mountains between Poncha Pass on the northwest, and La Veta Pass on the southeast. The WSA is about 70 mi long and 5 to 8 mi wide. The boundary generally follows the foot of the mountains except where roads or private property cause deviations (pl. 1).

The WSA is accessible by county, forest service, BLM, ranch, and mine roads from U.S. Highway 50 on the north, U.S. Highway 285 and Colorado Highways 17 and 150 on the west, U.S. Highway 160 on the south, and Colorado Highway 69 on the east (fig. 1). Colorado Highway 150 ends at the Great Sand Dunes National Monument which adjoins the WSA on the west side between Mosca and Medano Passes. North of the Monument, the WSA adjoins the Luis Maria Baca No. 4 (Baca Land Grant). The land grant is 12 1/2 mi square, and contains a triangle of the Sangre de Cristo Mountains not included in the WSA. Kit Carson

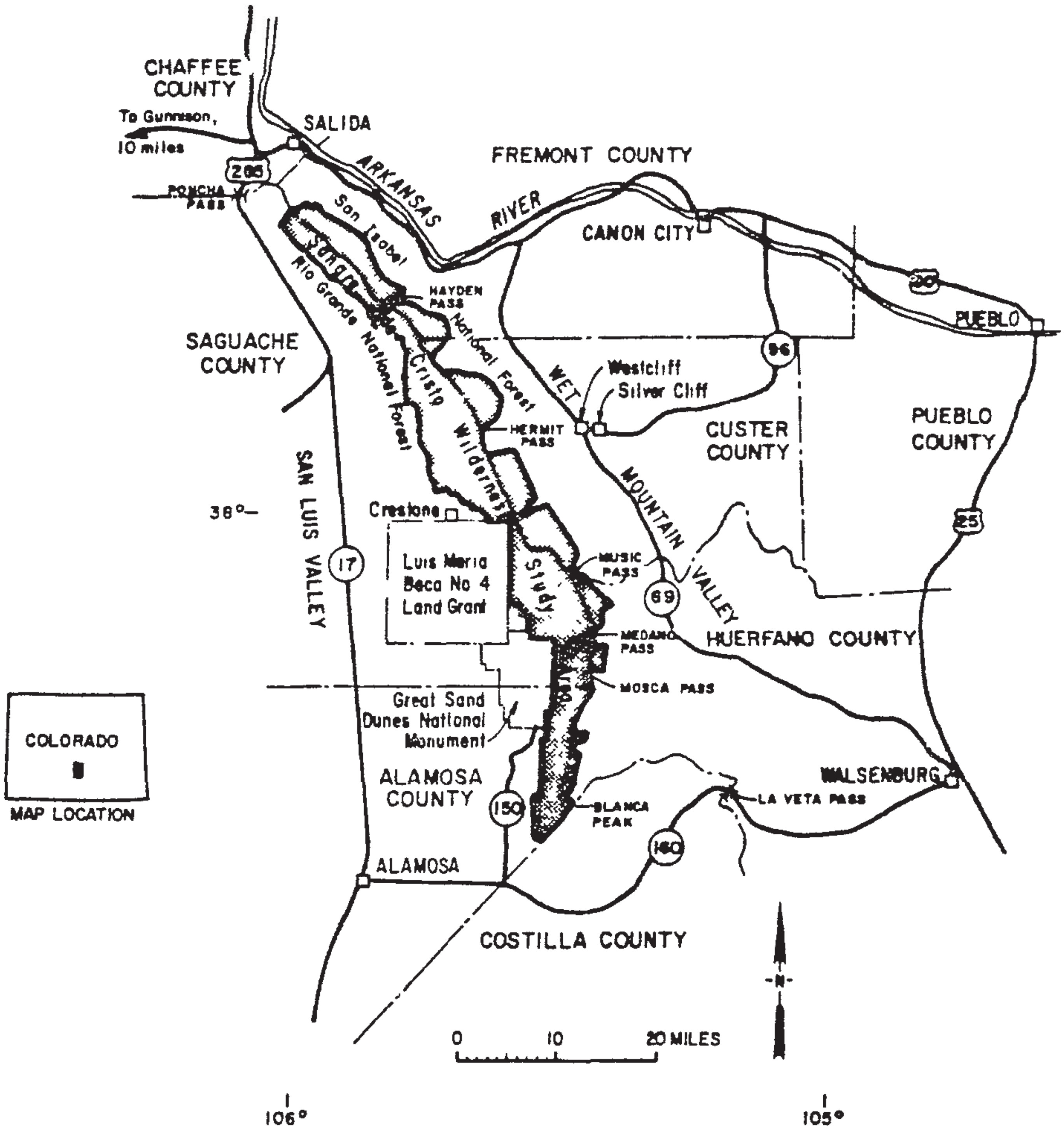

Figure 1.--Index map of the Sangre de Cristo Wilderness Study Area, Alamosa, Custer, Fremont, Huerfano, and Saguache Counties, Colorado.

Mountain, on the c~est of the range, is approximately on the northeast corner of the land grant. Foot access through the grant is generally allowed, but vehicular access is restricted.

Jeep trails across Hayden and Medano Passes divide the WSA into three parts. A gravel road extends to the top of Mosca Pass from the east. About 10 mi north, the Music Pass road is drivable from the eastern base of the range to within about 1 mi of the summit. Three mine roads extend into the east side of the WSA in its central part: the South Colony road ends at an abandoned uranium mine near the 14,000 ft plus Crestone Peaks; about 14 mi farther north, the Hermit Pass road crosses the range to a uranium prospect, but is now blocked at the range crest; about 16 mi farther north there is a road to the Stamina Mine in Cloverdale Basin (pl. 1).

Principle towns of the region are Salida, about 8 mi north of the WSA; Alamosa, about 20 mi southwest; Walsenburg, about 35 mi southeast; and Canon City, about 25 mi northeast. Westcliffe and Silver Cliff, adjacent towns about 6 mi east of the WSA, are the population center in the Wet Mountain Valley. Crestone is at the western base of the range (fig. 1).

The Sangre de Cristo Mountains rise abruptly from the San Luis Valley on the southwest, and the Wet Mountain Valley on the northeast. The range crest is generally above 12,000 ft elevation except between Mosca and Medano Passes--about 15 mi north of the south end of the WSA--and near Hayden Pass--about 15 mi southeast of the northwest end of the WSA. The highest elevation is 14,363 ft on Blanca Peak at the southern end of the WSA. The lowest elevation is about 8,000 ft only 5 mi west, at the base of the range.

The Sangre de Cristo Mountains are bounded by the Alvarado fault on the northeast and the Sangre de Cristo fault--a component of the Rio Grande Rift--

on the southwest. The rocks between these faults are mostly Precambrian igneous and metamorphic rocks or Pennsylvanian and Permian clastic sedimentary rocks. Lower Paleozoic rocks are exposed along the western base of the range, and in a band crossing the northern end of the range (Johnson and others, 1983).

Previous studies

The mineral deposits in the Sangre de Cristo Mountains may be the least studied deposits in the state of Colorado. Bagg (1908) briefly examined the Rita Alta copper deposit. Worchester (1918) briefly examined molybdenum prospects in Cloverdale Basin. Stone (1934) studied the Orient iron mine. Parker (1952) reviewed the history of the Crestone gold district. Gableman (1953) defined a mineral belt which includes the Sangre de Cristo Wilderness Study Area.

Many studies have been made of the stratigraphy and structure of the range. De Voto (1971) contains a good bibliography.

U.S. Bureau of Mines and Colorado Division of Mines records contain references to many workings that should be in or near the WSA, but the locations given were generally vague. In some cases, workings matching the described workings were located, but in most cases the described workings could not be matched with workings found during this study.

Present investigation

During the course of the study, the WSA had slightly different boundaries under RARE, RARE II, and Public Law 96-560. To preclude the possibility of an incomplete study should further boundary changes occur, the study covered all ground (excluding the Baca Grant) between the faults that bound the range, and extended at least 1 mi beyond the ends of the boundary.

Prior to field investigations, a background search was made of published literature, Bureau of Mines Files, and files of the Colorado Division of Mines. County courthouse and Bureau of Land Management records were searched for mining claims, oil and gas leases, and geothermal leases.

Mines, prospects, and mineralized areas were mapped and sampled. Samples were taken from structures and mineralized zones exposed at workings or in outcrop. Samples were taken on a grid across the dump, where the working was inaccessible. Most workings examined were discovered during field investigations, and we estimate that 75 to 85 percent of the workings in the WSA were examined. The remainder would be generally below timberline and hidden from aerial view. A few workings were observed at a distance, but time did not allow an examination. An investigation of an area of this size would generally take two or more field seasons, but the report deadline (December, 1983) imposed by Public Law 96-560 precluded two field seasons. To achieve the minimal coverage, sample density was decreased 30-40 percent. Although quantitative evaluation suffered, we do not believe qualitative evaluation would have changed greatly with additional time.

A total of 1,310 samples were taken; all were fire assayed for gold and silver, and spectrographically analyzed for 40 elements. Some samples were analyzed for specific elements by other means: copper, lead, and molybdenum by atomic absorption, tungsten by colorimetry, and uranium by fluorimetry. Complete analytical results are available for public inspection at the Bureau of Mines, Intermountain Field Operations Center, Building 20, Denver Federal Center, Denver, Colo. 80225.

Acknowledgements

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Dunes National Monument; David C. Scott of the Bureau of Mines; Ray Burney, helicopter pilot; claim owners Bill Humble, Cecil Pickens, Leroy Rusher, George Simmons, and Wright Engineering; and land owners Bill Bunker, Dr. Haller, Henry Lamb, and Walt Weiss.

Mining activity

Mining activity inside the WSA in recent years has been limited to exploration for uranium, molybdenum, copper, and gold. From the late 19th century, mining claims have been staked throughout most of the Sangre de Cristo Mountains. Since most of the old mining claims on record at the courthouses contain vague or misleading locations, only claims currently on file with BLM (as of 1982) are shown on plates 1 and 2. During the 20th century, gold has been produced from various properties along the west side of the WSA, copper production was attempted (with unknown success) near Cotton Creek on the west side of the WSA, and uranium was produced from a few workings scattered through the WSA. No mines with significant recorded production are inside the WSA. The Orient Mine, located outside the western boundary of the area, produced iron ore from 1880-1931. Although there is little recorded production for the Independent Mine, located in the Crestone district outside the western boundary of the area, it reportedly made its two owners millionaires. The Crestone district had several smaller producing mines prior to 1904, when a Supreme Court decision brought about eviction of all miners from the Baca Land Grant (Parker, 1952, p. 27). None of this production is recorded. Production from other properties given in this report, is an estimate derived from Bureau of Mines work on this project.

Records of production are nonexistant for most workings in the Sangre de Cristo Mountains. To give the reader a comprehension of approximate production from workings and mineralized areas, production was estimated from sample assays and tonnage removed from the ground. These estimates contain two flaws. First, they are inevitably too low, as high grade pockets were generally mined out, leaving only low grade material for sampling. Second, they are an approximation of what was removed from the ground, but recovery of the contained metals may have been poor or nonexistant, at least for some of the metals.

MINING DISTRICTS AND MINERALIZED AREAS

Mining districts

Within the Sangre de Cristo Mountains, in and adjacent to the WSA, are the following mining districts: Blake (Mirage), Blanca, Bushnell Lakes, Cedar Creek, Cloverdale Basin, Cotton Creek, Crestone, Crestone Needles, Hayden Pass, Hermit Pass, Horn Peak, Liberty (Music), Marble Mountain, Orient, Raspberry Creek, Rita Alta (Spruce Creek), San Isabel, South Rock Creek, Steel Canyon, Verde, West Blanca, and Wild Cherry Creek (fig. 2). No boundaries have been defined for any of these districts. Except for references to the part of the Crestone district on the Baca Land Grant, there will be no further mention of districts. Instead, all subdivisions of the area will be on the basis of mineralization and to a minor extent, geology.

Mineralized areas

The Mineralized Areas from north to south are: Raspberry Creek, Bushnell Lakes, Steel Canyon, Cloverdale Basin, Rita Alta copper mine, Orient iron mine, Garner Creek, Cotton Creek, Wild Cherry Creek, Verde Creek, Marshall Gulch, Dimick Gulch, Red beds, Crestone, Liberty, Carbonate Mountain, West Blanca, and Blanca Peak. Locations of the mineralized areas are on figure 3. Details of these areas are on table 1.

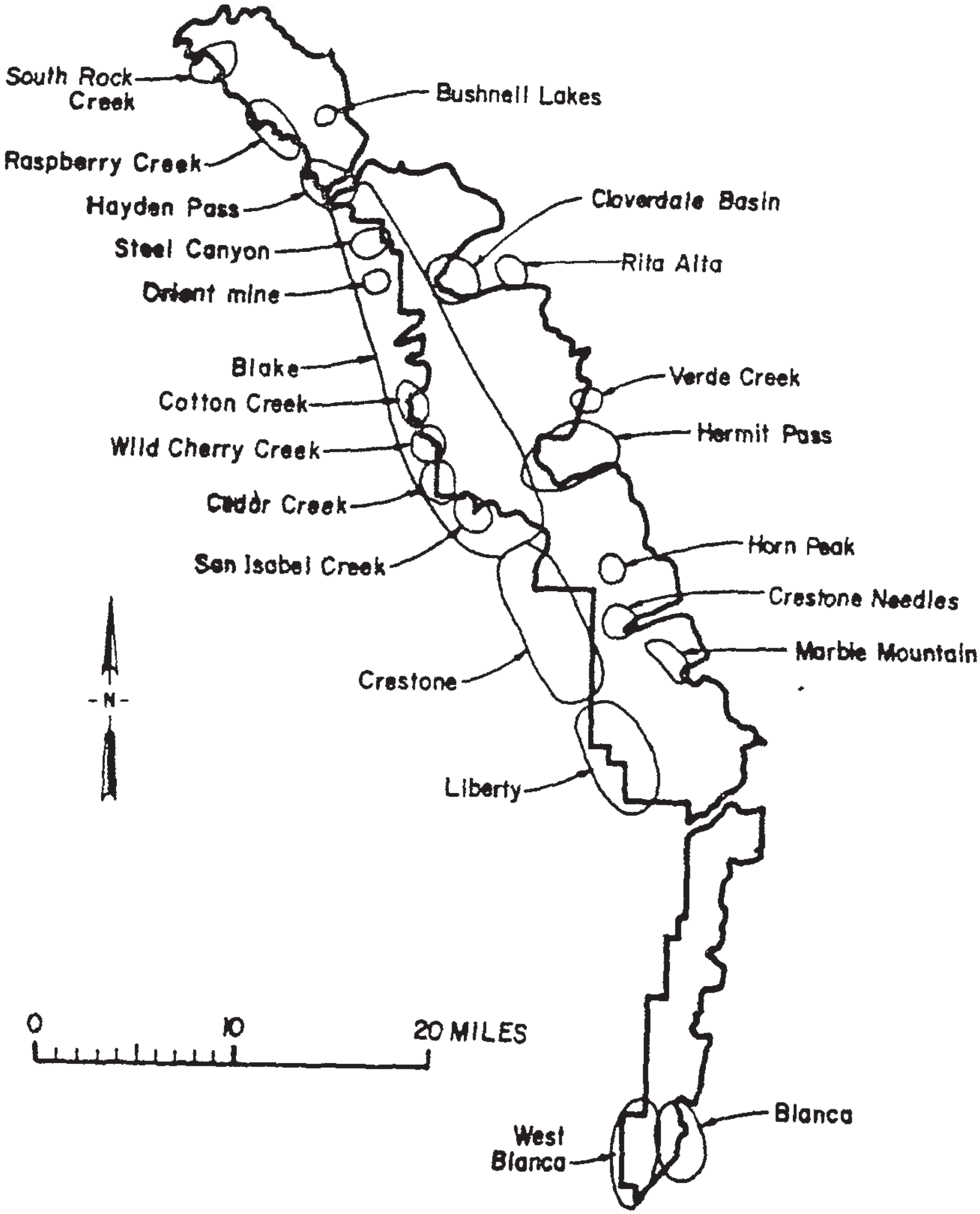


Figure 2.--Map showing locations of mining districts in and around the Sangre de Cristo Wilderness Study Area.

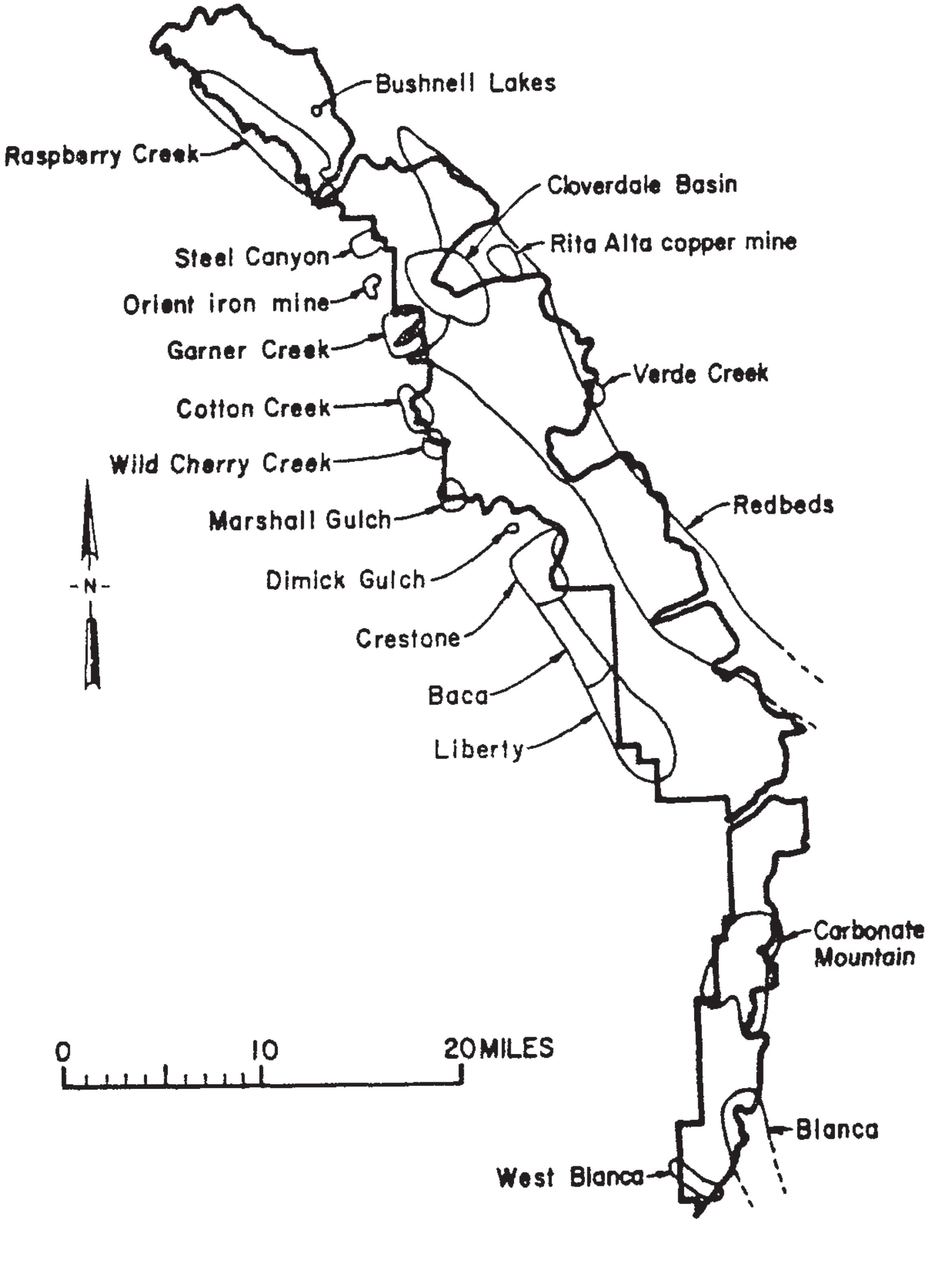


Figure 3.--Map showing locations of mineralized areas in and around the Sangre de Cristo Wilderness Study Area.

Raspberry Creek

The elongate Raspberry Creek area extends along the west side of the WSA from South Rock Creek to Hayden Pass, and from the base to the crest of the Sangre de Cristo Mountains (pl.1).

Precambrian igneous and metamorphic rocks underlie the part of the Raspberry Creek area north of Galena Peak, which is about 1 mi north of Hayden Pass. The lower Paleozoic section, consisting mostly of limestones and dolomites, crosses the crest of the range on the south side of Galena Peak. The Paleozoic rocks dip steeply east and strike nearly north-south.

Small quartz veins, containing galena and chalcopyrite with gold and silver (table 2), have been prospected in Precambrian granite and gneiss from Hayden Pass (fig. 4) to Galena Peak, mostly along the crest of the range. The Paleozoic rocks show no mineralization except for calcite veining and iron staining on Hayden Pass.

The large numbers of caved workings along the base of the range may have been an attempt to intersect the small veins at depth. Mine inspector's reports for 1912 and 1913 mention over 1,400 ft of workings on the Adelaide claims, and three veins containing lead and copper that were followed or intersected. The Adelaide workings were not identified during this study. Except for three dump samples containing gold and silver (table 2, samples 42, 43, 68,) samples from caved workings in the Raspberry Creek area were relatively barren. The rocks along the base of the range, where the caved workings are generally located, are highly fractured because of their close proximity to the Sangre de Cristo fault. Outcrop is very sparse, and in most cases dumps did not show evidence of mineralization or structure except for moderate iron staining. A few dumps had fragments of vuggy quartz with limonite coatings. No resource can be identified in this area, although opening the many caved workings would provide access to much new information, and might allow one or more small- to medium-size resources of lead, gold, and silver to be defined. Such resources could extend into the WSA.

Bushnell Lakes

Inside of the WSA, on the east side of the range, Paleozoic limestone has been intruded by a small monzonite body. Several prospects (pl. 1) in the limestone show brecciation, baking, and introduction of iron. Assays from these pits (fig. 5) show gold and silver in small quantities; prospects nearer the contact with the monzonite have silicified and serpentinized limestone with sparse chrysotile asbestos.

The exposure is not adequate to identify a resource here, although a small resource or precious metals could exist at depth.

A prospect in faulted limestone further up the Bushnell Lakes trail (pl. 1) was caved, and the dump sample was essentially barren.

Steel Canyon

Steel Canyon is just south of Hayden Pass on the west side of the WSA (pl. 1). Most of the area is in Paleozoic rocks, although Precambrian rocks crop out along the base of the range. The Paleozoic section strikes approximately north, and dips nearly vertically. Cambrian Quartzites overlie Precambrian granite and gneiss at the mouth of the canyon. The lower Paleozoic carbonate rocks are tightly folded parallel to their strike. Pennsylvanian Minturn Formation crops out along the crest of the range.

Workings in the area are adits and a shaft in tightly folded limestone and small marble quarries in locally gently-folded limestone.

Quartz-calcite veins strike about east-west, cutting across the folds. Near the surface, the veins are highly oxidized, leaving a gossan composed of limonite with minor quartz, calcite, traces of barite, fluorite, and malachite. Where exposed underground, the veins are composed of calcite, limonite, quartz, galena, chalcopyrite, and fluorite. Assays of samples show silver, occasionally gold, and traces of zinc and antimony (table 3; figs. 6-8).

The major veins are exposed in two adits about 1/2 mi apart (figs. 6, 7), and one caved adit in between explored a gossan on the trend. A fourth working on this trend was seen from the air, but never found on the ground because the vein(s) crop out in dense timber on a north-facing slope. Quartz vein material containing silver (table 3) is on the dump of a prospect in Precambrian granite near the western adit. This could be a parallel vein. About 1/2 mi outside the WSA, near the ridge top, are two shafts on smaller veins of similar orientation (fig. 8).

The vein system could be related to a rhyolite dike that crops out on the ridge at the head of Steel Canyon, although there is no evidence of veining in the Minturn Formation sandstones and shales which are between the dike and the vein exposures. The dike is an offshoot of the Tertiary Rito Alto stock, and is inside the WSA.

A large mill building was standing in Steel Canyon in 1982. According to claim owner George Simmons (oral communication, 1982) the mill operated briefly in about 1901. The only remaining equipment is a boiler.

About a third of the workings that were active in 1902 to 1904, according to mine inspector reports, were not found during this study. The Mountain Lion Mine, largest recorded lead producer in the Sangre de Cristo Mountains, is located just north of Steel Canyon according to Bureau of Mines production records. No workings were found during this investigation which could have yielded the tonnage attributed to the Mountain Lion; however, the relative quantities of metals in veins in Steel Canyon, and the fact that at least one large working was seen only from the air, suggest that the Mountain Lion is in the Steel Canyon area.

The estimated metal production from Steel Canyon was 5 oz of gold, 7,000 oz of silver, 70,000 lb of lead, and 8,000 lb of copper.

A small silver-lead resource is present in Steel Canyon, outside the WSA. The silver-lead vein(s) could extend into the WSA.

Cloverdale Basin

Cloverdale Basin is partly in an embayment into the eastern side of the WSA. The Tertiary Rito Alto stock crops out in the basin and along the crest of the range within the WSA. The Rito Alto stock is a composite granitic pluton that intrudes the Sangre de Cristo and Minturn Formations. Contacts of the stock with the surrounding Sangre de Cristo and Minturn Formations are: 1) faults with minor alteration, and 2) intrusive contacts with intense but local thermal alteration and remobilization of iron.

The stock was prospected for molybdenum both recently, by Molycorp, and before 1918 (Worcester, 1918, p. 52-53). The molybdenite occurrence is associated with quartz veins and a rhyolite dike within the stock, although many other samples from other parts of the stock contain trace amounts of molybdenum and copper (table 4). Gold, silver, and tungsten were also found in assays of samples from prospects in the Rito Alto stock.

The Stamina (Cloverdale) Mine, in the basin, was driven about 1,600 ft between 1922 and 1950 (fig. 9). The target of the effort was a copper-bearing vein in the Minturn Formation. A few ounces of gold may have been produced in 1931, but the copper-bearing vein was not intersected. The vein outcrop was not found in the limited time of the study.

No resource was identified within the immediate area of outcrop of the

Rita Alta copper mine

The Rita Alta Mine is about 1/2 mi outside the eastern boundary of the WSA (pl. 1). The mineralized area is in sandstone and siltstone of the Pennsylvanian-Permian Sangre de Cristo Formation, between two faults that parallel the base of the range. Veins of barite, quartz, and charcopyrite along bedding planes and joints are exposed in an open cut.

Underground workings were not accessible, but development would have been at least a few thousand feet according to dump size.

The mine produced copper, silver, and gold in the early 1900's. The mineralization could be related to the faults or the Rito Alto stock about 2 mi to the west. A small copper resource could extend into the WSA.

In the mid 1950's, tantalum was believed discovered in the 3,200 ft Peerless Tunnel (fig. 10) about 1/2 mi south of the Rita Alta Mine. An investigation, including sampling, by the Bureau of Mines and the Geological Survey (Harshman, E. N., and Salsbury, M. H., 1954, DMEA Report 3236, Bureau of Mines files, Denver, Colo.) resulted in the conclusion that no tantalum or columbium was present. The examiners concluded that the analyses that reported tantalum were faulty because tantalum determinations were difficult and false results common.

Orient iron mine

The Orient Mine is outside the western edge of the WSA (pl. 1). Between 1881 and 1931 the mine produced 1.7 million tons of iron ore (Stone, 1934, p. 317) from an oxidized replacement deposit in sheared Leadville Limestone, adjacent to the Sangre de Cristo fault. According to Stone, the ore was limonite after siderite, however, the possibility exists that the Orient deposit is a gossan over a sulfide deposit. Bureau sampling in the Orient was done to compare minor elements with those in other gossans. The comparisons were inconclusive, and Orient Mine sample analyses are not presented here at the request of Colorado Fuel and Iron Steel Company. The Orient was originally a copper prospect, and sparse chalcopyrite and barite occur throughout the ore body. Gold was reported in some assays (Stone, 1934, p. 325).

