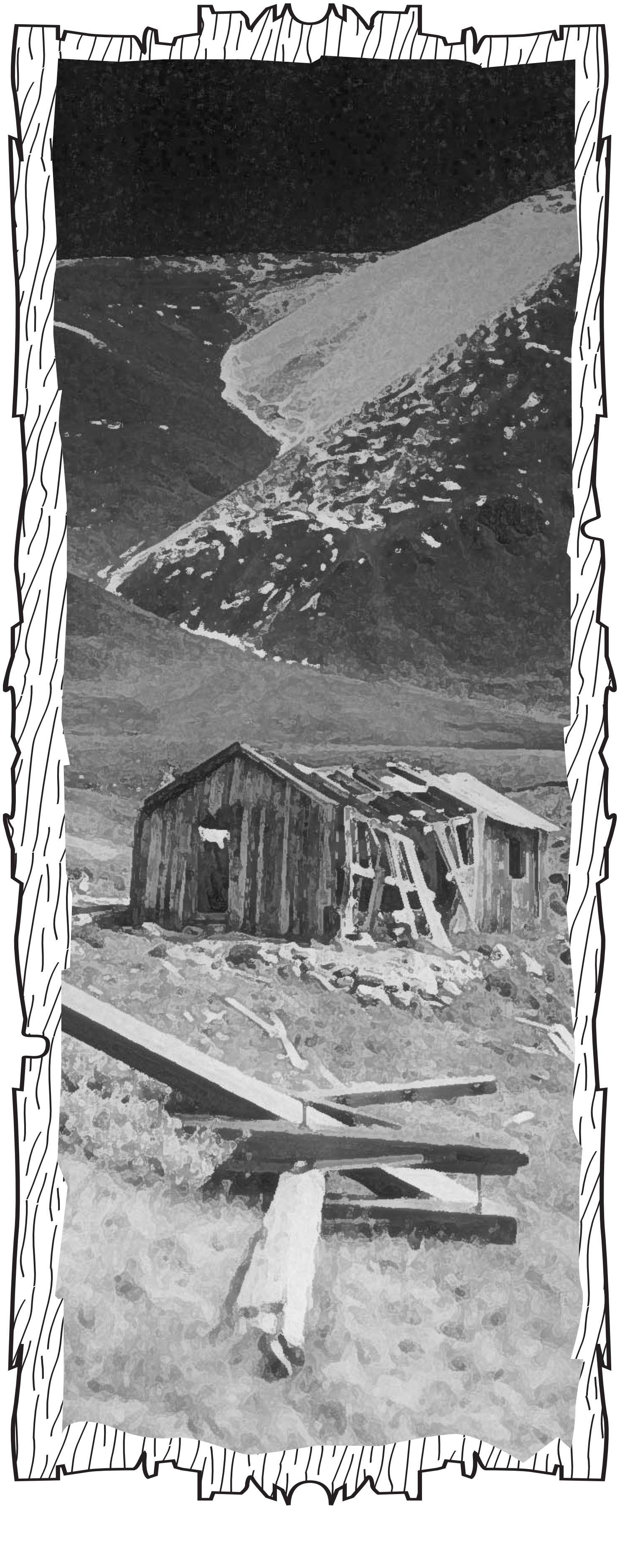

Resource Series 40

Geology and Mineral Resources of Park County, Colorado

By L. Alex Scarbrough, Jr.

Colorado Geological Survey
Division of Minerals and Geology
Department of Natural Resources
Denver, Colorado
2001

Book and map designs by Cheryl Brchan
Illustrations, and photos by Larry Scott
Cover by Cheryl Brchan and Larry Scott

Foreword

The purpose of Colorado Geological Survey Resource Series 40, *Geology and Mineral Resources of Park County, Colorado* is to describe the geological setting and to list and describe the various mineral and mineral fuel deposits of Park County. The report discusses the known occurrences of precious and base metal deposits, industrial minerals, uranium deposits, coal, oil and gas, and the geothermal resources of Park County. The report contains two maps, a geological map and a mineral prospect map, both at a scale of 1:100,000. L. Alex Scarbrough, Jr. wrote this report in 1999 and early 2000. The objective of this publication is to provide geological information to resource developers, government planners, and interested citizens.

Funding for this project came from the Colorado Department of Natural Resources Severance Tax Operational Fund. Severance taxes are derived from the production of gas, oil, coal, and minerals.

James A. Cappa
Chief, Mineral Resources Section

Vicki Cowart
State Geologist and Director


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Introduction

This report reviews the geology of Park County and is a comprehensive compilation of all known mineral deposits, including base- and precious-metal, uranium, coal, oil, and gas. The report will be useful to prospectors, exploration companies, government agencies (especially county planners), and interested citizens.

Various base- and precious-metal deposits mined from Park County are described herein, and examples are given for each deposit type. Detailed information on individual mines, including location, host rock, mine type, tonnage, grade, and ore controls, has been compiled from the United States Geological Survey (USGS) Mineral Resources Data System (MRDS; McFaul and others, 2000) and is presented in two appendices. Descriptions of ore controls have been updated. Production statistics for both the county and individual districts and subdistricts have been compiled, but may be incomplete. Map plates include geologic and topographic maps at 1:100,000 scale, both show locations of all shafts and adits shown on topographic maps and in the MRDS data file.

Geologic Setting

SUMMARY

Park County in central Colorado is one of the largest counties (2,178 square miles) in the State. The diverse geology, which ranges in age from Early Proterozoic to Tertiary (Plate 1, Figures. 1, 2), occurs in various tectonostratigraphic and physiographic settings that include highly faulted mountain ranges composed of Proterozoic schist and gneiss and Paleozoic marine carbonate, shale, and siltstone. Expansive open high plains are underlain by gently folded Mesozoic and Cenozoic clastic sedimentary rocks of marine, continental-lacustrine, and volcaniclastic origin. Tertiary intrusive rocks are widely scattered and are most notable in the Mosquito Range and the central and southern South Park Basin (Epis and Chapin, 1968). Quaternary gravel terraces of periglacial origin are associated with major streams in the county and mantle much of the northern and central portions of South Park Basin (Harmon, 1984).

South Park, which is both a topographic and structural basin, is 50 miles in length and 35 miles in width and is one of four north-trending intermontane basins located in the Southern Rocky Mountains (Stark, and others, 1949; Harmon, 1984). Within South Park, flat to gently rolling plains are punctuated by low north- to north northwest-trending ridges. The western portion of South Park is underlain primarily by Paleozoic sedimentary rocks like those in the bordering Mosquito Range. The central portion of South Park is underlain by Jurassic and Cretaceous sedimentary rocks of continental, lacustrine, and marine origins. Sandstone units form several prominent hogback ridges (Harmon, 1984). The Tertiary-age, northwest-trending Denver (South Park?) Formation borders the Tarryall Mountains near the eastern edge of the South Park physiographic province (Harmon, 1984).

The Mosquito Range along the western boundary of the County is faulted and mineralized. The Range is composed mainly of Cambrian to Mississippian carbonate and sandstone and Pennsylvanian siltstone and shale units. Minor Early Proterozoic pelitic metasedimentary rocks are also present. Locally abundant Cretaceous and Tertiary igneous sills and stocks of felsic to intermediate composition intrude the sequence.

Quaternary deposits include extensive moraine and outwash deposits related to several stages of alpine and possible piedmont glaciation.

The Kenosha Mountains and the western extension of the Front Range of Jefferson and Clear Creek Counties form the northern portion of the county and are composed almost entirely of Early and Middle Proterozoic age metasedimentary, metavolcanic, and metaplutonic schist and gneiss of the upper plate of the Elkhorn Thrust Fault.

The Tarryall Mountains dominate the eastern portion of Park County. They are compositionally and structurally similar to rocks in the Kenosha Mountains. The topographically subdued Arkansas Hills in southern Park County are underlain by rocks that range in age from Proterozoic to Tertiary. The Tertiary Thirtynine Mile Mountain volcanic field covers approximately 300 square miles of in the Arkansas Hills.

The northwestern portion of the County includes South Park Basin, a syncline that plunges gently to the south between the Front Range to the east and the Mosquito Range to the west (Tweto, 1980). The western portion of South Park Basin and the Mosquito Range constitute an east-dipping tilted fault block, which lies between the Elkhorn Thrust in the Tarryall Mountains to the east and the Mosquito and London Faults of the Mosquito Range to the west (Plate 1) (Harmon, 1984). Many faults in the County are northwest trending and appear to be structurally related (Gould, 1948). Localized folding characterizes the central portion of South Park Basin. A broad northwest-trending syncline occupies the eastern third of South Park Basin (Sawatzky, 1964) and the Trout Creek-Antero Reservoir area (Harmon, 1984).

Major streams draining the Park County region include various forks of the South Platte River and Tarryall Creek, which have headwaters in the Mosquito

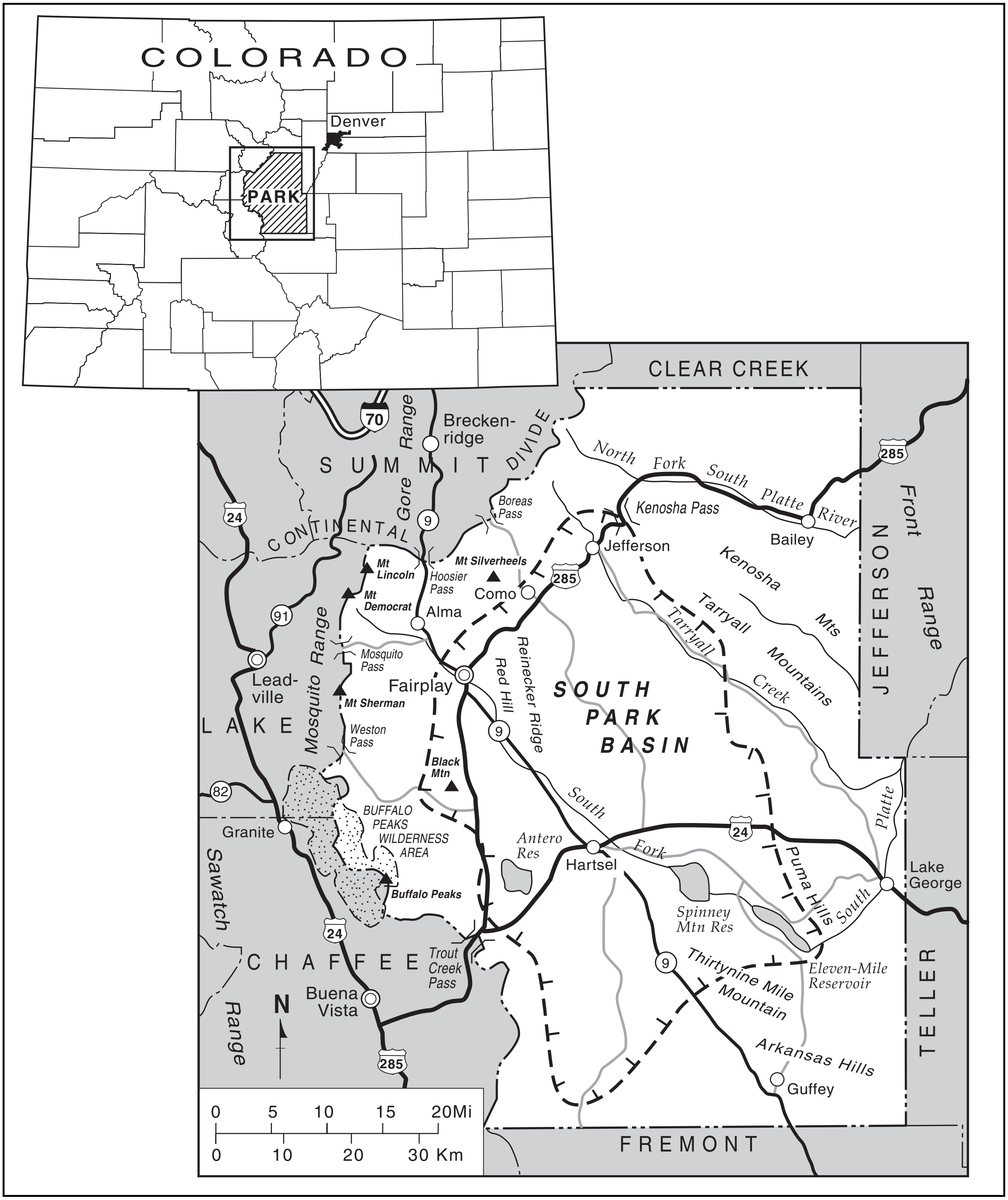


Figure 1. Index map of Park County, Colorado, showing locations and physiographic features mentioned in text.

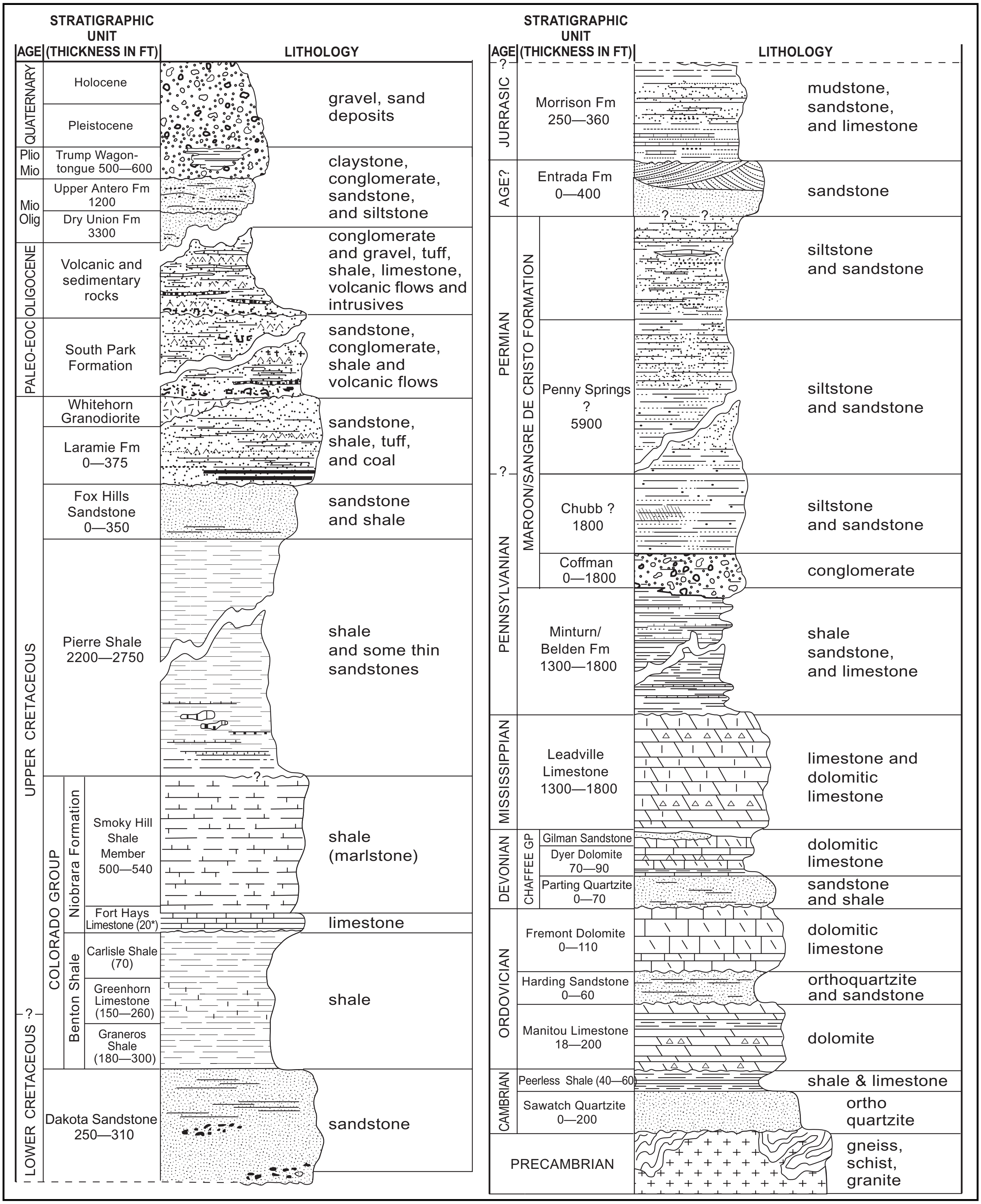


Figure 2. Composite stratigraphic column showing rocks of the Park County region (Beggs, 1977).

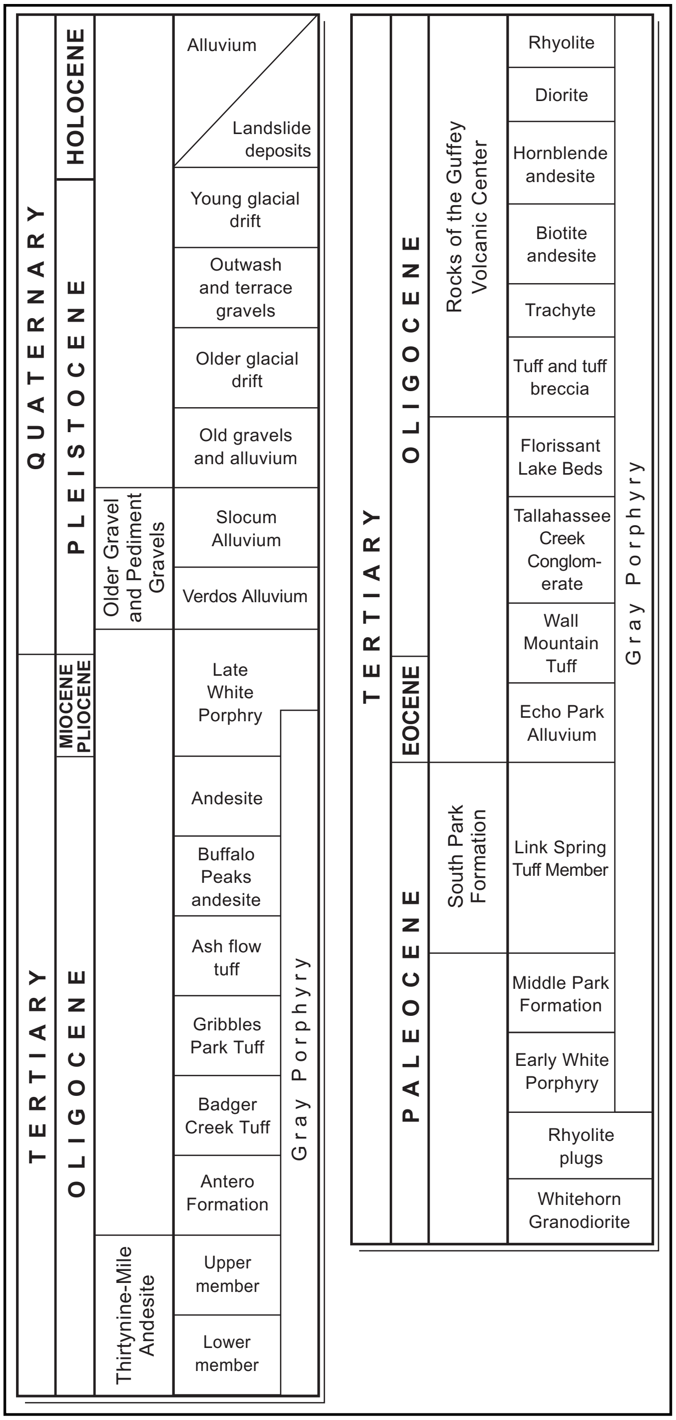


Figure 2a. Age relationships of major post-Precambrian volcanic, volcaniclastic and other igneous rocks of Park County.

Range and Boreas Pass area, respectively, in northwestern Park County. Both flow southeasterly across South Park. Tarryall Creek flows into the South Platte River in the southeastern Tarryall Range. The South Platte River flows north and east out of Park County and into the Great Plains southwest of Denver (Harmon, 1984).

TECTONIC AND GEOMORPHIC HISTORY

The geologic history of the central Colorado region is presented in Gould (1948) and DeVoto (1971). The geologic history of the Park County area is summarized from these sources.

- Deposition of pelitic sediments and mafic volcanic sequences took place in early Proterozoic time.
- Multiple phases of Proterozoic tectonism and metamorphism, which included intrusion of alkalic, granitic, and monzonitic batholiths, stocks, and gabbro sills that altered the early Proterozoic sedimentary and volcanic rocks. Tungsten-tin-molybdenum and copper-zinc skarn deposits as well as pegmatite and non-pegmatitic-hosted beryllium and rare-earth mineral deposits were formed during or slightly after the intrusive episodes.
- Erosion of these metamorphic and igneous rocks resulted in the formation of a peneplain in late Proterozoic time.
- Marine sedimentation took place in Paleozoic time interrupted by several periods of non-deposition. Non-marine deposits derived from an eastern part of the ancestral Rocky Mountains were deposited in Permian time.
- Early Mesozoic erosion followed Paleozoic sedimentation. In the central, eastern, and northern parts of South Park Basin, Paleozoic strata were removed exposing Proterozoic basement rocks.
- Jurassic marine and continental lacustrine deposits, and Cretaceous nearshore and shallow marine deposits covered exposed Proterozoic rocks.
- Folding, faulting, and initial intrusions of concordant and discordant felsic to intermediate igneous bodies with attendant gold-silver-lead-zinc mineralization took place during the Laramide (late Cretaceous and Tertiary) tectonic event.
- Deposition of the Denver (South Park?) Formation took place in early Tertiary time, coincident with continuing Laramide tectonism, and was followed by middle Tertiary erosion, deposition of lakebeds, and volcanism in the form of both lavas and extensive airfall deposits.
- Continued intrusion of sills and stocks took place with emplacement of associated base and precious metals, molybdenum, and other types of metallic minerals, through the mid-Tertiary.
- Pleistocene glaciation and deposition produced moraine and outwash deposits that contain gold-silver placer deposits.
- Post-glacial breaching of moraines and dissection of terraces took place in Holocene time and glacial placers were modified by fluvial outwash systems.

EARLY PROTEROZOIC AGE (APPROXIMATELY 1,700 MA) ROCKS

METAMORPHIC ROCKS

AMPHIBOLITE AND FELSIC GNEISS

This unit is composed of approximately equal portions of felsic gneiss and amphibolite in approximately equal proportions. Felsic gneiss in part occurs as intrusive bodies in the amphibolite. May contain some layers of calc-silicate gneiss near contact with amphibolite and calc-silicate gneiss. In the Montezuma area near the eastern edge of Park County, the unit may represent a pre-metamorphic intrusive complex (Bryant and others, 1981).

FELSIC GNEISS

This unit consists of biotite-quartz-plagioclase-microcline gneiss containing various proportions of plagioclase and microcline; contains layers and lenses of amphibolite and, less commonly, layers of biotite-quartz-plagioclase schist. Grain-size ranges from fine to coarse. In areas west and south of Mt. Evans, the amphibolite occurs as small irregular bodies that appear intrusive into the felsic gneiss. May represent volcanic flows and pyroclastic rocks, and hypabyssal intrusive rocks. Interfingers with and grades into biotite gneiss west of Golden (Bryant and others, 1981).

BIOTITE GNEISS

This unit consists of biotite-quartz-plagioclase schist and gneiss. It commonly contains abundant sillimanite and less abundant muscovite. Locally there are some layers of cordierite-biotite gneiss, garnet-biotite gneiss, hornblende gneiss, and calc-silicate gneiss. Lenses, pods, and thin layers of pegmatite are abundant. In some regions layers and lenses of granodiorite and quartz monzonite are also abundant and rock grades to migmatite. The biotite gneiss unit is probably derived from the metamorphism of shale, siltstone, and sandstone (Bryant and others, 1981).

In west-central Park County, Hedlund (1985) describes the unit as medium-gray foliated migmatitic gneiss invaded by contorted quartzo-feldspathic stringers and aggregated bleb-like quartz grains. The composition is about 50 percent quartz, but also contains up to 25–30 percent biotite and 2–5 percent muscovite and minor fibrolitic sillimanite. Numerous small irregularly shaped bodies of granite are interspersed throughout the migmatite.

MIGMATITE

In Park County, this unit consists of interlayered and intergrading biotite-quartz-plagioclase-gneiss, sillimanite-biotite-quartz-plagioclase gneiss, granodiorite gneiss, and quartz monzonite gneiss. Contacts with adjacent units are gradational.

AMPHIBOLITE AND CALC-SILICATE GNEISS

This unit consists of amphibolite that contains numerous layers of calc-silicate gneiss and calc-silicate quartzite, some layers of felsic gneiss, muscovite quartzite, and, in the eastern part of the Front Range, a few layers of marble. This unit was probably derived from the metamorphism of interbedded sediment and tuff.

IGNEOUS ROCKS

GABBRO AND MAFIC ROCKS

This unit consists of medium-grained, hornblende-pyroxene gabbro pluton south of Keyser Creek. In western Park County, this unit consists mainly of metagabbro. Small plutons of mafic diorite and monzonite are present (Scott and others, 1978; Tweto and others, 1976; Tweto and others, 1978).

In northeastern Park County in the Tarryall Creek area, this unit consists mainly of metadiorite and biotite-hornblendite. In southeastern Park County, the unit consists of dark-greenish-gray, massive to foliated, metamorphosed gabbro and ultramafic rock (Scott and others, 1978).

Granitic Rocks

In west-central Park County this unit consists of 1,700 Ma undifferentiated granitic rocks. This unit includes the Cross Creek Granite of Gore and northern Sawatch Ranges, the Denny Creek Granodiorite of the central Sawatch Range, and equivalent rocks (Tweto and others, 1978).

Quartz Diorite

In west-central Park County, this unit consists of medium to dark gray, massive to foliated, medium to coarsely-crystalline, locally foliated, hypidiomorphic-granular quartz diorite rock containing 30–35 percent oligoclase, 30 percent biotite, 20 percent hornblende, and 10 percent quartz, and accessory epidote, apatite, and microcline. The quartz diorite commonly contains inclusions of biotite schist and gneiss. The unit is 1,700 Ma and locally occurs as small bodies in migmatitic rocks and in the marginal phases of granodiorite (Hedlund, 1985).

Granodiorite

In west-central Park County, this unit consists of medium-light-gray, medium to coarse-grained, porphyritic granodiorite exhibiting aligned microcline phenocrysts that measure up to 0.80 inches.

Composition ranges from granodiorite to quartz monzonite and typically contains 60 percent oligoclase, 15 percent biotite, 6–12 percent microcline, 8–10 percent quartz, and 5 percent hornblende, and accessory sphene, muscovite, chlorite, and iron oxide (Hedlund, 1985). The rock is considered to be correlative with the 1,700 Ma Boulder Creek Granodiorite.

Quartz Monzonite and Granodiorite

This unit is fine- to coarse-grained, foliated, quartz monzonite and granodiorite with numerous inclusions of biotite gneiss and hornblende gneiss. It is locally migmatitic and contorted with diffuse boundaries between inclusions and the surrounding rocks that this unit intrudes.

MIDDLE PROTEROZOIC (APPROXIMATELY 1,400 MA) ROCKS

GRANITIC ROCKS

This unit consists of 1,400 Ma undifferentiated granitic rocks, including the Vernal Mesa Quartz Monzonite, Curecanti Quartz Monzonite, Silver Plume Granite, and St. Kevin Granite, and equivalent rocks (Tweto and others, 1976; Tweto and others, 1978). Other granitic rocks of undetermined age are shown on the accompanying geological map (Plate 2).

QUARTZ MONZONITE OF ELEVENMILE CANYON

This unit consists of 1,450 Ma medium-grained, porphyritic, biotite quartz monzonite (Scott and others, 1978).

QUARTZ MONZONITE

In west-central Park County this unit consists of medium- to light-gray to orange, fine- to medium-grained, allotriomorphic-granular to porphyritic quartz monzonite containing 32–38 percent perthitic microcline, 25–37 percent sodic oligoclase, 18–25 percent quartz, 7–10 percent biotite, and as much as 4 percent muscovite, with accessory sphene, apatite, and iron oxide minerals (Hedlund, 1985). Aplite and pegmatite bodies are locally present. This unit includes the Silver Plume Quartz Monzonite in the Silver Plume batholith. Bryant and others (1981) assign an age of 1,450 Ma to the unit.

CRIPPLE CREEK QUARTZ MONZONITE

This 1,450 Ma unit in eastern Park County consists of medium-grained biotite-muscovite quartz monzonite (Scott and others, 1978).

PEGMATITE AND APLITE (EARLY TO MIDDLE PROTEROZOIC)

Pegmatite and aplite bodies are found throughout the metamorphic and igneous rocks as irregular pods and dikes primarily composed of massive coarse-grained milky quartz, perthitic microcline, albite-oligoclase, muscovite, and biotite. Magnetite, garnet, tourmaline, and beryl are present locally.

MIDDLE PROTEROZOIC (APPROXIMATELY 1,000 TO 1,100 MA) ROCKS

ROCKS OF THE PIKES PEAK BATHOLITH

The 1,000 Ma Pikes Peak Batholith and its associated plutons (Tarryall Creek Pluton, Redskin Stock and

Lake George Pluton) are mostly granitic and syenitic in composition. Minor gabbros are also present. The syenites include light-tan to gray-green, fine- to coarse-grained syenite, quartz syenite, and leucosyenite, with localized occurrences of ferrohastingite, fayalite, and hedenbergite.

The following descriptions of units within the Rocks of Pikes Peak Batholith are from Bryant and others (1981) unless otherwise noted:

Pikes Peak Granite

This granite is the predominant rock type of the Pikes Peak Batholith. It consists of pink to reddish, medium- to coarse-grained, biotite or hornblende-biotite granite.

The fine-grained phase of the Pikes Peak Batholith consists of pink, fine- to medium-grained porphyritic biotite granite with phenocrysts of spherical gray quartz and subhedral microcline and oligoclase.

In parts of Park County Scott and others (1978) mapped a medium-grained Pikes Peak Granite, which is locally porphyritic. The coarse-grained phase of the Pikes Peak Batholith consists of coarse-grained seriate, porphyritic, biotite granite with tabular microcline phenocrysts. Parts of the Pikes Peak Batholith are medium- to coarse-grained, porphyritic hornblende-biotite quartz monzonite to granodiorite, locally containing xenocrysts of sodic labradorite with albite rims.

Tarryall Creek Pluton of the Pikes Peak Batholith

The Tarryall Creek Pluton has multiple phases but it consists primarily of white, coarse-grained, hornblende-biotite quartz monzonite, which grades inward to fine-grained porphyritic quartz monzonite containing phenocrysts of quartz, plagioclase, and potassium feldspar. The outer zone of the pluton consists of dark green, medium- to coarse-grained olivine gabbro.

Redskin Stock of the Pikes Peak Batholith

The Redskin Stock is located on the on the southeast side of South Tarryall Peak, T. 10 S., R. 72 W. and consists of three units.

Fine-Grained Granite

Pink to reddish, fine-grained equigranular muscovite-biotite granite; forms core of stock.

Porphyritic Granite

Pink, medium-grained, seriate, porphyritic muscovite-biotite granite containing phenocrysts of potassic feldspar, albite, and locally, quartz.

Medium-Grained Granite

White to pale-pink, medium-grained equigranular biotite granite.

Lake George Pluton of the Pikes Peak Batholith

This complex pluton contains many phases.

Quartz Syenite and Fayalite Granite

Fine- to medium-grained fayalite quartz syenite and fayalite granite in discontinuous ring dikes

Alkali Diorite

Fine-grained alkali diorite containing andesine, augite, olivine, and abundant secondary biotite. Occurs as large elongate bodies in syenomonzonite

Syenomonzonite

Dark green, coarse-grained, augite-ferrohastingsite syenomonzonite in center of stock and fine-grained ferrohastingsite syenite near margin of stock.

Gabbro

Fine-grained gabbro composed of andesine-labradorite, augite, and biotite.

PHANEROZOIC ROCKS

PALEOZOIC SEDIMENTARY ROCKS

Cambrian Rocks

Sawatch Quartzite (Upper Cambrian)

The Sawatch Quartzite, in exposures that occur only in western Park County, is light-gray, thin- to medium-bedded, fine-grained quartzose sandstone. It ranges in thickness up to 150 feet, but thins to the southeast, pinching out south of Buffalo Peaks area in the Mosquito Range (Hedlund, 1985). In the Greater Alma district, the formation consists of the following informal members (Shawe, 1990):

- **Lower White Quartzite—**White, fine-grained, thick-bedded, quartzite; conglomeratic at base, (46–88 feet thick).
- **Lower Limy Beds—**Brown-weathering, thin-bedded, quartzite; limy quartzite; sandy limestone, shale, and rare limestone (10–13 feet thick).
- **Upper White Quartzite—**White, fine-grained, thick-bedded quartzite (7–13 feet thick).
- **Purple Quartzite**—Purplish to blackish quartzite (3–16 feet thick).

Peerless Shale (Upper Cambrian)

The Peerless Shale consists of thin to flaggy-bedded, olive-drab- to brownish-weathering, white to brown to greenish-gray limestone and dolomitic limestone with shaly partings interbedded with shaly limestone and green-weathering light- to dark-colored limy shale. Outcrops occur only in western Park County. Thickness ranges from 60 feet to 90 feet (Singewald and Butler, 1941). In the Greater Alma district, the Peerless Shale consists of several informal members described below (Shawe, 1990):

- **Middle Limy Beds—**Brown-weathering, dolomitic limestone with shale partings (16–30 feet thick).
- **Lower Shaly Beds—**Brown- and green weathering, thin-bedded dolomitic limestone and shale (20–30 feet thick).
- **Upper Limy Beds—**Brown-weathering, somewhat sandy, dolomitic limestone with limy shale partings (16–30 feet thick).
- **Upper Shaly Beds**—Interbedded brown- and green-weathering dolomitic limestone, shaly limestone, and shale (13–26 feet thick).

In the Leadville district to the west, the Peerless Shale consists of thin-bedded, maroon, buff, and green dolomite and dolomitic shale, which grades downward into brown, glauconitic sandstone (Tweto, 1968).

ORDOVICIAN ROCKS

MANITOU LIMESTONE (LOWER ORDOVICIAN)

The Manitou Limestone is a medium-light-gray to light brownish-gray, medium-bedded to massive, sugary-textured, cliff-forming dolomite. At the base, the unit locally contains thinly-bedded laminated, silty algal limestone that is 40 feet thick north of Buffalo Peaks in western Park County (Hedlund, 1985). A 20 foot-thick interval containing abundant white lenticular and bedded chert occurs 20–45 feet above the base of the formation. Thickness ranges from 190 to 230 feet (Hedlund, 1985). Shawe (1990) describes the Manitou Limestone in the Greater Alma district as a whitish and bluish-gray crystalline limestone, locally slightly sandy, and as thick as 130 feet.

HARDING (QUARTZITE) SANDSTONE (MIDDLE ORDOVICIAN)

The Harding (Quartzite) Sandstone is a light-gray, medium- to even-bedded, very fine- to fine-grained quartzite containing minor beds of siltite (Hedlund, 1985). The formation is up to 50 feet in thick, but pinches out approximately 4.5 miles northwest of Trout Creek Pass. However, it is present between Rough and Tumbling Creek and the South Fork of the Platte River in west-central Park County (Hedlund, 1985). The Harding (Quartzite) Sandstone is present locally in the Greater Alma district.

FREMONT DOLOMITE (UPPER ORDOVICIAN)

In westernmost Park County, the Fremont Dolomite is light-gray, massive, cliff-forming, sugary-textured dolomite about 90 feet thick. The uppermost 10 feet consists of light-yellowish-gray, thin-bedded-silty dolomite (Hedlund, 1985). The Fremont Dolomite occurs locally in the Greater Alma district.

DEVONIAN ROCKS

CHAFFEE GROUP (UPPER DEVONIAN AND LOWER MISSISSIPPIAN)

The Parting Quartzite is the basal formation of the Chaffee Group and consists of a brown-weathering, medium-gray, thin-bedded, cross-bedded, moderately indurated, discontinuous quartzose sandstone. (Hedlund, 1985). In the Greater Alma district, the unit consists of light- to dark-brownish gray-weathering, cross bedded , conglomeratic quartzite, sandy limestone, and minor shale. The Parting Quartzite averages 15 feet in thickness and is as much as 56 feet thick in Park County (Shawe, 1990).

In western Park County, the Dyer Dolomite of the Chaffee Group is made up of two members. The lower member consists of 45 feet of olive-gray, medium-bedded, fine-grained limestone overlain by 35 feet of pinkish-gray to light-brownish-gray, thin-bedded to laminated, fine-grained, silty dolomite (Hedlund, 1985). In the Greater Alma district, the formation consists of 40-78 feet of whitish and bluish-gray, buff weathering, dense, thin-bedded, dolomitic limestone (Shawe, 1990). The Gilman Sandstone, the uppermost formation of the Chaffee Group, consists of about 15 feet of yellowish-gray sandstone (Scott, 1975). In the Greater Alma district, the formation is composed of a lenticular, dense, white quartzite as much as 10 feet in thickness (Shawe, 1990).