Stone's work identified reserves below the main (5th) level. A sixth level was started, but was never advanced to the remaining ore. This resource is outside the WSA, and does not continue along strike into the WSA, because the Leadville Limestone is cut off by a fault just north of the mine. The Sangre de Cristo fault is a convenient source for the mineralizing fluids, however, the mineral assemblage (barite and chalcopyrite) is the same as the Rita Alta Mine and elsewhere around the Rito Alto stock. The fault or the stock could be the source of mineralizing fluids. Most of the area between the stock and the Orient Mine is within the WSA.

Garner Creek

Approximately one quarter of the Garner Creek area, just south of the Orient Mine, is in the WSA (pl. 1). The area is composed of small fault blocks of Precambrian and Paleozoic rocks.

Hot Springs Canyon, the north part of the area, is in Precambrian granodiorite. Two short adits explore a small quartz vein with sparse chalcopyrite (fig. 11). Near the mouth of the canyon a third adit explores a barite vein with minor chalcopyrite in the Minturn Formation sandstone (fig. 12).

Garner Canyon, in the middle of the area (fig. 13A), has a number of small workings in Precambrian granite and quartzite, and Minturn Formation shale and sandstone. A fracture zone in quartzite exposed in an adit (fig. 13B), has fillings of limonite, and chalcopyrite. Some wall rock replacement is evident. Assays show minor silver content in this material. The Rito Alto stock contact-zone is exposed in prospects not far up the canyon. Copper, cobalt, molybdenum and barite are present in most of the samples from Garner Canyon (table 5, figs. 13A, B).

Major Canyon, south of Garner Canyon, has two short adits (fig. 14) on a brecciated contact between lower Paleozoic limestone and quartzite. Limonite has replaced some of the limestone. This is considered an iron prospect because: 1) iron content averaged 51 percent, and 2) gold content averaged 0.094 oz/ton--more than adequate reason for more extensive workings. Although about 50 oz of gold came from the small workings, none may have been recovered.

A small gold resource is identified in Major Canyon along a contact that is not present in the WSA (about 1,500 tons of 0.10 oz/ton gold), and a small copper resource may be present in Garner Canyon, outside of, but possibly extending into the WSA.

Cotton Creek

Cotton Creek is just south of Major Creek on the west side of the Sangre de Cristo Wilderness Study Area (pl. 1). Over half of the mineralized area is in the WSA.

Chalcopyrite is found disseminated in Precambrian gneiss and granite, along foliation planes in gneiss, in quartz veins, and in quartz-barite veins from Cotton Creek nearly to Wild Cherry Creek (table 6). The most intense mineralization is between Cotton Creek and Spring Creek (figs. 15A-C, 16A-C).

Adits, open cuts, pits, and drill holes were used to explore the deposit. Mining attempts date from about 1900 to the mid 1960's. Inspiration

Consolidated Copper Co. claimed much of the area in 1977. Leaching was attempted in 1929, and smelting on site in 1958. There are no records to indicate either was successful. Road maintenance was observed in 1982, but no exploration or development work.

The barite-chalcopyrite mineralization suggests a possible relationship to mineralization at the Orient and Rita Alta Mines, and in Garner Canyon. Silver and gold are present in some samples (figs. 15A, B, C, 16A, B, C, and tables 6, 7). The deposit could be related to either the adjacent Sangre de Cristo fault or the Rito Alto stock, or have been influenced by both.

Estimated production was about 300 oz of gold, 2,000 oz of silver, and 300,000 lb of copper.

An indicated resource of 3,700 tons of 0.09 oz/ton gold, 0.17 oz/ton silver, and 0.86 percent copper is present in the WSA. An indicated resource of 90,000 tons of 0.007 oz/ton gold, 0.06 oz/ton silver, and 0.55 percent copper is at least half inside the WSA.

Wild Cherry Creek

On the west side of the WSA, south of Cotton Creek, the Precambrian gneiss and granite is cut by quartz veins and faults trending N. 10° W. to N. 20° E. Seven adits explore these structures (pl. 1; fig. 17A).

On the north side of Wild Cherry Creek, two narrow, parallel N. 20° E.-trending quartz veins containing galena and sparse chalcopyrite are explored by two adits and a 30-ft shaft (fig. 17B). Both veins contain silver averaging 0.6 oz/ton. A lower adit that should have cross cut to both veins is caved. All other structures in the area are almost barren (figs. 17A, C-F, table 8).

Estimated production from these veins was about 100 oz of silver, 6,000 lb of lead, and 500 lb of copper.

A very small silver-lead resource is identified in the WSA at the two northern adits on Wild Cherry Creek: 1,400 tons averaging 0.032 oz/ton silver, 0.78 percent lead, and 0.06 percent copper.

Verde Creek

The Verde Creek area is outside the eastern boundary of the WSA (pl. 1). Precambrian granite is faulted against the Sangre de Cristo Formation, and the granite is the host for most of the mineralization. Quartz veins contain chalcopyrite, and minor galena and barite. Vein trends are unknown because outcrops are sparse and all workings are caved (fig. 18).

The larger workings all were started in granite, but sandstone on some dumps indicates that those workings crossed the fault and penetrated the sandstone. Only a few prospects were started in sandstone (table 9, samples 690, 691, 701, 703), and while not barren, did not expose mineralization as rich as that found in the granite. Assays show silver in about half the samples and gold in a few (table 9).

The area was prospected in the early 1880's and at least one property had production prior to 1901. Unless the deposit(s) was competely mined out, a silver-copper resource is present, but cannot be shown to extend into the WSA.

Marshall Gulch

On the west side of the WSA, south of Cedar Creek, shallow workings explore shear zones and quartz veins in Precambrian granite inside the WSA (fig. 19A). The structures trend north-northwest, parallel to the Sangre de Cristo fault.

Gold, silver, and copper are present in some samples--enough to encourage prospecting. Approximately half of the samples are barren (figs. 19A, B). No resource was identified in the Marshall Gulch area.

Dimick Gulch

The Dimick Gulch area is on the west side of the WSA, south of San Isabel Creek (pl. 1). Along Dimick Gulch, shallow workings (fig. 20A) explore a gossan zone in lower Paleozoic limestones and quartzites overlying Precambrian granite on a possible thrust fault. Trace amounts of silver, gold, cobalt, arsenic, molybdenum, and lead were found in many samples from Dimick Gulch (table 10, figs. 20A-C).

No resource was identified in the Dimick Gulch area.

North of San Isabel Creek there are extensive, but caved and possibly barren adits. Several workings mentioned in the Colorado Division of Mines files were not found. One mile farther northwest are a number of workings on pegmatites. Data for these samples are on miscellaneous table 28.

Red beds

The red beds uranium-copper area is mostly in the WSA, in the central part of the Sangre de Cristo range (pl. 1). The red beds are the Pennsylvanian Minturn and Pennsylvanian-Permian Sangre de Cristo Formations which extend along the crest of the range from Music Pass on the south, almost to Hayden Pass on the north.

Uranium is localized in gray siltstones near the top of the Minturn. The stratigraphic unit is continuous, but the mineralization is spotty and weak. Few prospects gave scintillometer readings over 200 counts per second (against a background of 40-60 counts per second). Sixty-seven samples were analyzed for uranium; only eight contained over 100 ppm U_3O_8 (table 11). The major producer was near South Colony Lakes (fig. 21). About 170 lb of U_3O_8 was produced in 1958 and 1959.

Copper is found in both the Sangre de Cristo and Minturn beds. Occurrences are scattered, and contain malachite staining and rare chalcopyrite near faults (figs. 22, 23), and small barite veins with sparse chalcopyrite. The Hermit Pass Mine (fig. 23) was an unsuccessful attempt to mine a low-grade (table 12) deposit by underground methods in about 1900.

Although both uranium and copper are widely distributed in the two formations in the WSA, the occurrences are too small and low grade (tables 11, 12, figs. 21-23) to be resources.

Crestone

The Crestone gold-silver area is midway along the west side of the WSA (pl. 1). It is the northern end of the Crestone mining district, and is immediately east of the small town of Crestone. The southern 2/3 of the district is on the privately owned Baca Land Grant.

Steeply dipping quartz veins containing limonite and pyrite strike north to northwest through Precambrian granite (figs. 24A-E), roughly paralleling the Sangre de Cristo Fault. In the accessible workings, the veins would persist at most, a few hundred feet. Ore shoots within the veins were generally small.

North of the Baca Grant, in the Crestone district, a dozen mines reportedly shipped ore. Because of poor access, few of the workings could be positively identified. In 1979, all three mines in Pelican Gulch (informal name for canyon just south of Burnt Gulch) were caved (fig. 24A, table 13). In early 1982 one adit had been re-opened (fig. 24D), and was partly examined, but heavy rain caused the portal to again cave before the stoped area could be examined. Most of the Sunbeam Mine(?) was examined (figs. 24E, F, table 14), although hip waders were required in the first 120 ft. At least four possible vein intersections in the Burnt Gulch-Pelican Gulch vicinity have not been explored.

Several workings in the Crestone area are essentially barren (figs. 24G, 25-28). Only one of the structures examined in North Crestone Creek (figs. 25-28) showed any consistant mineralization (fig. 25, tables 15, 16). No workings were found accessible in South Crestone Creek, but a dump sample from one caved adit (table 13, sample 577, fig. 24A) had good gold and silver values. Prospects between South Crestone Creek and Willow Creek (figs. 24A, G) yielded samples containing gold, silver, and copper.

Oxidized quartz veins were first worked by Spanish explorers (Parker, 1952, p. 25). The Crestone district boomed during the 1880's and 1890's, but a U.S. Supreme Court decision granted all mineral rights to the owners of the Baca Land Grant, and by 1904 the miners were removed (Parker, 1952, p. 27). The northern part of the district, around the town of Crestone (fig. 24A), was not as rich, and mining activity declined rapidly after 1904.

Production from the Crestone district outside of the Baca Land Grant was at least 300 oz of gold and 400 oz of silver. A small to medium-size goldsilver resource remains, mostly in unoxidized veins that could not be profitably milled in the 1880's and 1890's. In the 1930's the cyanide process was successfully used to extract gold from these veins (Parker, 1952, p. 43), but World War II curtailed the operation. It was never resumed. No part of the identifiable resource is in, or extends into the WSA.

Liberty

The Liberty area is on the west edge of the WSA, on the southeast edge of the Baca Land Grant, and on the north edge of the Great Sand Dunes National

Monument (pl. 2). Country rocks are Precambrian gneisses, granites, and a thin sliver of Paleozoic sedimentary rocks. Northeast to northwest trending faults and quartz veins roughly paralleling the Sangre de Cristo fault are the mineralized structures except at a working (fig. 29) near the edge of the Baca Land Grant, which may be a disseminated gold deposit.

Most workings in the area are in Pole Canyon (figs. 30A-I) or on Short Creek above the ghost town of Liberty (figs. 31A-D), however the largest working is in the WSA on Sand Creek about 2 mi east of Liberty. About 1 1/2 mi farther southeast near Cold Creek (pl. 2), hematite-quartz filled breccia zones were prospected.

The mine in Sand Creek was caved, as were the workings on Milwaukee Hill (fig. 30A). Examination of the other workings (figs. 30A-I, 31A-D, tables 17, 18, 19, 20, 21) showed discontinuous veins which once contained a few high-grade pockets of ore. Galena, chalcopyrite, and sphalerite are present in one vein in Pole Canyon (fig. 30A and table 17).

The main mining activity in the Liberty area was between 1889 and 1904 (Parker, 1982, p. 27). Mill and tramway remains are present in Pole Canyon, Sand Creek, and Short Creek.

Estimated production from the Liberty mineralized area was at least 150 oz of gold and 1,000 oz of silver. A small gold-silver resource may be present in Pole Canyon, inside the WSA; however, additonal work is needed to confirm or disprove the possibility.

Carbonate Mountain

The Carbonate Mountain area is mostly inside the WSA south of Mosca Pass and southeast of the Great Sand Dunes National Monument (pl. 2).

Prospecting was extensive in Morris and Evans Gulches, adjacent to the National Monument. The rocks here are a contorted mass of metamorphosed sediments, probably Minturn Formation and older igneous and metamorphic rocks. Copper, gold, and silver minerals are locally present (fig. 32, table 22), but their relationship to structure or rock type is not apparent because of poor exposures.

The crest of the range, from Mosca Pass south for 7 mi, was extensively prospected (pl. 2). Three caved adits are on the east side of the ridge south of Carbonate Mountain. Accessible prospects are on northwest-trending quartz veins in Precambrian gneiss and granite. Gold, silver, copper, and lead are shown in some assays (table 22).

There are several shallow adits in Precambrian gneiss and granite near the mouth of North Arrastre Creek (figs. 33A-C). Chalcopyrite is present in a decline that explores a thrust fault on the north side of the canyon (fig. 33B). Samples from this fault and from four dumps across the canyon contain small amounts of gold. No definite relationship can be established between the various workings because the adits on the south side of the canyon were caved and outcrop on the south side of the canyon was lacking.

A small gold resource may exist in the WSA at North Arrastre Creek, but there is insufficient evidence to identify a resource at this time.

Blanca Peak

On the southeast end of the WSA, a N. 30° W.-trending quartz vein cuts Precambrian granodiorite and gneiss at Blanca Peak, and is exposed for about 2 1/2 mi along strike (fig. 34A). The vein enters the WSA, but is hidden under talus and its extent within the WSA is unknown. A northern branch of the vein probably enters the WSA also. The vein and its main branch (fig. 34A) have over 3,000 ft of development (figs. 34B-E). Gold and silver are present in almost every sample, and average 0.1 oz gold per ton and 2 oz silver per ton across an average 4 ft mining width (tables 23, 24, 25). Scheelite is visible in shoots unrelated to gold and silver distribution. Gold is associated with pyrite. Silver is present in a red-gray mineral.

Platinum has been reported in assays from the veins (Wright Engineering, written communication, Nov. 13, 1981). Platinum assays are difficult, and often erroneous. No platinum was detected in any of the 11 samples analyzed for platinum in this study. The country rock is granodiorite cut by mafic dikes. Near the veins, the rock is too sheared and chloritized to determine which rock type is locally present. Lenses of gabbro and pyroxinite are present in the granodiorite mass, some containing a few percent sulfide minerals (pyrite and chalcopyrite). Platinum would not be out of place in the ultramafic rocks, but mining would be impractical because the lenses are small and scattered. It is possible that some byproduct platinum might be recovered if the veins were mined.

The veins crop out at elevations between about 11,600 ft and 13,800 ft. Mines are at 11,600, 12,300, and 13,000 ft. Prospects are as high as 13,200 ft. The two major workings--on the Eagle Plume and Dividend claims--have their portals low on the north face of Blanca Peak. Both portals are in, or adjacent to, gullys that are also avalanche chutes. Most years the portals are not visible until mid-August when the avalanche snow has melted. Mine managers reports are available for only 1900 and 1901. The reports claim about 1,600 ft of development in this time period--an impressive rate of advance--from 120 ft to 1,700 ft. The mine (both adits) has about 2,300 ft of development. The mine had a tram to a mill about 1/2 mi below, in the valley. The upper tram station has been thoroughly mangled by avalanches. A cross-cut adit was begun in a relatively avalanche free site, about 1,800 ft from the veins, but was only driven about 200 ft. About 20 cords of cut wood for boilers at mine and mill are scattered around the basin. Exactly when it became clear that the avalanche problem could not be successfully dealt with is unknown.

The only recorded production from the area was about 40 oz of gold. The estimated production of gold was 400 oz. The ore was not oxidized and would have required cyanide processing for good recovery. About 7,000 oz of silver was removed from the ground, and some may have been recovered. Over 1,000 short ton units of tungsten were removed from the ground, but there is no reason to believe any was recovered. This estimate of production includes the workings above Winchell Lakes (fig. 35). One adit (fig. 34F) north of Blanca Peak was barren.

Quartz veins on the south side of Blanca Peak and a breccia pipe northeast of Blanca Peak (pl. 2; table 26) contain the same minerals as the major vein. Veins west of Blanca Peak (fig. 36; table 26) are relatively barren.

A medium-size gold-silver-tungsten resource (table 1) is present outside the WSA, and extends some distance into the WSA.

West Blanca

The West Blanca area is inside the WSA on its south end (pl. 2). Workings explore northerly-trending quartz veins and irregular altered zones in Precambrian granodiorite, granite, gneiss and schist (figs. 37-39). A few samples contained gold and silver, and several showed copper, cobalt, molybdenum, and bismuth (figs. 37-39, table 27). An area below Como Lake on Holbrook Creek appears to have been hydraulically worked for placer gold.

The Swab Mine (fig. 38) in the south end of the WSA, followed a 30° E. dipping, northeast-trending fault for about 120 ft. Copper-gold mineralization was present at the portal, but disappeared within about 40 ft. A tramway extends from the mine to the base of the range. Debris found at the camp between mine and tram base indicate the operation took place in the late 1920's to early 1930's.

The Commodore, Little Bear, Homestake, and Calumet Mines, listed as being in the district around 1900, were not found.

No resource was identified in this area.

Miscellaneous resources

Precambrian pegmatites scattered along the west side of the Sangre de Cristo range have been worked for uranium (Nelson-Moore and others, 1978, p. 389-393), feldspar, and beryl; a little manganese was produced from a fault in Rito Alto Creek; decorative quartz was quarried from a vein near Crestone; one prospect adit near Liberty showed traces of copper and molybdenum (fig. 40); and veins near Liberty were worked for fluorite. All of these occurrences are localized, and no resource related to any of th-- could be identified in the WSA.

East of the WSA, at Coaldale, gypsum is being mined from Minturn Formation horizons which are not known to exist in the WSA.

Limestone has been quarried on the northeast side of the WSA for use in sugar beet refineries and Colorado Fuel and Iron Corporation's steel mill (Argall, 1949, p. 262). The limestone crops out from Hayden Pass to the Arkansas River. Much of the outcrop is in the WSA, and many claims were staked for limestone near Hayden Pass, however substantial amounts are available near the Arkansas River where there is highway and railroad access.

Bentonite was being mined north of the WSA in 1979. The mines were idle in 1982. The bentonite is in a Tertiary volcanic unit not present in the WSA.

A small quarry near the bentonite mines yielded building stone from a rhyolite tuff of very local extent. Decorative marble was quarried and shipped from Steel Canyon in small quantities according to Argall (1949). Pink, yellow, black, blue, and green marble are mentioned. The pink marble is an iron stained sandstone. The yellow marble is buff, fine-grained marble, too tightly broken by bedding and joints to yield blocks larger than about 2 ft on a side. No black, blue, or green quarries were found, although much of the limestone might be described as blue. The marble does not extend into the WSA.

Prior to establishment of the Great Sand Dunes National Monument, the dunes were placered for gold. Part of the gold was in magnetite and not readily recoverable (Siebenthal, 1910, p. 48).

Most samples taken outside mineralized areas were relatively barren or showed weak and spotty mineralization (table 28).

The Sangre de Cristo fault which bounds the Sangre de Cristo Mountains on the west is a component of the Rio Grande Rift. Hot springs are not uncommon along the rift. Valley View Hot Springs, just south of the Orient Mine is the only known hot spring along the Sangre de Cristo fault. Two Known Geothermal Resource Areas are within 2 mi of the WSA. As of November 1982, there were ten geothermal leases and four geothermal lease applications within 2 mi of the WSA boundary (fig. 41). Geothermal lease applications in the WSA total 750 acres.

As of November 1982, there were ten oil and gas leases and nine oil and gas lease applications within 2 mi of the WSA boundary (fig. 42). Inside the WSA, 60 acres were leased for oil and gas, and 10,600 acres were under oil and gas lease application.

CONCLUSIONS

A north-northwest trending zone of mineralized terrane parallels the still active Sangre de Cristo fault north of the Great Sand Dunes National Monument. Where the fault bends more nearly north-south, in the area of the dunes, the zone of mineralized veins and faults continues south-southeast through Blanca Peak. Figure 3 shows gaps in this zone which may be real or merely a lack of information. The structures along this trend are associated with all but three of the structurally-related mineralized areas in the Sangre de Cristo WSA.

North of the sand dunes, Precambrian rocks have been faulted against Pennsylvanian-Permian rocks. Subsequent movement along the Sangre de Cristo fault caused the fractures which were later filled with ore mineral-bearing quartz veins. The age of mineralization is considered Laramide to Tertiary.

The Tertiary Rito Alto stock contains molybdenum-copper-gold-tungsten mineralization, and has a possible relationship with six other mineralized areas. All six of these areas are in the vicinity of one of the two faults bounding the Sangre de Cristo range. It is unclear whether the faults or the stock, or both are genetically related to these mineralized areas. A few productive veins in these areas have trends which do not relate to movement along the Sangre de Cristo or Alvarado faults.

Precious metal, base metal, and tungsten resources exist along the north-northwest trending mineralized zone. From Blanca Peak to Arrastre Creek, deposits contain gold, silver, and tungsten. Between Arrastre Creek and Pole Canyon, the deposits contain gold, silver, and minor amounts of base metals. Deposits between Pole Canyon and Crestone contain gold and silver. From Crestone to Wild Cherry Creek deposits contain gold and silver, but in lower concentrations. From Wild Cherry Creek to Cotton Creek the deposits grade from silver-lead with minor copper to copper with gold and silver. This appears to be zoning away from the Cotton Creek copper deposit. From Cotton Creek to just north of the Orient Mine, the deposits contain copper, gold, silver, and iron. Deposits between the Orient Mine and Galena Peak contain lead and silver with minor amounts of copper and gold.

Around the Rito Alto stock, deposits contain copper, gold, barite, and iron. Molybdenum deposit(s) may be related to the stock, but this has not yet been established.

Resources within the area were identified at Cotton Creek (copper-gold-silver), Wild Cherry Creek (silver-lead), Liberty (gold, silver), and Blanca Peak (gold-silver-tungsten). Resources identified at Steel Canyon (silver-lead), Rita Alta Mine (copper), and Crestone (gold-silver) cannot, at this time, be shown to extend into the WSA.

REFERENCES

Argall, G. O., Jr., 1949, Industrial minerals of Colorado: Colorado School of Mines Quarterly, v. 44, no. 2, 477 p.

Bagg, R. M., Jr., 1908, Some copper deposits in the Sangre de Cristo range, Colorado: Economic Geology, v. 3, p. 739-749.

De Voto, R. H., Peel, F. A., and Pierce, W. H., 1971, Pennsylvanian and Permian stratigraphy, tectonism, and history, northern Sangre de Cristo range, Colorado: New Mexico Geological Society, 22nd Annual Field Conference. San Luis Basin, p. 141-163.

Gabelman, J. W., 1953, Definition of a mineral belt in south central Colorado: Economic Geology, v. 48, p. 177-211.

Johnson, B. R., Lindsey, D. A., Bruce, R. M., Ashe, S. J., 1983, Reconnaissance geologic map of the Sangre de Cristo Wilderness Study Area, south-central Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-____, scale 1:62:500.

Nelson-Moore, J. L., Collins, D. B., and Hornbaker, A. L., 1978, Radioactive mineral occurrences of Colorado: Colorado Geological Survey Bulletin 40, 1,054 p.

Parker, C. O., Jr., 1952, A history of gold mining in the Sangre de Cristo's: Mines Magazine, v. 42, no. 5, p. 25-27, 43.

Siebenthal, C. E., 1910, Geology and water resources of the San Luis Valley, Colorado: U.S. Geological Survey Water Supply Paper 240, 128 p.

Stone, J. B., 1934, Limonite deposits at the Orient Mine, Colorado: Economic Geology, v. 29, no. 4, p. 317-329.

Worcester, P. G., 1918, Molybdenum deposits of Colorado: Colorado Geological Survey Bulletin 14, 131 p.

MINERAL INVESTIGATION OF THE LOST CREEK WILDERNESS,
PARK AND JEFFERSON COUNTIES, COLORADO

By Clarence E. Ellis, Bureau of Mines

INTRODUCTION

The Bureau of Mines conducted a mineral investigation of the Lost Creek Wilderness, as part of a joint effort with the Geological Survey, to evaluate the mineral resources of the area (fig. 1). Courthouse and Bureau of Land Management records were searched during the spring of 1980 for mining claim locations. Bureau of Mines personnel Clarence E. Ellis, David C. Scott, Alan M. Bielski, David R. Goddard, and Richard E. Gertsch began field work in Lost Creek in the summer of 1980. Field work was completed by Ellis and Scott in June 1981.

Field studies included an examination of mines, prospects, and mineralized areas (pl. 1). Structures or mineralization at the workings examined were sampled. Samples were taken on a grid across the dump where workings were inaccessible. Panned-concentrate samples were taken from stream sediments of major drainages. All 172 samples taken were fire assayed for gold and silver, and spectrographically analyzed for 34 elements. Seventy-four samples were analyzed for beryllium by atomic absorption. Specific analyses were done for molybdenum, tungsten, uranium, and fluorite where they were observed or where they were indicated by the spectrographic analysis. Results of all sample analyses are available for public inspection at the Bureau of Mines, Intermountain Field Operations Center, Denver, Colo. 80225.

Location, size, and geographic setting

The Lost Creek Wilderness was created from two RARE II areas. The 58,040-acre Lost Creek RARE II Further Planning Area and 71,000-acre Lost Creek RARE II Wilderness Recommendation Area were designated by the Forest Service in its Second Roadless Area Review and Evaluation, January 1979

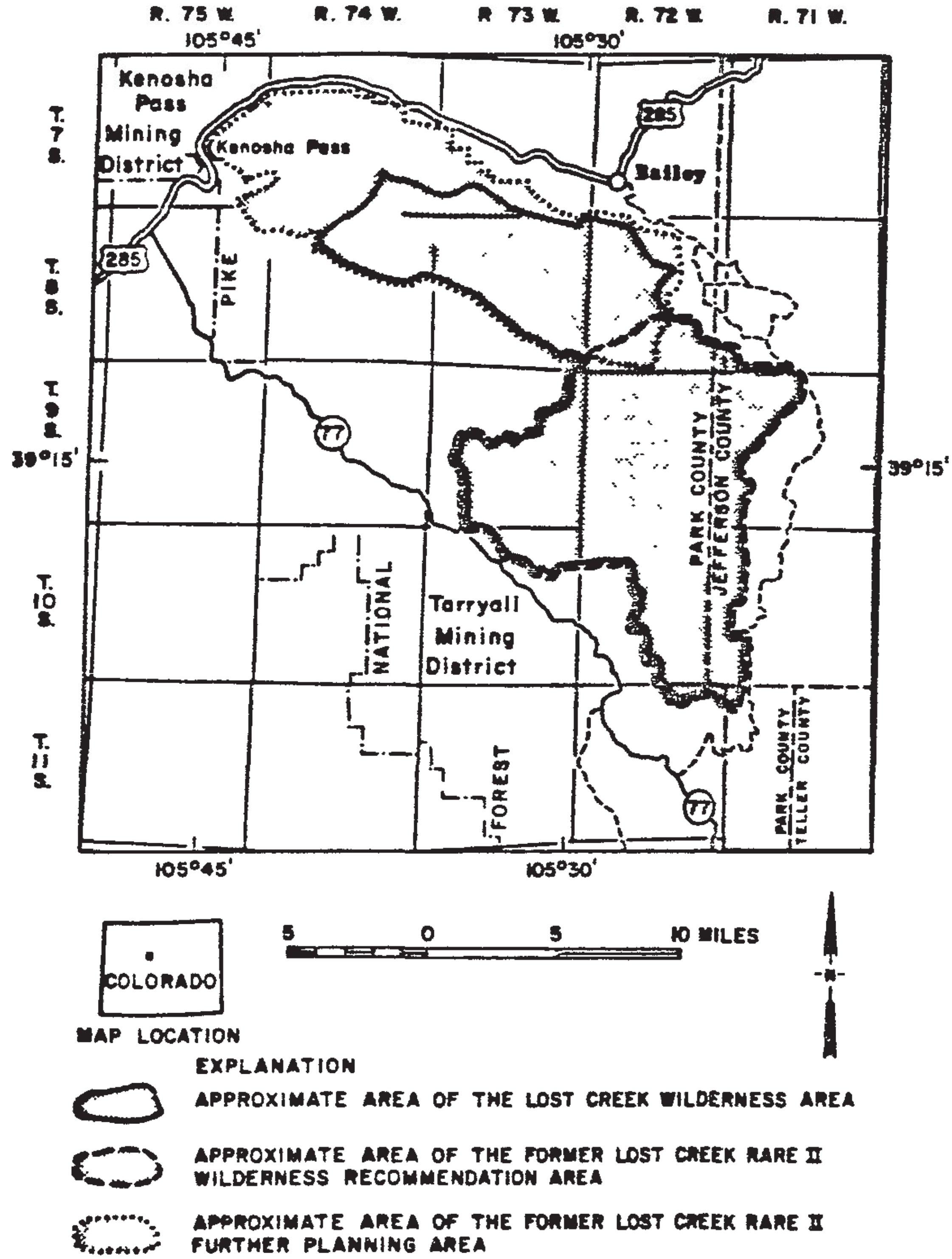


Figure 1.--Index map of the Lost Creek Wilderness and RARE II Areas.