MISSISSIPPIAN ROCKS

LEADVILLE LIMESTONE (LOWER MISSISSIPPIAN)

In westernmost Park County, the Leadville Limestone consists of dark-gray, medium-bedded, fine-grained, locally fetid limestone. Black ropy chert is abundant in the upper part of the formation and algal oncolites are locally present near the base (Hedlund, 1985). Average thickness is about 140 feet. In the Greater Alma district, the Leadville Limestone is as much as 164 feet in thickness, and consists of bluish-gray to dark-gray, dense, massive bedded, dolomitic limestone containing chert and solution breccia (Shawe, 1990). Within areas of mineralization, carbonate rocks are locally vuggy, replaced by jasperoid, and altered by a combination of preferential dissolution and carbonate replacement, forming “zebra” rock.

PENNSYLVANIAN ROCKS

MINTURN FORMATION (MIDDLE AND LOWER PENNSYLVANIAN)

The Minturn Formation is composed of reddish-brown siltstone, light-brown-sandstone, and minor conglomerate, locally interbedded with thin, dark-gray, gypsiferous shale near its base (Hedlund, 1985). Thickness is variable due to a large unconformity at the top of the Formation, but ranges to as thick as 6,000 feet. In the Leadville district, 1,000 feet of the Minturn Formation have been described (Tweto, 1968). In the Greater Alma district, the formation consists of 3,900 feet of interbedded quartzite, conglomerate, arkose, shale (carbonaceous in part), and sparse limestone (Shawe, 1990). In Park County, portions of the Minturn Formation are facies-equivalent to the Maroon Formation.

Belden Formation (Lower Pennsylvanian)

The Belden Formation consists of up to 1,700 feet of dark-gray to black, highly fissile shale, with minor limestone, siltstone, and sandstone (Hedlund, 1985). Thin, dark-gray, fetid limestone beds are common in the lower and middle portions of the unit. In the Leadville district, the unit thickens to the southeast, reaching a maximum thickness of 400 feet (Tweto, 1968).

Weber Formation (Permian and Pennsylvanian)

The Weber Formation is a yellow-gray sandstone about 100 feet thick in the vicinity of the Grand Hogback near Meeker. The unit thins toward its depositional margins to the south and east toward Park County (Tweto and others, 1978). In both the Greater Alma district and the adjoining Leadville district, the Weber Formation is described as consisting of two units now assigned to the Belden and Minturn Formations (Patton and others, 1912; Tweto, 1968).

The lower unit (Weber Shale) is now termed the Belden Shale, and consists of 150–400 feet of basal black carbonaceous shale and interbedded, thin-bedded, dark-gray limestone and sandstone containing localized beds of bony coal. The unit thickens to the southeast in the Leadville district.

The upper unit (Weber Grits) is now termed the Minturn Formation, and, in the lower 500 feet, is composed of even-bedded, black to white, coarse-grained micaceous quartzite and gray to black shale. The upper 1,000 feet is composed of lenticular feldspathic sandstone and conglomerate (Tweto, 1968).

Sangre de Cristo Formation (Permian and Pennsylvanian)

The Sangre de Cristo Formation in Park County consists of a lower member-Red and green sandstone, conglomerate, and siltstone. The maximum thickness is about 12,000 feet.

Maroon Formation (Permian and Pennsylvanian)

The Maroon Formation, facies equivalent to portions of the Minturn Formation, is composed of maroon and grayish-red sandstone, conglomerate, and mudstone. The Maroon Formation is 9,500 feet thick in the vicinity of Aspen, but thins to the northeast to the depositional margins along the west flank of the Gore Range located west and northwest of Park County (Tweto and others, 1978). Members of the Maroon Formation shown on the stratigraphic column are not recognized in the geologic maps of Park County.

PALEOZOIC IGNEOUS ROCKS

Diabase (Ordovician or Cambrian)

There is a north-trending, potassic, feldspar-bearing augite diabase dike east of South Park.

MESOZOIC ROCKS

Jurassic Rocks

Entrada Formation (Upper Jurassic)

The Entrada Formation is a gray to brownish-red, medium-grained, cross-bedded sandstone with a maximum thickness of 300 feet in South Park. Locally, there is a quartz- and chert-granule conglomerate at base (Scott and others, 1978).

Morrison Formation (Upper Jurassic)

The Morrison Formation is composed of red and green siltstone, mudstone, claystone, and sandstone containing dinosaur bones. Locally, there is a quartz pebble conglomerate at the base. The Morrison Formation is about 320 feet thick (Scott and others, 1978).

Cretaceous Rocks

Dakota Sandstone (Lower Cretaceous)

The Dakota Sandstone consists of yellow-brown sandstone with some gray to brown quartzite, siliceous chert-pebble conglomerate, and gray-green non-calcareous shale. Carbonized plant fragments and trace fossils are locally present (Wyant and Barker, 1976). Locally, the Dakota Sandstone is accorded Group status and is divided into two formations:

- **South Platte Formation—**Three yellowish-gray sandstone layers separated by two dark-gray, indurated, silty shale layers interbedded with thin gray sandstone layers.
- **Lytle Formation—**Yellowish-gray or yellowish-brown, medium- to fine-grained iron stained sandstone and conglomerate.

The Dakota Sandstone is about 400 feet thick.

Graneros Shale (Upper Cretaceous)

The Graneros Shale is composed of dark-gray shale containing carbonaceous siliceous siltstone at the base (Wyant and Barker, 1976). The unit is about 180 to 300 feet thick, and poorly exposed.

Greenhorn Limestone (Upper Cretaceous)

The Greenhorn Limestone is a poorly exposed brown, fetid, calcareous, Globegerinid-rich sandstone and gray shaly limestone (Wyant and Barker, 1976). The unit is 150 feet to 260 feet thick and is poorly exposed.

Carlisle Shale (Upper Cretaceous)

The Carlisle Shale consists of about 70 feet of poorly exposed medium- to dark-gray shale and siltstone overlain by 5 to10 feet of brown, fossiliferous, fetid, calcareous fine-grained sandstone (Wyant and Barker, 1976).

Niobrara Formation (Upper Cretaceous)

The Fort Hays Limestone Member of the Niobrara Formation is a poorly exposed, gray, fossiliferous, marine limestone containing abundant Inoceramid prisms (Wyant and Rogers, 1976). The unit is about 100 feet thick.

The Smoky Hill Shale Member of the Niobrara Formation is a poorly exposed dark-gray, yellow-weathering, spotted, calcareous, marine shale about 350 feet thick (Wyant and Barker, 1976).

Pierre Shale (Upper Cretaceous)

The Pierre Shale consists of as much as 4,200 feet of black to olive-gray-green fossiliferous shale containing layers of bentonite, minor sandstone, ironstone concretions, and phosphatized fossil beds. Within the Pierre Shale, transitional beds containing calcareous concretions, composed of brown, yellow, olive-brown, and gray beds of marine shale, siltstone, and sandstone, overlie and interfinger with the main body of the Pierre Shale (Wyant and Rogers, 1976). The transitional beds are as much as 1,800 feet thick.

Fox Hills Sandstone (Upper Cretaceous)

The Fox Hills Sandstone is yellow to brown, well-sorted, cross-bedded, fine-grained sandstone near the top, and grades downward to light-gray, fine-grained, calcareous, sparsely fossiliferous, even-bedded, marine sandstone and interbedded gray marine shale. The Fox Hills Sandstone is 200–350 feet thick (Wyant and Rogers, 1985).

Laramie Formation (Upper Cretaceous)

The Laramie Formation consists of lenticular beds of olive gray to yellowish-brown to dark gray shale and sandstone containing iron oxide-coated plant casts and coal. There are two locally developed coal beds: the uppermost coal bed is commonly less than 3.0 feet thick, and the basal coal bed is commonly 2–8 feet thick, locally exceeding 40 feet in thickness at the King Cole Mine (Wyant and Rogers, 1976). The formation is about 300 feet thick, but thins to a featheredge south of the west central portion of the county.

Cretaceous Igneous Rocks

Whitehorn Granodiorite

The Whitehorn Granodiorite is a exposed in a small laccolith in southwestern Park County. It is composed of fine- to medium-grained, quartz-plagioclase-orthoclase-augite-hornblende-biotite granodiorite.

Tertiary-Cretaceous Rocks

Intrusive Rocks (Eocene, Paleocene, Upper Cretaceous)

Porphyritic rocks are composed of quartz monzonite, granodiorite, rhyolite, and quartz diorite in stocks, sills, and dikes (Tweto and others, 1978). Mapped and described units include the Early White Porphyry, Late White Porphyry, and Gray Porphyry described by Vanderwilt (1947), Tweto (1968), Shawe (1990) and others in descriptions of the Alma and Leadville districts. Igneous rocks mapped by Hedlund (1985) in the Buffalo Peaks Wilderness Study Area in west-central Park County are also included, but their correlation to other igneous rocks in Park County is uncertain. The White and Gray Porphyry unit typically is associated with base- and precious metal mineralization in the Greater Alma district.

Rhyolite dikes are composed of very light-gray, cryptocrystalline to slightly porphyritic rhyolite. To the west in the Granite Mining district of neighboring Chaffee County, the dikes are up to 20 feet thick and locally form the footwall of gold-pyrite-quartz veins. Other dikes within Park County contain sparsely disseminated oxidized pyrite cubes up to 0.08 inches across (Hedlund, 1985). Rhyolite plugs are very light-gray rhyolite porphyry containing 10–15 percent phenocrysts of oligoclase, sanidine, quartz, and biotite (Hedlund, 1985).

The Early White Porphyry consists of typically sericitized, fine-grained, light-gray to white, quartz latite porphyry and is equivalent to the Pando Porphyry in the adjoining Leadville district located to the west of the Greater Alma district (Tweto, 1968). The Early White Porphyry is not abundant in the Greater Alma district, but where present, usually consists of northeast-trending dikes of strongly altered, whitish-gray rock containing sparse to abundant, small- to medium-sized phenocrysts of albite, orthoclase, quartz, and muscovite (Shawe, 1990).

The Gray Porphyry of the Greater Alma district occurs as sills and stocks, and is equivalent to several units observed in the adjoining Leadville district, including the Sacramento, Evans Gulch, Johnson Gulch, Lincoln, and younger porphyries (Tweto, 1968). The Gray Porphyry unit in the adjoining Leadville district typically consists of gray to gray-green to bluish-green quartz-monzonite porphyry containing 0.25-to 1.00-inch phenocrysts of potassium feldspar, plagioclase, and quartz. Texture ranges from prominently porphyritic to equigranular.

The Late White Porphyry consists of slightly porphyritic, white, intrusive rhyolite which is equivalent to the Rhyolite Porphyry of the adjoining Leadville district located to the west of the Greater Alma district (Tweto, 1968). In the Greater Alma district it is present as sills of whitish-gray rock containing sparse quartz and muscovite phenocrysts scattered through a homogeneous strongly altered ground mass (Shawe, 1990).

CENOZOIC SEDIMENTARY ROCKS

TERTIARY SEDIMENTARY ROCKS

SOUTH PARK FORMATION (PALEOCENE)

The Reinecker Ridge Volcanic Member of the South Park Formation consists of a lower flow and breccia unit and an upper conglomerate and tuffaceous sandstone unit (Wyant and Rogers, 1976). The lower part consists of brown, gray, green, or purple hornblende-andesite porphyry flows and breccias. The lower unit is overlain in the upper and middle portions by thick lenticular beds of conglomerate composed of many varieties of well-rounded porphyry cobbles (mainly andesite) in a ferruginous tuffaceous matrix. The conglomerate beds are interbedded with brown platy to massive water-laid tuffaceous sandstone beds composed of feldspar, quartz, augite, and clinoptilolite. Total thickness of the member is 500–1,000 feet (Wyant and Rogers, 1976). The Reinecker Ridge Conglomeratic Member of the South Park Formation consists of buff to dark-greenish-gray and brown lenticular beds of conglomerate, sandstone, and tuffaceous mudstone containing abundant biotite, plant fragments, and leaf impressions. The lower part of the member is composed of subrounded cobbles and boulders of silicified wood, Cretaceous and Paleocene porphyritic rock, gray quartzite, chert-pebble conglomerate, and red silty sandstone of Paleozoic age. Thickness of the Reinecker Ridge Conglomeratic Member is about 4,500 feet (Wyant and Rogers, 1976).

The Link Spring Tuff Member of the South Park Formation is composed of laminated water-laid tuff, gray, brown, and pale-green volcanic breccia, flows of andesite, and minor porphyry cobble conglomerate in a tuffaceous matrix. The maximum thickness is about 700 feet, and the Member thins to the northwest to a wedge edge in the Milligan Lakes area (Wyant and Rogers, 1976).

The Arkosic Member of the South Park Formation consists of pale-pink to gray lenticular beds of arkosic sandstone, conglomerate, and mudstone composed of poorly sorted, friable, subangular grains and fragments of Proterozoic granitic and metamorphic rock (Wyant and Rogers, 1976). The Member is as much as 3,500 feet thick.

ECHO PARK ALLUVIUM (EOCENE)

The Echo Park Alluvium occurs in southern Park County adjacent to the Currant Creek Fault Zone. In the Guffey 15-minute quadrangle of southwestern Park County, it consists of brown, crudely stratified, poorly sorted, unconsolidated, boulder alluvium in a sandy matrix. Near Guffey the unit occupies a broad east-trending paleovalley, and is probably less than 50 feet thick (Epis and others, 1979). In other areas the Echo Park Alluvium is reported to over 1,000 feet thick in paleovalleys and grabens.

TALLAHASSEE CREEK CONGLOMERATE (OLIGOCENE)

The Tallahassee Creek Conglomerate is yellowish-gray, poorly sorted, conglomerate up to 300 to 400 feet thick. The conglomerate contains clasts of Proterozoic rock, quartzite, porphyritic volcanic rock, and some clasts from the Wall Mountain Tuff. The Tallahasse Creek Conglomerate is an important host for uranium deposits in the Tallahassee Creek district, which is southeast of the Guffey 15-minute quadrangle (Epis and others, 1979). The unit lies within paleovalleys adjacent to the Currant Creek Fault Zone and other similar structures in southern Park County and is commonly confused with the Echo Park Alluvium because both units share similar physical characteristics and stratigraphic position.

FLORISSANT LAKE BEDS (OLIGOCENE)

The Florissant Lake Beds occur in Park County only in the Lake George area, and consist of pink arkosic conglomerate, purple and gray andesitic tuff and volcanic mudflow breccia, light-colored laminated tuffaceous shale and mudstone, white pumiceous tuff, and gray volcanic conglomerate (Wobus and Epis, 1978). Tuffaceous shale and mudstone beds near the middle of the sequence contain abundant plant and insect fossils. The underlying andesitic tuff beds and mudflows contain tree stumps and petrified logs.

ANTERO FORMATION (OLIGOCENE)

The Antero Formation is a clastic and volcaniclastic unit that contains water-laid ash, air-fall tuff, siltstone, sandstone, and algal limestone. The Antero Formation is moderately widespread in central and southwestern Park County. In the Guffey 15-minute quadrangle this unit consists of as much as 2,000 feet of water-laid andesitic ash interlayered with air-fall and ash-flow tuff and lahar breccia, and white, yellowish-gray, and gray platy siltstone, paper shale, and algal limestone. The formation contains fossil plants, insects, mollusks, and fish (Epis and others, 1979).

WAGONTONGUE FORMATION (MIOCENE)

The Wagontongue Formation consists of pebble and cobble gravel, sandstone, siltstone and tuff. It is about 500 feet thick in a syncline northeast of Antero Reservoir in South Park (T. 12 S., R. 76 W.). The formation thickens to 950 feet south of Antero Reservoir.

Gravel (Pliocene? or Miocene)

This unit consists of boulder gravel capping ridges above major streams in the mountains east of the Continental Divide in the drainage of the North Fork of the South Platte River.

Dry Union Formation (Pliocene and Miocene)

The Dry Union Formation consists of light-brown sandy siltstone and interbedded friable sandstone, conglomerate, and volcanic ash. The total thickness is greater than 3,000 feet west of Park County in the Arkansas River valley southwest of Leadville.

Tertiary Igneous Rocks

Latite Porphyry (Eocene)

These latite porphyry rocks are intruded along Trout Creek Fault southwest of Antero Reservoir.

Tertiary Intrusive Rocks (Oligocene)

These mid-Tertiary intrusive rocks consist of granodiorite and hornblende-biotite monzonite, pyroxene-hornblende biotite monzonite and quartz monzonite. They are typically porphyritic, but are equigranular in some large bodies. These rocks occur in stocks, sills, and irregular intrusions, and include various igneous formations in the Buffalo Peaks Wilderness Study Area mapped by Hedlund (1985) and parts of the Gray Porphyry of Vanderwilt and others (1947) described above.

Wall Mountain Tuff (Oligocene)

The Wall Mountain Tuff is present primarily in southern Park County, although small remnant outliers are scattered about the northeast quadrant of the county. In the Guffey 15-minute quadrangle, the unit is about 50 feet thick, consisting of reddish-brown to yellowish-gray, moderately to densely welded, eutaxitic, devitrified, rhyolitic ash-flow tuff, containing abundant glassy sanidine and less abundant biotite in an argillized plagioclase matrix (Epis and others, 1979). The maximum thickness is about 200 feet. Several radiometric ages indicate an age of about 36 Ma (Epis and Chapin, 1974).

The unit occurs mainly as remnants within paleovalleys, especially along the margins of basins filled with the Antero Formation.

Thirtynine Mile Andesite (Oligocene)

The Thirtynine Mile Andesite forms an extensive blanket of andesitic to basaltic flows, breccias, and tuffs that cover most of southern Park County. Members are described below (Epis and others, 1979):

- **Lower Member—**Is primarily of lahar origin, and consists of purple, gray, brown, and black, non-sorted, well-indurated breccia composed mainly of non-vesicular pyroxene andesite and some hornblende- and biotite-bearing andesite. Some flow breccia, bedded ash, and lava flows of similar composition are also present. The unit has a maximum thickness of 1,400 feet, averaging about 500 feet.
- **Upper Member—**Composed of dark-brownish-gray, stratified, basaltic andesitic lava flows, interbedded andesitic breccia, and minor ash-flow tuff. Most andesite contains pyroxene phenocrysts and some more silicic varieties contain biotite and hornblende phenocrysts. Thickness is about 1,200 feet.

There are black dense basalt flows and gray, flow-layered, porphyritic hornblende andesite domes and domal lavas within the Thirtynine Mile volcanic center in the area south of Guffey.

Rocks of the Guffey Volcanic Center—(Oligocene)

The Guffey Volcanic Center is composed mostly of extrusive volcanic flows and tuffs of rhyolitic, andesitic, and basaltic composition, and small plugs of diorite. The complex is located in southwest Park County. Members are described below (Epis and others, 1979):

- **Rhyolite Member—**consists of light-pink porphyritic rhyolite in small plugs and dikes.
- **Diorite Member—**composed of greenish-gray fine-grained pyroxene diorite in small plugs.
- **Hornblende Andesite Member—**consists of dark-greenish-gray, flow-layered porphyritic andesite in exogenous domes, lava flows and dikes.
- **Biotite Andesite Member—**consists of light-reddish-gray, flow-layered porphyritic biotite andesite in domes, lava flows, and dikes.
- **Trachyte Member—**contains light-pink sanidine trachyte in lava flows and sub-volcanic intrusives (Wobus and Epis, 1978).
- **Tuff and Tuff Breccia Member—**consists of bedded andesitic lapilli tuff and pyroclastic breccia.

Other volcanic rocks in the area south of Guffey are gray porphyritic flow-layered dome and domal biotite andesite lavas of East and West Antelope Mountains.

Andesite (Oligocene)

This unit is a hornblende-biotite and biotite andesite and flow breccia, which is about 900 feet thick on the west limb of a syncline northeast of Antero Reservoir. The unit fills a paleovalley southeast of Kenosha Pass (T. 7 S., R. 75 W.).

Ash-Flow Tuff (Oligocene)

These rocks are ash-flow tuffs from caldera sources in the San Juan Mountains and in the Sawatch Range. They range from crystal-poor rhyolite to crystal-rich quartz latite. Degree of welding varies widely from unit to unit, and with distance from source.

Inter-Ash Flow Andesitic Lavas and Breccias (Oligocene)

Fine-grained to porphyritic intermediate andesitic lavas and breccias are found between ash flow units.

Gribbles Park Tuff (Oligocene)

The Gribbles Park Tuff is found in southern Park County in the Gribbles Park area. These tuffs consist of biotite-sanidine rhyolite ash-flow tuff.

Buffalo Peaks Andesite (Oligocene)

The Buffalo Peaks Andesite consists of several informal members composed of basaltic and andesitic flows, tuff, and volcaniclastic breccia. The unit occurs only in west-central Park County, primarily within the Buffalo Peaks Wilderness Study Area (Hedlund, 1985).

The andesite member of the Buffalo Peaks Andesite is about 1,200 feet thick. The unit consists of medium-gray, slabby, porphyritic flows containing about 25 percent phenocrysts. The phenocrysts include zoned andesine, and 12 percent diopsidic augite, hypersthene, and hornblende within a felsic to pilotaxitic groundmass (Hedlund, 1985).

The basaltic andesite member of the Buffalo Peaks Andesite exhibits a dark-gray, pilotaxitic groundmass containing andesine microlites and magnetite-ilmenite granules. Phenocrysts of andesine and hypersthene/diopsidic augite constitute 30 percent and 10 percent, respectively, of the rock (Hedlund, 1985).

Badger Creek Tuff (Oligocene)

The Badger Creek Tuff, which consists of ash flow and air-fall tuffs and lahar breccia, is here considered a separate formation. It has been described as a member of the Buffalo Peaks Andesite (Hedlund, 1985). The Badger Creek Tuff consists of light-brown, eutaxitic, densely welded, ash-flow tuff with 25 percent crystal fragments and locally abundant black, vitric, collapsed blocks of pumice as much as 3 inches long (Hedlund, 1985). On the north side of West Buffalo Peak, the formation near its base includes beds up to 300 feet thick of air-fall tuff, lithic-rich non-welded tuff, and some laharic breccia (Hedlund, 1985).

The lahar breccia of the Badger Creek Tuff is as thick as 300 feet and is composed of light-purplish-gray, poorly sorted, angular clasts of andesite as long as 6 inches (Hedlund, 1985).

The upper ash-flow tuff of the Badger Creek Tuff is intercalated with andesite and is as much as 20 feet thick. The tuff is light-brown to grayish-orange, eutaxitic, and densely welded, containing 15–25 percent crystal fragments and abundant black, vitric, collapsed pumice fragments up to 2 inches long (Hedlund, 1985).

Basalt (Miocene)

There are olivine basalt flows at Herring Park north of Cameron Mountain.

Quaternary Deposits

Alluvial Deposits

Alluvial deposits described below come from the geologic map unit explanations from the four 1° x 2° quadrangle maps that were used to compile the geologic map used in this report (Plate 2). Much, if not all, of the names of these alluvial units were derived from studies of Quaternary sand and gravel alluvial units on the east side of the Front Range and in the high plains of eastern Colorado, and are probably not applicable to the alluvial units in Park County. For purposes of completeness all these Front Range and high plains units are described below-they are generally sand, silt, and gravel deposits with varying amounts of clasts and clast sizes. On the geologic map in this report (Plate 2) they are all included in one map unit—Qal.

- **Nussbaum Alluvium (Nebraskan? Glaciation of the Pleistocene)—**Consists primarily of weathered gravel on pediment surfaces 450 feet above modern stream levels.
- **Verdos Alluvium (Yarmouth Interglaciation or Kansan Glaciation)—**Consists of gray, bouldery gravel covering steep pediments around Thirtynine Mile Mountain (Epis and others, 1979).
- **Slocum Alluvium (Sangamon Interglacial or Illinoian Glaciation)—**Consists of gray, crudely stratified, poorly sorted, bouldery alluvium in pediments around Thirtynine Mile Mountain, and yellowish-brown fairly-well stratified and sorted alluvium in high terrace remnants along South Platte River(Tweto and others, 1978).
- **Pinedale Glaciation Gravel Deposits (Pleistocene)—**Consist of thick gravel deposits, which are, in part, outwash gravels.
- **Old Gravels and Alluvium (Pre-Bull Lake, Pleistocene)—**Composed of terrace, outwash, and pediment gravels (Tweto and others, 1978).
- **Young Outwash and Terrace Gravels (Pinedale andBull Lake)—**Consist of poorly sorted pebble to boulder gravel in stream, terrace, and outwash deposits (Tweto and others, 1978).
- **Older Fan Alluvium (Pleistocene)—**Consist of gravel, sand, silt, and locally, boulders in fan-shaped deposits above present drainage systems.
- **Broadway Alluvium (Pleistocene)—**Consists of grayish-brown, moderate-yellowish-brown, light brown, and reddish-brown, fine- to coarse-grained, well-sorted, crudely stratified sand and finer grained well-stratified silty humic sand. It has a locally well-developed soil at the top as thick as 3 feet. The unit forms terrace 5 feet to 40 feet above streams. The thickness is as much as 30 feet, and is locally absent.
- **Louviers Alluvium (Pleistocene)—**Consists of brown, grayish-brown, yellowish-brown, and red-

dish-brown clayey silt and sand and coarse-cobbly clayey sand and gravel. It generally exhibits graded bedding with contorted clay and silt layers, and contains iron- and manganese-oxide staining. Commonly, a well-developed soil is present at top. It was deposited on well-developed terrace 30 to 60 feet above modern streams. The thickness is as much as 100 feet, and is locally absent.

- **Alluvium (Holocene)—**Consists of Post-Piney Creek alluvium, Piney Creek Alluvium, and pre-Piney Creek Alluvium; may also include some Broadway and Louviers Alluviums where those deposits are too small to map. Post Piney Creek alluvium consists of light yellowish gray to grayish-brown unconsolidated silt, sand, and coarse pebble to cobble gravel containing interbedded dark-brown clayey and silty lenses. Locally the unit is magnetite rich. The unit is poorly to well stratified, commonly cross bedded. It is locally humic, commonly containing plant debris. It generally lacks soil development. It forms flood plain and the lowest terrace deposits above most streams. Thickness is as much as 30 feet; generally less than 10 feet thick.

  The Piney Creek Alluvium consists of dark-gray to dark-brownish-gray, humic clay, silt, and sand. It is generally gravelly in lower part. It is usually well stratified and locally contains charcoal. Generally the unit has a poorly developed soil at top. The Piney Creek Alluvium forms terrace 7 to 10 feet above stream level in most stream valleys. Thickness is as much as 30 feet. Pre-Piney Creek Alluvium consists of light-brown, moderate-brown, moderate-yellowish-brown, and reddish-brown stratified silt and sand containing thin lenses of pebbles. Soil at the top is generally weakly developed. The pre-Piney Creek Alluvium form terrace deposits only in small stream valleys and has a thickness as much as 40 feet, generally less than 10 feet.

Alluvial and Colluvial (Holocene and Pleistocene

This unit consists of poorly sorted boulders, cobbles, pebbles, sand, silt, and peat; occurs near valley heads of some streams in nonglaciated areas, especially in the Kenosha and Tarryall Mountains.

Landslide Deposits (Holocene and Pleistocene

Landslide deposits include slump blocks, mudflows, and talus deposits. They are poorly sorted; particle sizes range from clay to blocks more than 350 feet long (Tweto and others, 1978).

Glacial Deposits

- **Older Glacial Drift (Pre-Bull Lake)—**Older Glacial Drift is composed of unsorted, bouldery, glacial deposits (till) that lack or have subdued morainal form (Tweto and others, 1978).
- **Young Glacial Drift (Pinedale and Bull Lake)—** Young Glacial Drift is composed of unsorted, bouldery, glacial deposits (till) and associated sand and gravel deposits (Tweto and others, 1978).
- **Rock Glaciers (Holocene and Uppermost Pleistocene)—**Rock glaciers consist of angular boulders and cobbles at the surface, embedded in a matrix of sand and silt below the surface. They form a bouldery deposit in a mountainous terrain with a convex cross profile.

Structural Geology

MAJOR FAULTS

Faults within Park County consists of (Stark and others, 1949): 1) low-angle, eastward-dipping, northwest-trending reverse faults having sinuous traces (e.g., the east-dipping Elkhorn Thrust Fault); 2) high-angle, east-dipping, north- to northwest-trending reverse faults having relatively straight traces (e.g., the Mosquito, London, Weston, and South Park Faults); 3) northwest-trending faults located north of the South Park Fault that exhibit predominantly horizontal movement; 4) normal faults that have various trends, usually showing small separation.

MOSQUITO FAULT

The Mosquito Fault (Figure 3) is a north northeast-trending, west northwest-dipping, reverse fault adjacent to the Mosquito Range along the boundary between Park County and Lake County. Together with its southerly extension, the Weston Fault in west-central Park County, the Mosquito Fault has a strike length of about 38 miles and constitutes the most extensive fault in the Mosquito Range (Singewald and Butler, 1941). Indications of reverse and normal movement are locally observed on the fault (Stark and others, 1949).

LONDON FAULT

The London Fault is a north northwest-trending, north-east-dipping, reverse fault located in northwest Park County. It is the second longest fault in the Mosquito Range (Singewald and Butler, 1941) and has been traced to the southeast for over 20 miles. The Mosquito Fault truncates the structure (Figure 3). Total vertical separation is about 3,000 feet on the north side of Pennsylvania Mountain (Plate 1); 1,600 feet of displacement is attributable to faulting and 1,400 feet of displacement is due to associated folding (Singewald and Butler, 1941). Ubiquitous auxiliary fractures and breaks with small displacements on the west side of the London Fault have provided the locus for prolific gold-silver-lead-zinc mineralization formerly exploited by the North London, South London, London Extension, and Butte Mines. The New York, Sherwood, and Mudsill silver-lead-zinc mines are adjacent to the main fault and are probably genetically related to it (Singewald and Butler, 1941).

SHERMAN FAULT

The Sherman Fault, which has a strike length of about 5 miles, is a northwest-trending, southwest-dipping, reverse fault located between the London and Weston Faults (Figure 3) (Singewald and Butler, 1941). The Hilltop silver-lead-zinc mine is located approximately 0.5-mile southwest of the structure. Fractures adjacent to the Sherman Fault provided conduits for fluids that formed the Hilltop Mine ore deposit.

FRONTAL FAULT

The Frontal Fault is a north-northwest-trending, north-east-dipping, reverse (?) fault located in northwest Park County (Figure 3).

WESTON FAULT

The Weston Fault is a north northwest-trending, south-west-dipping normal fault located in the Mosquito Range and has a strike length of about 14 miles (Figure 3). Stark and others (1949) and Behre (1939) consider the structure to represent a southern extension of the Mosquito Fault. Maximum vertical displacement is on the order of 3,000 feet. Evidence for both dip reversal and reverse movement is observed locally on the Weston Fault (Stark and others, 1949).

CURRANT CREEK FAULT

The Currant Creek Fault is a north northwest-trending, east northeast dipping, normal(?) fault. It extends for

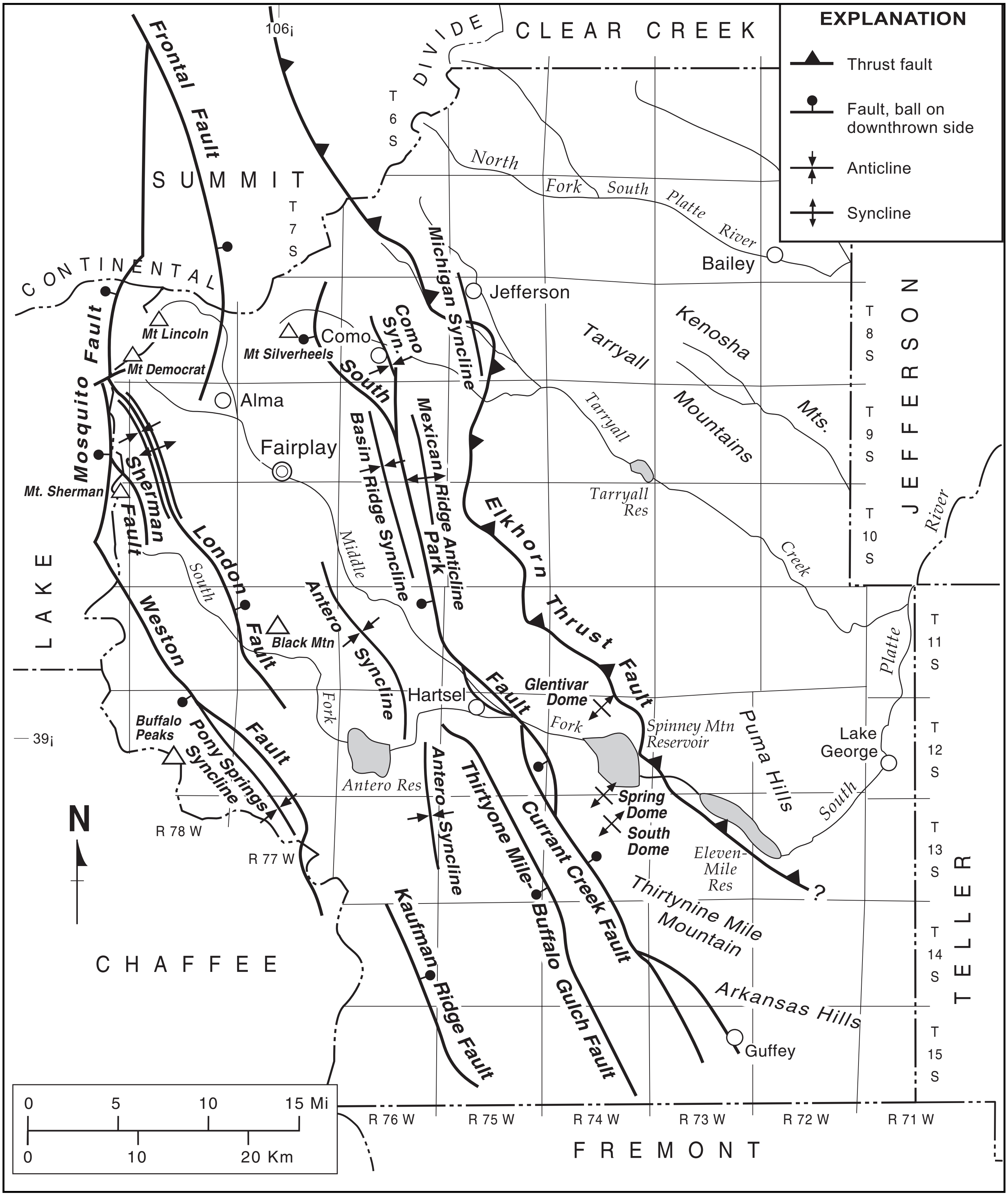


Figure 3. Principal structural features, Park County, Colorado (modified from Stark and others, 1949).

about 30 miles (Figure 3) from the southern terminus of the South Park Fault near the south end of Reinecker Ridge in central Park County south south-eastward across much of Thirtynine Mile volcanic field to Currant Creek Pass between Thirtynine Mile Mountain and Dicks Peak in southwest Park County. The trace of the Currant Creek and South Park Faults may represent a continuation. Opposing dips suggest that they are separate faults; however, both may be related to movement on the west-dipping Elkhorn thrust. The normal Currant Creek Fault may result from overturning and, prior to movement on the Elk Creek Thrust Fault, may have been a reverse fault.

THIRTYONE MILE-BUFFALO GULCH FAULT

The Thirtyone Mile-Buffalo Gulch Fault is a north northwest-trending, southwest-dipping, normal (?) fault located in southwest Park County (Figure 3).

KAUFMAN RIDGE FAULT

The Kaufman Ridge Fault is a north northwest-trending, northeast-dipping, reverse (?) fault located in southwest Park County that exhibits a strike length of approximately 12 miles (Figure 3).

SOUTH PARK FAULT

The South Park Fault is a north northwest-trending, west southwest dipping, reverse (?) fault that extends about 30 miles from northwest to central Park County (Figure 3). The South Park Fault lies on the west side of Bald and Boreas Mountains near the county line, extends along the west side of Little Baldy Mountain, parallels the east side of Reinecker Ridge, and terminates against the Currant Creek Fault near the southern end of Reinecker Ridge. The South Park Fault is estimated to have vertical displacement of 1,200–6,000 feet and horizontal displacement of 2,500–5,000 feet (Stark and others, 1949).

ELKHORN THRUST FAULT

The Elkhorn Thrust Fault is a north-northwest to north-northeast-trending, northeast-dipping, sinuous thrust fault extending for over 60 miles across central and northwest Park County (Figure 3). The structure juxtaposes Early and Middle Proterozoic age metamorphic and igneous rocks over Cretaceous and Tertiary sedimentary and volcanic rocks.