(fig. 1). Both RARE II areas are in the Pike National Forest. The further planning area is adjacent to and northwest of the wilderness recommendation area, and entirely in Park County, central Colorado. The wilderness recommendation area is in Park County except for a small part that is in Jefferson County. The Colorado Wilderness Bill (Public Law 96-560, December 22, 1980) deleted the northwest end of the further planning area while creating the approximately 106,000-acre Lost Creek Wilderness from the combined RARE II areas.

The northeast part of the wilderness is located about 1 mi southwest of the town of Bailey and 26 mi southwest of Littleton, a suburb adjacent to the southern city limits of Denver. U.S. Highway 285 on the northeast, Colorado Highway 77 and Forest Service roads on the southwest, and Forest Service roads on the east bound the wilderness (fig. 1).

Within the northwest-trending wilderness area are the Platte River Mountains, Kenosha Mountains, and the southeast end of the Tarryall Mountains (pl. 1). In general, elevations in the Platte River Mountains decrease from northwest to southeast and are slightly higher than 12,000 ft. The highest point in the wilderness is 12,431-ft Bison Peak in the Tarryall Mountains. The north and west parts of the wilderness are, primarily, steep slopes forested up to timberline (about 11,500 ft elevation). Above timberline the terrain is rolling and tundra covered. The southeast part of the wilderness is mostly exposed rock, in the form of pinnacles and gigantic boulders, and scattered stands of timber.

The Kenosha Mountains and Tarryall Mountains are separated by a creek bearing two names: the upper end, called Lost Creek, goes underground beneath giant boulders in the center of the wilderness; where it reappears, the creek is called Goose Creek.

Geologic setting

The following brief description of the Lost Creek Wilderness Area geology is based on published work and field observations and is included to facilitate understanding of this report. Additional information, developed by the Geological Survey during its part of this investigation, will add to or change this preliminary description.

Rocks of the Lost Creek Wilderness are Precambrian in age, and have been identified as Idaho Springs Formation, Boulder Creek Granodiorite, and Silver Plume (Gallagher, 1976, p. 4), Pikes Peak, and Redskin Granites (Hawley, 1969, p. A4) (fig. 2).

The metamorphic Idaho Springs Formation, the oldest rocks of the area, is present on the north, west, and south sides of the wilderness. It is composed of gneiss, with lesser amounts of pegmatite and amphibolite. Boulder Creek Granodiorite (Precambrian X) and Silver Plume Granite (Precambrian Y) intrude the Idaho Springs Formation in the western part of the wilderness (Gallagher, 1976; Tweto, 1979). The intrusive rocks form the high, central ridges of the Platte River Mountains. These two intrusive units were not differentiated in the field.

Pikes Peak Granite (Precambrian Y) covers more than half the wilderness and extends eastward beyond its boundaries. The coarse-grained pink Pikes Peak Granite forms the pinnacles, domes, and arches in the southeastern third of the wilderness. It is younger than the Silver Plume (Hawley, 1969, p. A4) and probably intrusive into it, although the contact was not observed.

The Redskin stock, the youngest rock of the area, is a fine-grained pink granite that intrudes the Pikes Peak Granite on the southern edge of the area. Hawley (1969, p. A5) mapped its boundaries during his studies of beryllium mineralization in the Tarryall district.

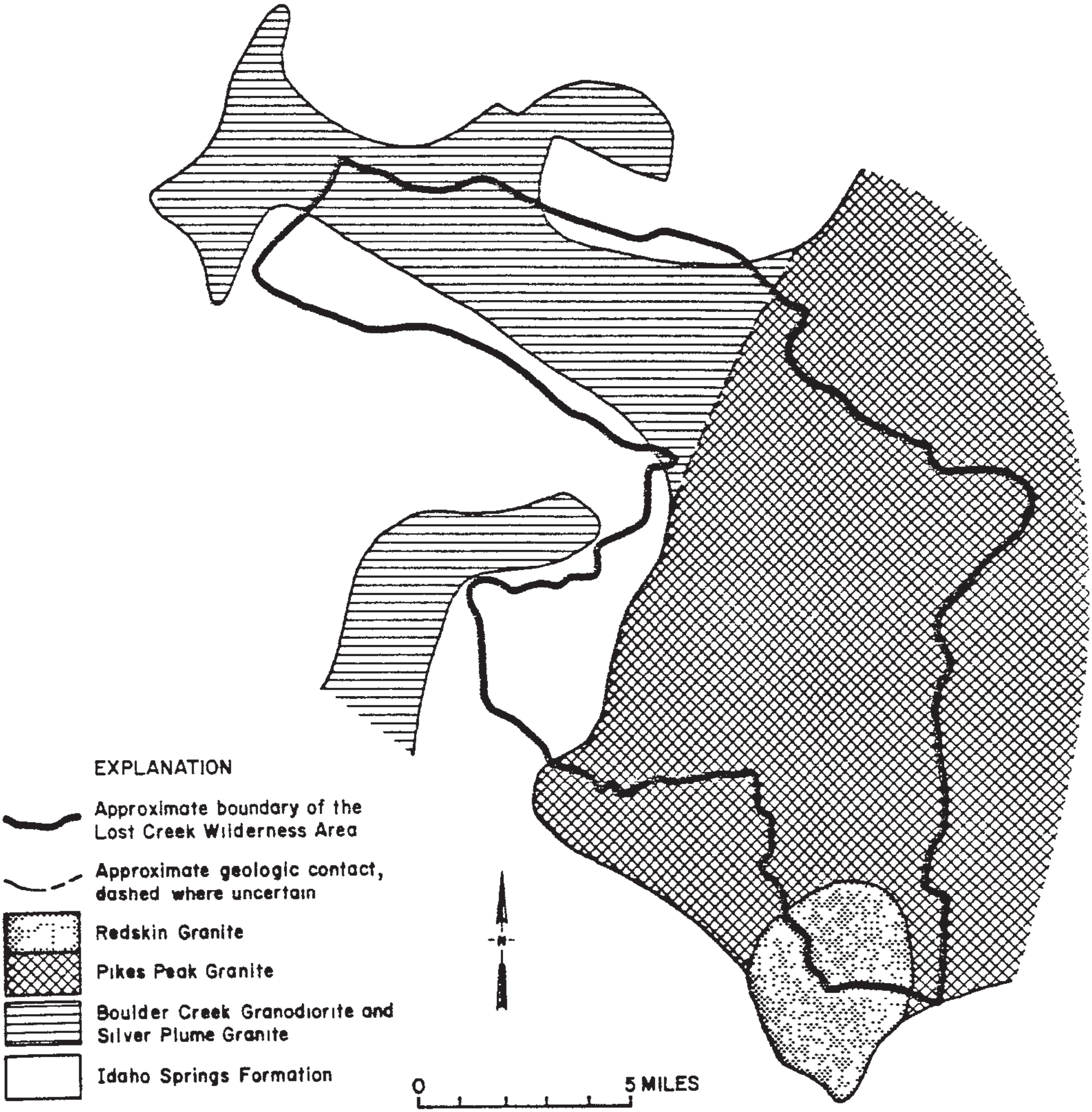


Figure 2.--Generalized geologic map of the Lost Creek Wilderness, modified from Tweto (1979) and Hawley (1969).

A northwest-trending Precambrian set of faults control the topography of the western half of the wilderness (Tweto, 1979). In the Tarryall district, a northeast-trending set, also originating in the Precambrian, is present. Both sets are locally mineralized (Hawley, 1969, p. A7).

Mining activity

Except for mineral collecting, there is no evidence of any mineral production within the wilderness. Evidence of even prospecting in the wilderness is very slight.

A small underground uranium mine was operating in 1980 about 1 mi northwest of Kenosha Pass (fig. 1), and a small open-pit uranium mine was scheduled to start operating in the same area in the summer of 1981. These deposits are near, but outside of, the further planning area. The Tarryall mining district, south of the wilderness, originally produced precious and base metals in small quantities, but is better known for the beryllium produced in the 1950's and 1960's.

The Redskin Mine in Redskin Gulch (pl. 1), south of the wilderness, may have shipped a little molybdenum during World War I (Hawley, 1969, p. A33).

Mapping of the Bearcat Mine, south of the wilderness, during the present study indicates an estimated production of 960 to 1,600 tons of fluorite.

Pegmatites, near the wilderness, yielded more than 32,000 tons of potassium feldspar, and a few tons of biotite mica during the 1950's and 60's (Bureau of Mines files, Intermountain Field Operations Center, Denver, Colo. 80225, 1959).

The Redskin claims near Shawnee, north of the wilderness (pl. 1), produced 141 lbs of U_3O_8 (Nelson-Moore and others, 1978, p. 369).

MINING DISTRICTS AND MINERALIZED AREAS

The Kenosha Pass fluorite-uranium district and the Tarryall beryllium-tungsten-fluorite district (also known as the Badger Flats or Lake George district) are adjacent to the RARE II areas: Kenosha Pass on the northwest end of the further planning area and Tarryall south of the wilderness (fig. 1).

Courthouse records show 17 mining claims, which are located within the wilderness, and another 64 claims that are outside of the wilderness but within 1 mi of its boundary. None of these claims are patented.

The Kenosha Pass district produced a few tons of fluorite in 1913-14 (Traver, W. W., Jr., 1944, Guernsey (Kenosha Pass) fluorspar deposits, Park County, Colorado: War Minerals Report in Bureau of Mines files, Intermountain Field Operations Center, Denver, Colo. 80225). Uranium occurrences have been mined sporadically from 1956 to the time of the present field investigation. Uranium occurs as secondary uranium minerals in deeply weathered zones localized along fractures in the granite and surrounding gneiss. Although the bedrock geology is similar to that in parts of the wilderness, the Kenosha Pass district is much flatter than the wilderness, allowing for a greater degree of in-place weathering. Although adjacent to the former further planning area, the district is 5 mi outside the wilderness boundary and will not be discussed further.

Tarryall mining district

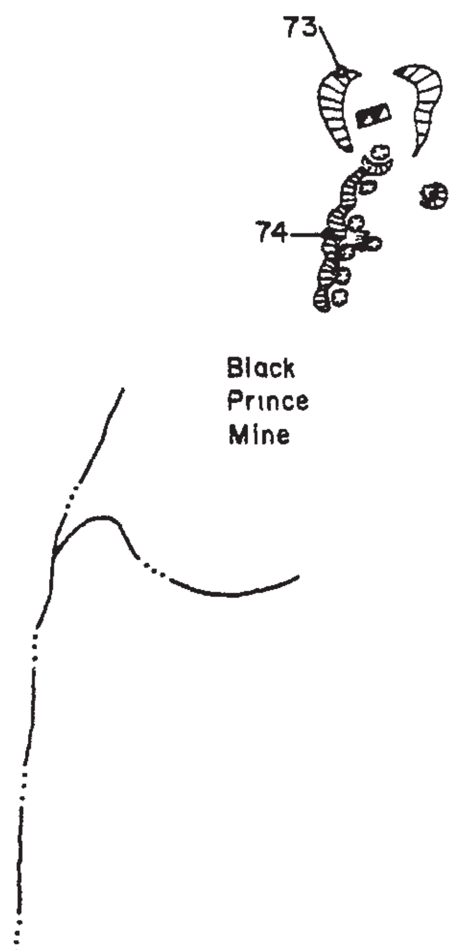
The Tarryall mining district, southwest of the wilderness, began as a placer gold district in the 1860's, but was of little importance until beryllium was discovered at the Boomer Mine, 3 mi south of the wilderness (not shown on pl. 1), in 1955. During approximately 10 years of operation, the Boomer produced about 150 tons of BeO (Nelson-Moore and others, 1978, p. 365). Other properties in the district made small contributions to the district's beryllium production.

Beryllium-bearing greisens occur as pipes in or near the Redskin Granite. Beryl and bertrandite are the principal beryllium minerals (Hawley, 1969, p. A11). The Boomer Mine was a major beryllium producer starting in 1956 (Meeves, 1966, p. 29).

In Redskin Gulch, less than 1 mi south of the wilderness (fig. 3), the Redskin, Minerva, and Black Prince workings explore greisen pipes in the porphyritic facies of the Redskin Granite (Hawley, 1969, p. A33). Sixteen samples were taken: three from the Redskin Mine, Four from the Minerva J workings, two from the Black Prince, one from the Minerva D-E-F (fig. 3), and six from other prospects. The Redskin Mine samples averaged 0.112 percent beryllium and 78 ppm U_3O_8 (nos. 77-79); the Minerva J samples averaged 0.067 percent beryllium and 12 ppm U_3O_8 (nos. 81-84); the Minerva D-E-F sample contained 0.018 percent beryllium and 10 ppm U_3O_8; and the Black Prince samples averaged 55 ppm U_3O_8, and one also contained 0.0031 percent beryllium. The seven scattered samples (pl. 1, nos. 69-72; fig. 3, nos. 76, 80) contained no detectable beryllium and averaged only 12 ppm U_3O_8. Molybdenite is present at the Redskin Mine; a chip sample taken across the greisen (sample 77) contained 0.05 percent molybdenum. One sample from each of three workings assayed more than 1 oz silver per ton.

Greisens also occur at the contact of the Silver Plume(?) Granite and a granite-aplite facies of the Redskin Granite on the A & C and Hazel Marie claims; the claims were located on the China Wall cupola (fig. 4), about 1 1/4 mi southwest of the wilderness boundary (Hawley, 1969, p. A30). The greisen here is hematite-stained; beryl crystals were found in one pit. Thirteen samples taken from prospects in the cupola averaged 0.04 percent beryllium, with a high of 0.269 percent beryllium (fig. 4, nos. 88-97; pl. 1, nos. 98-100).

Sample			Analytical data		
			Be	Mo	U_3O_8
No.	Type	Description	percent		ppm
73	Dump	Shaft in greisen.	---	---	97
74	Dump	3 pits in greisen.	0.0031	---	13
75	Dump	Pit in granite.	.018	---	10
76	Dump	Pit in weak greisen.	---	---	13
77	5-ft chip	Across greisen.	.190	0.05	40
78	Dump	25-ft pit in greisen.	.063	---	29
79	Dump	Shaft in greisen pipe.	.083	.01	165
80	Dump	Shaft in greisen.	---	---	18
81	Dump	Shaft in greisen.	.051	---	15
82	Dump	Shaft in greisen.	.218	.002	22
83	Dump	Shaft in granite.	---	---	6
84	Dump	Trench in granite.	---	---	7



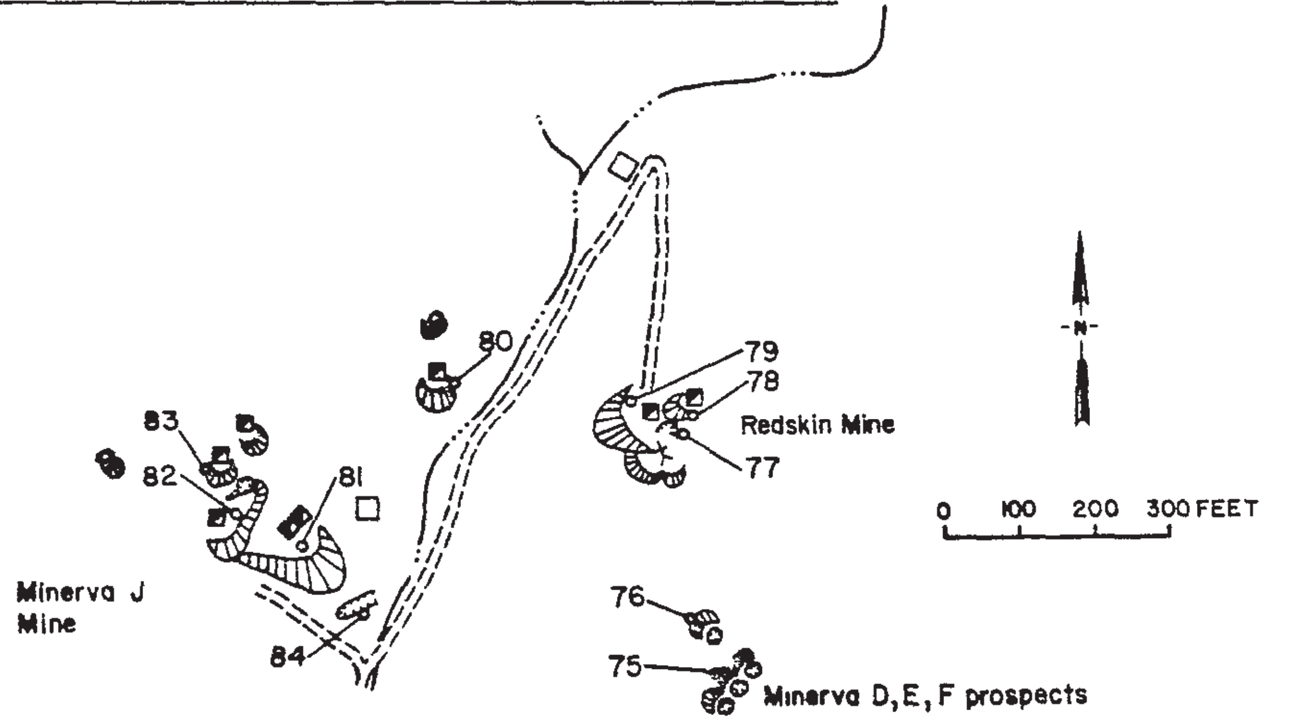


Figure 3.--Sketch of the Redskin Gulch area showing sample localities 73-84; table shows sample data. The symbol "---" on the table indicates the element was not detected.

Sample			Analytical data		
			Be	Mo	U_3O_8
No.	Type	Description	percent		ppm
88	6-ft chip	Trench in greisen.	—	—	4
89	Dump	18-ft pit in greisen.	0.269	—	7
90	3-ft chip	Pit in greisen.	.0026	0.002	7
91	Dump	Pit in greisen.	.157	.002	15
92	Dump	Shaft in greisen.	.011	—	7
93	Dump	Caved shaft in greisen.	.03	.004	17
94	4-ft chip	1-ft quartz vein.	.009	—	3
95	2-ft chip	Pit in greisen.	.003	.05	10
96	Dump	6-ft pit in greisen.	.0053	—	5
97	Dump	Caved pit in greisen.	—	—	4

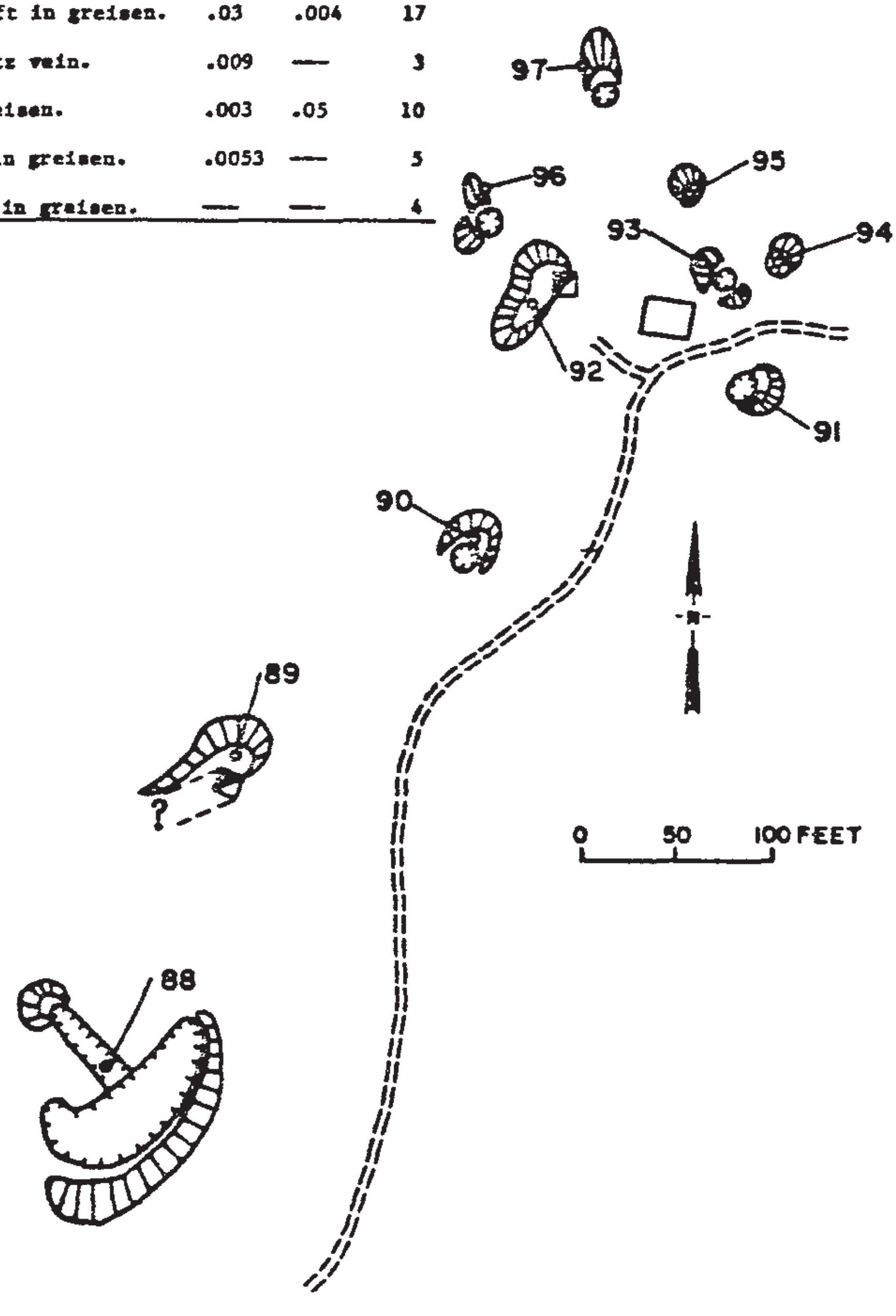


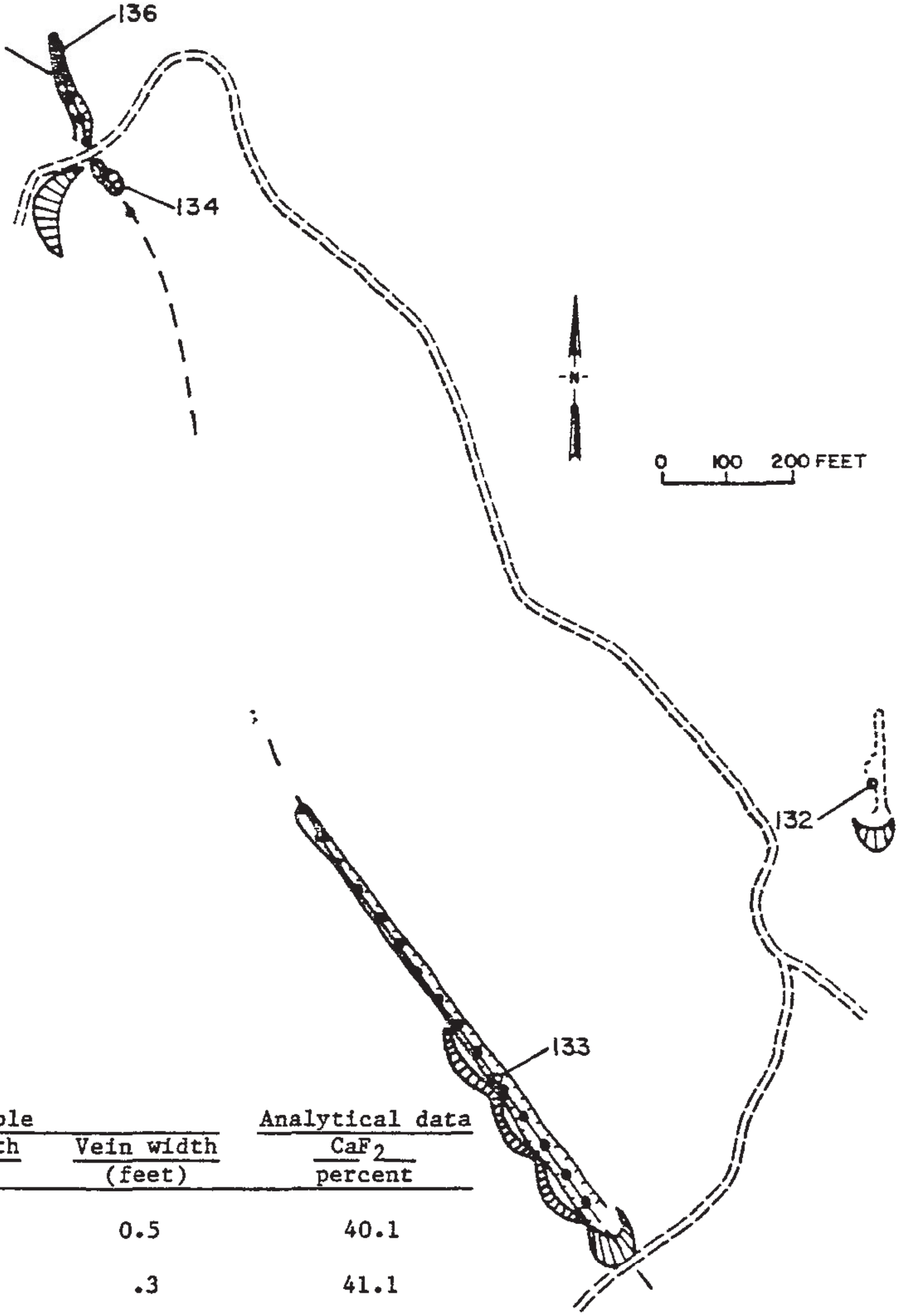
Figure 4.—Sketch of the China Wall cupola area, showing sample localities 88-97; table shows sample data. The symbol "—" on the table indicates the element was not detected.

Both known areas of beryllium-bearing greisens nearest the wilderness are near the edge of the Redskin Granite. The Redskin Granite extends into the southern part of the wilderness, and similar greisens should be expected here, and might constitute a beryllium resource in the wilderness. The terraine, along the Redskin Granite border in the wilderness, is very rugged compared to the terraine where greisens have been found.

A vertical, N. 25° W.-trending fluorite vein is exposed at the Bearcat Mine (fig. 5), less than 1 mi south of the wilderness. Trenching exposed the vein for about 1,200 ft along strike, but it was mined to a depth of about 20 ft for only about 200 ft along strike. Where mined, the vein is as wide as 2 ft, but the rest of the exposed 1,200-ft vein averages less than 1 ft in width. Just northwest of the mine, the vein pinches out completely; to the southeast it is narrow, but persistent. Where mined, no pinching was observed in the 20 ft of vein exposed downdip; therefore small resources remain below the mined level. The vein does not extend into the wilderness.

About 1/2 mi southwest of South Tarryall Peak approximately 650 yd^3 of material was removed from an open cut on a pegmatite (pl. 1, samples 107 and 108). Sample 107 (quartz) contained 93.0 percent SiO_2. Sample 108 (feldspar) contained 73.7 percent SiO_2, 17.3 percent Al_2O_3, 6.0 percent Na_2O, and 1.5 percent K_2O. Quartz and microcline are the main constituents of the pegmatite; biotite, lepidolite, and tourmaline are present, but rare. Approximately 1,000 tons of material was shipped from the cut. Feldspar may have been the only product shipped, as quartz is stockpiled on the site (table 1). Pegmatites are common throughout the wilderness.

At least 3 mi south of the wilderness, in belts of Precambrian gneiss separated by granite, are scheelite-bearing lenses of calc-silicate rocks (Tweto, 1960, p. 1413). Similar occurrences (skarns) may exist in the wilderness



	Sample		Analytical data
No.	Chip length (feet)	Vein width (feet)	CaF_2 percent
132	2.0	0.5	40.1
133	.4	.3	41.1
134	1.0	.9	51.4
135	2.0	2.0	24.7
136	1.2	.3	36.0

Figure 5.--Sketch of the Bearcat Mine showing sample localities 132-136; table shows sample data.

where the Idaho Springs Formation contacts Silver Plume or Pikes Peak Granite (fig. 2). Wolframite and scheelite occur in greisens in the Silver Plume(?) Granite near Tappan Mountain, about 3 mi south of the wilderness (Hawley and Griffitts, 1968, p. 16). This type of occurrence could exist in the wilderness, possibly in any of the granites.

Numerous pits near the southern edge of the wilderness were dug by topaz collectors. Figure 6 shows prospects in greisens near Hay Creek which may have been either topaz or beryllium prospects. No beryllium was detected.

Miscellaneous areas and occurrences

Two mi northwest of The Castle and less than 1/2 mi northeast of the wilderness (pl. 1), the Lone and Lonesome pegmatite was mined for potassium feldspar, biotite, and, possibly, topaz. Minor fluorite and sparse lepidolite and columbite also are present.

Lovering and Goddard (1950, p. 71) referred to a Lost Park silver-lead deposit. An unpublished map by Goddard shows its location in sec. 26, T. 9 S., R. 72 W., but a Bureau of Mines mineral property file places the prospect in sec. 29 of the same township and range. In fact, more than one such silver-lead vein may exist, but a search of both areas by Bureau personnel revealed no trace of a metal deposit. Smoky quartz, fluorite, barite, and chrysoberyl were observed in prospects in sec. 26 near Refrigerator Gulch (table 1). Lead was present with the fluorite and barite, but not visible. Possibly, these are lead-silver prospects, although some of the pits are obviously mineral collecting sites.

The shaft symbol, shown on topographic maps on Goose Creek downstream from Refrigerator Gulch (pl. 1) well inside the wilderness, represents the remains of an attempt in the early 1900's to sink a shaft to the subterranean

Sample			Analytical data		
			Ag	Cu	Pb
No.	Type	Description	oz/ton	percent	
120	5-ft chip	Shaft in greisen.	1.0	0.02	1.0
121	Dump	Caved shaft in weak greisen.	.2	---	.2
122	Dump	Adit start in weak greisen.	.2	.02	.2
123	Dump	Trench in weak greisen.	---	---	---
124	Dump	Pit in weak greisen.	---	---	---

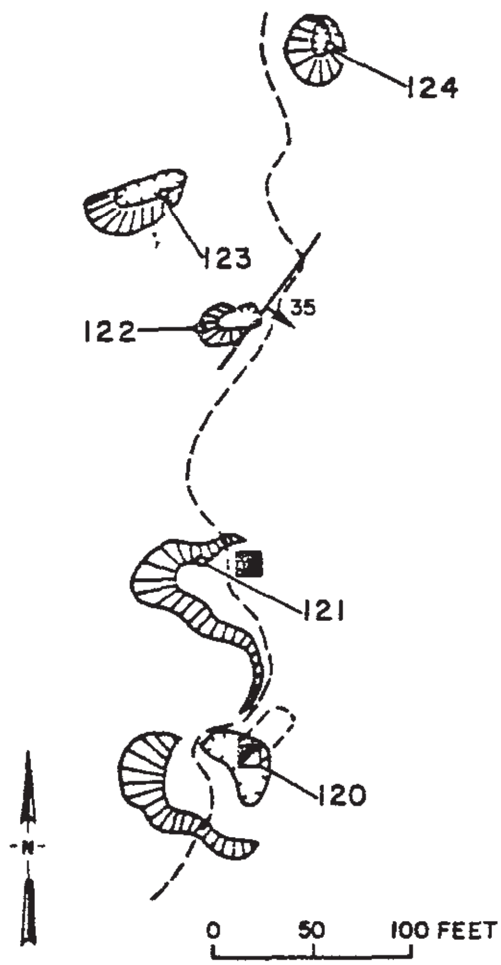


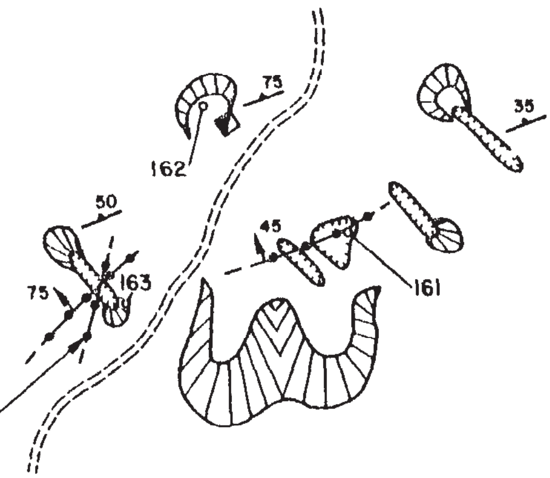
Figure 6.--Sketch of prospect area south of Hay Creek showing sample localities 120-124; table shows sample data. The symbol "---" on the table indicates the element was not detected.

Lost Creek and then pump in concrete to form an underground dam. The plan failed, however, when the water simply found passages around the concrete (Forest Service Lost Creek Scenic Area map, Pike National Forest).

Gallagher (1976, p. 16) reported radiometric backgrounds from uranium to be average in the Idaho Springs Formation, low in the Pikes Peak Granite, and high in the Silver Plume and Redskin Granites. During the present study, Bureau of Mines personnel found that the Idaho Springs Formation and the Pikes Peak Granite also have generally high radiometric backgrounds. In areas below timberline that are topographically flat or rolling, deep weathering may have resulted in secondary enrichment of the uranium. The Kenosha Pass deposits and the deposits at the Redskin claims near the town of Shawnee, just north of the wilderness, are examples of such weathering and secondary enrichment. Most of the area studied, however, is either too steep or above timberline, in few places is the bedrock deeply weathered. The exceptions are Craig Park, East Lost Park, and a few small meadows along various creeks. Scintillometer readings were background or lower in these areas.

A copper-iron prospect is located above Johnson Gulch (pl. 1) about 1 mi southwest of the northwest end of the wilderness. A 3-ft wide, malachite-stained vein of specular hematite is exposed in a shallow open cut (fig. 7). About 150 ft west of this exposure another vein, with 10 in. of specular hematite on the footwall, is exposed in a trench. The dump from a shallow shaft 150 ft northeast of, and almost on strike with, the second vein is composed of hematite-coated gneiss. The country rock is Idaho Springs Formation calc-silicate gneiss. The contact with Boulder Creek Granodiorite and Silver Plume Granite is not far away (Tweto, 1979), and the granite could be the source of the mineralization. Mineralization is scant or absent in the

	Sample		Analytical data	
			Fe	Cu
No.	Type	Description	percent	
161	4.5-ft chip	3-ft specularite vein.	19.5	1.0
162	Dump	Shaft in gneiss.	15.5	.1
163	4-ft chip	3-ft specularite-quartz vein.	17.0	.07
164	Dump	Trench in gneiss.	10.0	.07
165	2-ft chip	Trench in gneiss and marble.	---	---
166	Dump	Trench in gneiss and marble.	---	---
167	5-ft chip	Trench in gneiss and marble.	---	---



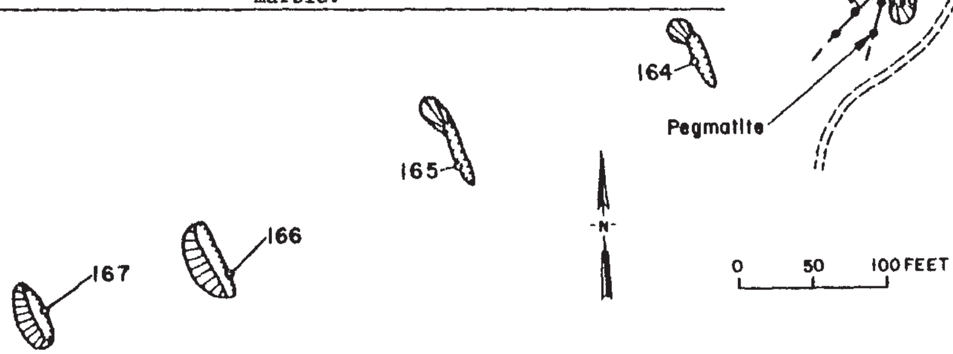


Figure 7.--Sketch of prospect near Johnson Gulch showing sample localities 161-167; table shows sample data. The symbol "---" on the table indicates the element was not detected.

other trenches of the prospect. Insufficient evidence is available to identify a resource at this prospect.

An adit in gneiss of the Idaho Springs Formation is about 1 1/2 mi north of the wilderness, near Glenisle (pl. 1). Traces of copper, silver, and molybdenum were found in samples from the adit (fig. 8).

There were no oil and gas leases or applications in or near the wilderness as of July 1980.

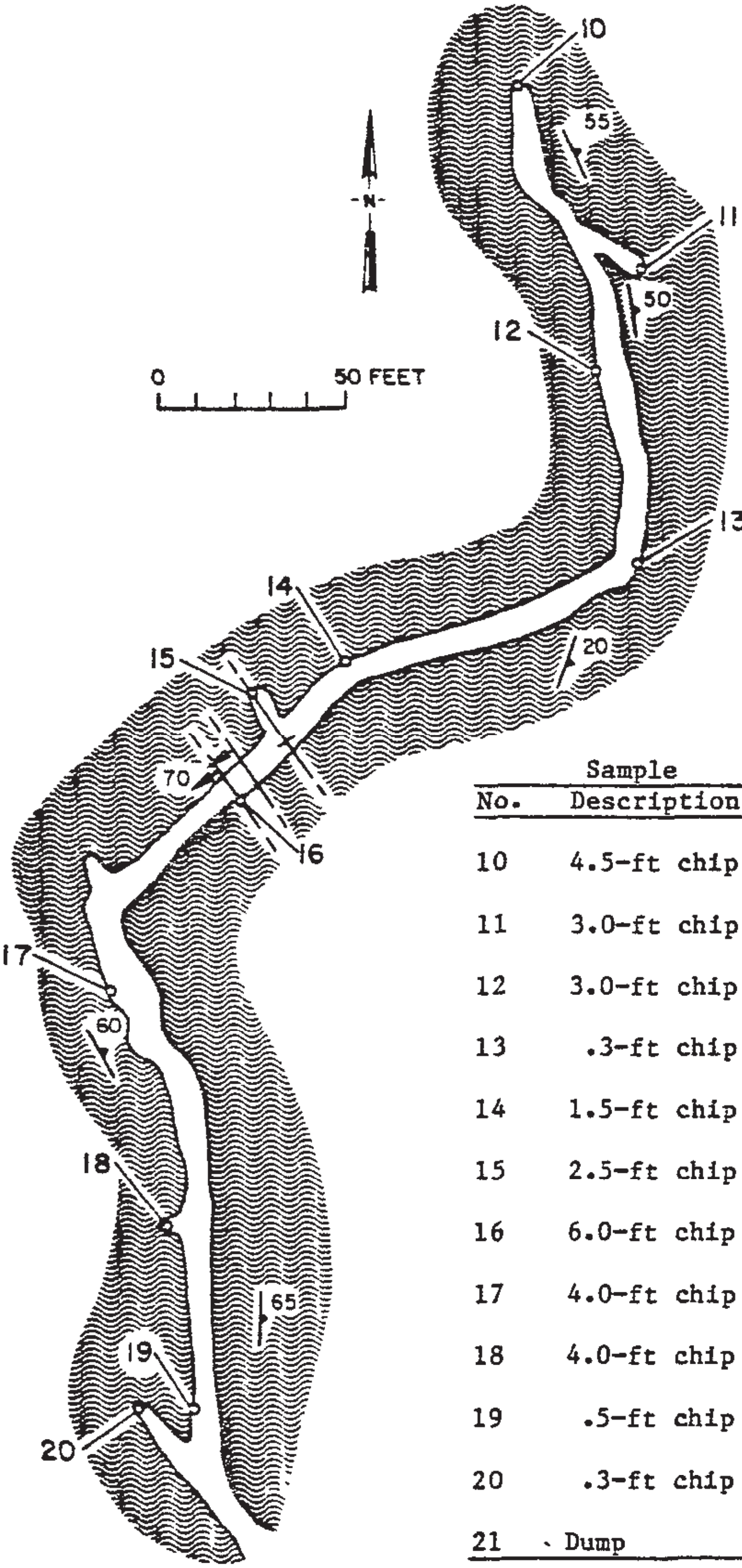
CONCLUSIONS

Although no mineral resources, other than mineral specimens, were identified by the Bureau of Mines in the Lost Creek Wilderness, beryllium deposits may exist around the border of the Redskin Granite (fig. 2). One known mineral specimen resource is near Refrigerator Gulch.

Fluorite veins are not uncommon in the area, but few are of minable size. The Bureau did not identify a fluorite resource in the wilderness.

Although pegmatites are common in the wilderness and surrounding areas, only a little mineral production, primarily potassium feldspar, has resulted from them. None of the pegmatites inside the wilderness have been mined. The rare minerals (columbite, lepidolite, spodumene, beryl, etc.) found in complex pegmatites have been detected in the pegmatites mined, but the quantities have been minute, and no recovery has been recorded. Potassium feldspar can be recovered either from pegmatites or from the Pikes Peak Granite at many locations in the region.

Tungsten-bearing skarns may exist in the gneisses of the Idaho Springs Formation near contacts with the Silver Plume and Pikes Peak Granites within the wilderness, but none has been discovered. Those skarns prospected outside the wilderness have no recorded production.



	Sample	Analytical data Ag	Cu	Mo
No.	Description	oz/ton	percent	
10	4.5-ft chip	---	---	0.001
11	3.0-ft chip	0.2	0.005	---
12	3.0-ft chip	.4	---	---
13	.3-ft chip	---	---	---
14	1.5-ft chip	.2	.001	.005
15	2.5-ft chip	---	.003	---
16	6.0-ft chip	.2	.003	---
17	4.0-ft chip	---	.003	---
18	4.0-ft chip	---	---	.001
19	.5-ft chip	.2	---	.02
20	.3-ft chip	---	---	.001
21	Dump	.2	.001	---

Figure 8.--Map of the adit north of Glenisle showing sample localities 10-21; table shows sample data. The symbol "---" on the table indicates the element was not detected.

Molybdenum is associated with beryllium or tungsten occurrences in this region. Small amounts could be persent in undiscovered greisens or skarns, if they exist in the wilderness.

Uranium, which is generally slightly more plentiful in granites of the area than in granites in general, has been concentrated by weathering in fracture zones near Kenosha Pass. The concentrations exist where relatively flat topography and heavy vegetative growth allow deep in-place weathering; however, the wilderness is virtually devoid of flat topography below timberline, except for Craig Park, East Lost Park, and smaller but similar, relatively flat parts of these and other drainages.

REFERENCES

Gallagher, G. L., 1976, Uranium favorability of the Precambrian rocks in the Badger Flats-Elkhorn Thrust area, Park and Teller Counties, Colorado: U.S. Energy Research and Development Administration open file report GJBX-55 (76), Bendix Field Engineering Corporation, Grand Junction, Colorado, 39 p.

Hawley, C. C., 1969, Geology and beryllium deposits of the Lake George (or Badger Flats) beryllium area, Park and Jefferson Counties, Colorado: U.S. Geological Survey Professional Paper 608-A, 44 p.

Hawley, C. C., and Griffitts, W. R., 1968, Distribution of beryllium, tin, and tungsten in the Lake George area, Colorado: U.S. Geological Survey Circular 597, 18 p.

Lovering, T. S., and Goddard, E. N., 1950, Geology and ore deposits of the Front Range, Colorado: U.S. Geological Survey Professional Paper 223, 319 p.

Meeves, H. C., 1966, Nonpegmatitic beryllium occurrences in Arizona, Colorado, New Mexico, Utah, and four adjacent States: U.S. Bureau of Mines Report of Investigations 6828, 68 p.

Nelson-Moore, J. L., Collins, D. B., and Hornbaker, A. L., 1978, Radioactive mineral occurrences of Colorado and bibliography: Colorado Geological Survey Bulletin 40, 1054 p.

Tweto, Ogden, 1960, Scheelite in the Precambrian gneisses of Colorado: Economic Geology v. 55, no. 7, p. 1406-1428.

_____ 1979, Geologic map of Colorado: U.S. Geological Survey, scale 1:500,000.

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Mineral Resource Potential of the Greenhorn Mountain Wilderness Study Area, Huerfano and Pueblo 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.

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[2]U.S. Bureau of Mines

STUDIES RELATED TO WILDERNESS

Under the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and related acts, the U.S. Geological Survey and the U.S. Bureau of Mines have been conducting mineral surveys of wilderness and primitive areas. Areas officially designated as "wilderness," "wild," or "canoe" when the act was passed were incorporated into the National Wilderness Preservation System, and some of them are presently being studied. The act provided that areas under consideration for wilderness designation should be studied for suitability for incorporation into the Wilderness System. The mineral surveys constitute one aspect of the suitability studies. The act directs that the results of such surveys are to be made available to the public and be submitted to the President and the Congress. This report discusses the results of a mineral survey of the Greenhorn Mountain Wilderness Study Area, San Isabel National Forest, Huerfano and Pueblo Counties, Colo. The Greenhorn Mountain Wilderness Study Area was so established by the Colorado Wilderness Act, Public Law 96-560, December 22, 1980.

MINERAL RESOURCE POTENTIAL
SUMMARY STATEMENT

Mineral resource studies by the U.S. Bureau of Mines and U.S. Geological Survey indicate that one area within the Greenhorn Mountain Wilderness Study Area has low to moderate mineral resource potential. Chemical analyses of stream-sediment samples suggest that the Precambrian igneous and metamorphic rocks underlying the drainage basin of South Apache Creek have very high concentrations of tungsten. Although mineralized rock was not located, similar Precambrian rocks elsewhere in Colorado have tungsten in skarn-type deposits. The potential for tungsten in this basin is deemed low to moderate on the basis of geologic environment and the tungsten geochemical anomaly. The Greenhorn Mountain Wilderness Study Area has no known potential for oil and gas, coal, geothermal resources, or other energy-related commodities.

INTRODUCTION

The Greenhorn Mountain Wilderness Study Area (WSA) in south-central Colorado covers about 22,300 acres in Huerfano and Pueblo Counties (fig. 1). It lies 20 mi southwest of Pueblo and 130 mi almost due south of Denver. Cities within 10 mi include Rye to the northeast, San Isabel to the north, and Gardner to the southwest.

The Greenhorn Mountain WSA lies across the southernmost end of the Wet Mountains and is characterized by a steep eastern flank with V-shaped canyons and a gently sloping western side typified by flat-bottomed arroyos. Elevations range from 12,347 ft at Greenhorn Mountain to 7,600 ft at the southern end of the WSA. Badito Cone, a round symmetrical peak (8,942 ft) rises prominently just south of the WSA boundary. Access to the periphery of the study area is provided by dirt roads, one of which leads nearly to the top of Greenhorn Mountain. Foot trails provide access to the interior of the WSA and traverse across the Wet Mountains.

A mineral survey of the Greenhorn Mountain WSA was done by the U.S. Geological Survey (USGS) during the summer of 1982 and by the U.S. Bureau of Mines (USBM) during September and October 1981 and June 1982. The USBM studied mines, prospects, and mineralized areas (Baskin, 1983), and the USGS performed geological and geochemical investigations. This report summarizes the findings of the mineral survey and assesses the mineral resource potential of the WSA. A geologic map of the southern Wet Mountains by Boyer (1962) was field checked and modified for the geologic base map used in this report (fig. 2). Information on oil and gas potential was obtained from reports by Creely and Saterdal (1956) and Landes (1970).

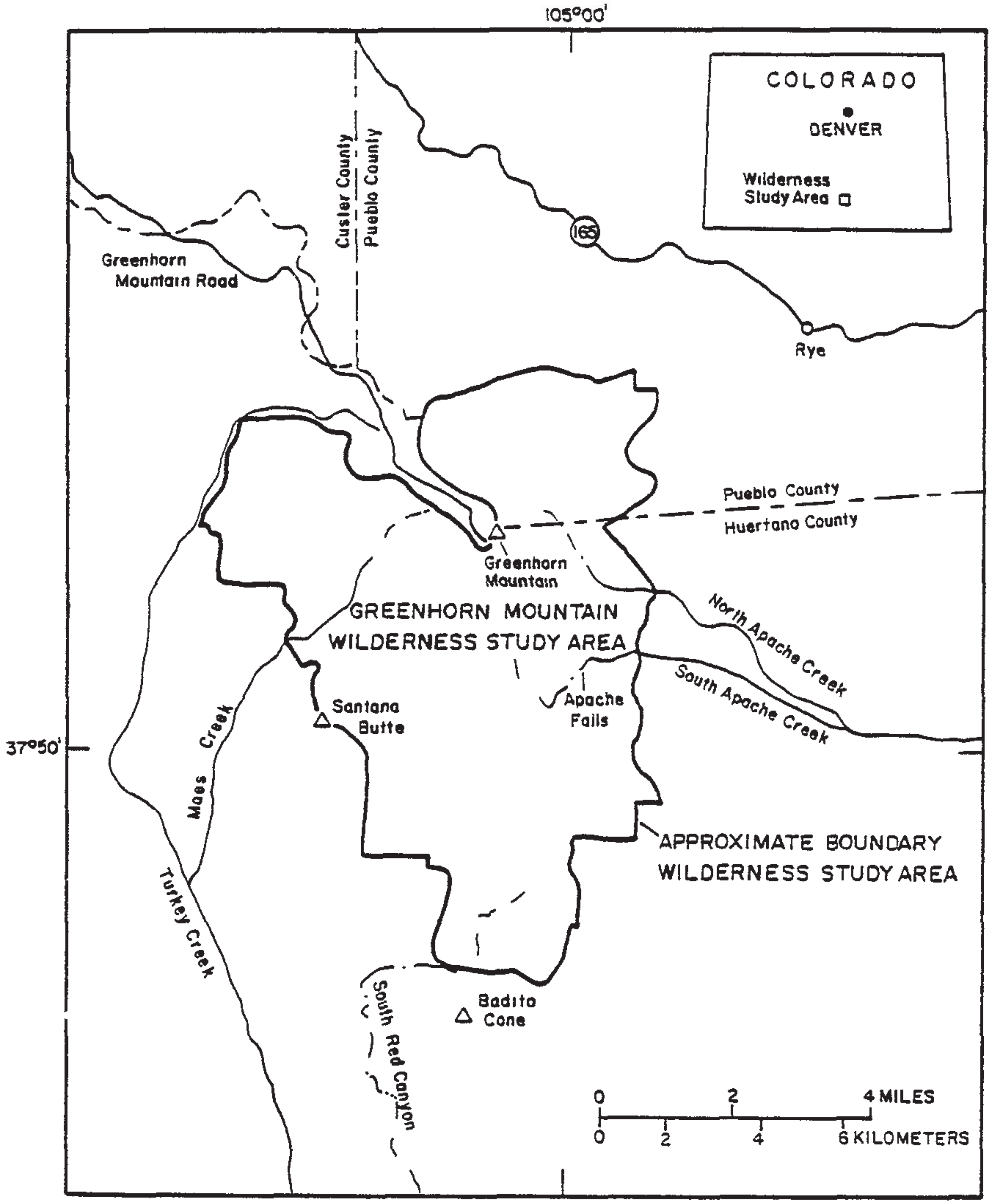

Figure 1.--Index map showing location of the Greenhorn Mountain Wilderness Study Area, Huerfano and Pueblo Counties, Colo.

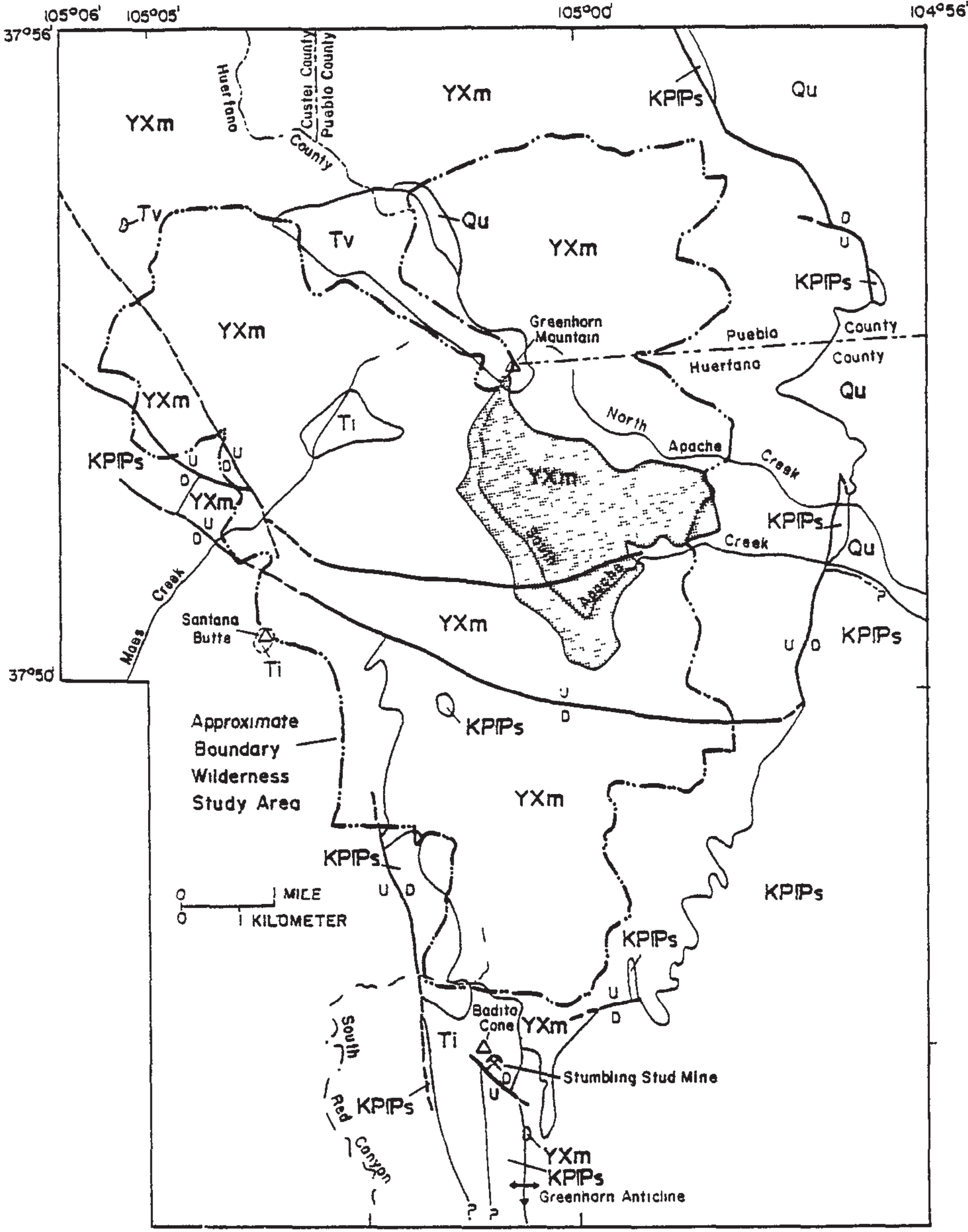

Figure 2.—Map showing geology and location of areas of mineral resource potential in the Greenhorn Mountain Wilderness Study Area. (Description of map units and explanation on following page).