MAJOR FOLDS

The most obvious folds in northwest Park County are long narrow structures directly associated with major reverse faults. Their formation was a multi-stage process; early compressional movements produced folds that subsequently ruptured to form reverse faults, and continued movement along the faults later created drag folds. The most notable examples are (Singewald and Butler, 1941): 1), the north-northwest-trending London or Sheep Mountain Anticline and an unnamed syncline pair associated with the London fault. Structural contours on the top of the Leadville Limestone indicate that the plunge of these folds is to the southeast (Figure 3); 2), unnamed north northwest-to northwest-trending anticline-syncline pairs associated with the Sherman Fault. Structural contours on the top of the Leadville Limestone indicate that the plunge of these folds is the to the southeast. Folding related to regional compression is present in other areas of Park County, but is subdued. In the northwest Park County, folding is manifest in structural terraces with anticlinal and synclinal noses. An example is the northwest-trending anticline whose axis passes between Mount Lincoln and Mount Bross (Singewald and Butler, 1941). Folds related to regional compression are summarized below (Stark and others, 1949):

MICHIGAN RIDGE SYNCLINE

Michigan Ridge Syncline is located in northwest Park County. It is a broad, canoe-shaped syncline, the axis of which trends about 335 degrees (Figure 3). The east limb of the fold is covered by Proterozoic metamorphic rocks that constitute the upper plate of the west directed, east-dipping Elkhorn thrust. The west limb of the fold is marked by a ridge located about 3 miles west of Michigan Ridge, which is composed of the basal Denver (South Park?), Laramie, and Fox Hills Formations (Stark and others, 1949).

COMO SYNCLINE

Como Syncline is located in northwest Park County and is superimposed on the west limb of South Park Basin (Figure 3). The subordinate structure extends from at least 2 miles northwest of Como to the southwest into South Park; its axis strikes northwest and passes through the town of Como (Stark and others, 1949). The structure is best outlined by beds of the Denver (South Park) and Laramie Formations (Stark and others, 1949). South of Como faulting obscures the structure.

BASIN (REINECKER?) RIDGE SYNCLINE

Basin (Reinecker?) Ridge Syncline is a narrow, north northwest trending, doubly plunging, asymmetric structure whose axis roughly parallels the topographic feature of Basin Ridge (Reinecker?) Ridge in northwest and central Park County (Figure 3). The east limb dips 30–50 degrees; the west limb dips 20–30 degrees. The structure is well defined by units of the Denver (South Park) Formation. Both limbs and noses have prominent topographic expression (Stark and others, 1949).

MEXICAN RIDGE ANTICLINE

Mexican Ridge Anticline is located in northwest Park County and in northwest-trending and south plunging. It is the anticlinal complement of the adjacent Basin (Reinecker?) Ridge syncline (Figure 3). Mexican Ridge is composed of the Fox Hill, Laramie, and basal Denver (South Park?) formations that form the east limb of the Mexican Ridge anticline (Stark and others, 1949).

ANTERO SYNCLINE

Antero Syncline is centered about four miles east-southeast of Antero Junction in southwest Park County. The Antero Syncline is easily visible owing to lacustrine beds of the Antero Formation which make up the ridge (Figure 2). The northerly trending, doubly plunging structure is about 6 miles long and 4 miles wide (Stark and others, 1949).

PONY SPRINGS SYNCLINE

Pony Springs Syncline is located in southwest South Park in south-central Park County. The Pony Springs Syncline is northwest trending, doubly plunging, and about 10 miles long (Figure 3). The west limb is exposed between the spurs extending southeast of Buffalo Peaks and Coffman Ridge; the east limb is truncated by the Weston Fault. Although the west limb is significantly narrower than the east limb, both dip about 30 degrees toward the axis. Small cuestas composed of resistant Permo-Pennsylvanian and other units outline the structure (Stark and others, 1949).

SOUTH DOME

South dome is the largest of three small domes located just west of the Elkhorn Thrust Fault in southern South Park in southwest Park County (Figure 3). It is located in sections 10, 11, 14, and 15, T. 13 S., R. 74 W. The 3-mile axis of the structure trends 320–325 degrees. The width of the dome is about 1.5 mi. Proterozoic granodiorite is exposed in the center of the dome rimmed by Cretaceous sedimentary rocks that range from Lower Cretaceous Dakota Sandstone to Upper Cretaceous Pierre Shale (Stark and others, 1949).

GLENTIVAR DOME

Glentivar dome is the second largest of three small domes located west of the Elkhorn thrust in southern South Park in southwest Park County (Figure 3). The dome is located in sections 3, 4, and 10, T.12 S., R. 74 W. and forms an oval hill about one mile long and 0.5 mile wide, which is capped by the Dakota Sandstone. The Dakota Sandstone dips 25 to 30 degrees quaquaversally Stark and others, 1949).

SPRING DOME

Spring dome is the smallest of the three domes located west of the Elkhorn Thrust Fault in southern South Park in southwest Park County (Figure 3). It is located in section 34, T. 11 S., R. 74 W., and is structurally similar to the Glentivar dome. A small northwest-trending fault drops the northeast side of the structure (Stark and others, 1949).

Mines and Prospects

SUMMARY

Between 1859 and 1989 (when the London Mine shut down after the last of several brief post World War II revivals), mines in Park County produced in excess of 9,404,623 ounces of silver, 1,366,374 ounces of gold, 12,668,632 pounds of zinc, 63,333,051 pounds of lead, and 3,334,886 pounds of copper worth over $470 million at 1999 metal prices (silver—$5.00/ounce, gold—$280.00/ounce, zinc—$0.50/pound, lead = $0.50/pound, copper—$0.75/pound).

The USGS compiled data on over 235 mines and prospects in Park County within the Mineral Resource Data System (MRDS) database. Of this total, 101 occur in northwest Park County, 49 occur in the east-central Park County, and 24 are located in southeast Park County. The remaining 61 mines and prospects are scattered. It is estimated, from an examination of topographic maps and other literature sources, that there are at least 600 old workings in the County. Half are located in northwest Park County. In northwest Park County, Reiber (unpublished report, 1999) documented the presence of over 3,000 patented mining claims. These inactive and abandoned mines and prospects are distributed among 9 major and 26 minor districts (Figure 4). The most important mines and districts are located east of the crest of the Mosquito Range and west of U.S. Highway 285 and Colorado State Highway 9 in northwest Park County. From north to south, the most productive districts are classified as subdistricts within the Greater Alma district. These are Consolidated Montgomery, Buckskin (also known as Buckskin Joe), Horseshoe, Mosquito, Pennsylvania, and Sacramento. Tarryall Creek, Beaver Creek, and Fairplay districts lie adjacent to the Greater Alma district.

Other, less important districts are dispersed throughout Park County. These include Bath, Black Mountain, Buffalo Peak, Como, Cresson-Princeton, Fairmount, Florissant-Fish Creek, Garo, Guffey (also known as Fourmile, Freshwater, Alhambra, and Red Ruth), Halls Valley, Hartsel, Iron Hill, Kenosha Pass, Lake George (Badger Flats)-Pulver-Micanite, Michigan Creek, Mountaindale, Platte Ranch, Puma, Reynolds Switch, Shawnee, South Park, South Platte Pegmatite, Tarryall Springs, Weston Pass, Weston Springs, and Wilkerson Pass.

Mineral occurrences in the Park County mineral districts are diverse and include both lode and placer deposits. Gold, silver, zinc, and lead have been extracted from both deposit types. Other metallic commodities exploited in the past from lode deposits include copper, iron, manganese, molybdenum, radium, tin, titanium, thorium, tungsten, uranium, and vanadium. Deposit types include vein-,fissure-, fault-, and fracture-controlled mineralization, mantos, and stratabound and nonstratabound disseminated mineralization.

Non-metallic lode commodities include barite, beryl, feldspar, fluorite, garnet, mica, monazite, rare-earth elements, rhodochrosite, topaz, and vermiculite. Deposit types include manto, vein, pegmatite, skarn, greisen, and bulk-mineralized systems. Construction materials such as building stone, crushed stone, and sand and gravel also exist in the County. A significant amount of coal was mined in the late 1800s from the Como district and is present in outcrops of the Laramie Formation in the Kenosha Pass and Hartsel districts.

Most lode and placer production has come from northwest Park County, accounting for an estimated 95 percent of the precious metal and 85 percent of the base metal production from the County. Lode output was primarily from the Mosquito, Buckskin, Horseshoe, and Consolidated Montgomery subdistricts, especially from the London Mine Group, Sherman-Hilltop Mine complex, the cluster of mines centered on and around Mount Lincoln and Mount Bross (Russia and Moose Mines), and Phillips Mine Group. Placer output was primarily from Alma and Fairplay Placers on the South Platte River and from Tarryall Creek and Beaver Creek Placers that drain the south and east slopes of Mt. Silverheels. Aggregate production of the principal commodities from the various districts

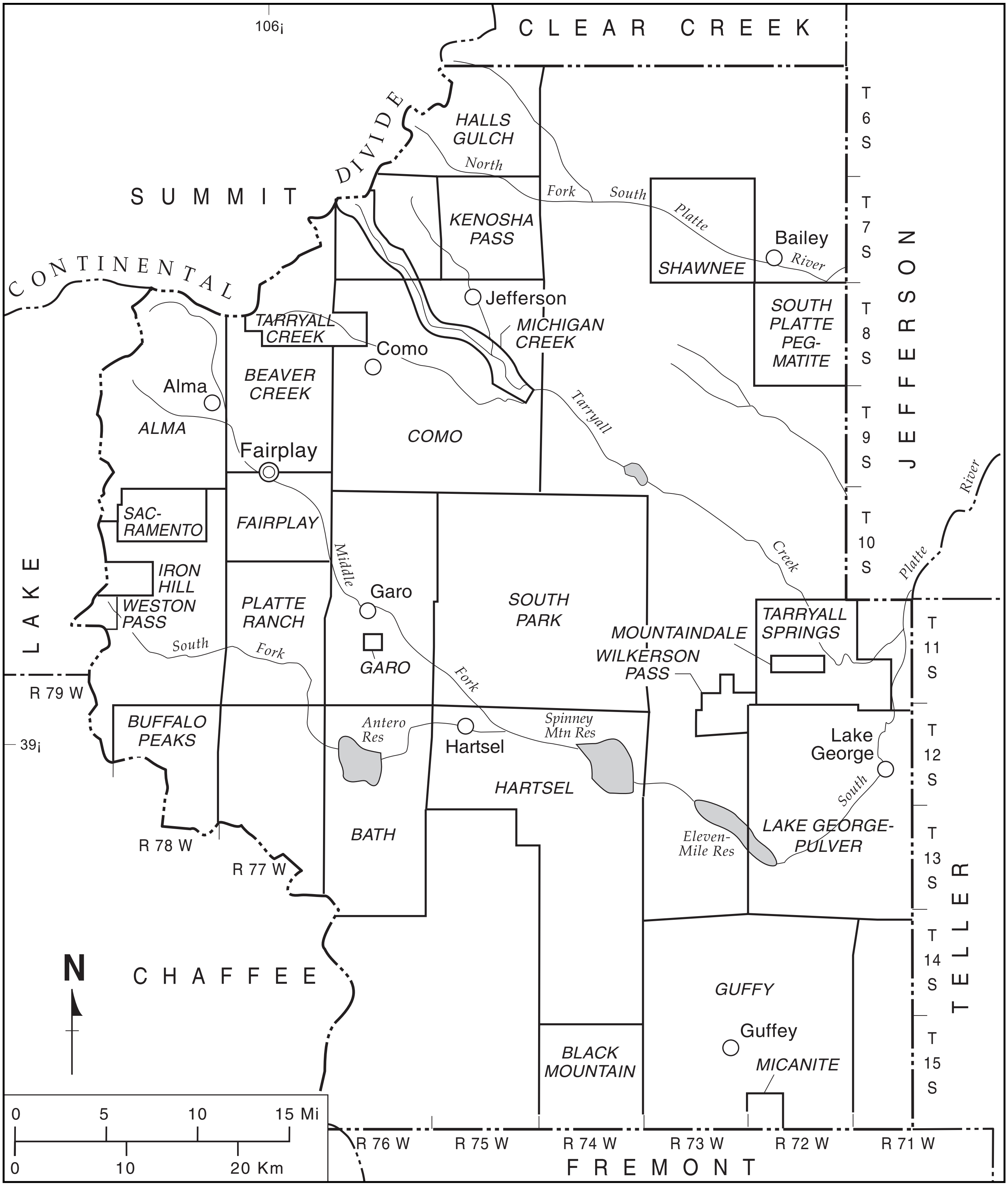


Figure 4. Mining districts, Park County, Colorado.

Table 1. Recovered metals from Park County lode and placer mines, 1859–1998 (U.S. Bureau of Mines Yearbooks). NA—data not available.

Year	Total Gold (oz)	Total Silver (oz)	Copper (lb)	Lead (lb)	Zinc (lb)
1859 –1867	120,580	NA	NA	NA	NA
1868	2421	NA	NA	NA	NA
1869	1937	NA	NA	NA	NA
1870	3,874	NA	NA	NA	NA
1871	1937	15,094	NA	5,000	NA
1872	2421	142,209	NA	50,000	NA
1873	3873	307,633	169,493	111,400	NA
1874	5,641	333,764	203,391	NA	NA
1875	5,050	412,022	72,150	25,000	NA
1876	2905	386,719	68,333	50,000	NA
1877	2905	309,375	170,000	150,000	NA
1878	2905	309,375	175,000	150,000	NA
1879	2905	324,844	200,000	300,000	NA
1880	2420	293,906	200,000	300,000	NA
1881	2,420	270,703	100,000	312,000	NA
1882	4,841	193,359	100,000	312,000	NA
1883	9,684	135,352	NA	312,000	NA
1884	2,904	193,359	NA	398,066	NA
1885	2,904	71,310	NA	398,066	NA
1886	7,180	71,310	NA	624,000	NA
1887	31,401	107,513	NA	708,713	NA
1888	1643	450,457	NA	7,641,720	NA
1889	6,040	224,743	855	4,640,682	NA
1890	1804	156,975	NA	1,886,504	NA
1891	2436	185,200	NA	19,656	NA
1892	1,921	43,792	NA	25,698	NA
1893	5,318	62,350	10,000	30,000	NA
1894	4,714	43,817	10,000	30,000	NA
1895	6,379	46,658	2,938	98,791	NA
1896	6,639	117,095	28,593	297,714	NA
1897	7,439	199,945	58,002	4,517,614	NA
1898	7,722	198,711	20,957	1,953,001	NA
1899	7,410	72,137	7,903	540,849	NA
1900	5,643	43,138	15,000	682,107	NA
1901	4,663	69,175	9,657	421,955	NA
1902	6,897	49,968	8,113	261,046	NA
1903	6,599	52,128	5,895	802,489	NA
1904	9,441	50,013	5,920	757,703	NA
1905	15,537	49,202	12,199	543,303	NA
1906	19,130	144,815	14,399	966,193	NA
1907	24,852	111,215	NA	1,062,732	NA
1908	20,862	12,047	37,106	495,985	728,000
1909	26,726	102,375	61,023	2,237,093	366,574
1910	12,859	117,037	88,748	2,041,204	659,796
1911	2,848	69,072	24,216	923,089	407,772
1912	3,291	31,234	10,321	167,756	132,275
1913	2,422	94,293	29,161	506,046	98,623
1914	3,267	20,215	8,023	168,154	57,940
1915	7,715	9,227	12,303	190,830	472,992
1916	11,345	13,231	22,598	330,609	47,560
1917	5,682	14,705	12,824	278,709	NA
1918	3,059	18,280	12,704	233,873	NA
1919	6,273	70,949	20,436	305,908	NA
1920	6,917	51,023	18,674	1,085,625	NA
1921	1,996	47,547	7,550	654,090	NA
1922	6,881	15,528	4,215	155,982	NA
1923	7817	18,701	5,558	19,401	NA
1924	6,740	16,906	25,206	110,062	20,000
1925	2,555	15,657	18,000	77,500	2,000
1926	1,803	7,835	1,750	48,500	0
1927	1,921	3,913	3,298	39,477	2,487
1928	12,321	8,684	6,583	163,724	0
1929	10,003	8,953	1,693	148,206	0
1930	21,872	11,709	8,100	328,800	0
1931	42,172	28,531	21,198	779,190	0
1932	125,746	63,236	16,000	1,634,000	0
1933	60,146	40,526	82,000	1,319,300	0
1934	85,867	61,510	72,100	2,625,800	0
1935	71,942	62,294	92,000	1,908,500	0
1936	56,267	50,302	25,000	1,634,000	0
1937	48,733	61,357	67,000	1,272,000	6,000
1938	38,688	56,891	55,000	838,000	0
1939	43,467	38,691	69,000	1,078,000	0
1940	NA	NA	NA	NA	NA
1941	45,682	31,230	79,000	738,000	614,000
1942	37,370	26,830	78,400	543,600	912,000
1943	8,434	21,597	68,000	400,000	1,133,000
1944	2,300	15,826	53,000	160,000	1,124,000
1945	8,538	11,340	36,000	102,000	764,000
1946	20,088	15,995	17,000	122,000	683,000
1947	15,123	20,890	20,800	160,300	764,600
1948	9,120	7,867	2,000	104,000	280,000
1949	10,205	14,829	6,000	238,000	506,000
1950	16,321	11,363	28,000	116,000	510,000
1951	13,266	10,121	30,000	124,000	520,000
1952	2,019	6,193	30,000	64,000	456,000
1953	1,470	7,659	26,000	66,000	550,000
1954	509	3,927	10,000	36,000	198,000
1955	30	647	6,000	6,000	4,000
1956	70	895	6,500	9,600	19,700
1957	264	13,547	8,900	433,300	117,800
1958	58	37,886	12,000	1,354,000	0
1959	80	26,992	6,000	796,000	0
1960	16	804	6,000	14,000	18,000
1961	98	726	2,000	6,000	2,000

Table 1. Continued.