DESCRIPTION OF MAP UNITS

Qu	UNDIFFERENTIATED ALLUVIUM AND TALUS (QUATERNARY)
Tv	VOLCANIC ROCKS (TERTIARY)
Ti	INTRUSIVE ALKALIC IGNEOUS ROCKS (TERTIARY)
KPIPs	SEDIMENTARY ROCK (CRETACEOUS TO PERMIAN-PENNSYLVANIAN)
YXm	METAMORPHIC AND INTRUSIVE IGNEOUS ROCK (PROTEROZOIC (X) AND PROTEROZOIC (Y))
——— — — —?	CONTACT--Dashed where approximately located or inferred. Queried where extension is uncertain
——— — —	FAULT--U, upthrown side; D, downthrown side. Dashed where approximately located
	ANTICLINE--Showing trace of axial plane and direction of plunge of axis
	MINE
	AREA DRAINED BY STREAMS WITH ANOMALOUS TUNGSTEN IN SEDIMENT SAMPLES
	APPROXIMATE BOUNDARY OF GREENHORN MOUNTAIN WILDERNESS STUDY AREA

GEOLOGIC SETTING

The core of the Greenhorn Mountain WSA consists of complexly related Proterozoic X granite gneiss, hornblende gneiss, amphibolite, biotite and biotite-hornblende schist, migmatite, and minor amounts of calc-silicate gneiss and Proterozoic Y San Isabel Granite. Unconformably overlying the basement rock are Permian-Pennsylvanian to Cretaceous interlayered conglomerate, sandstone, siltstone, shale, and limestone as much as 4,150 ft thick. Tertiary alkalic hypabyssal rocks intrude the Precambrian sedimentary rocks at Badito Cone, in Maes Creek, and at Santana Butte. The intrusive rocks are white to light gray and contain 5-10 percent phenocrysts of plagioclase, oxyhornblende, and acmite in an aphanitic groundmass. The ages of the stocks are unknown but may be Miocene, based on correlation with similar appearing rocks in the adjacent Huerfano Park (Briggs and Goddard, 1956). Crystal-vitric rhyolite tuff of both lacustrine and fluvial origins and of Oligocene(?) or Miocene(?) age is preserved in the southwestern and northeastern faces of Greenhorn Mountain. Overlying the rhyolite tuff are erosional remnants of several dark-green to black andesitic lava flows as much as 100 ft in composite thickness, and of Oligocene(?) or Miocene(?) age. The flows contain 5-20 percent phenocrysts of plagioclase, augite, and oxyhornblende in an aphanitic groundmass.

The southern Wet Mountains form a southeast-plunging anticline defined by tilted sedimentary rocks that flank the range and wrap around its southern end. The mountains are bounded by high-angle, northwest-trending normal faults on both the east and west sides of the range. Also trending northwest, minor faults, dikes, and joint sets parallel the elongation of the range, but strike east-west in places. Faults are commonly expressed as brecciated zones that contain hematite, chlorite, and epidote, and abundant slickensides. Several periods of faulting are recognized, and most faults have Laramide (late Campanian Cretaceous to late Eocene) or younger movement; the youngest faults are commonly marked by breaks in the topographic slopes. An extensive, nearly flat erosion surface was formed in late Eocene time before mid-Tertiary uplift of the range, and remnants of it are present along the crest of the mountains near Greenhorn Mountain and beneath the volcanic rocks forming this peak.

GEOCHEMICAL SURVEY

A geochemical survey of the WSA by the USGS included sampling stream sediments and rocks for chemical analysis. Thirty-one samples of stream sediments were taken; the drainage basin areas of the streams varied between 2 and 3 mi^2. The samples were collected as close to the WSA boundary as was feasible, but as most of the sedimentary rocks on the east side of the range crop out east of the WSA boundary, these were not included in the sampling. Large-volume composite samples were collected at each stream site and were separated into three fractions before analysis. Different concentrating techniques were used to produce a fine fraction (consisting mostly of clays), nonmagnetic fraction (consisting of nonmagnetic minerals greater than clay size), and a magnetic fraction (consisting of magnetic minerals greater than clay size). These concentrating techniques were used to enable better recognition of anomalous samples. Composite rock samples were also taken of fresh representative bedrock outcrops and also wherever alteration or evidence of mineralization was present.

All samples were analyzed for 30 elements by six-step semiquantitative emission spectrography (Grimes and Marranzino, 1968). The data for each element were composited into histograms for the various fractions of the stream sediments and for the rock samples. Chemically anomalous samples were defined as the higher population wherever a well-defined separation was present in the data. Analyses of these anomalous samples were usually 2 or 3 spectrographic intervals higher than the rest of the analyses.

The stream-sediment samples from the Greenhorn Mountain WSA generally lack anomalous concentrations of elements associated with metallic deposits. Isolated anomalies are present for some elements but could not be traced to a geologic source. Barium and lanthanum are slightly anomalous in many stream samples; one sample from South Red Canyon contains 10,000 ppm barium in the nonmagnetic fraction of the sediment sample. Anomalous thorium (200 ppm) is present in the nonmagnetic fraction of a sample from Turkey Creek; tin was detected in the nonmagnetic fraction of four widely spaced samples, ranging in concentration from 20 to 50 ppm. A slightly anomalous tungsten content (100-150 ppm) is present in the sediments from streams draining Precambrian igneous and metamorphic rocks in the southernmost part of the WSA.

Stream-sediment samples from six adjacent streams draining into South Apache Creek contain anomalous amounts of barium, lanthanum, yttrium, and tungsten. Three of the streams also have highly anomalous tungsten (100, 300, and 500 ppm) in the nonmagnetic fraction, and the two drainages to the north of South Apache Creek also contain anomalous tungsten (100 and 150 ppm) in this fraction. Reconnaissance geologic studies did not locate a geologic source for this tungsten, and chemical analyses of samples from the granite gneiss in this area did not indicate chemical anomalies, except for a barium content slightly higher than normal for this rock type.

Rock samples from the Greenhorn Mountain WSA are also low in metals associated with mineralized systems; and most of the geochemical anomalies that were found are restricted to isolated samples. Barium, chromium, and nickel have anomalous values in a few igneous and metamorphic rock samples from widely separated localities, and tin was detected in a biotite-hornblende-plagioclase gneiss (30 ppm). Boron is present in anomalous concentrations (200 ppm) in a tourmaline-rich pegmatite.

The Tertiary alkalic stocks around Badito Cone (outside of WSA) and in Maes Creek contain anomalous amounts of niobium (70 and 150 ppm). Along the northeast margin of the stock at Badito Cone, metals occur in an inlier of sedimentary rock along a narrow fault zone in the Dakota Sandstone, just below the contact with the Graneros Shale. The sandstone contains detectable amounts of molybdenum (30 and 50 ppm) and arsenic (300 ppm); it has a high zirconium content (1,000 ppm). Because of its proximity and composition, the highly differentiated alkalic stock is regarded as the source for the metals which were deposited in the sandstone. No anomalous concentrations of any elements were detected in the streams draining the mineralized area.

SCINTILLOMETER SURVEY

A reconnaissance scintillometer survey of the WSA was made by recording measurements at randomly distributed locations and along obvious shear zones. By taking a large number of measurements, we were able to establish the background radiation level (2,000-4,000 counts per second (cps)) and therefore define anomalous radiation levels.

Most of the measurements were within the range of the expected background, but one sample from a fault zone in granite gneiss on the west side of the WSA has 7,500 cps; the source of radiation is unknown. The mineralized Dakota Sandstone at the Stumbling Stud Mine south of the WSA has anomalous radiation of 5,000 cps (Baskin, 1983), and background readings are 80 cps for unaltered rock. These high radiation levels are most likely due to anomalous concentrations of uranium and thorium in the sandstone.

MINES, PROSPECTS, AND MINERALIZED AREAS

Fifty samples from known mines, prospects, and mineralized zones were collected by the USBM for analysis (Baskin, 1983). Samples at the workings consisted of chip samples taken across visible or suspected zones of altered or mineralized rock, and grab and select samples of dump material. Most samples were analyzed for gold and silver by fire-assay, U_3O_8 by radiometric analysis, specific elements in selected samples by atomic absorption, and 40 elements by semiquantitative spectrographic analysis. Results of all analyses are available for public inspection at the USBM, Intermountain Field Operations Center, Denver Federal Center, Denver, Colo. 80225.

Mining history and production

Prospecting in and around the WSA probably began in the late 1860's but there are no records of production before 1900. Most of the workings in and near the WSA are small prospect pits, probably dug for gold or silver. There is no evidence of production from any prospects examined in the WSA.

Several oil and gas leases and lease applications were on record in the WSA and vicinity in September 1982. Only about 100 acres of the WSA were covered by oil and gas lease application and no test drilling has taken place on those properties.

Mining districts and mineralized areas

No mining districts are in or near the Greenhorn Mountain WSA but several small prospects are inside the WSA boundary.

The Maes Creek prospects on the western boundary consist of a few small pits and one 20-ft adit, and the Apache Falls prospect on the eastern boundary consists of one small pit. Scant mineralization is present in the gneisses and granitic gneisses at these workings; assay results from samples taken at these workings show only minor amounts of copper (Baskin, 1983). The Greenhorn Mountain prospects on the northern boundary consist of two small pits in gray andesite; a trench on the Red Canyon claims on the southern boundary is in alluvium. Samples taken from these locales contain no significant amounts of silver, gold, or uranium.

Two mineralized areas lie approximately 1 mi outside the boundary of the WSA. To the northwest of the WSA, the Little Joe claims are staked along a fault zone in quartz-biotite gneiss and biotite schist. Specular hematite occurs in sheared and fractured quartz lenses, blebs, and veinlets that are approximately parallel to the foliation in the gneiss. Two of three samples taken at this location assayed 0.2 oz silver per ton; gold was not detected. Although the fault extends about 1,000 ft inside the WSA, no evidence of mineralization was found along this fault inside the study area.

To the south of the WSA, the Stumbling Stud Mine consists of a group of pits and trenches along a contact between inliers of Cretaceous Dakota Sandstone in a Tertiary alkalic stock. Fluorite and uranium occur as disseminations and veinlets in the sandstone and in lesser amounts in the stock, and appear to be confined primarily to the area around the contact between the intrusive and the sandstone. None of the mineralized area extends into the WSA. Samples from the workings contained as much as 0.12 percent U_3O_8, 0.07 percent V_2O_5, 5.98 percent fluorine, and 1.4 percent zirconium (Baskin, 1983). Production of 510 tons of uranium-bearing rock was reported, but no uranium was extracted because it is chemically bound to a refractory mineral (Nelson-Moore and others, 1978).

The alkalic stock at Badito Cone extends to the southern boundary of the WSA where it is in contact with Precambrian granitic gneisses. The intrusive-sandstone contact does not extend into the WSA and no mineral occurrences of the type described above were observed in the WSA. Two similar stocks crop out in the area of Maes Creek and Santana Butte; the stock in Maes Creek intrudes Precambrian gneiss and the stock at Santana Butte intrudes Cretaceous sediments. No evidence of mineralization was observed at either locality.

Creely and Saterdal (1956) report favorable structural and stratigraphic conditions for oil and gas reserves immediately south of the WSA within the Greenhorn anticline. Most of the drill holes reported by them had shows of oil and (or) gas but none of the holes had any production as of 1956. Although part of the Greenhorn Anticline extends into the WSA, closed structures, which act to trap oil and gas, are absent. Furthermore, extensive erosion has removed the vast bulk of the sedimentary rocks that Creely and Saterdal (1956) report as favorable for oil and gas reserves. No potential for oil and gas is inferred inside the WSA.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

Geological, geochemical, and scintillometer surveys, combined with the examination of mines, prospects, and claims, revealed few indications of near-surface mineral resources within the Greenhorn Mountain WSA; thus, there is little likelihood for occurrence of mineral resources in most of the WSA. Our studies indicate that one area in the WSA has a low to moderate mineral resource potential (fig. 2).

Most of the geochemical anomalies in the stream-sediment and rock samples are isolated in their occurrence, are low in value, and have no known geologic source. One cluster of barium, lanthanum, yttrium, and tungsten anomalies is present in the streams draining into South Apache Creek. Although tungsten occurrence is indicated for this area, our mapping did not locate evidence of mineralization in the Precambrian rocks in these drainages. Comparison with other tungsten-bearing Precambrian rocks elsewhere in Colorado (Tweto, 1960; Heinrich, 1981) suggests that large inclusions of calc-silicate gneiss or amphibolite in the Precambrian granite gneiss are a likely source for the tungsten. Detailed mapping would be necessary to establish the location of the mineralized rock in the area of the stream anomalies. The mineral potential for tungsten assigned to this area is therefore low to moderate.

There is no known geological evidence for nonmetallic resources, oil and gas, coal, geothermal resources, or other energy-related commodities within the WSA.

REFERENCES

Baskin, G. D., 1983, *Mineral investigation of the Greenhorn Mountain* Wilderness Study Area, Huerfano and Pueblo Counties, Colorado: U.S. Bureau of Mines Open-File Report MLA-26-83.

Boyer, R. E., 1962, Petrology and structure of the southern Wet Mountains: Geological Society of America Bulletin, v. 73, p. 1047-1070.

Briggs, L. I., and Goddard, E. N., 1956, Geology of Huerfano Park, Colorado, in Guidebook to the geology of Raton Basin, Colorado: Rocky Mountain Association of Geologists, p. 40-45.

Creely, R. S., and Saterdal, A. O., 1956, Badito-Alamo area, Huerfano County, Colorado, in Guidebook to the geology of the Raton Basin, Colorado: Rocky Mountain Association of Geologists, p. 71-74.

Grimes, D. J., and Marranzino, A. P., 1968, Direct-current arc and alternating-current spark emission spectrographic field methods for the semiquantitative analysis of geologic materials: U.S. Geological Circular 591, 6 p.

Heinrich, E. W., 1981, Precambrian tungsten and copper-zinc skarn deposits of south-central Colorado: Colorado Geological Survey Resource Series, no. 21, 115 p.

Landes, K. K., 1970, Petroleum geology of the United States: New York, Wiley Interscience, p. 379-397.

Nelson-Moore, J. L., Collins, D. B., and Hornbaker, A. L., 1978, Radioactive mineral occurrences of Colorado and bibliography: Colorado Geological Survey Bulletin 40, 1054 p.

Tweto, Ogden, 1960, Scheelite in the Precambrian gneisses of Colorado: Economic Geology, v. 55, p. 1406-1428.

MISCELLANEOUS FIELD STUDIES
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PAMPHLET

MINERAL RESOURCE POTENTIAL OF THE SPANISH PEAKS WILDERNESS STUDY AREA, HUERFANO AND LAS ANIMAS COUNTIES, COLORADO

By

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STUDIES RELATED TO WILDERNESS

Under the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and related acts, the U.S. Geological Survey and the U.S. Bureau of Mines have been conducting mineral surveys of wilderness and primitive areas. Areas officially designated as "wilderness," "wild," or "canoe" when the act was passed were incorporated into the National Wilderness Preservation System, and some of them are presently being studied. The act provided that areas under consideration for wilderness designation should be studied for suitability for incorporation into the Wilderness System. The mineral surveys constitute one aspect of the suitability studies. The act directs that the results of such surveys are to be made available to the public and be submitted to the President and the Congress. This report discusses the results of a mineral survey of the Spanish Peaks Wilderness Study Area, San Isabel National Forest, Huerfano and Las Animas Counties, Colo. The area was established as a wilderness study area by Public Law 96-560, December 22, 1980.

MINERAL RESOURCE POTENTIAL SUMMARY STATEMENT

A geologic and geochemical investigation and a survey of mines and prospects have been conducted to evaluate the mineral resource potential of the Spanish Peaks Wilderness Study Area, Huerfano and Las Animas Counties, in south-central Colorado. The study area is underlain by sedimentary rocks of Paleozoic to Tertiary age (Johnson, 1969). Stocks and dikes were emplaced between 20 and 25 m.y. ago (Smith, 1979) forming East and West Spanish Peaks and the White Peaks.

Most of the study area lacks significant geochemical anomalies and has a low mineral potential. Anomalous concentrations of gold, silver, copper, lead, and zinc in the rocks and drainage basins in the vicinity of the old mines and prospects on West Spanish Peak indicate a moderate potential for small mineralized veins in this area. Ore-bearing veinlets have been worked in the past, primarily for silver and lead; however, the sparsity, small size, and low grade of the veins diminish their significance.

The depth of several thousand feet at which coal may underlie the surface rocks of the study area makes it a resource with little likelihood of development. The potential for oil and gas appears low because of the apparent lack of structural traps and the intense igneous activity in the area.

INTRODUCTION

The Spanish Peaks Wilderness Study Area covers about 19,570 acres of the San Isabel National Forest in south-central Colorado (fig. 1). The study area is in the westernmost part of the Great Plains, bordering the eastern foothills of the Sangre de Cristo Mountains. Elevations range from 13,626 ft on the summit of West Spanish Peak to about 8,400 ft in the western part, near Cuchara. The east half of the study area is characterized by rugged terrain in which the land and drainages slope radially away from East and West Spanish Peaks. The principal drainages are Wahatoya and Trujillo Creeks. In the west half of the study area, the terrain is less severe. The major drainages are the north-flowing Chaparral and Echo Creeks. North, Middle, and South White Peaks (elevation 10,446 ft) are near the west boundary of the study area.

Colorado Highway 12 and the Cucharas River parallel the study area on the west. U.S. Forest Service Route 415 and the Apishapa River parallel the southern margin. Secondary roads are sparsely located near the boundary of the study area.

Details of the geology of the study area (Budding and Lawrence, 1983b) and the results of the geochemical survey (Budding and Lawrence, 1983a) are presented as separate maps of the Spanish Peaks Wilderness Study Area. Only the aspects of the work pertinent to resource appraisal are included here. No geophysical work was done.

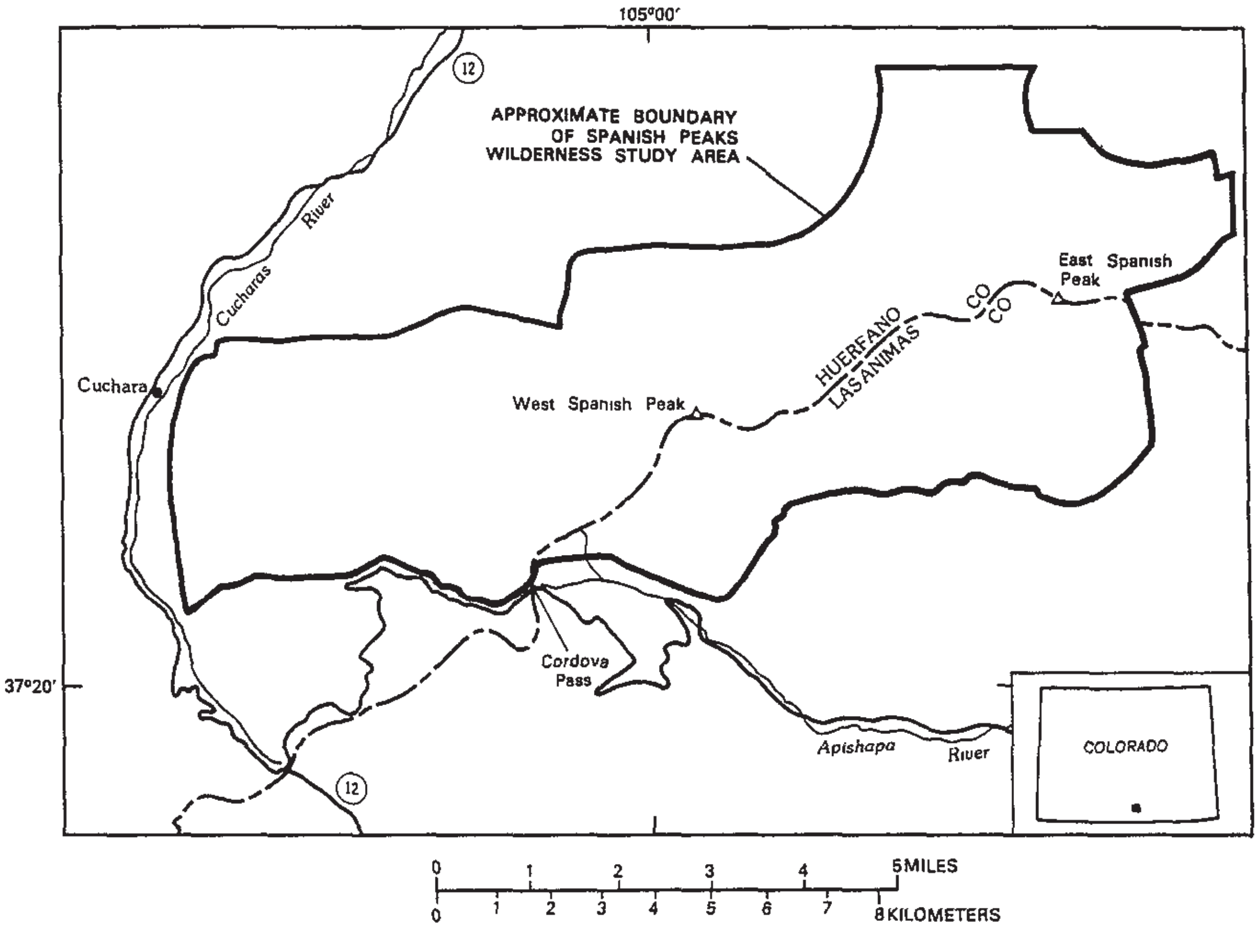


Figure 1.—Index map showing location of the Spanish Peaks Wilderness Study area, Huerfano and Las Animas Counties, Colo.

GEOLOGY

Sedimentary rocks, Paleozoic to Tertiary in age, crop out near the Spanish Peaks. In the western part of the study area, these include sandstone, shale, limestone, siltstone, coal, and conglomerate from the Upper and Lower Cretaceous Dakota Sandstone upward through the Paleocene Poison Canyon Formation (Johnson, 1969). Most of the sedimentary rocks are included in the Eocene sandstone, siltstone, claystone, and shale of the undifferentiated Cuchara and Huerfano Formations (Robinson, 1966; Scott and Taylor, 1975).

The sedimentary rocks were invaded by the granite porphyry of East Spanish Peak 21.7±1.0 m.y. ago (Stormer, 1972); this event was closely followed by the intrusion of the compositionally similar granite of North, Middle, and South White Peaks. The core of East Spanish Peak was then intruded by porphyritic granodiorite. The syenodiorite of West Spanish Peak was emplaced 22.9±2.0 m.y. ago (Smith, 1973) and is composed of several compositional varieties of syenodiorite. A large aureole of metamorphosed sedimentary rocks surrounds the body of syenodiorite. An impressive swarm of radial dikes, having trends related to stresses developed around the West Spanish Peak during magmatic activity, is found in the study area. Four radial dikes south of the peaks range in age from 22.4±3.1 m.y. to 28.5±5.0 m.y. (Smith, 1973). The compositions of the radial dikes vary from trachyte to augite-plagioclase lamprophyre; most are trachyandesite porphyries (Smith, 1977).

MINES AND PROSPECTS

History and production

All known workings in the study area are found in the zone of contact-metamorphosed sedimentary rocks surrounding the West Spanish Peak intrusive. Mineralized veinlets along a shear zone trending N. 65° E. have been worked in the Bulls Eye Mine on the north side of West Spanish Peak (fig. 2). Quartz veins bear argentiferous galena, tetrahedrite, chalcopyrite, and sphalerite, associated with siderite, calcite, and barite. Two mines on the eastern side and southeastern side of West Spanish Peak (here named "Mine 1" and "Mine 2," fig. 2), along with workings on several ridge tops, indicate areas of past mining activity. Vein material here is similar to that found at the Bulls Eye Mine (Kluender, 1983).

The total production prior to 1908 from the mines on West Spanish Peak was 168 oz of gold, 1,176 oz of silver, 92 lb of copper, and 1,067 lb of lead (Vanderwilt, 1947). Placer gold was reported by Hills (1901) from streams tributary to Wahatoya Creek and the Apishapa River. In 1932 and 1934, a few ounces of placer gold was produced from the north side of the study area. Four tons of lead-silver ore was shipped from the study area in 1934 and 1935 (Vanderwilt, 1947).

No workings are extensive, although at the Bulls Eye Mine the vein is traceable more than 0.5 mi along strike and about 2,000 ft vertically above the main workings. In the Bulls Eye Mine adit accessible at the time of this study, the vein is 6-12 in. wide; a vein sample taken at the face of the adit contained 0.026 oz/ton gold, 2.2 oz/ton silver, 2.28 percent lead, and 4.40 percent zinc (Kluender, 1983). Minor amounts of copper and antimony were also found in a few of the samples.

Mining and exploration activity

No active mining or exploration efforts were underway in 1982. Records and patented mining claims on the Bulls Eye Mine, Mine 1, and along two ridges on West Spanish Peak are filed with the U.S. Bureau of Land Management. There has been recent drilling for petroleum or for carbon dioxide just south of the study area boundary, in the Apishapa River drainage. Most of the land within the study area is currently under oil and gas lease application.

GEOCHEMICAL SURVEY

To assist the assessment of the mineral resource potential of the study area, a geochemical survey was made, utilizing stream-sediment, panned-concentrate, and rock samples. Each sample—rock, stream sediment sieved to less-than-80 mesh, and the nonmagnetic heavy-mineral fraction of the panned concentrate—was analyzed semiquantitatively for 31 elements using an optical emission spectrograph. Additional analyses for gold, bismuth, antimony, arsenic, zinc, and cadmium by atomic absorption and for uranium by fluorimetry were made on the rocks and stream sediments.