Year	Total Gold (oz)	Total Silver (oz)	Copper (lb)	Lead (lb)	Zinc (lb)
1962	0	0	0	0	0
1963	20	5,352	2,000	84,000	16,000
1964	181	15,340	12,000	168,000	116,000
1965	79	24,346	22,000	372,000	92,000
1966	69	17,881	10,000	244,000	36,000
1967	468	161	0	900	0
1968	187	3,366	2,000	24,000	82,000
1969	112	2,237	4,000	16,000	106,000
1970	54	67	900	2,000	6,000
1971	42	0	0	0	
1972	84	1,108	0	0	0
1973	0	0	0	0	0
1974	0	0	0	0	0
1975	0	0	0	0	0
1976	0	0	0	0	0
1977	0	0	0	0	0
1978	0	0	0	0	0
1979	96	9,394	900	900	0
1980	Withheld	18,915	0	586,000	0
1981	378	67,894	12,000	154,000	56,000
1982	Withheld	44,652	Withheld	36	0
1983	Withheld	Withheld	Withheld	Withheld	0
1984	Withheld	Withheld	Withheld	Withheld	0
1984	0	0	0	0	0
1986	0	0	0	0	0
1987	NA	NA	NA	NA	NA
1988	NA	NA	NA	NA	NA
1989	NA	NA	NA	NA	NA
1990	NA	NA	NA	NA	NA
1991	NA	NA	NA	NA	NA
1992	NA	NA	NA	NA	NA
1993	NA	NA	NA	NA	NA
1994	NA	NA	NA	NA	NA
1995	NA	NA	NA	NA	NA
1996	NA	NA	NA	NA	NA
1997	NA	NA	NA	NA	NA
1998	NA	NA	NA	NA	NA
TOTAL	1,328,369	7,989,717	3,205,586	62,430,051	12,688,119

Table 2. Lode vs. placer recovery of precious metals from Park County mines, 1859–1998 (U.S. Bureau of Mines Yearbooks). NA—data not available.

Year	Lode Gold (oz)	Placer Gold (oz)	Total Gold (oz)	Lode Silver (oz)	Placer Silver (oz)	Total Silver (oz)
1859–1867	34,382	86,198	120,580	NA	NA	NA
1868	NA	2,421	2421	NA	NA	NA
1869	NA	1,937	1937	NA	NA	NA
1870	1,937	1,937	3,874	NA	NA	NA
1871	NA	1,937	1937	NA	NA	15,094
1872	NA	2,421	2421	NA	NA	142,209
1873	968	2,905	3873	NA	NA	307,633
1874	2,421	3,220	5,641	NA	NA	333,764
1875	1,176	3,874	5,050	NA	NA	412,022
1876	968	1,937	2905	NA	NA	386,719
1877	968	1,937	2905	NA	NA	309,375
1878	968	1,937	2905	NA	NA	309,375
1879	968	1,937	2905	NA	NA	324,844
1880	968	1,452	2420	NA	NA	293,906
1881	1,210	1,210	2,420	NA	NA	270,703
1882	3,631	1,210	4,841	NA	NA	193,359
1883	8,716	968	9,684	NA	NA	135,352
1884	1,452	1,452	2,904	NA	NA	193,359
1885	1,452	1,452	2,904	NA	NA	71,310
1886	5,728	1,452	7,180	NA	NA	71,310
1887	22,201	9,200	31,401	NA	NA	107,513
1888	530	1,113	1643	NA	NA	450,457
1889	4,007	2,033	6,040	NA	NA	224,743
1890	661	1,143	1804	NA	NA	156,975
1891	774	1,662	2436	NA	NA	185,200
1892	1,437	484	1,921	NA	NA	43,792
1893	3,866	1,452	5,318	NA	NA	62,350
1894	2,777	1,937	4,714	NA	NA	43,817
1895	4,927	1,452	6,379	NA	NA	46,658
1896	5,429	1,210	6,639	NA	NA	117,095
1897	6,519	920	7,439	NA	NA	199,945
1898	7,384	338	7,722	NA	NA	198,711
1899	6,442	968	7,410	NA	NA	72,137
1900	4,772	871	5,643	NA	NA	43,138
1901	3,792	871	4,663	NA	NA	69,175
1902	6,220	677	6,897	NA	NA	49,968
1903	6,018	581	6,599	NA	NA	52,128
1904	8,957	484	9,441	NA	NA	50,013
1905	15,403	134	15,537	NA	NA	49,202
1906	18,642	488	19,130	NA	NA	144,815
1907	24,516	336	24,852	NA	NA	111,215

Table 2. Continued.

Year	Lode Gold (oz)	Placer Gold (oz)	Total Gold (oz)	Lode Silver (oz)	Placer Silver (oz)	Total Silver (oz)
1908	20,278	584	20,862	NA	NA	12,047
1909	25,547	1,179	26,726	NA	NA	102,375
1910	12,237	622	12,859	NA	NA	117,037
1911	1,666	1,182	2,848	NA	NA	69,072
1912	2,361	930	3,291	NA	NA	31,234
1913	1,708	714	2,422	NA	NA	94,293
1914	2,138	1,129	3,267	NA	NA	20,215
1915	7,241	474	7,715	NA	NA	9,227
1916	10,841	504	11,345	NA	NA	13,231
1917	5,419	263	5,682	NA	NA	14,705
1918	3,059	NA	3,059	NA	NA	18,280
1919	6,073	200	6,273	NA	NA	70,949
1920	6,892	25	6,917	NA	NA	51,023
1921	1,976	20	1,996	NA	NA	47,547
1922	2,065	4,816	6,881	NA	NA	15,528
1923	821	6,996	7817	NA	NA	18,701
1924	1,258	5,482	6,740	15,712	1,194	16,906
1925	2,527	28	2,555	15,650	7	15,657
1926	1,797	6	1,803	7,835	0	7,835
1927	1,907	14	1,921	3,908	5	3,913
1928	12,321	0	12,321	8,684	0	8,684
1929	10,003	0	10,003	8,953	0	8,953
1930	21,868	4	21,872	11,709	0	11,709
1931	42,167	5	42,172	28,531	0	28,531
1932	NA	NA	125,746	NA	NA	63,236
1933	59,900	246	60,146	40,480	46	40,526
1934	83,910	1,957	85,867	61,214	296	61,510
1935	67,134	4,808	71,942	61,454	840	62,294
1936	52,933	3,334	56,267	49,681	621	50,302
1937	42,275	6,458	48,733	60,724	5,643	61,357
1938	34,109	4,579	38,688	56,034	857	56,891
1939	34,597	8,870	43,467	36,926	1,765	38,691
1940	NA	NA	NA	NA	NA	NA
1941	24,415	21,267	45,682	27,343	3,887	31,230
1942	17,189	20,181	37,370	23,154	3,676	26,830
1943	8,420	14	8,434	21,593	4	21,597
1944	2,296	4	2,300	15,826	0	15,826
1945	1,177	7,361	8,538	10,049	1,291	11,340
1946	NA	NA	20,088	NA	NA	15,995
1947	NA	NA	15,123	NA	NA	20,890
1948	NA	NA	9,120	NA	NA	7,867
1949	NA	NA	10,205	NA	NA	14,829
1950	NA	NA	16,321	NA	NA	11,363
1951	NA	NA	13,266	NA	NA	10,121
1952	NA	NA	2,019	NA	NA	6,193
1953	NA	NA	1,470	NA	NA	7,659
1954	NA	NA	509	NA	NA	3,927
1955	NA	NA	30	NA	NA	647
1956	NA	NA	70	NA	NA	895
1957	NA	NA	264	NA	NA	13,547
1958	NA	NA	58	NA	NA	37,886
1959	NA	NA	80	NA	NA	26,992
1960	NA	NA	16	NA	NA	804
1961	NA	NA	98	NA	NA	726
1962	0	0	0	0	0	0
1963	NA	NA	20	NA	NA	5,352
1964	NA	NA	181	NA	NA	15,340
1965	NA	NA	79	NA	NA	24,346
1966	NA	NA	69	NA	NA	17,881
1967	NA	NA	468	NA	NA	161
1968	NA	NA	187	NA	NA	3,366
1969	NA	NA	112	NA	NA	2,237
1970	NA	NA	54	NA	NA	67
1971	NA	NA	42	NA	NA	0
1972	NA	NA	84	NA	NA	1,108
1973	NA	NA	0	NA	NA	0
1974	NA	NA	0	NA	NA	0
1975	NA	NA	0	NA	NA	0
1976	NA	NA	0	NA	NA	0
1977	NA	NA	0	NA	NA	0
1978	NA	NA	0	NA	NA	0
1979	NA	NA	96	NA	NA	9,394
1980	NA	NA	Withheld	NA	NA	18,915
1981	NA	NA	378	NA	NA	67,894
1982	NA	NA	Withheld	NA	NA	44,652
1983	NA	NA	Withheld	NA	NA	Withheld
1984	NA	NA	Withheld	NA	NA	Withheld
1984	NA	NA	0	NA	NA	0
1986	NA	NA	0	NA	NA	0
1987	NA	NA	NA	NA	NA	NA
1988	NA	NA	NA	NA	London re-opened 6/88	NA
1989	NA	NA	NA	NA	London shut-down 6/9/89	NA
1990	NA	NA	NA	NA	NA	NA
1991	NA	NA	NA	NA	NA	NA
1992	NA	NA	NA	NA	NA	NA
1993	NA	NA	NA	NA	NA	NA
1994	NA	NA	NA	NA	NA	NA
1995	NA	NA	NA	NA	NA	NA
1996	NA	NA	NA	NA	NA	NA
1997	NA	NA	NA	NA	NA	NA
1998	NA	NA	NA	NA	NA	NA
Total			1,328,369			7,989,717

during the main period of mining activity in Park County are shown in Tables 1 and 2.

MINERAL DEPOSIT TYPES OF NORTHWEST PARK COUNTY

Metallic mineral deposits of northwest Park County (the Greater Alma district) contain primarily gold, silver, lead, zinc, and copper in sedimentary-hosted deposits of Paleozoic age. Although zoning among some groupings of deposits is observed, regional zoning is poorly developed in the district (Shawe, 1990). Vein-type deposits carrying the highest gold values lie along the London Fault near the central portion of the district, and silver-lead manto deposits generally occur 0.5-5.0 miles from the fault. The manto deposits show internal zoning, constituting a silver-rich core with prominent barite on the periphery. Additionally, some veins transition downward into Proterozoic-hosted silver-lead-manganese veins, grading into gold-pyrite veins. Ores of the Greater Alma district were probably formed 35 Ma years ago from magmatic and connate solutions heated by intrusion of various porphyry phases (Shawe, 1990).

Five types of base- and precious-metal deposits occur in northwest Park County, based on their geometry and the metals present (Vanderwilt, 1947; Shawe, 1990).

GOLD VEINS OF THE LONDON MINE TYPE

This prolific and productive vein-type deposit, typified by the London Mine group, carries about equal weights of gold and silver, and is composed of quartz with subordinate pyrite, sphalerite, galena, and chalcopyrite (Vanderwilt, 1947). Notable mines of this type include the North London, South London, London Extension, and Butte mines of the Mosquito district (Figure 5). Gold grades during early mining averaged 1.86 opt (ounces per ton) (Shawe, 1990). Significant lead and silver and subordinate zinc was also recovered from the ores, but grades are not available. Mineralized veins strike parallel to the north-northwest trending, northeast-dipping London Fault, and occupy auxiliary southwest-dipping fissures occurring along the footwall of the structure. The fissures are subparallel to the upturned strata that are formed by drag against the main fault (Figure 6) (Vanderwilt, 1947). Host rocks are composed of a 175–275 foot thick shattered zone near the base of Pennsylvanian Minturn or Belden (Weber?) Formation where siltstone, sandstone, and shale beds are intruded by a series of thick quartz monzonite and rhyolite sills (the London ore porphyry zone). However, Pennsylvanian Minturn or Belden Formation above the sills as well as the upper dolomitic portions of the Mississippian Leadville Limestone and Devonian-Mississippian Dyer Dolomite also host ore of the London Mine-type (Singewald and Butler, 1941; Vanderwilt, 1947).

GOLD VEINS AND MANTOS IN THE SAWATCH QUARTZITE

Polymetallic precious- and base metal sulfide veins, with attendant mantos of very modest size exhibiting a gold to silver ratio ranging from 1:1 to 1:10, are hosted by the Cambrian Sawatch Quartzite (Figure 7) (Patton and others, 1912; Vanderwilt, 1947; Shawe, 1990). Ores are mostly oxidized, but hypogene by-product minerals include sphalerite, galena, and chalcopyrite; gangue minerals include ferroan dolomite, pyrite, and quartz (Vanderwilt, 1947). Mines of this type include the Paris, Phillips, and Orphan Boy of the Buckskin subdistrict, and the Atlantic-Pacific of the Consolidated Montgomery subdistrict (Figure 5) (Singewald and Butler, 1941; Shawe, 1990). Grades in quartzite-hosted deposits exhibit wide variation, even within contiguous deposits. Individual ore shoots within the Orphan Boy Mine averaged 0.05–0.30 opt gold and 0.30–10.0 opt silver; base metals varied from 5.0–10.0 percent lead, 3.0–35.0 percent zinc (Shawe, 1990).

SILVER-LEAD MANTOS AND VEINS IN CARBONATE HOST ROCKS

Stratabound, blanket-like, base and precious metal bodies (mantos) that follow the course of solution channels and attendant feeder veins are hosted by various carbonate units of Paleozoic age (Figure 8). Ore minerals include semi-oxidized argentiferous galena, sphalerite, and subordinate pyrite, with minor chalcopyrite, tetrahedrite, and freibergite; gangue minerals include ferroan dolomite, barite, jasperoid, and quartz (Vanderwilt, 1947; Shawe, 1990). Although the most ubiquitous and largest deposits occur in dolomite of the upper Mississippian Leadville Limestone similar significant, but smaller, deposits occur in all other pre-Pennsylvanian carbonate units, such as the Lower Ordovician Manitou Limestone, and Devonian-Mississippian Dyer Dolomite (Vanderwilt, 1947). Mines of this type include the Russia, Moose, and Dolly Varden in the Consolidated Montgomery subdistrict, the Hock Hocking in the Buckskin subdistrict, the Sherman and New York in the Mosquito subdistrict, the Hilltop in the Horseshoe subdistrict, and the Sherwood, Sacramento, Mudsill, and Wagner in the Sacramento subdistrict (Figure 5) (Singewald, and Butler, 1941). Ore grades in manto and vein deposits are reported to be 6.0–10.0 percent lead, 5.016 percent zinc, 14–100 opt

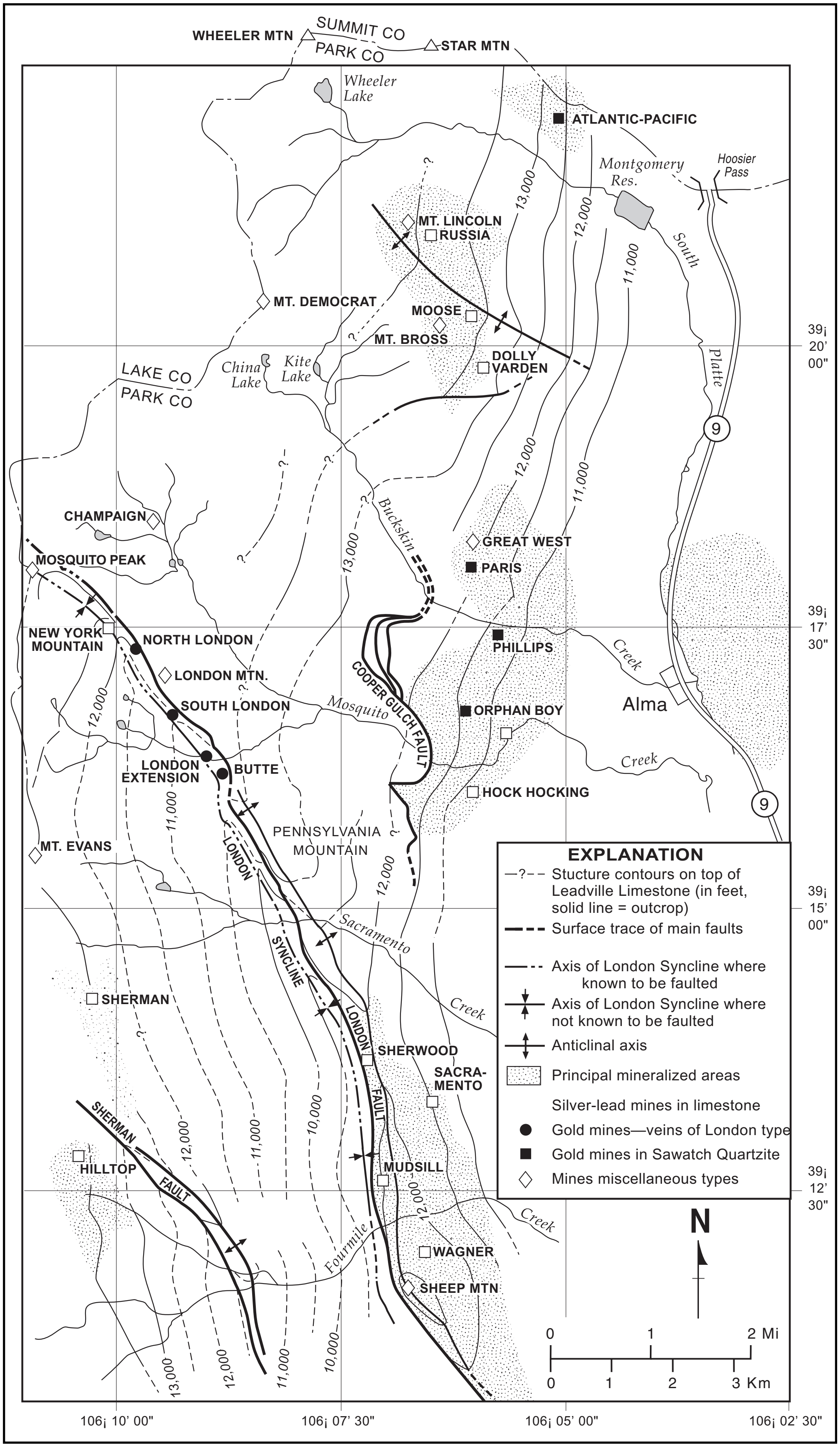


Figure 5. Areas of high mineral potential, northwest Park County, Colorado (modified from Singewald and Butler, 1941).