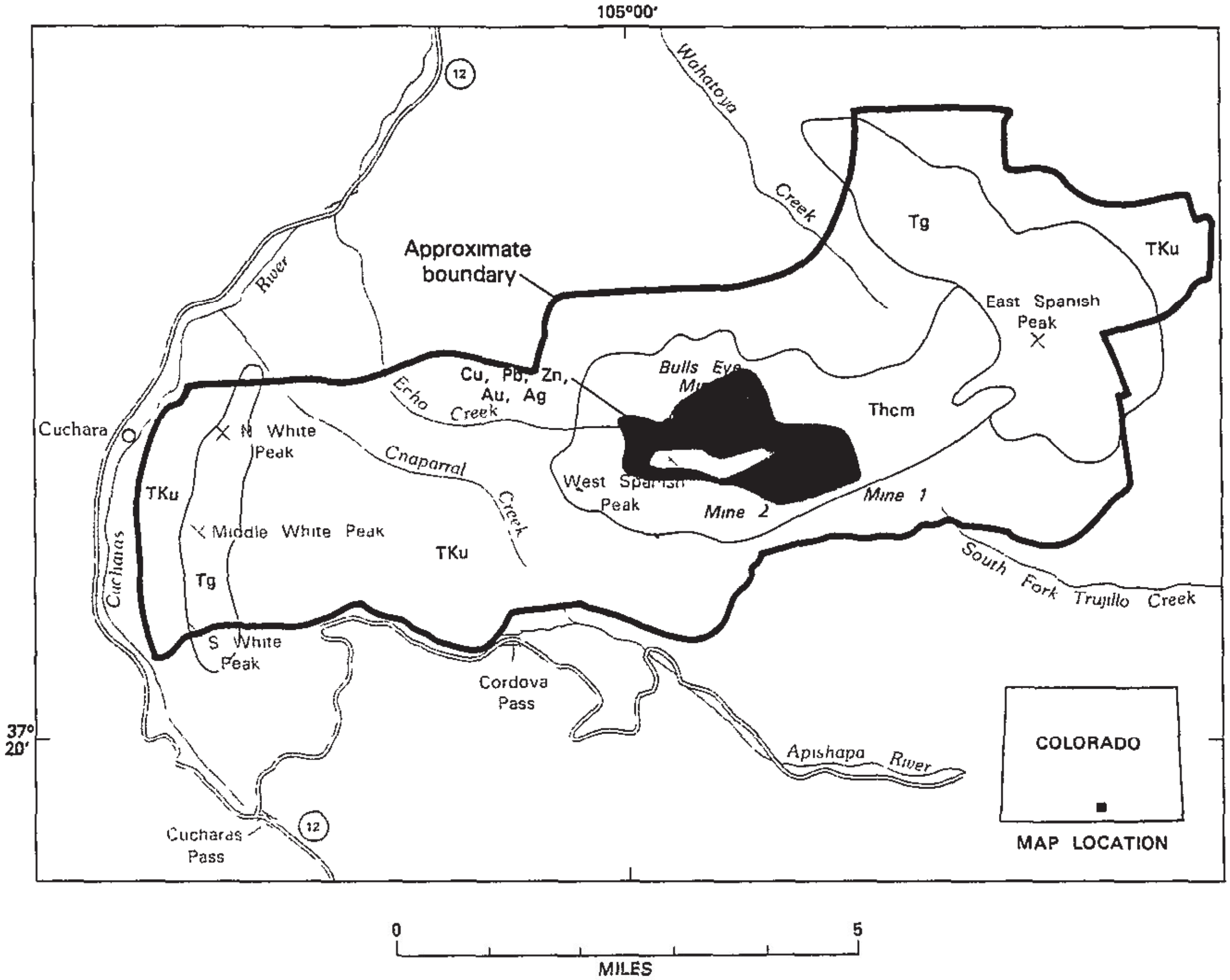
The majority of the geochemical anomalies were found in the vicinity of the old workings on West Spanish Peak. Table 1 describes the samples in the mineralized areas and lists their elements present in anomalous concentration—primarily lead, zinc, silver, copper, and minor gold. The rock samples that are not associated with the mines were collected from ridge tops in the northern and eastern parts of West Spanish Peak.

No gold was detected in the samples from tributaries to the Apishapa River and Wahatoya Creek, contrary to early reports by Hills (1901).

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

The mineralized areas in the study area are associated with veins in the aureole of metamorphosed sedimentary rocks surrounding the West Spanish Peak intrusive. The veins are present near the contact with the intrusive mass, and many are associated with shear zones. The mineralized veinlets are few and low in grade; therefore, a moderate potential for small deposits of lead, zinc, copper, silver, and gold is assigned to those areas proximal to the old workings and to other mineralized or anomalous areas as indicated in figure 2.

Most of the study area lacks significant anomalies related to metallic deposits. Coal may underlie the study area, but only at a depth of several thousand feet; therefore, it is a resource that has little likelihood of development. The oil and gas potential likewise appears low because of the apparent lack of structural traps and the igneous activity in the area.



EXPLANATION

(black area)	Area having *moderate potential* for small deposits of lead, zinc, copper, silver, and gold
Cu	Copper
Au	Gold
Pb	Lead
Ag	Silver
Zn	Zinc
Ts	Syenodiorite (Tertiary)
Tg	Granite, granodiorite (Tertiary)
TKu	Undifferentiated sedimentary rocks (Tertiary and Cretaceous)
Thcm	Metasedimentary rocks (Tertiary)
———	*Contact*

Figure 2.--Map showing area of mineral resource potential in the Spanish Peaks Wilderness Study Area, Huerfano and Las Animas Counties, Colo.

Table 1.—Chemically anomalous samples from West Spanish Peak

[Sample: SS, stream sediment; PC, panned concentrate; R, rock chip; X indicates anomalous concentration]

Sample no.	Ag	Bi	Cu	Mo	Ni	Pb	Zn	As	Au	Cd	Co	Sb	Sn	Sample description
SP-35-SS-----	X	X	X	X			X	X	X	X		X		From drainage directly below Bulls Eye Mine.
SP-35-PC-----						X								Do.
SP-37-SS-----						X	X	X		X	X			From larger drainage basin farther below Bulls Eye Mine.
SP-37-PC-----	X		X		X	X	X	X						Do.
SP-28-R------	X	X	X			X	X	X	X	X		X		Channel sample of vein gouge at Bulls Eye Mine.
SP-146-R-----	X	X				X	X	X	X	X		X		Gossan from prospect on ridge.
SP-539B-R----	X	X				X	X	X	X					From iron-stained shear zone in syeno-diorite on ridge.
SP-559-R-----			X					X						Iron-stained syenodiorite containing sulfides, from ridge.
SP-122-R-----				X										Iron-stained syenodiorite from ridge.
SP-150-R-----									X					Hornfels containing sulfides, from ridge.
SP-524-SS,PC-							X							From drainage below Mine 1.
SP-158-R-----						X							X	Iron-stained hornfels containing pyrite boxwork, Mine 1.
SP-159-R-----	X		X				X	X		X				Sulfide-rich syenodiorite from dump below Mine 1.
SP-161-R-----	X		X			X	X	X		X				Iron-stained hornfels containing sulfides, from dump below Mine 1.
SP-52-SS,PC--							X							From drainage below Mine 2.
SP-162-R-----	X	X	X			X	X	X						Channel sample from Mine 2.
SP-164-R-----		X	X				X	X						Iron-stained, sulfide-rich rock and gossan from dump below Mine 2.

REFERENCES

Budding, K. E., and Lawrence, V. A., 1983a, Geochemical maps of the Spanish Peaks Wilderness Study Area, Huerfano and Las Animas Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-1542-B, scale 1:50,000.

_______1983b, Reconnaissance geologic map of the Spanish Peaks Wilderness Study Area, Huerfano and Las Animas Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-1542-A, scale 1:50,000.

Hills, R. C., 1901, Spanish Peaks folio: U.S. Geological Survey Geologic Atlas, Folio 71, 7 p.

Johnson, R. B., 1969, Geologic map of the Trinidad quadrangle, south-central Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-558, scale 1:250,000.

Kluender, S. E., 1983, Mineral investigation of the Spanish Peaks Roadless Area, Huerfano and Las Animas Counties, Colorado: U.S. Bureau of Mines Open-File Report MLA 58-83.

Robinson, Peter, 1966, Fossil mammalia of the Huerfano Formation, Eocene, of Colorado: Yale University, Peabody Museum of Natural History Bulletin 21, 95 p.

Scott, G. R., and Taylor, R. B., 1975, Post-Paleocene Tertiary rocks and Quaternary volcanic ash of the Wet Mountain Valley, Colorado: U.S. Geological Survey Professional Paper 868, 15 p.

Smith, R. P., 1973, Age and emplacement structures of Spanish Peaks dikes, south-central Colorado [abs.]: Geological Society of America Abstracts with Programs, v. 5, p. 513-514.

_______1977, Geology of dikes in part of the Spanish Peaks dike system, south-central Colorado: Geological Society of America Map and Chart Series MC-22, 2 p.

_______1979, Early rift magmatism at Spanish Peaks, Colorado, in Riecker, R. E., ed., Rio Grande Rift—tectonics and magmatism: American Geophysical Union, Santa Fe, N.Mex., October 1978, p. 313-321.

Stormer, J. C., 1972, Ages and nature of volcanic activity on the southern high plains, New Mexico and Colorado: Geological Society of America Bulletin, v. 83, p. 2443-2448.

Vanderwilt, J. W., 1947, Metals, nonmetals, and fuels, Pt. 1, in Vanderwilt, J. W., Mineral resources of Colorado: Denver, Colo., Colorado Resources Board, p. 1-290.

MINERAL RESOURCE POTENTIAL OF THE BUFFALO PEAKS WILDERNESS STUDY AREA, LAKE, PARK, AND CHAFFEE COUNTIES, COLORADO

By

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STUDIES RELATED TO WILDERNESS

Under the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and the Joint Conference Report on Senate Bill 4, 88th Congress, the U.S. Geological Survey and the U.S. Bureau of Mines have been conducting mineral surveys of wilderness and primitive areas. Areas officially designated as "wilderness," "wild," or "canoe" when the act was passed were incorporated into the National Wilderness Preservation System, and some of them are presently being studied. The act provided that areas under consideration for wilderness designation should be studied for suitability for incorporation into the Wilderness System. The mineral surveys constitute one aspect of the suitability studies. The act directs that the results of such surveys are to be made available to the public and be submitted to the President and the Congress. This report discusses the results of a mineral survey of the Buffalo Peaks Wilderness Study Area, Pike and San Isabel National Forests, Lake, Park, and Chaffee Counties, Colo. The area was established as a wilderness study area by Public Law 96-560, December 22, 1980.

MINERAL RESOURCE POTENTIAL SUMMARY STATEMENT

During 1981 and 1982, the U.S. Geological Survey and the U.S. Bureau of Mines conducted field investigations to evaluate the mineral resource potential of the Buffalo Peaks Wilderness Study Area. The study area encompasses 57,200 acres (about 89 mi^2) of the Pike and San Isabel National Forests in Lake, Park, and Chaffee Counties, Colo.

There are six separate areas (A through F) having mineral resource potential. Area A, along the northeast margin of the study area has a moderate resource potential for silver in base-metal veins and bedded replacement deposits. Within area A a small zone near Weston Pass has a high potential for silver resources in veins. The northwest part of the study area (area B) has a low to moderate potential for silver and gold resources in quartz-pyrite veins. Most veins occur outside the study area. Area C is along the southwest margin of the study area, and has a low to moderate potential for silver and gold resources in quartz-pyrite veins. Most veins occur outside the study area. In addition, area C has low potential for uranium resources in veins. Area D has an identified uranium resource and a low to moderate potential for additional uranium resources in uraniferous jasperoids in the Sawatch Quartzite along the southeast margin of the study area. In the rest of area D there is a low to moderate resource potential for lead and barite in fault controlled deposits. Within area D a small zone along the northeast side of the Middle Fork of Salt Creek has a low to moderate resource potential for silver in vein deposits. Anomalous amounts of barium (2,000-10,000 ppm) and lead (30-1,500 ppm) were discovered by the geochemical sampling of stream sediments in areas E and F along the east margin of the study area. However, no bedded replacement or vein deposits of barite or galena were observed during geologic mapping, and therefore a low to moderate resource potential is assigned for barite and lead in areas E and F. The six mineralized areas are largely related to fault systems and to Laramide intrusive activity.

There is little or no indication of oil or gas, or geothermal energy resources in the study area.

INTRODUCTION

Location and geographic setting

The Buffalo Peaks Wilderness Study Area occupies 57,200 acres (about 89 mi^2) within the Pike and San Isabel National Forests in Lake, Park, and Chaffee Counties of Colorado (fig. 1). The study area is reached on the north by U.S. Forest Service road 425 along the South Fork of the South Platte River and over Weston Pass (altitude 11,921 ft) into Big Union Creek on the west. To the south, the study area is accessible from the Otero aqueduct line and the Lenhardy cutoff road. To the west, the Arkansas River and U.S. Highway 24 provide access to the Fourmile Forest Service Road 200 and the Buffalo Meadows

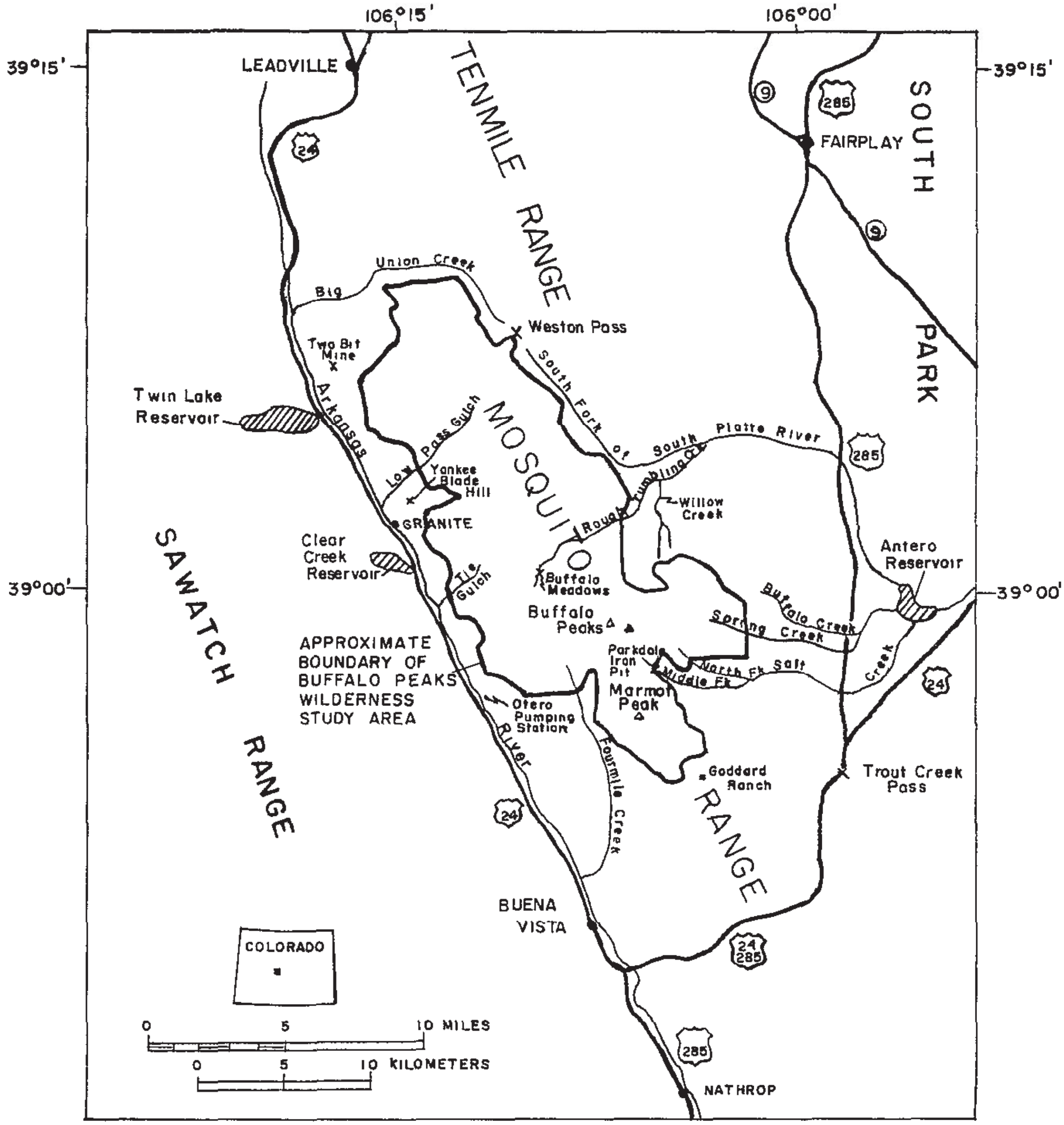

Figure 1.--Index map showing location of the Buffalo Peaks Wilderness Study Area.

trailhead along Fourmile Creek. The Low Pass Gulch road leading north from Granite and extending over Yankee Blade Hill into Hayden Gulch, provides access to the gold mines of the Granite district. On the east side of the Mosquito Range the numerous side roads such as the Buffalo Springs and Salt Creek roads that branch off from U.S. Highway 285 provide access to the southeastern part of the study area.

The study area is within the Mosquito Range, a major divide that separates the Arkansas River and its tributaries from South Park and the tributaries of the South Platte to the east. Elevations of peaks range from 12,892 ft on South Peak near Weston Pass to 13,326 ft on West Buffalo Peak. The Arkansas River valley, which is along a major rift structure that separates the Sawatch Range on the west from the Mosquito Range to the east, has elevations that range from 8,200 to 8,880 ft.

The Mosquito Range is located structurally on the N. 30° W.-striking east flank of the faulted Sawatch anticline (Tweto, 1975). The anticline has a core of Precambrian igneous and metamorphic rocks and an east flank of eroded Paleozoic strata. Paleozoic strata dip 25°-30° E.

Present and previous studies

Present investigations by the U.S. Geological Survey and the U.S. Bureau of Mines included mapping an area of about 125,000 acres in and around the study area. The U.S. Geological Survey investigations include geologic mapping at a scale of 1:50,000 (Hedlund, in press), an aeromagnetic survey (Hedlund, in press), and a geochemical sampling of rocks, stream sediments, and spring water (Nowlan and Gerstel, in press; Nowlan and others, in press). The U.S. Bureau of Mines has reviewed past and present mining activity, and the numerous mines and prospects of the study area were examined and sampled by Wood (1983). During the period of this study no actual mining was observed, although prospecting and claim staking activities in the vicinity of Weston Pass and along Union Gulch were noted.

Previous geologic studies in the study area include the reconnaissance maps by Tweto (1974) and Scott (1975); both maps are at a scale of 1:62,500. More detailed work includes the report on the geology of the Weston Pass mining district (Behre, 1932); a description of the gold veins in the Granite district by E. C. Eckel (unpub. data. 1932) and J. C. Hersey (unpub. data, 1982); and various maps and descriptions of the Salt Creek uraniferous jasperoids that were submitted to J. V. Dodge, owner of the Bronoc-Lady Elk claims by C. M. Armstrong (written commun., 1977, 1978) and Jack Di Marchi and Edward Duke (written commun., 1979). Production records for the Fourmile district are from Vanderwilt (1947). Radioactive mineral occurrences just south of the Buffalo Creek area and at the Josephine mines are reported by Nelson-Moore and others (1978).

ACKNOWLEDGMENTS

We gratefully acknowledge the assistance of J. C. Hersey of Gunnison, Colo., for providing the mining history and some of the production figures for various mines in the Granite district. We also thank J. V. Dodge of Canon City, Colo., for providing the mining history and reserve estimate for the Bronc-Lady Elk claims.

GEOLOGY

The Mosquito Range, which is continuous with the Tenmile Range north of Weston Pass, is a part of the N. 30° W.-striking east flank of the large, highly faulted Sawatch anticline (Tweto, 1975). Precambrian igneous and metamorphic rocks comprise the core of this anticline, and east-dipping Paleozoic strata along the east side of the Mosquito Range represent the eastern limb.

Precambrian rocks comprise a little more than three-fourths of the outcrop area and include older Proterozoic migmatite, amphibolite, and granodiorite group of rocks that is intruded by younger Proterozoic Y granitic rocks. The migmatite in the Granite district is probably part of a synformal structure having an axial plane that strikes N. 70° E. and shows closure to the west-southwest. The mineralized faults and rhyolite dikes within this migmatitic gneiss are approximately conformable to the foliation within the gneiss.

The Paleozoic strata include the Cambrian Sawatch Quartzite, about 150 ft thick; the Ordovician Manitou Dolomite, about 190-230 ft thick; the Ordovician Harding Sandstone, as much as 50 ft thick; the Ordovician Fremont Dolomite, about 90 ft thick; the Devonian and Lower Mississippian(?) Chaffee Group with an aggregate thickness of about 100 ft; the Lower Mississippian Leadville Limestone, about 140 ft thick; and the undivided Pennsylvanian Belden and Minturn Formations that are about 7,700 ft thick. Some formations are absent due to normal faulting, such as in the vicinity of Weston Pass, where the Ordovician Fremont Dolomite and beds of the Chaffee Group are absent. Numerous disconformities separate the lower Paleozoic formations; the Cambrian Sawatch Quartzite thins appreciably to the southeast of the study area and is absent through nondeposition or erosion in the vicinity of Trout Creek Pass. Similarly, the Ordovician Harding Sandstone thins northwest of Trout Creek Pass. Vuggy and locally silicified beds of the Mississippian Leadville Limestone are host for some of the bedded replacement ore bodies in the Weston Pass-Union Gulch districts. In places, the dolomitization of the Leadville Limestone to form 'zebra-striped' rock was probably an important factor for increasing porosity and providing sites for later ore deposition.

Laramide intrusions include a small biotitic rhyolite plug (61.4±2.2 m.y. old; dated by potassium-argon method) along the east side of Rough and Tumbling Creek and thin rhyolite dikes (65.3±2.4 m.y. old; dated by potassium-argon method) in the Granite district (R. F. Marvin and others, written commun., 1983). Other, and probably later intrusions of rhyolite dikes, in the vicinity of Fourmile Creek, are of Oligocene(?) age.

Deposits of Tertiary and Quaternary age include the thick (1,500-ft) sequence of Oligocene (34-m.y.-old) volcanic rocks in the Buffalo Peaks area, the Miocene and Pliocene Dry Union Formation and the diverse colluvium and glacial deposits of Quaternary age. The Buffalo Peaks Andesite overlies the crystal-rich ash-flow tuffs of the Oligocene Badger Creek

Tuff, but in places the ash-flow tuffs and associated laharic breccias are intercalated with the lower andesite flows.

Faults have had an important influence on the localization of mineral deposits. The silver-bearing base-metal veins of the Weston Pass-Union Gulch districts are along a branched fault system that is coextensive with the large Weston fault. Some of these faults displace older northeast-striking faults that are not mineralized. The quartz-pyrite-gold-tourmaline veins of the Granite-Two Bit districts occupy closely spaced east-northeast-striking faults in migmatite. In area C (fig. 2), along both sides of Fourmile Creek, the quartz-pyrite-gold veins are coextensive with north-northwest-striking fault systems that show evidence of repeated movement. The uraniferous jasperoids at the Parkdale iron pit are probable hydrothermal vein and bedded replacement deposits that are localized along fractures and small faults in the Sawatch Quartzite and underlying Precambrian granite.

GEOCHEMISTRY

Geochemical sampling was done during June and July of 1982 (Nowlan and Gerstel, in press; Nowlan and others, in press). Sampling density was about one site per square mile. At each site, where possible, stream-sediment, stream-water, and two panned-concentrate samples were collected. Spring water was sampled where springs were encountered. Totals of about 80 stream-sediment samples, 160 panned concentrate samples, and 100 water samples were collected.

Stream-sediment samples were analyzed for 31 elements by emission spectrography (Grimes and Marranzino, 1968) and for arsenic, zinc, cadmium, bismuth, and antimony by a modification of the atomic-absorption-spectrographic method described by Viets (1978). Water samples were analyzed for about 25 constitutents using methods outlined by Ficklin and others (1981). One panned-concentrate sample from each site was panned until black minerals started to leave the pan: this concentrate was subjected to a series of heavy-mineral and electromagnetic separations in order to obtain a heavy, nonmagnetic fraction. The heavy, nonmagnetic sample was pulverized and analyzed for 31 elements by emission spectrography. A second concentrate from each site was panned until the light-colored, light-weight minerals were gone; the entire sample was then pulverized and a 10 g portion was analyzed for gold by atomic-absorption spectroscopy (Thompson and others, 1968).

Elemental values at the 90th percentile or greater are generally considered anomalous for the study area, and elemental values between the 75th and 90th percentiles are considered high (table 1). Some elements, such as silver, molybdenum, and tin in stream sediment or bismuth and vanadium in nonmagnetic heavy concentrates, were detectable in so few samples that any detectable amount is considered anomalous. Geochemical patterns are more significant than single-site, single-element anomalies. Elemental patterns that roughly coincide with areas of known mineralization are significant, especially if the elements giving the pattern are elements known to be part of the mineralization. The coincidence of patterns of many variables, even in areas of no known mineralization, is also significant. Nowlan and Gerstel (in press) summarized the geochemical associations and classified parts of the study area as being high or anomalous in various elements (see table 1 of their report).

Significant geochemical patterns are evident in five general areas (see table 2): Weston Pass-Union Gulch districts (area A, fig. 2); Granite-Two Bit districts (area B, fig. 2); Fourmile Creek-Buffalo Peaks districts (area C, fig. 2); southeastern part of the study area (areas D and E, fig. 2); and in the vicinity of the Laramide rhyolite stock between Rough and Tumbling and Willow Creeks (area F, fig. 2). Statistics for analyses of stream-sediment and panned-concentrate samples are shown in table 1 (this report).

The geochemical studies show that, in general, the geochemistry of various parts of the study area reflect known mineralization in adjacent areas outside the study area, even though elemental concentrations generally seem low for being adjacent to known mineralized areas. Stream-sediment samples from the Weston Pass-Union Gulch districts (area A, fig. 2) are anomalous in arsenic (>5 ppm), cadmium (>0.9 ppm), lead (>100 ppm), and zinc (>140 ppm); this anomaly is compatible with its proximity to the silver-bearing base-metal ores of the Weston Pass-Union Gulch districts.

Stream-sediment samples from the vicinity of the Granite-Two Bit districts (area B, fig. 2) have anomalous amounts of cadmium (>0.9 ppm), manganese (>1,500 ppm), nickel (>20 ppm), uranium (>21 ppm), and zinc (>140 ppm); panned concentrates from the vicinity of area B are anomalous in tungsten (>70 ppm). Stream-sediment and samples from the vicinity of area B are high in arsenic (5 ppm), copper (50 ppm), and lead (100 ppm); panned concentrates from the same area are high in boron (15-50 ppm), barium (500-1,500 ppm), manganese (1,000 ppm), lead (100-200 ppm), and thorium (300-700 ppm). Gold was chemically detected in several panned concentrates; the highest value is 0.95 ppm. This association of elements in samples from the Granite-Two Bit districts is compatible with the tourmaline-bearing quartz-pyrite-gold veins of the districts.

Stream-sediment samples for the Fourmile Creek-Buffalo Peaks districts (area C, fig. 2) have anomalous amounts of zinc (>140 ppm) and tin (detectable at 10 ppm). Panned concentrates from area C have anomalous amounts of copper (>14 ppm) and molybdenum (10 ppm). In addition, stream-sediment samples are high in copper (50 ppm), manganese (1,500 ppm), nickel (20 ppm), lead (100 ppm), and uranium (10-21 ppm). Panned concentrates from area C are high in manganese (1,000 ppm), lead (100-200 ppm), and thorium (300-700 ppm). Gold was chemically detected in several panned concentrates; the highest value is 1.0 ppm. The association is compatible with the high-temperature quartz-pyrite-gold veins along Fourmile Creek.