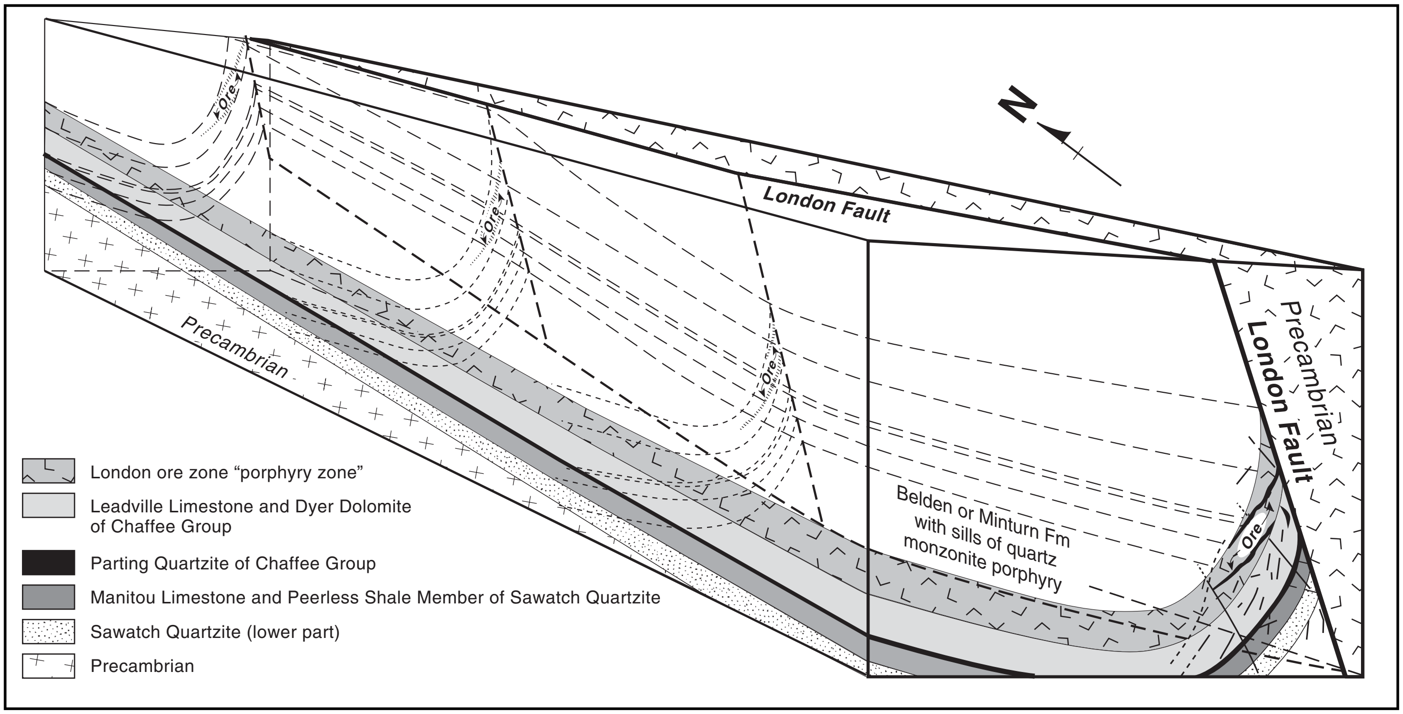


Figure 6. Structural and stratigraphic ore controls at the London gold mine, Park County, Colorado (Singewald and Butler, 1941).

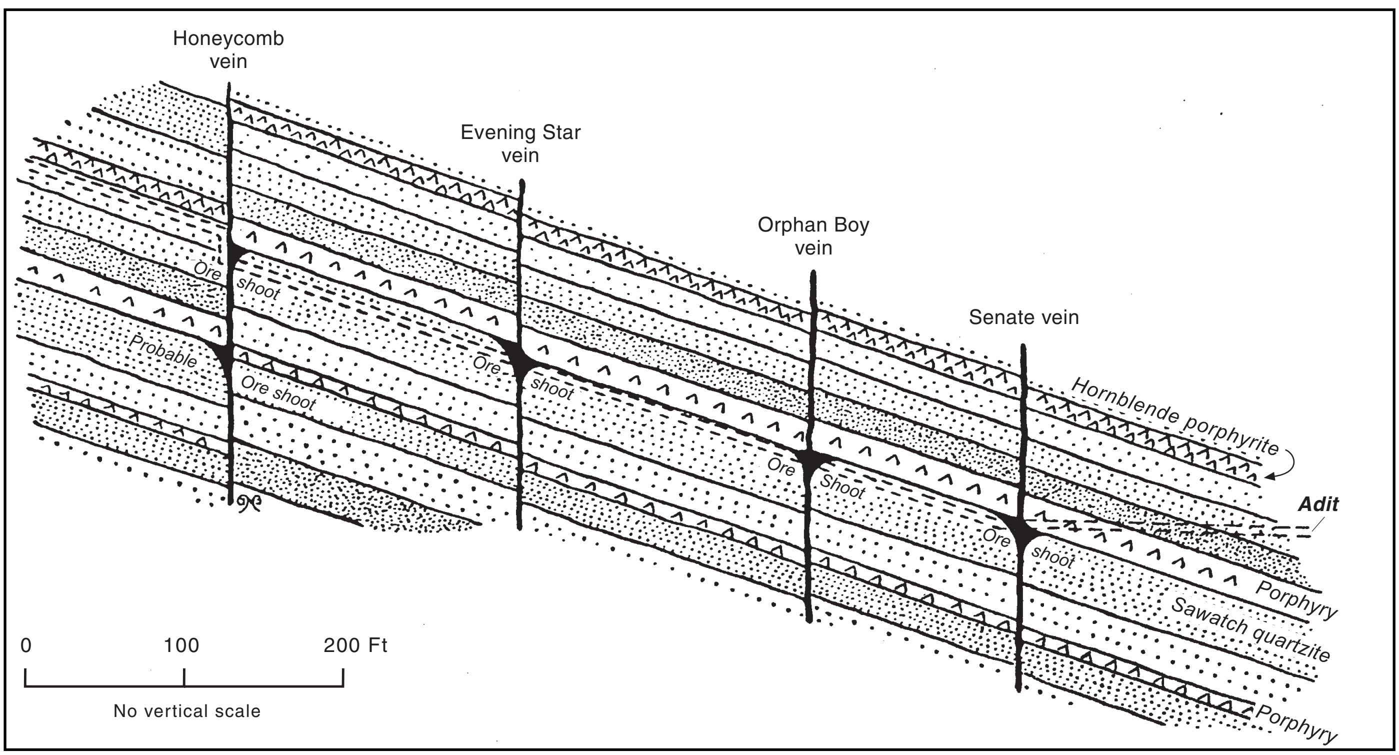
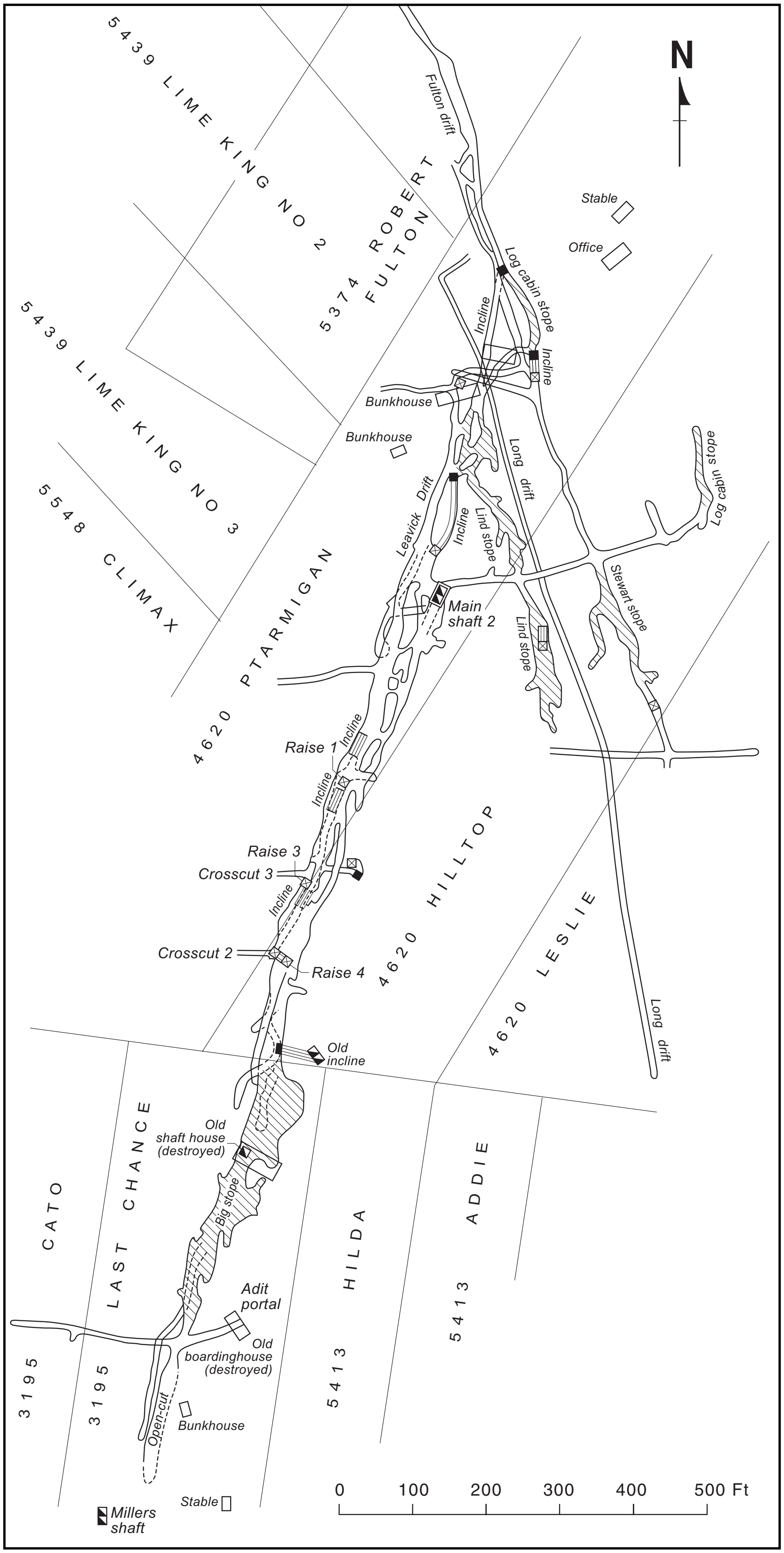


Figure 7. Distribution of mantos and veins at the Orphan Boy gold mine, Park County, Colorado (Patton, Hoskin, and Butler, 1912).



silver, and 0.04–0.26 opt gold; ore grades up to 0.75 opt gold, 700 opt silver, and 33.5 percent zinc are reported from some mines (Shawe, 1990).

MISCELLANEOUS TYPES OF BASE- AND PRECIOUS- METAL AND NONMETALLIC VEINS IN PROTEROZOIC ROCK

Some vein deposits are hosted in Proterozoic igneous and metamorphic rock and include the following commodities in a variety of metallic combinations: gold, silver, copper, lead, zinc, iron, molybdenum, tin, tungsten, bismuth, cobalt, uranium, vanadium, manganese, and fluorite. Mines of this type include the Great West in the Buckskin subdistrict and the Champaign of the Mosquito district (Figure 5) (Singewald and Butler, 1941).

The Sweet Home Mine is in Buckskin Gulch and was originally located as a silver mine in 1876. The veins and fractures are hosted by a white Proterozoic biotite granodiorite that is heavily altered around the veins and fractures. The graniodiorite was intruded into the surrounding Proterzoic gneiss. The Sweet Home Mine was not successful as a silver mine, however, the large rhodochrosite crystals found in the fractures attracted attention as early as the 1870s (Voynick, 1998).

There are three main fracture directions observed at the Sweet Home Mine; an early northwest to east-west fracture trend that is parallel to the foliation in the surrounding Proterozoic gneisses; a northeast

Figure 8. Distribution of workings and claims at the Hilltop-Last Chance lead-zinc-silver mine, Park County, Colorado (Behre, 1953). Refer to Plate 1 for location.

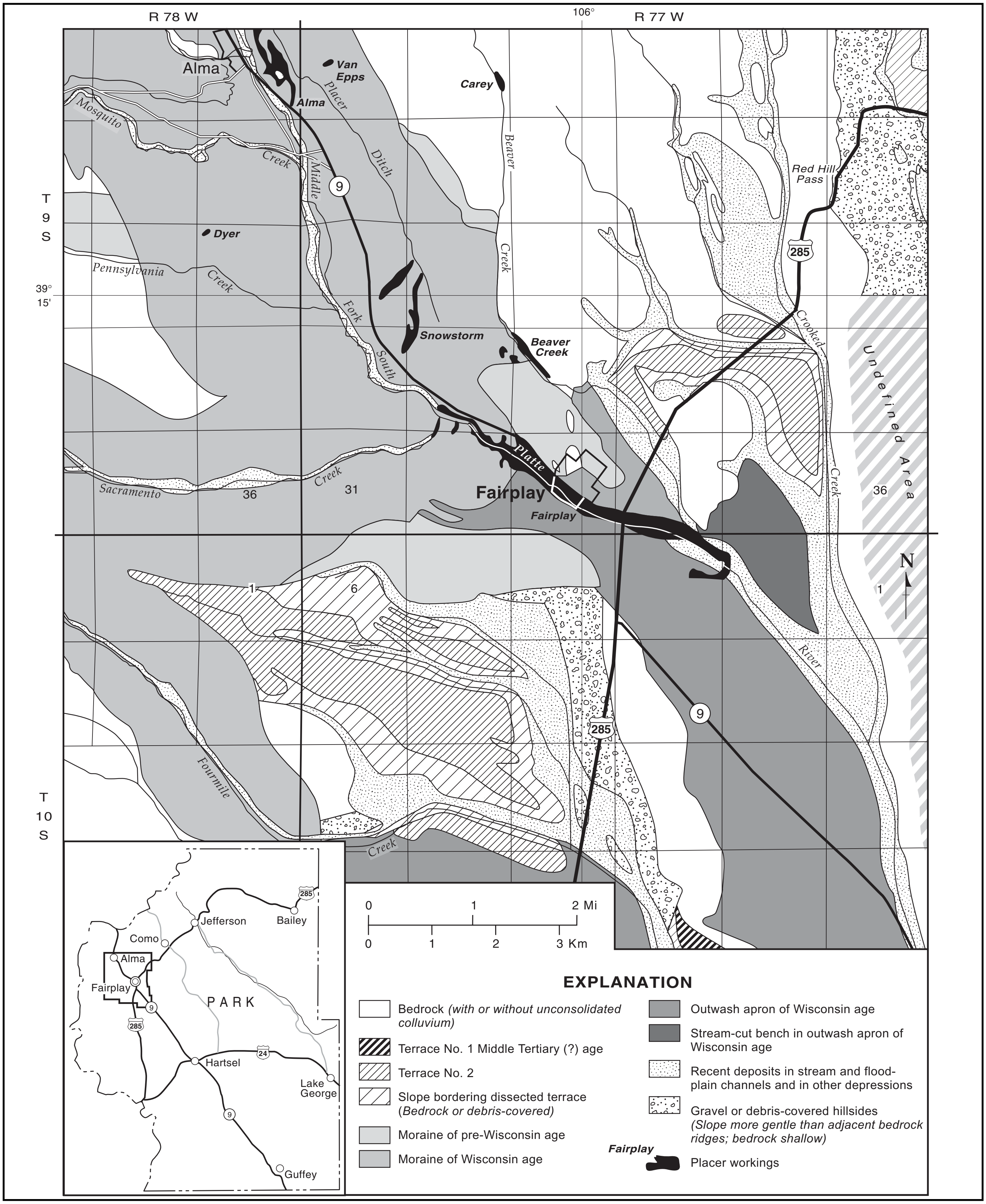


Figure 9. Geologic setting of the Fairplay gold placer, Park County, Colorado (modified after Singewald, 1950).

fracture system that contains the majority of the silver-base metal mineralization; and a later north-south fracture system. The large, deep-red rhodochrosite crystals are found primarily in fracture intersections (Misantoni and others, 1998). The mine is currently (2001) operating as a gemstone mine only.

PLACER GOLD DEPOSITS IN PLEISTOCENE AND QUATERNARY ALLUVIUM

Placer gold deposits are hosted by glacial moraines and outwash aprons of Pleistocene age and in alluvium of present day (Recent) streams (Patton and others, 1912; Vanderwilt, 1947; Singewald, 1950). Greatest production is from the outer portion of distal terminal moraines and the proximal portions of outwash aprons associated with the maximum advance of Wisconsin-stage glaciation in South Platte Valley (Figure 9). Successional and lateral moraines have also been placer mined at some locations. Although the largest deposits with the highest grades of gold lies adjacent to bedrock in channel deposits, two lenticular paystreaks, each about one foot thick and 10–50 feet wide, are commonly found at 10 feet and 25 feet above bedrock (Singewald, 1950). Rarely, another less rich and more lenticular auriferous layer is present.

The most prolific placers were Fairplay, Alma, and Snowstorm Placers in the South Platte River Valley (Figure 9); the first was worked by opencut, hydraulic mining, and bucketline dredging; the other two were exploited by extensive opencut and hydraulic mining (Vanderwilt, 1947; Singewald, 1950). Other notable placers include Beaver Creek, Carey, and Miller-Sheldon placers on Beaver Creek, and the Peabody-Fortune, Ironwood, and Deadwood placers on Tarryall Creek (Singewald, 1950). Although over half of the total output of placer gold took place between the time of first discovery in 1859 and 1868, substantial, sometimes intermittent, production continued through mid-January, 1952. Fineness of the gold averaged 0.800 between 1904 and 1938 (Singewald, 1950; 1952 U.S. Bureau of Mines Yearbook). Source of the placer gold in the South Platte River Valley and east-draining tributaries was probably the northeast-trending mineralized belt in the Mosquito Range where several areas of closely grouped and scattered lode deposits are present. Source of the gold for placers in the Upper Tarryall Creek drainage basin was probably the Montgomery-Deadwood mineralized area in northwest Park County about 2.5 miles southeast of the Continental Divide (Singewald, 1950).

TYPICAL MINES OF NORTHWEST PARK COUNTY

Detailed descriptions of some of the more productive mines in northwest Park County are summarized below, organized by deposit type.

GOLD VEINS OF THE LONDON MINE TYPE

LONDON MINE GROUP (LONDON, NORTH LONDON (VIENNA), SOUTH LONDON, LONDON EXTENSION, AND BUTTE MINES) OF THE MOSQUITO SUBDISTRICT, GREATER ALMA DISTRICT

LOCATION

The London Mine Group is located on both the north and south sides of London Mountain about 4.5-5.5 miles west of Alma in the Mosquito subdistrict, Greater Alma district (Figure 5).