Area D (fig. 2) has uraniferous jasperoids and several silver-bearing veins. A pattern of anomalous boron (>50 ppm), molybdenum (10-20 ppm), lead (>200 ppm), and thorium (>700 ppm) in panned concentrates is present in an area that includes areas D and E (fig. 2). Stream-sediment samples from areas D and E and vicinity are high in copper (50 ppm), manganese (1,500 ppm), molybdenum (5 ppm or greater), nickel (20 ppm),

Table 1.--Statistics for analyses of stream-sediment and panned-concentrate samples from the Buffalo Peaks Wilderness Study Area, Colorado

[Leaders (---) indicate not applicable; dash (-) indicates value of zero; N, element not detected; L, element present in amount less than lower limit of determination; G, element present in amount greater than upper limit of determination; valid, number of unqualified values. Minimum, maximum, mean, and standard deviation are for the unqualified data]

Element	Minimum deviation	Maximum deviation	Mean deviation	Standard deviation	Number of samples			
					N	L	G	Valid
Stream sediments								
ppm								
Ag	3	3	3.000	---	84	-	-	1
As	5	10	5.770	1.8800	31	41	-	13
Ba	150	700	409.000	128.0000	-	-	-	85
Bi	2	2	2.000	.0000	5	51	-	29
Cd	.2	9	.661	.9760	-	-	-	85
Co	5	30	9.480	4.3800	-	-	-	85
Cu	10	70	28.100	11.3000	-	-	-	85
Mo	5	7	5.500	1.0000	81	-	-	4
Ni	5	30	14.000	7.3700	-	-	-	85
Pb	15	300	75.800	48.3000	-	-	-	85
Sn	10	30	20.000	14 1000	83	-	-	2
Th	200	500	150.000	104.0000	57	13	-	15
Zn	40	190	95.400	29 5000	-	-	-	85
Nonmagnetic panned concentrates								
percent								
Fe	.1	3	.315	.389	-	2	-	76
Mg	.05	5	.332	.715	-	20	-	58
Ca	3	30	11.800	6.660	-	-	-	78
Ti	.1	2	1.130	.637	-	-	18	60
B	20	150	38.400	32 700	52	7	-	19
Ba	50	10,000	724.000	1,790.000	-	5	1	72
Be	2	15	2.610	2.260	32	13	-	33
Bi	50	200	100.000	86.600	75	-	-	3
Co	10	70	17.800	17.100	61	1	-	16
Cr	20	200	53.000	32.300	1	7	-	70
Cu	10	30	13.300	5.880	36	27	-	15
La	100	2,000	987.000	613.000	-	-	8	70
Mn	200	2,000	699.000	370.000	-	-	-	78
Mo	10	150	31.300	48.500	68	2	-	8
Nb	50	100	59.500	13.600	30	28	-	20
Ni	10	30	17.500	7.070	70	-	-	8
Pb	20	1,500	142.000	263.000	-	-	-	78
Sc	15	50	22.700	5.450	-	-	-	78
Sn	20	70	35.000	17.200	53	7	-	18
Sr	200	1,500	600.000	394.000	61	-	-	17
Th	200	2,000	532.000	497.000	27	7	-	44
V	20	200	38.600	41.500	18	11	-	49
W	100	200	125.000	50.000	71	3	-	4
Y	200	2,000	877.000	390.000	-	-	-	78
Sr	2,000	2,000	2,000.000	.000	-	-	76	2
Raw panned concentrates								
ppm								
Au	.0S	4.7	.820	1.420	67	1	-	10

Table 2.--Partial semiquantitative spectrographic analyses, fire assays, and atomic absorption analyses of selected samples from the Buffalo Peaks Wilderness Study Area, Colorado

[Source of data: USBM, U.S. Bureau of Mines; USGS U.S. Geological Survey, PID, released data from private industry; N.A., not analyzed, L, below limits of detection, -, not reported. Conversion factor 1 oz/ton = 34.3 g/t]

Locality No.	Source of data	Mine	Number of samples	Gold (oz/ton)	Gold (ppm)	Silver (oz/ton)	Silver (ppm)	Copper (ppm)	Lead (ppm)	Zinc (ppm)	eU_3O_8 (ppm)
Area A.	(Includes parts of the Weston Pass and Union Gulch districts)--Siver-bearing base-metal ores occur as bedding replacement and fissure vein deposits in chiefly the Leadville Limestone. Prior to 1916 the total Ag production is estimated at about 125,000 oz of which over half was from the Ruby-Cincinnati group of mines. Some veins were especially in Zn and Pb but the production figures for these metals are not known. There has been very little mining in these districts since 1918.										
2	USGS----	Ruby-Cincinnati group	2	-	L	-	5	300	5,000	7,000	N.A.
				-	L	-	50	300	70,000	30,000	N.A.
2	--do----	Collin-Campbell-------	1	-	L	-	15	100	15,000	15,000	N.A.
2, 3, 4, 5.	USBM----	Weston Pass mines-----	11 (average)	<0.005	-	<0.2-0.5	-	50	240	N.A.	N.A.
6, 7, 8	--do----	Union Gulch mines-----	22 (average)	<.005	-	<.2-.5	-	70	270	N.A.	N.A.
1	USGS----	Mines near Rich Creek Campground.	1	-	L	-	L	7	50	200	N.A.
1	USBM----	----do---------------	8 (average)	<.005	-	<.2	-	40	N.A.	N.A.	N.A.
Area B.	(Includes parts of the Granite--Two Bit districts)--Au placers were discovered in the vicinity of Granite in 1859 and the quartz-pyrite-gold veins on Yankee Blade Hill in the early 1860's. The total production value prior to 1878 has been variously estimated at about $750,000 (E. B. Eckel, unpub. data, 1932) to $2,000,000 (J. C. Hersey, written commun., 1982). Probably the best production figure ranges from 65,000 to 97,000 oz of Au. Most of the Au came from the mines on Yankee Blade Hill and from the mines north of Low Pass Gulch (Belle of Granite mine). Au production after 1880 was insignificant.										
11	USGS----	Two Bit mine dump-----	1	-	0.45	-	100	1,500	700	500	N.A.
12	--do----	Two Bit mine extension (trench).	1	-	.10	-	10	200	700	500	N.A.
11, 12	USBM----	Two Bit Gulch district mines.	11 (average)	<.005	-	<.2-.8	-	60	120	N.A.	N.A.
4	USGS----	Granite tunnel dump-	1	-	1.7	-	.15	200	200	L	N.A.
4	USBM----	----do---------------	14 (average)	<.005	-	<.2	-	50	150	40	N.A.
4	--do----	----do---------------	9 (average)	.201	-	.08	-	170	2,500	850	N.A.
3	PID-----	Diverse (4) mines of Yankee Blade Hill.	18 (average)	1.74	-	.8	-	280	590	560	N.A.
3	USBM----	Diverse mines of Yankee Blade Hill.	35 (average)	<.005-.254	-	<.2-1.3	-	100	160	N.A.	N.A.
3		Mine 114 (Wood)-------	1	.31	-	.4	-	N.A.	N.A.	N.A.	N.A.
6	USGS----	The Belle of Granite mine dump.	1	-	1.0	-	2.0	500	500	500	N.A.

7	--do----	Mine No. 4------------	1	-	.5	-	L	15	70	L	N.A.
5	USBM----	Free Gold, Yosemite, Hattie Jane.	33 (average)	<.005-10	-	<.2-.3	-	140	160	N.A.	N.A
8	--do----	Mines of Spring Creek	14 (average)	<.005-.5	-	<.2-.5	-	80	20	N.A.	N.A.
9	--do----	Mines of upper Low Pass Gulch.	5 (average)	<.005	-	<.2	-	80	100	N.A.	N.A.
10	--do----	----do----------------	1	<.005	-	<.2	-	100	100	N.A.	N.A.
				Mines in Tie Gulch							
1, 2	--do----	Unknown---------------	5 (average)	<.005-.016	-	<.2-.2	-	25	N.A.	N.A.	N.A.

Area C. (Includes parts of the Fourmile and Buffalo Peaks mining districts)--The quartz-pyrite-gold veins along Fourmile Creek and extending to the Arkansas River have been extensively explored but most deposits are small and have yielded only small amounts of Au. The Little Annie group of mines probably produced 53 oz of Au from 1935 through 1937 and 39 oz of Ag in 1940 (Vanderwilt, 1947, p. 45). The other mines in the district are relatively small, although there has been extensive exploration along the quartz veins of the Bonanza-Midway claims.

5, 6	--do----	Josephine mines-------	8	<.005	-	<.2-.2	-	80	N.A.	N.A.	1, 2, 6, 1, 3.
2	USGS----	Divines Gusto No. 1---	1	-	.25	-	L	L	L	L	N.A.
4	--do----	Little Annie mine-----	1	-	L	-	L	20	70	L	N.A.
4	USBM----	Little Annie mine group.	15	<.005-.396	-	<.2	-	30	N.A.	200	N.A.
1	USGS----	Bonanza-Midway claims	1	-	L	-	L	2	50	L	N.A.
1	USBM----	----do----------------	17	<.005-.058	-	<.2	-	45	N.A.	N.A.	N.A.

Area D. (Salt Creek area uranium)--Mineral occurrences within the Salt Creek area of the Fourmile and Buffalo Peaks mining districts. U was first discovered by J. Amrine in the mid-1950's at the Parkdale iron pit near the head of Middle Fork of Salt Creek. The U is in a vuggy jasperized ironstone and in jasperized breccias that probably formed by hot spring activity. As much as 52 tons of uraniferous jasperoid was shipped to a mill at Rifle, Colo. This ore shipment averaged in excess of 0.1 percent U_3O_8. No other work was done on the property until 1976 when J. V. Dodge of Canon City, Colo., acquired the property and began a detailed study of the prospect. As a result of this work (2,805 ft of rotary drill cuttings, geophysical studies, and an open pit) an estimated resource of 4,000 tons per vertical foot of U ore averaging 0.04-0.05 percent U_3O_8 was established in an area of 1,200 by 40 ft at the Parkdale iron pit. The thickness of this deposit is at least 3-4 ft as indicated by test pits and trenches.

1	USGS----	Parkdale Iron Pit-----	2	-	L	-	L	5	30	2,000	287, 288
				-	L	-	L	L	50	3,000	
1	USBM----	Parkdale iron pit and other prospects.	12	<.005	-	<.2-.3	-	55	135	1,300	135, 36, 241, 243.
4	--do----	Prospects of Middle Fork of Salt Creek.	7	<.005	-	<.2-.5	-	60	N.A.	N.A.	N.A.

and zinc (120-140 ppm). Panned concentrates from areas D and E and vicinity are high in boron (15-50 ppm) and manganese (1,000 ppm). Uranium is uniformly present in amounts less than the 75th percentile (<0.5 ppm) in stream-sediment samples from areas D and E, but water samples from area E are anomalous in uranium (1.5-6.8 micrograms per liter).

Two geochemical anomalies are present where there is little or no evidence of mining activity. Panned concentrates from area F (fig. 2), in the vicinity of the Laramide rhyolite stock between Rough and Tumbling and Willow Creeks, have anomalous amounts of barium (as much as 10,000 ppm) and lead (as much as 1,500 ppm). The panned concentrates are also anomalous in chromium (>70 ppm), iron (>0.5 percent), magnesium (>0.5 percent), molybdenum (>30 ppm), niobium (>50 ppm), tin (>30 ppm), strontium (>500 ppm), thorium (>700 ppm), titanium (>2 percent), and tungsten (>100 ppm). Stream-sediment samples from area F are anomalous in uranium (>21 ppm). In addition, stream-sediment samples from area F are high in arsenic (5 ppm), cadmium (0.68-0.92 ppm), manganese (1,500 ppm), nickel (20 ppm), and zinc (120-140 ppm); panned concentrates from area F are high in boron (15-50 ppm), calcium (15 percent), copper (10 ppm), and manganese (1,000 ppm). Water samples from some springs and streams around the stock are highly anomalous (Nowlan and others, in press). The waters contain concentrations of sulfate as high as 1,000 mg/l, copper as high as 14 μg/l, molybdenum as high as 15 μg/l, cobalt as high as 10 μg/l, and nickel as high as 1,500 μg/l.

The other geochemical anomaly in an area of little or no past or present mining activity is in Buffalo Meadows (fig. 2) where molybdenum (30-150 ppm) and tungsten (100 ppm) in panned concentrates are anomalous. The highest amount of gold in any sample from this study (4 7 ppm or about 0.13 oz/ton) was found in panned concentrate from Buffalo Meadows. This geochemical anomaly is near a north-northwest-striking fault in granite. Isolated anomalous values occur throughout the study area, but the coincidence of high gold, molybdenum, and tungsten in panned concentrates from Buffalo Meadows is probably the isolated anomaly of most consequence.

In the vicinities of areas D, E, and F (fig. 2) are several areas of anomalous barium (2,000-10,000 ppm) and lead (30-1,500 ppm) values in panned concentrates. The barium and lead anomalies occur along or near faulted outcrops of the Belden and Minturn Formations. The silver values are low, less than 1 ppm. No barite deposits were verified by geologic mapping.

GEOPHYSICS

A residual aeromagnetic map (Hedlund, in press) is derived from the U.S. Geological Survey aeromagnetic map (1982) that is published at a scale of 1:62,500. The survey was flown at an elevation of 1,000 ft above ground along northeast-southwest oriented flight lines spaced 0.5 mi apart.

The aeromagnetic map shows the magnetic expression of some of the major rock types in the study area. For example, an arcuate magnetic low of -103 to -253 gammas occurs over the migmatite in the Granite district and a similar magnetic low of +9 to -129 gammas occurs over the migmatite of the Goddard Ranch area. Low gamma values are also observed over the Paleozoic strata and Cenozoic valley-fill deposits. Strong positive anomalies of as much as +400 and +570 gammas occur over Precambrian dioritic intrusions and the magnetite-enriched parts of the Silver Plume granitic rocks at the higher elevations. The rhyolite stock near the mouth of Rough and Tumbling Creek has no magnetic expression. Sharply defined, closed, negative anomalies are locally paired with small positive anomalies over the basaltic andesite flows of West and East Buffalo Peaks. These dipoles probably indicate the presence of negatively polarized flows in this area.

The aeromagnetic survey did not indicate the presence of any hidden mineralized areas. Many of the magnetic anomalies were checked on the ground with a Scintrex SM-5[1] magnetometer, but the ground survey failed to reveal any correlation with alteration zones or igneous plutons of possible Laramide age.

MINING DISTRICTS AND MINERALIZED AREAS

Six areas having mineral resource potential (A-F) have been delineated in the Buffalo Peaks Wilderness Study Area (fig. 2) These areas do not necessarily correspond to specific mining districts but do encompass areas of similar mineralization. The study area is within, or adjacent to parts of the following mining districts: Weston Pass, Granite, Buffalo Peaks, Fourmile, Two Bit, and Union Gulch (Henderson, 1926). There are no active mines within the study area, but about 2,000 acres of the Buffalo Peaks Wilderness Study Area are covered by mining claims on file with the U S. Bureau of Land Management (Wood, 1983). Table 3 summarizes information about mines and prospects in the study area. The various mineral resources within the described areas are discussed in order from A to F and not necessarily in order of decreasing mineral potential.

Weston Pass-Union Gulch districts (includes area A)

The silver-bearing base-metal veins of this area (fig. 2) are along the Weston fault zone that extends southeast along the South Fork of the South Platte River at the northeast margin of the study area. This fault zone, of probable Laramide and Pliocene-Miocene age, includes the Weston-Buffalo Creek faults, numerous branches of the Weston fault, and an older east-northeast-trending fault system. Area A extends southeast to workings about 0.5 mi south of Rich Creek Campground.

The Weston Pass-Union Gulch districts were active from 1890 to 1902 with a brief period of renewed mining during World War I. It is estimated that the past production value of $125,000 for the Weston Pass district is equivalent to about 125,000 oz of silver; the value of the base metals is not known. The Ruby-Cincinnati Group of mines was the leading producer (about 30,000 oz of silver) followed by the Gates, Collin Campbell, and Payrock mines. Most of the production came from oxidized ore bodies in the

[1]The use of trade names is for descriptive purposes only and does not constitute endorsement by the U.S. Geological Survey

zone of supergene enrichment, generally at depths of less than 300 ft (Behre, 1932). Cerussite, anglesite, smithsonite, and hemimorphite were common minerals in this oxidized zone that also contained cerargyrite and native silver(?). The enriched silver ores from the Ruby-Cincinnati mine averaged about 15 oz of silver per ton, but some rich pockets at the Payrock mine contained as much as 35 oz of silver per ton (Behre, 1932). Many of the enriched supergene ore bodies have been exhausted, most mines are now caved or flooded, and the protores have only 0.1-0.5 oz of silver per ton.

The ore minerals occur as disseminations, vug fillings, and bedded replacement bodies within brown, silicified fault breccias chiefly within the Leadville Limestone but also in the Manitou Dolomite. Most faults strike N. 30°-40° W. and dip 20°-55° NE; underground, overturning of the beds and thrust faulting was observed by Behre (1932, p. 62). Some of the silicified shatter zones are as much as 8 ft wide. The hypogene ore minerals included sphalerite, argentiferous galena, traces of chalcopyrite, and probably arsenpolybasite. Ores from the Ruby Tunnel contain as much as 1,500 ppm arsenic that is concentrated in a silver-bearing sulfosalt, such as the pearceite-polybasite group. Some of the sphalerite-rich ores contain as much as 70 ppm cadmium.

In summary, the northwest-striking faults of the Weston fault system are favorable sites for further exploration, especially where they intersect older northeast-striking faults and carbonate strata.

Granite-Two Bit districts (includes area B)

The mines within area B were among the earliest producers of gold in Colorado. Placer gold was discovered near Granite in 1859 and the vein deposits on Yankee Blade Hill were exploited in the early 1860's. Most of the lode mines were developed to depths of 100-380 ft in the oxidized parts of the vein systems, and the veins were worked almost continuously from about 1862 to about 1878. Thereafter, the rich lead and silver discoveries at Leadville drew most of the mining activity away from Granite. In 1908, the Granite Tunnel Company was organized and work began on a tunnel driven south from Low Pass Gulch in order to develop the veins of Yankee Blade Hill to a greater depth. The veins persisted to depths of 500-800 ft below ground level, and as many as 19 veins were cut by the adit over a distance of 2,054 ft (J. C. Hersey, written commun., 1982). Numerous samples taken during this exploratory work indicated an average gold content of about 2 oz/ton, but some ore shoots averaged a much higher grade.

The total past production figures are largely estimates and range from about 65,000 to 97,000 oz of gold. Most of this production came from Yankee Blade Hill and from the Belle of the Granite mines between 1862 and 1878. The following table shows a breakdown of the production figures for the principal mines in the Granite district.

The quartz-pyrite-gold veins are steeply dipping and strike predominantly N. 70°-80° E. within the Precambrian migmatite. The veins are slightly discordant to the foliation in the migmatite and occur in swarms on Yankee Blade Hill and there are as many as 19 veins in a 2,054-ft interval. Some veins are as much as 3,000 ft long, 1-3 ft wide, but show numerous pinch-outs along the strike. A few veins extend eastward into the study area but most are outside, within 1 mi of the boundary. The gneissic and migmatized wall-rocks are commonly silicified adjacent to the veins but the outer envelope is commonly altered to chlorite and sericite. The veins have a relatively simple mineralogy and have appreciable amounts of pyrite but minor amounts of galena (lead, about 900 ppm), sphalerite (zinc, about 650 ppm), and chalcopyrite (copper, about 280 ppm). The gold to silver ratio is about 2.5:1 and the silver values range from about 0.7 oz/ton to about 0.64 oz/ton. The gold values are highly variable and range from 0.005 to 10 oz/ton; most veins from Yankee Blade Hill average about 1.7 oz/ton. Boron geochemical anomalies (50-200 ppm) are associated with many of the veins and indicate the presence of tourmaline in many of the deposits.

Mine	Estimated ounces (troy) of gold produced
Yankee Blade	23,000
The Belle of Granite	24,000
Magenta	9,600
Robert George	4,800
New Year	3,800
Bunker Hill	3,300
Washington	2,800
D.C.C.	1,200
Gopher	960
California	380
Yosemite-Keystone	350
B and B	400
Hattie Jane	46
Total	64,635

The quartz-pyrite-gold veins are probably related to the intrusion of east-northeast-striking rhyolite dikes during the Laramide orogeny (potassium-argon age of dikes is 65.3±2.4 m.y., R. F. Marvin and others, written commun., 1983). At the Yosemite-Keystone mine, a rhyolite dike locally forms the south footwall of the vein, and about 2,200 ft south of the Belle of Granite mine a rhyolite dike contains partially oxidized pyrite cubes a few millimeters across. In the vicinity of the silver-bearing veins at the Two Bit mine, a thin rhyolite dike is sheared along a vein, thus suggesting some postdike mineralization.

In summary, the quartz-pyrite-gold veins of the Granite district, which is adjacent to the study area, are characterized by intensive silicic and chloritic wallrock alteration, the presence of anomalous boron, a relatively low base-metal content, a gold to silver ratio of 2.5:1, and a spatial association with rhyolite dikes. The gold content of the veins varies from 0.005 to about 2 oz/ton, whereas the silver values range from about 0.07 to about 0.64 oz/ton. The quartz-pyrite-gold veins crop out mainly within migmatitic gneiss in the Granite district, chiefly outside of the study area.

Table 3.--Mineral deposits and mineral occurrences of the Buffalo Peaks Wilderness Study Area, Colorado

[Prospect or mine number corresponds with locality shown on map. All prospects and mines within the study area were inactive at the time of fieldwork in 1981 and 1982. Au, gold, Ag, silver, Cu, copper, Pb, lead, Zn, zinc, U, uranium. Conversion factor. 1 oz/ton = 34.3 g/t]

Prospect No.	Name	Commodity	Development	Geology	Production	Reference
Area A.	(Includes parts of the Weston Pass and Union Gulch districts)--Silver-bearing base metal ores occur as bedding replacement and fissure vein deposits in chiefly the Leadville Limestone Prior to 1916 the total silver production is estimated at about 125,000 oz of which over half was from the Ruby-Cincinnati group of mines. Some veins were especially rich in Zn and Pb but the production figures for these metals are not known. There has been very little mining in these districts since 1918.					
1	Mines near Rich Creek Campground	Ag, Zn--	Several shafts and numerous prospect pits.	Highly jasperized fault breccias that strike N. 60°-65° E. are displaced by a series of small N. 50° W.-striking fractures and faults. The northwest fractures are weakly mineralized and contain as much as 200 ppm Zn.	Unknown-----------------------------	None.
2	Ruby-Cincinnati group	Ag, Zn Pb.	Incline, shafts, and numerous prospect pits. Over 1,400 ft of workings.	Ore in discontinuous masses in vuggy, jasperized zones within limestone beds. Ores localized along northwest-trending Weston fault zone.	Oxidized ore in zone of supergene enrichment yielded about 3,000 tons of ore. Grade varied from 0 2 to 15 oz of Ag per ton. Production was valued at about $100,000.	Behre (1932, p. 69-70, 73); Chapman and Stephens ([illegible], p. 207).
2	Collin-Campbell mine.	--do----	Shaft about 300 ft deep.	Ore bodies in silicified breccia zones within limestone.	Three to four carloads of ore valued at about $20,000.	Behre (1932, p. 70, 73).
3	Mines of the Gates claim.	--do----	Shafts and prospects----	Oxidized sphalerite, galena, and silver sulphoarsenides along northwest-striking fissure veins. Some ore bodies enriched with sphalerite.	Probably small----------------------	Behre (1932, p. 71, 73).
4	Payrock group of mines.	--do----	Several small shafts and tunnels.	Ag-bearing base-metal sulfides along N. 30°-35° W.-striking fault.	Unknown, probably small------------	Behre (1932, p. 71).
5	Unknown-----------	--do----	Several prospect pits.	Small gossan and jasperized vein----------------	Insignificant.	
6	----do-----------	--do----	Two adits trend N. 80° E. into Weston fault.	Small amounts of pyrite in Belden shales---------	Unknown-----------------------------	None.
7	----do-----------	--do----	Trench and fault------	Sparse amounts of sulfides along N. 20° E.-striking fault breccia. Small silicified gossan zone.	----do-----------------------------	Do.
8	----do-----------	--do----	Caved adit trends S. 60° E.	Sparse amounts of sulfides along northeast striking fault.	----do-----------------------------	Do.
Area B.	(Includes parts of the Granite and Two Bit districts)--Au placers were discovered in the vicinity of Granite in 1859 and the quartz-pyrite-gold veins on Yankee Blade Hill in the early 1860's. The total production value prior to 1878 has been variously estimated at about $750,000 (E B. Eckel, unpub. data, 1932) to $2,000,000 (J. C Hersey, written commun., 1982). Probably the best production figure ranges from 65,000 to 97,000 oz of Au. Most of the Au came from the mines on Yankee Blade Hill and from the mines north of Low Pass Gulch (Belle of Granite mine). Au production after 1880 was insignificant.					
1	B and B mine-------	Au, Ag--	Two inclined shafts-----	Quartz-pyrite-Au vein within granite apophysis in migmatite. Vein strikes east-northeast and can be traced for about 700 ft	Past Au production small, about 400 oz.	E. B Eckel (unpub. data, 1932).
2	Unknown-----------	--do----	Shaft and series of four shallow pits aline N. 70° E.	Quartz-pyrite-Au vein near intersection with N. 20° W.-striking fault.	Probably negligible----------------	Do.

3	Yankee Blade group, including the Yankee Blade, Magenta, Robert George, New Year, Washington, Gopher, California and other smaller mines.	--do----	Numerous shafts, tunnels, adits, and prospects many of which are caved. At least eight mines have had production.	A closely spaced series of about 18 quartz-pyrite-Au-tourmaline veins that strike east-northeast. Intense silicification and chloritization of the wallrocks, chiefly migmatite. Appreciable supergene enrichment of the Au. Minor amounts of chalcopyrite, galena, and sphalerite	Estimated Au production is as follows Yankee Blade (23,000 oz), Magenta (9,600 oz), Robert George (4,800 oz), New Year (3,800 oz), Bunker (3,300 oz), Washington (2,800 oz, Gopher (960 oz), and California (380 oz).	E. B. Eckel (unpub data, 1932), J C. Hersey, (unpub data, 1982).
4	Granite tunnel----	--do----	Tunnel trends S. 55° E. and is about 2,054 ft long.	Tunnel intersects as many as 18 veins on Yankee Blade Hill. Native Au occurs in vuggy quartz veins in association with minor sphalerite, galena, and chalcopyrite. Pyrite is relatively common. Many east-northeast-striking veins persist over a length of about 2,000 ft but show branching and pinch-outs along strike	Tunnel was driven to drain and consolidate the old shallow mines on Yankee Blade Hill and to explore various veins and ore shoots below the old mines at a depth of 500-800 ft. The Granite Tunnel Company was organized in 1908.	Do.
5	Yosemite-Keystone, Hattie Jane, and Free Gold mines	--do----	Yosemite (two caved adits and small prospect pits), Hattie Jane (several small pits and a 36-ft shaft), Free Gold (adit about 400 ft long.	Quartz-pyrite-Au veins along east-northeast-striking fissure veins in migmatite. Abundant limonite along some of the veins.	Yosemite mine has produced about 530 oz of Au in the 1930's The Hattie about 46 oz of Au and 8 oz of Ag Production from the Free Gold mine is unknown but probably small.	E B. Eckel (unpub. data, 1932)
6	The Belle of Granite.	--do----	Developed by 450-ft-deep shaft with six levels and over 3,000 ft of workings.	Quartz-pyrite-Au vein 16 in to 5 ft wide strikes east-northeast in migmatite Abundant pyrite but minor amounts of sphalerite and galena Vein is about 1,000 ft long	Production prior to 1912 was about 24,000 oz of Au valued at $500,000	E B Eckel (unpub. data, 1932), J C Hersey, (unpub data, 1982)
7	"Mine No. 4"------	--do----	Shaft----------------	Quartz-pyrite-Au vein strikes east-northeast within migmatite. Small gossan has yielded about 0 015 oz of Au per ton	Unknown----------------------------	None
8	Mines of Spring Creek.	--do----	Numerous prospect pits and small adits.	Quartz-pyrite-Au veins that strike east-northeast.	----do-----------------------------	Do
[1]9	Unknown, mines of upper Low Pass Gulch.	--do----	Small adits and prospect pits	Quartz-pyrite-Au vein strikes N. 40° W in granite. Minor sphalerite and galena	Unknown----------------------------	Do
[1]10	Unknown, mines of Low Pass Gulch.	--do----	Trench and prospect pits.	Reddened quartz vein in granite is only a few inches thick Vein strikes N 20° W. and is about 15-20 ft long. Radioactivity is about two times background. Some smoky quartz	No production----------------------	Do
11	Two Bit mine------	Ag, Au--	Shaft-----------------	Ag-bearing base-metal vein strikes N. 75° E. Minor amounts of chalcopyrite, galena, and sphalerite in dump. Chloritized granite wallrock. The presence of 300 ppm antimony in analyzed samples suggests the presence of Ag sulfosulfosalts. As much as 100 ppm Ag in some vein material.	Unknown----------------------------	Do
12	Two Bit extension.	--do----	Trench and caved incline.	Abundant manganese oxides along quartz vein in granite. Vein strikes N. 65° E. and locally follows faulted rhyolite dike. Traces of sphalerite and chrysocolla.	----do-----------------------------	Do
				Mines in Tie Gulch		
1	Unknown------------	Au, Ag--	Two shafts and adit-----	Limonite-stained quartz veins along northwest-striking fault. Trace of Au and Sg.	----do-----------------------------	Do
2	----do------------	--do----	Shaft and adit----------	----do--	----do-----------------------------	Do.

Table 3.--Mineral deposits and mineral occurrences of the Buffalo Peaks Wilderness Study Area, Colorado--Continued

Prospect No.	Name	Commodity	Development	Geology	Production	References
Area C	(Includes parts of the Fourmile and Buffalo Peaks mining districts)--The quartz-pyrite-Au veins along Fourmile Creek and extending to the Arkansas River have been extensively explored but most deposits are small and have yielded only small amounts of Au. The Little Annie group of mines probably produced 53 oz of Au from 1935 through 1937 and 39 oz of Ag in 1940 (Vanderwilt, 1947, p. 45). The other mines in the district are relatively small, although there has been extensive exploration along the quartz veins of the Bonanza-Midway claims.					
1	Bonanza-Midway claims	Au-----	Numerous shafts and prospect pits.	Several quartz veins that strike northwest are persistent over a length of about 3,000 ft. Veins are as much as 3 ft thick and dip steeply to the southwest. Some veins are highly brecciated with hematitic alteration.	Unknown------------------------------	Do.
2	Divines Gust[illegible] No. 1	--do----	Small incline trending N 40° W.	Small gossan in migmatite within granite, altered zone is about 3 ft wide, strikes N. 70° E. and dips 25°-30° N.	----do------------------------------	Do.
3	Unknown-----------	--do----	Two prospect pits------	Quartz-pyrite-Au vein strikes northwest in chloritized granite. Quartz vein poorly exposed.	----do------------------------------	Do.
4	Little Annie mine group	Au, Ag, Cu, Pb, Zn	Two caved adits and numerous prospect pits	Quartz-pyrite-Au veins in granite strike northwest. Sparse amounts of magnetite, barite, amethyst quartz, and manganese oxide gangue.	Production small, about 53 oz of Au between 1935 and 1937 and 39 oz of Ag in 1940.	Vanderwilt (1947, p 45)
5	Josephine mine----	U, Au---	Shaft, tunnel about 305 ft long, and numerous prospect pits, mines caved during construction of Otero pumping station	Quartz pyrite vein strikes west-northwest and is about 800 ft long Slightly radioactive, about twice background. Samples show 1-5 ppm U_3O_8 (table 2).	Unknown-------- -- ---- --- -- -	Nelson-Moore and others (1978)
6	----do----- -- ---	U-------	Shafts, opencuts, trenches	Peridotite porphyry dikes at contact with granite are radioactive. Dikes strike N 20° W. and locally contain abundant granite xenoliths.	----do------ -------------- --- -	None
7	Unknown (Frost Mining Co claims)	Au------	Over 850 ft of trenching and a 125-ft adit	Small northwest-trending shear in diorite stock. No visible Au. Probable source for Au placer operation at mouth of Buffalo Creek. This placer claim (Amanda Ann) covers 13 8 acres	----do--------------------------	Do.
Area D	(Salt Creek area uranium[1])--Mineral occurrences within the Salt Creek area of the Fourmile and Buffalo Peaks mining districts U was first discovered by [illegible] Aamire in the mid-1950' at the Parkdale iron pit near the head of Middle Fork of Salt Creek The U is in a vuggy jasperized ironstone and in jasperized breccias tha probably formed by hot spring activity. As much as 52 tons of uraniferous jasperoid was shipped to a mill at Rifle, Colo This ore shipment averaged in excess of 0 1 percent U_3O_8. No other work was done on the property until 1976 when J. V Dodge of Canon City, Colo , acquired the property and began a detailed study of the prospect As a result of this work (2,805 ft of rotary drill cuttings, geophysical studies, and an open pit) an estimated resource of 4,000 tons per vertical foot of U ore averaging 0 04-0 05 percent U_3O_8 was established in an area of 1,200 by 40 ft at the Parkdale iron pit. The thickness of this deposit is at least 3-4 ft as indicated by test pits and trenches.					
1	Parkdale iron pit of the Bronco claims	U, Zn---	Open pit, trenches and numerous prospect pits.	Vuggy jasperoid with opaline-quartz vug linings Various samples have assayed 243, 400, 241, 287, 135, 80, and 36 ppm U_3O_8 and 0.2, 0.3 and 0.13 percent Zn. The thorium content is only 13 ppm. The extent of the mineralized ground is only tentative owing to the soil cover.	About 52 tons of uranium ore---- --	C. M Armstrong (unpub data, 1977), Jack DiMarchi and Edward Duke (unpub data, 1979)
2	COMINCO property---	U, Pb, Zn.	Two trenches and numerous prospect pits	Vuggy jasperoid developed in the Manitou Dolomite No appreciable radioactivity but nearby granite has 80 ppm equivalent U and is more radioactive than the jasperoids.	No production-----------------------	None
3	Unknown-----------	Ag, Zn Pb.	Dozer cut, shaft and prospect pit.	Gossan along northeast-striking fault Cherty dolomite of the Manitou is slightly pyritized and altered.	Negligible-------------------------	Do.
4	----do-------------	Ag------	Trench, shafts, and numerous prospect pits.	Slightly mineralized northwest-striking fault within the Belden Formation. A few analyses indicate a maximum of about 0.5 oz of Ag per ton.	----do---------------------------- -	Do

[1]Occurrence inside the wilderness.

Fourmile-Buffalo Peaks districts (includes area C)

The quartz-pyrite-gold veins of this area are localized along north-northwest-striking faults that extend from Marmot Peak westward to the Arkansas River and northward to Buffalo Creek; the southern limit is not shown (fig. 2). Most of these veins extend less than 2 mi outside of the study area.

Production records are mainly from Vanderwilt (1947, p. 45). Because the largest mine in the Fourmile district is the Little Annie, and most prospects are small, it is inferred that the production figures cited by Vanderwilt are for the Little Annie mine. The Little Annie mine operated from 1935 through 1937 and produced about 78 tons of ore yielding 53.5 oz of gold. In 1940, the operation was renewed but the production figures are unknown.

The quartz-pyrite-gold fissure veins at the Little Annie mine and at mines about 1.5 mi southeast strike N. 40°-50° W., dip steeply to the southwest, and are persistent over a length of about 2,000 ft. The quartz veins are branched, show abrupt pinch-outs, are generally less than 2 ft thick and locally are brecciated and have hematitic alteration. Pyrite cubes as much as 0.4 in. across are locally common, but specularite, galena, sphalerite, and chalcopyrite are present in only sparse amounts. Fire assays for gold from the dump material at these caved mines indicate gold values of 0.04-0.07 oz/ton; silver values are generally less than 0.2 oz/ton.

Other metal occurrences near the study area include: (1) Divines Gusto No. 1 mine in the SW1/4 sec. 7, T. 13 S., R. 78 W.—a gossanized quartz-pyrite-gold vein that strikes N. 70° E. in a migmatite lens within granite. The vein is about 35 ft long and 3 ft wide and contains about 0.25 ppm gold. (2) A series of trenches and an adit explore a N. 40° W.-striking quartz vein in a diorite plug along Buffalo Creek. Samples from this vein contained as much as 0.07 oz gold per ton, 0.2 oz silver per ton, and 0.2 percent copper. (3) Josephine mine group—A slightly uraniferous (1, 2, and 6 ppm equivalent U_3O_8) quartz-pyrite vein strikes N. 60° W. for 150 ft near the Otero pumping station. The vein is most radioactive at the intersection with hornblende schist xenoliths in granite. Fire assays indicate less than 0.05 oz of gold per ton by fire assay and less than 0.2 oz of silver per ton in vein samples. Other uranium-bearing quartz-gold veins in this area have been reported by Nelson-Moore and others (1978, p. 364-365). Extensive prospecting along the peridotite porphyry dikes a few feet north of the Otero pumping station road was for an unidentified mineral occurrence, probably uranium or elements of the platinoid group. Some of the dikes are slightly radioactive, especially along the contact with granite, but the dikes do not constitute a uranium resource. (4) Veins along Tie Gulch—chiefly hematite stained quartz veins just to the north of area C (fig. 2) that strike northwest, cut Precambrian granite, and are contiguous with large displacement faults of the Rio Grande-Arkansas Valley rift system. Fire assays of the vein indicate 0.005 oz of gold per ton and 0.2 oz of silver per ton.

Unlike the gold veins of the Granite district, the veins along Fourmile Creek and Tie Gulch lack anomalous concentrations of boron, strike north-northwest within the granitic rocks, contain fewer base metals, commonly contain magnetite and specularite, show high concentrations of bismuth, molybdenum, and tin and are not associated with rhyolite dikes. Most of the veins are outside the study area and generally have low gold values, 0.04-0.07 oz/ton.

Salt Creek area of the Fourmile-Buffalo Peaks districts (includes area D)

The vuggy, uraniferous jasperoid deposits at the Parkdale iron pit are along the study area boundary at the head of the Middle Fork of Salt Creek. This deposit was discovered by J. L. Amrine in the mid-1950's; shortly thereafter, about 52 tons of uraniferous jasperoid averaging 0.12 percent U_3O_8 and 0.20 percent V_2O_5 were shipped to the mill at Rifle, Colo. (Nelson-Moore and others, 1978, p. 365). The property remained idle until about 1976 when J. V. Dodge staked numerous claims that encompass much of the uraniferous jasperoid outcrops. A subsequent evaluation of the property indicated a reserve of about 4,000 tons of uraniferous jasperoid per vertical foot averaging 0.04 percent U_3O_8 within an area of 1,200 by 40 ft (C. M. Armstrong, written commun., 1977, 1978). Only about 3-4 ft of jasperoid is exposed in the Parkdale iron pit and in nearby trenches, but according to J. V. Dodge (oral commun., 1982) a drilling program conducted by Noranda Exploration, Inc., indicated that the uraniferous jasperoid is as much as 45 ft thick at the Parkdale iron pit.

At least 12 radioactive anomalies are known within or near the top of the Cambrian Sawatch Quartzite that forms a N. 40° W.-striking ridge in the district. The anomaly associated with the vuggy jasperoid at the Parkdale iron pit is as much as 40 times background. No uranium mineral was identified in this study; fission-track maps show that uranium is dispersed as an amorphous colloid through the ferruginous jasper. Opaline-quartz vug linings fluoresce yellowish green under ultraviolet light but do not contain significant amounts of uranium as compared with the jasperoid. Some vugs are also filled with manganosiderite but this carbonate is not radioactive, and like the opal, represents a later vug filling. Analyses of the radioactive jasperoid for uranium indicate the following values of equivalent U_3O_8 in parts per million: 36, 135, 241, and 243. A gamma-ray analysis of the most radioactive sample indicates equivalent uranium values of 287 and 288 ppm ±10 ppm and ^{232}Th values of less than 10 ppm (C. A. Bush, written commun., 1983). Fission-track map studies of the jasperoid indicate only 80 ppm uranium in some samples, and the uranium particles are extremely small, that is, micron size (R. A. Zielinski, oral commun., 1983). Semiquantitative spectrographic analyses of the uraniferous jasperoid indicate the presence of at least 20 percent iron, although C. M. Armstrong (written commun., 1977, 1978) has reported as much as 40 percent iron in some samples. The 12 fire assay analyses for gold and silver indicate less than 0.005 oz of gold per ton, and most silver values range from 0.2 to 0.3 oz of silver per ton. Other element concentrations in the radioactive jasperoid are: 5,000 ppm manganese, 150 ppm vanadium, 2,000-3,000 ppm zinc, 30-50 ppm lead, 5-55 ppm copper, 30-50 ppm nickel, and 30-50 ppm cobalt. A separate radiometric analysis indicates only 10-13 ppm thorium.

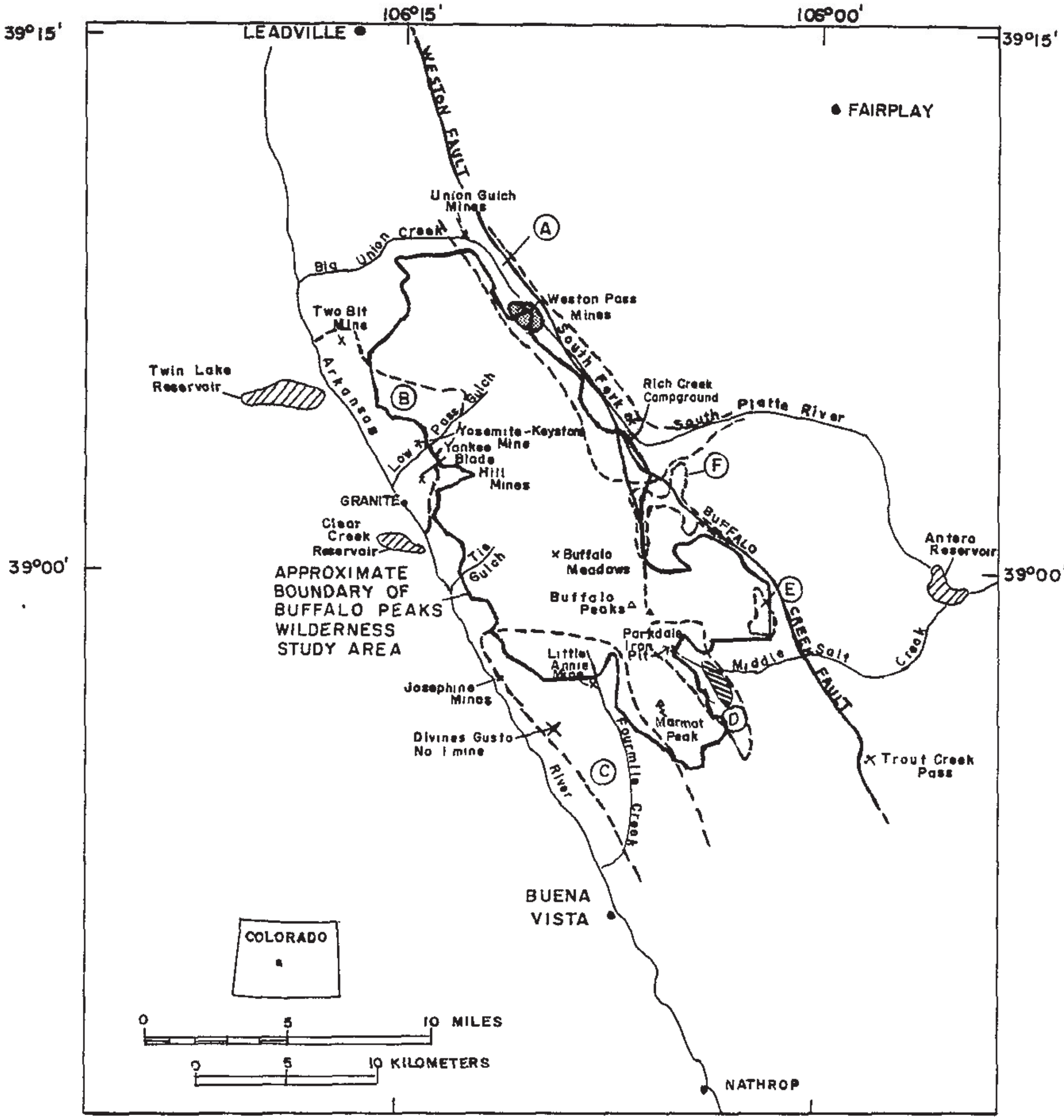

Figure 2.--Map showing areas having mineral resource potential in the Buffalo Peaks Wilderness Study Area, Colo.

EXPLANATION FOR FIGURE 2


AREA A--Moderate resource potential for silver in base-metal deposits; includes small area of high resource potential at Weston Pass indicated by stipple pattern


AREA B--Low to moderate resource potential for gold and silver in vein deposits


AREA C--Low to moderate resource potential for gold and silver in vein deposits and low resource potential for uranium in veins


AREA D--Low to moderate resource potential for uranium including a small low-grade uranium identified resource area around the Parkdale iron pit. Low to moderate resource potential for barite and lead in vein deposits. A small area along the northeast side of the Middle Fork of Salt Creek has low to moderate resource potential for silver in vein deposits; indicated by diagonal line pattern


AREAS E AND F--Low resource potential for barite and lead in vein deposits as defined by geochemical studies

Not all the jasperoids are radioactive and just south of the Parkdale iron pit a north-striking fracture zone of silicified, nonradioactive breccia forms a linear jaspery ridge that merges with the bedding replacement type of jasperoid at the pit. Trenches near the Parkdale pit are in a poorly exposed white, altered, biotite tuff of probable Oligocene age that possibly filled a paleovalley (Scott, 1975). The tuff is nonradioactive and has a very limited outcrop in the vicinity of the jasperoids.

Several hypotheses have been proposed for the origin of the uraniferous jasperoids: (1) the downward migration of acidic, meteoric waters have leached uranium from tuff during post-Oligocene time and have redeposited the uranium at the contact with the silica-rich Sawatch Quartzite, and (2) acidic hydrothermal fluids have leached uranium from the underlying fractured biotite granite (equivalent U_3O_8 = 80 ppm) and redeposited silica and uranium as a ferruginous gel at relatively low temperatures. The change of pH to alkaline conditions at the contact with the overlying Manitou Dolomite may have promoted precipitation of the uranium. Of the two hypotheses the hydrothermal source seems most probable since the fault-controlled jasperoids contain anomalous amounts of base metals, especially zinc, and the underlying Precambrian granite is anomalously radioactive.

In summary, the vuggy uraniferous jasperoids of the Parkdale iron pit straddle the study area boundary. At least 11 other smaller radioactive uranium-bearing jasperoids occur in the Sawatch Quartzite of area D (fig. 2) but the deposits lack continuity. The jasperoids contain less than 0.005 oz of gold per ton and the silver values range from less than 0.2 to 0.3 oz/ton. The deposits are not considered potential resources for iron ore because of their small size, although some jasperoids have as much as 40 percent iron, which would be a suitable grade for a taconite deposit if the deposits were closer to a processing facility.

The numerous small prospects along the east side of the Middle Fork of Salt Creek (area D, locality 4) have been extensively sampled by Wood (1983). These fault controlled deposits have negligible gold (0.005 oz/ton) but do contain minor amounts of silver (0.2-0.5 oz/ton).

A geochemical survey near the head of the North Fork of Salt Creek has indicated relatively high barium (5,000-10,000 ppm) and lead (30 to 1,500 ppm) anomalies in panned concentrates. These anomalies appear to be close to the northwest-striking fault that extends through locality 4.

Areas E and F

A geochemical survey (Nowlan and Gerstel, in press) has delineated two areas (E and F) of anomalous barium and lead values in stream-panned concentrates. The source areas of barite and galena were not discovered during this study.

Area E (fig. 2), in the vicinity of Spring Creek, yielded barium values of 2,000 and 10,000 ppm in analyzed stream-panned concentrates (Nowlan and Gerstel, in press). Other metals detected are 30 ppm lead, 10 ppm copper, and generally less than 500 ppm zinc.

Area F is elongate along the projection of the Buffalo Creek fault and also curves around the south edge of the rhyolite stock of Rough and Tumbling Creek (fig. 2). High barium values (3,000 to 10,000 ppm) are obtained from stream-panned concentrates along Willow Creek, about 2,000-3,000 ft east of the stock (Nowlan and Gerstel, in press). Some of these concentrates are also high in lead (70-1,500 ppm), and pyrite is observed in some samples. This area may be coextensive with area A and may represent an epithermal type mineralization that is synchronous with the ore deposition in the Weston Pass district to the northwest.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

A moderate resource potential was assigned to areas that met the following criteria (a low potential was assigned those areas that met only some of the criteria):

1. A favorable geologic environment such as the presence of numerous faults in a favorable host rock and the presence of Laramide and (or) Tertiary plutons.
2. Evidence of mineralization in adjacent areas along similar structural trends and favorable host rocks.
3. Anomalous metal values in rock and vein samples and in stream-sediment concentrates as determined from a geochemical study.
4. Aeromagnetic anomalies, such as extreme high and low gamma values in areas of broad magnetic gradients, may indicate the presence of hidden ore bodies.
5. Alteration halos related to hydrothermal fluids, for example, the chloritization of migmatite in the Granite district, the formation of vuggy jasperoids in the Salt Creek area. The dolomitization of Leadville Limestone to form "zebra-striped" rock in the Weston Pass-Union Gulch districts was probably important for favoring increased porosity and providing sites for later ore deposition.
6. The mineralized rock in and near the study area is of sufficient volume, grade, and accessibility so as to indicate a potential for the occurrence of resources.

These criteria are briefly discussed for the six mineralized areas, A through F.

There are no active mines within the study area, but about 2,000 acres of the Buffalo Peaks Wilderness Study Area are covered by mining claims (Wood, 1983). The various mineral resources within the described areas A-F are chiefly along the periphery of the study area and are discussed in order of decreasing resource potential. There is little or no indication for oil or gas or geothermal energy resources in the study area.

The six mineralized areas are:

Area A: This area is rated as having a moderate potential for silver resources in base-metal-bearing fissure veins and bedded replacement deposits. A very small part of this area at Weston Pass has a high resource potential because silver-bearing veins at the Gates mine extend into the study area. This assessment is based on the large number of faults that displace favorable carbonate strata in the vicinity of known fault-controlled silver-bearing base-metal deposits. The extension of the Weston Pass mineral deposits to the northwest and southeast seems likely, and the intersection of the Weston fault zone with older northeast-striking faults would provide favorable structures for such deposits. Moreover, the presence of numerous silicified shatter zones and the favorable porosity provided by the dolomitized "zebra-striped" Leadville Limestone indicate possible sites for ore deposition.

Area B: This area has a low to moderate resource potential for gold and silver in vein deposits, but an extension of the precious-metal veins into the study area appears speculative.

Area C: The area has a low to moderate potential for gold and silver resources in veins. Most veins are outside of the study area, and the veins that are within the boundary are of low grade, that is, 0.04 oz of gold per ton and less than 0.02 oz of silver per ton.

Areas E and F: A geochemical survey has delineated several areas of anomalous barium and lead values in panned-stream concentrates. The sources of the probable barite-galena deposits were not discovered during this study, and therefore these areas have a low to moderate potential for the occurrence of barite and lead resources.

Area D: The uraniferous jasperoids of the Middle Fork of Salt Creek can be classified as an identified resource of low-grade uranium in the Parkdale iron pit area and the area has a low to moderate potential for additional uranium resources. The uraniferous jasperoids of the Bronco-Lady Elk claims have been thoroughly studied (J. V. Dodge, written commun., 1982) and a geologically inferred resource of about 4,000 tons per vertical foot of uraniferous jasperoid averaging 0.04 percent U_3O_8 and 0.20 percent V_2O_5 is suggested for an area of about 1,200 by 40 ft. The low-grade and the absence of precious metals make the uraniferous jasperoids at the Parkdale iron pit a low-grade uranium resource. The area of low-grade silver-bearing veins along the east side of the Middle Fork of Salt Creek (locality 4, tables 1 and 2) has a low to moderate resource potential for silver. The anomalous barium and lead values from panned concentrates at the head of the North Fork of Salt Creek suggest the presence of concealed barite-galena veins. On the basis of geochemical data, the resource potential for barite and lead in veins and bedded replacement deposits is low to moderate. Some of the jasperoid has as much as 40 percent iron, which would be a suitable grade for a taconite deposit if it was closer to a processing facility or if larger volumes of jasperoid were present.

REFERENCES

Behre, C. H., Jr., 1932, The Weston Pass mining district, Lake and Park Counties, Colorado: Colorado Scientific Society Procedures, v. 13, no. 3, p. 53-75.

Chapman, E. P., Jr., and Stephens, F. M., 1929, The Leadville district and adjoining territory: Colorado Mineral Survey Report, 262 p.

Ficklin, W. H., Preston, D. J., Welsh, E. P., and Nowlan, G. A., 1981, Analytical results for 78 ground-water samples from the Casa Grande vicinity, Arizona: U.S. Geological Survey Open-File Report 81-960, 16 p.

Grimes, D. J., and Marranzino, A. P., 1968, Direct-current arc and alternating-current spark emission spectrographic field methods for the semiquantitative analysis of geologic materials: U.S. Geological Survey Circular 591, 6 p.

Hedlund, D. C., in press, Residual aeromagnetic map of the Buffalo Peaks Wilderness Study Area, Lake, Park, and Chaffee Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-1628-D, scale 1:50,000.

______in press, Geologic map of the Buffalo Peaks Wilderness Study Area, Lake, Park, and Chaffee Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-1628-C, scale 1:50,000.

Henderson, C. W., 1926, Mining in Colorado: U.S. Geological Survey Professional Paper 138, 263 p.

Nelson-Moore, J. L., Collins, D. B., and Hornbaker, A. L., 1978, Radioactive mineral occurrences of Colorado: Colorado Geological Survey and Department of Natural Resources Bulletin 40, 1054 p.

Nowlan, G. A., Ficklin, W. H., and Dover, R. A., in press, Water geochemistry of the Buffalo Peaks Wilderness Study Area, Lake, Park, and Chaffee Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-1628-E, scale 1:50,000.

Nowlan, G. A., and Gerstel, W. J., in press, Stream-sediment and panned-concentrate geochemistry of the Buffalo Peaks Wilderness Study Area, Lake, Park, and Chaffee Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-1628-B, scale 1:50,000.

Scott, G. R., 1975, Reconnaissance geologic map of the Buena Vista quadrangle, Chaffee and Park Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-657, scale 1:62,500.

Thompson, C. E., Nakagawa, H. M., and VanSickle, G. H., 1968, Rapid analysis for gold in geologic materials, in Geological Survey research 1968: U.S. Geological Survey Professional Paper 600-B, p. B130-B132.

Tweto, Ogden, 1974, Reconnaissance geologic map of the Fairplay West, Mount Sherman, South Peak, and Jones Hills 7 1/2-minute quadrangles, Park, Lake, and Chaffee Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-555, scale 1:62,500.

______1975, Laramide (Late Cretaceous-Early Tertiary) orogeny in the Southern Rocky Mountains, in Cenozoic history of the Southern Rocky Mountains: Geological Society of America Memoir 144, p. 1-44.

U.S. Geological Survey, 1982, Aeromagnetic map of the Buffalo Peaks area, Colorado: U.S. Geological Survey Open-File Report 82-978, scale 1:62,500.

Vanderwilt, J. W., 1947, Mineral resources of Colorado: Colorado Mineral Resources Board, p. 45-47.

Viets, J. G., 1978, Determination of silver, bismuth, cadmium, copper, lead, and zinc in geologic materials by atomic absorption spectrometry with tricaprylmethylammonium chloride: Analytical Chemistry, v. 50, no. 8, p. 1097-1101.

Wood, R. H., 1983, Mineral investigation of the Buffalo Peaks Wilderness Study Area, Chaffee, Lake, and Park Counties, Colorado: U.S. Bureau of Mines Open-File Report 98-83, 46 p.

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