HISTORY, PRODUCTION, AND GRADE

The London Mine Group is a structurally controlled polymetallic quartz-vein deposit that was discovered on the basis of mineralized float and sporadic outcrops in 1873. It was subsequently developed as a mine in 1875. Production was continuous until at least 1931, when recovery totaled 263,273 ounces of gold, 237,178 ounces of silver, 5,879,725 pounds of lead, and 165,520 pounds of copper (Singewald and Butler, 1931). Recovery of zinc did not commence until 1937 (Shawe, 1990). Operations were continuous from 1875 until 1942; following World War II, production was intermittent through 1989. The tenor of the ore is illustrated by the 52,588 net (short?) tons of ore mined between 1895 and 1910, which averaged 2.895 opt gold, 2.585 opt silver, 4.13 percent lead, 2.66 percent zinc, 4.85 percent iron, 6.11 percent sulfur, and 76.80 percent silicon (Singewald and Butler, 1941). An estimated 750,000–1,000,000 ounces of gold were recovered from the London Group of Mines, which includes the London, North London, South London, London Extension, and Butte Mines (Dean Misantoni, Consulting Geologist, personal communication, 1999). The most recent report states that proven, probable, and inferred reserves (including dumps on the London Mine Group) total 502,000 short tons of ore ranging from 0.10 to 0.41 opt gold, with a weighted average of 0.19 opt gold (Johansing and Misantoni, 1992).

FORM OF DEPOSIT AND COMPOSITION OF ORES

Composition of the London veins is dominated by microcrystalline to coarsely crystalline milky quartz containing variable amounts of interstitial, intimately intergrown, or crudely banded pyrite, dark-colored sphalerite, galena, and chalcopyrite. The quartz commonly exhibits a poorly developed comb structure, which may be locally accentuated by sulfide minerals (Singewald and Butler, 1941). The vein pinches and swells, but thickness of the vein ranges from one foot to five feet, and locally is as much as 10 feet thick (Patton and others, 1912). Calcite may be present. Locally, the sulfide mineral content equals the volume of the quartz. Most gold is not visible to the unaided eye, although free-gold flakes and tiny veinlets are associated with rich ore, and are observed within and near masses of intergrown sulfide minerals, at quartz-sulfide mineral contacts, or disseminated within the quartz. The tenor of the gold is correlative with the abundance of sphalerite, galena, and chalcopyrite; where the vein is comprised exclusively of quartz or quartz and pyrite, it is too low-grade to mine profitably (Singewald and Butler, 1941).

Wallrock Alteration

Wallrock alteration adjacent to the veins varies from strong to slight, depending on the enclosing lithology. The most intense alteration is observed where the veins cut through igneous sills of porphyry and quartz monzonite. Here, although the original textures are preserved, the rock has been completely replaced by quartz, sericite, and subordinate apatite and other accessory minerals. Away from the immediate vein- wallrock contact, carbonate minerals are also present. Shale adjoining veins is recrystallized and sericitized; quartzites and carbonate rock, although slightly sericitized, are relatively unaltered (Singewald and Butler, 1941).

Structural and Stratigraphic Controls

Structurally, mineralization is almost exclusively restricted to the west side (footwall) of the London Fault. The London Fault is a north northwest-striking reverse fault varying from N. 30 W. to N. 50 W. that dips from 60 degrees to vertical, and exhibits up to 3,000 feet of vertical displacement. Although some of the movement took place after mineralization, evidenced by small amounts of brecciated and crushed ore minerals, most of the movement probably occurred prior to mineralization, based on large amounts of gouge and crushed rock that is present within and adjacent to the fault (Singewald and Butler, 1941). Ore bodies occur within an asymmetric, drag-induced syncline adjoining the fault on its footwall (west) side, and are further localized by auxiliary faults and fissures which lie parallel to the main fault, but which cut at a low angle across the steeply southwest-dipping strata of the northeast limb (Figure 6).

Stratigraphically, ore bodies are largely confined to a 175–275 foot-thick zone near the base of the Pennsylvanian Minturn or Belden Formation that is intercalated with several thick quartz monzonite and White Porphyry sills. Some ore also occurs near the top of the underlying Mississippian Leadville Limestone. Typically, the porphyry bodies overlie sedimentary rock that hosts the fault/fissure-type ore shoots. Large amounts of brecciated and offset ore indicate significant movement along these subordinate, southwest-dipping structures after the mineralizing event(s), in contrast with that of the main fault set that dips to the northeast. There are several sets of both non-mineralized and mineralized transverse normal faults that cut the trend of the both the main and subordinate sets of pre-ore faults and displace them. These normal transverse faults also displace all of the mineralized veins by a minimum of several feet up to 120 feet (Singewald and Butler, 1941).

GOLD VEINS AND MANTOS IN THE SAWATCH QUARTZITE

Orphan Boy Mine of the Buckskin Subdistrict, Greater Alma District

Location

The Orphan Boy Mine is the southernmost vein and manto deposit of the Phillips Mine Group. The mine is situated between Mosquito and Buckskin Creeks at the east foot of Loveland Mountain, about 2.5 miles west of the southern end of Alma (Figure 5) (Patton and others, 1912; Singewald and Butler, 1941).

History, Production, and Grade

By 1912, more than 11,000 tons of ore had been produced from the Orphan Boy Mine (Patton and others, 1912). The tenor of the material typically averaged 0.25–0.50 opt gold, 10-25 opt silver, 3–4 percent copper, and 20 percent zinc (Patton, Hoskin, and Butler, 1912). In 1942 a vein about 1.5 feet wide averaged 0.30 opt gold, 10 opt silver, 10 percent lead, and 35 percent zinc (Shawe, 1990). A tabular (manto) body approximately 3.3 feet thick displayed average values of 0.05 opt gold, 6.0 opt silver, and 3.0 percent zinc; a similar body 1.0–7.5 feet thick averaged 0.15 opt gold, 6.0 opt silver, 5.0 percent lead, and 17 percent zinc (Shawe, 1990). Patton and others (1912) report that substantial amounts of low-grade gold-silver and copper-zinc ore was never mined.

Form of Deposit and Composition of Ores

The Orphan Boy deposit is a typical Sawatch Quartzite-type manto and vein deposit in which the actual ore is restricted to weakly developed quartzite-hosted mantos composed of massive pyrite containing variable amounts of galena, sphalerite, and chalcopyrite. Locally these sulfides constitute up to 30 percent of the vein. Calcite gangue is also present (Patton and others, 1912).

Wallrock Alteration
Wallrock alteration is not discussed by Patton and others (1912).

Structural and Stratigraphic Controls
The east-dipping formations in the vicinity of the Orphan Boy Mine are cut by over twenty parallel, Steeply inclined faults located approximately 100–200 feet apart. Average strike is N. 35 E.; dips vary from 60 degrees east to vertical; three are west-dipping faults. Vertical displacement is small, ranging from a few inches to 54 feet with both sides of the fault locally constituting the upthrown block. Veins of the Orphan Boy Mine are confined to these structures and typically constitute two-inch streaks of gouge that incorporate crushed rubble of the enclosing porphyry and quartzite wall rock (Patton, Hoskin, and Butler, 1912). However, where these structures cut the contact between the Sawatch Quartzite and two lowest quartz monzonite(?) sills, the veins expand outward on both sides of the fault for an aggregate distance of 10-20 feet and produce small 5–8 feet-thick mantos. Some mantos are much as 18 feet thick (Figure 7). Ascending ore fluids were impounded by impervious porphyry and forced into the more permeable quartzite. The presence of calcareous cement in the quartzite probably aided the replacement process (Singewald and Butler, 1941; Shawe, 1990). Producing veins include the Senate, Orphan Boy, Honeycomb, New Years, Evening Star, Copper, and Good Samaritan veins (Patton and others, 1912).

SILVER-LEAD MANTOS AND VEINS IN CARBONATE HOST ROCKS

Russia Mine of the Consolidated Montgomery Subdistrict, Greater Alma District

Location
The Russia Mine is located about 0.2 mile southeast of the summit of Mt. Lincoln about 4 miles north-northwest of Alma (Figure 5).

History, Production, and Grade
The Russia Mine was discovered in 1872 and was one of the five largest silver mines in the Greater Alma district (Singewald and Butler, 1931; Shawe, 1990). Although the ores generally averaged less than 100 opt silver, some contained more than 700 opt silver and 0.5 opt gold (Shawe, 1990). In 1922 the Russia Mine produced ores that averaged 14–18 opt silver and 0.05 opt gold (Shawe, 1990).

Form of Deposit and Composition of Ores
Ore bodies of the Russia Mine are primarily blanket-like replacement bodies (mantos), which formed in shattered carbonate of the Mississippian Leadville Limestone. The mantos were proximal to one- to two feet-wide fissures and faults exhibiting less than 40 feet of displacement. Some ore extended as much as 15 feet upward along the main fractures (Singewald and Butler, 1931; Shawe, 1990). Mineralization was most extensive in the uppermost 50 feet of the Leadville Limestone, but was also present in the Ordovician Manitou Limestone (Shawe, 1990). Manto ore bodies varied in length from 10 feet to 300 feet, and were located adjacent and parallel to faults that shattered and displaced the host rocks (Shawe, 1990). Ore minerals in the Leadville Limestone include intimately intergrown clusters up to one inch in diameter of sphalerite, galena, pyrite, chalcopyrite, freibergite, and tetrahedrite. Gangue minerals include ankerite, barite, and milky quartz (Shawe, 1990). Supergene minerals included covellite, chalcocite, and native silver, and cerussite, anglesite, malachite, smithsonite, hemimorphite, cerargyrite, and jarosite (Heyl, 1964). Silver content of the ore was variable, occurring most often in freibergite rather than galena (Singewald and Butler, 1931).

Wallrock Alteration
Large amounts of limestone adjacent to ore bodies have been completely silicified and replaced by jasperoid (Shawe, 1990).

Structural and Stratigraphic Controls
The Russia Mine is located near the axis of a gentle southeast-plunging anticlinal nose (Shawe, 1990). Ore bodies have been localized by shattering (solution collapse brecciation?) in the Mississippian Leadville Limestone and Ordovician Manitou Limestone. Ore bodies were deposited adjacent to fissures and faults that exhibit a small amount of movement (Shawe, 1990). Shale of the Belden Shale or Minturn Formation (Weber Formation of Singwald and Butler, 1931) and a Lincoln Porphyry sill overlie Leadville Limestone host rock. The shale may have acted as an acquiclude to upward migrating ore-fluids (Singewald and Butler, 1931).

Hilltop-Last Chance Mine of the Horseshoe Subdistrict, Greater Alma District

Location
The Hilltop-Last Chance Mine is located east of the crest of the Mosquito Range, about 3,000 feet northeast

of Mount Sheridan. (Figure 5) (Behre, 1953). Alma is about 8.0 miles to the northeast.

History, Production, and Grade

The Hilltop-Last Chance deposit was discovered in about 1875 on the basis of mineralized outcrops on the Last Chance claim which adjoins the Hilltop claims to the south (Behre, 1953). The mine was in production until 1923 and consists of two shafts, extensive underground workings, an open cut, and several smaller workings. The grade of the ore prior to 1901 averaged about 25 opt silver and 20 percent lead. Some ore bodies contained 0.01–0.02 opt gold. In latter years, production was mostly from oxidized zinc ore; this ore contained as much as 40 percent zinc, 45 percent lead, 15 opt silver, and 0.06 opt gold (Behre, 1953). Smelter returns from one shipment of ore in 1923 contained 0.042 opt gold, 15.69 opt silver, 15.72 percent lead, and 5.16 percent zinc (Shawe, 1990). Reactivation of the mine in 1949–1950 yielded ore averaging 12.0 percent lead, 0.3 to 2.1 percent zinc, 6.5 opt silver, and 0.02 opt gold. Production from 1901 to 1923 recovered 7,842,672 pounds of lead, 2,530,935 pounds of zinc, 106,700 pounds of copper, 410,438 ounces of silver, and 1,842 ounces of gold (Behre, 1953).

Form of Deposit and Composition of Ores

The Hilltop-Last Chance Mine is a silver-lead-zinc-gold replacement orebody that was formed along a narrow solution channel typical of deposits near Alma. Similar deposits, but with a blanket-like geometry underlying extensive sheets of Tertiary porphyry, are observed in the more intensely mineralized portions of the nearby Leadville district about 5 miles to the northwest. The main Hilltop-Last Chance ore deposit was 1,450 feet long, a maximum of 70 feet wide, up to 70 feet thick, and had a gently northeast plunging cylindrical shape along its north northeast-trending axis (Figure 8). Several smaller north northwest-trending ore shoots adjoined the main ore shoot near the northern area of the mine. The Lind shoot was 440 feet long by up to 40 feet wide; the Stewart shoot was 840 feet long, 10–20 feet wide, and 15-40 feet thick (Behre, 1953).

Dolomite of the Mississippian Leadville Limestone and Devonian Dyer Dolomite is the host rock of the Hilltop-Last Chance ore body. Although oxidized lead and zinc mineralization extended to the deepest workings, hypogene ore was present; a typical ore shoot is described as composed of a central core of galena with very small amounts of sphalerite enclosed by a thick sheave of smithsonite. Material remaining on the dump consists of highly leached and oxidized limestone partly replaced by rosettes of barite and by irregular, spongy, textured areas of grayish or dull olive-green smithsonite. Oxidized ores are believed to be analogous to those observed in the central Leadville district where hypogene ore was comprised of galena and light-colored sphalerite, moderate- to high-grade silver in undetermined mineral species, a relatively large proportion of zinc carbonate in supergene ore, low grade irregularly distributed gold, and prominent barite gangue (Behre, 1953).

Wallrock Alteration

Wallrock alteration is not discussed by Behre (1953).

Structural and Stratigraphic Controls

The Hilltop deposit, located about 0.5 miles southwest of the northwest striking Sherman Fault, lies on the west side of, and within, the Hilltop Fault zone, which strikes N. 21 E. and dips 70 degrees northwest. The fault formed prior to mineralization. The Hilltop Fault offsets the contact between the Leadville Limestone and Belden and Minturn Formations. Field observation suggests either that: 1) the northern end is upthrown to the east; 2) the southern end is upthrown to the west, or 3), left-lateral movement has moved the east side of the fault northward (Figure 8). The third hypothesis is the most probable. The occurrence of a sill of White Porphyry and a dense basal quartzite of the Pennsylvanian Belden and Minturn Formation appears to have acted as an aquiclude or aquitard to mineralizing fluids upwelling along the Hilltop Fault, causing ponding and subsequent ore deposition within the underlying Mississippian Leadville Limestone and Devonian Dyer Dolomite (Behre, 1953). The presence of some type of aquiclude or aquitard is an almost universal situation observed within manto and vein-type ore bodies in both the Greater Alma and Leadville districts.

Hock Hocking Mine of the Buckskin Subdistrict, Greater Alma District

Hock Hocking Mine of the Buckskin subdistrict is located about 2.75 miles southwest of Alma (Figure 5). The deposit is a manto and vein-type silver-lead-zinc-gold deposit similar to the Hilltop Mine in the Horseshoe subdistrict and the Russia Mine in the Consolidated Montgomery subdistrict (Patton and others, 1912).

Weston Pass District

Location

Weston Pass district is located at the crest of Weston Pass about 5 miles south of Malta in sections 35 and 36; T. 10 S., R. 79 W. and sections 1 and 2; T. 11 S., R. 79 W. (Heyl, 1964).

History, Production, and Grade

The Weston Pass district was discovered about 1890 and was most active in 1900–1905 and 1912–1916. During World War I, about 800 (short?) tons of oxidized zinc ore were shipped from the Ruby Mine, and lesser subordinate amounts from the Cincinnati and Colin

Campbell Mines (Heyl, 1964). Grades ranged from 22 percent to 40 percent zinc, 5 percent to 18 percent lead, and 0.3 opt to 3.0 opt silver (Behre, 1932; Heyl, 1964)

Form of Depossit and Composition of Ores

The ores mined consisted of "bedded" (stratabound) replacement bodies composed primarily of cerussite, hemimorphite, and smithsonite associated with a small amount of chalcophane derived from the direct oxidation of lode deposits of galena, sphalerite, and chalcopyrite. Gangue minerals include chalcedony and limonite. The mineralized zone trends northwesterly for 6,800 feet and constitutes a 10 foot-thick blanket-like deposit within dolomites about 170 feet above the base of the Mississippian Leadville Limestone, (Heyl, 1964).

Wallrock Alteration

No wallrock alteration has been described for the Weston Pass deposits.

Structural and Stratigraphic Controls

The strongly stratabound nature of the ore within an unspecified dolomite unit of the Mississippian Leadville Limestone is suggestive of facies-controlled porosity or solution-collapse breccia. The deposit occupies a narrow, open, northwest-trending syncline whose northeast side has been upthrown by a series of faults that parallel the axis of the fold (Heyl, 1964). The faults probably provided conduits for upwelling ore fluids to migrate into favorable stratigraphic horizons.

PLACER GOLD DEPOSITS IN QUATERNARY ALLUVIUM

Fairplay Placer Mine, Fairplay District

Location

The Fairplay Placer is located on both sides of the South Platte River, extending from Sacramento Creek to more than one mile southeast of Fairplay (Singewald, 1950).

History, Production, and Grade

Fairplay Placer was discovered about 1861 and was initially worked by various methods including sluicing, hydraulic mining, and opencut mining. In 1941, a large bucketline dredge began operations which extended until mid-January, 1951 (Patton and others, 1912; Vanderwilt, 1947; U.S. Bureau of Mines Yearbook, 1952). Production from 1932 to 1958 totaled 97,041 ounces of gold (U.S. Bureau of Mines Yearbooks).

Form of Deposit and Composition of Ores

The exploited part of the Fairplay Placer Deposit is about 3.25 miles long and 300–-1,200 feet wide. Alluvial gold is localized in paystreaks or channels within sand and gravel of glacial and periglacial origin (Singewald, 1950). The outwash plain southwest of where the dredge ceased operations in 1952 is 0.5–1.0 mile wide. A wider, prospective valley occurs downstream (Vanderwilt, 1947)

Structural and Stratigraphic Controls

The crescent-shaped, sharp-crested Fairplay Terminal Moraine and the related, partially buried, outwash apron, which has been breached by the South Platte River, are the geologic features controlling the distribution of the gold in the Fairplay Placer Deposit (Figure 9). Although a great deal of gold was exploited from the outer portion of the terminal moraine, considerably more was produced from the down-ice outwash sediments. The majority of the gold was probably taken from within 2,000 feet of the boundary of the moraine (Singewald, 1950).

Alma Placer Mines of the Alma Placers Subdistrict, Greater Alma District

The Alma Placer operation was similar to the Fairplay Placer operation in that gravels of glacio- fluvial origin were exploited for their auriferous content immediately downstream/down-ice from terminal and/or recessional moraines.

Beaver Creek Placers of the Beaver Creek District, Greater Alma District

The Beaver Creek operation was similar to the Fairplay Placer operation in that gravels of glacio- fluvial origin were exploited for their auriferous content immediately downstream/down-ice from terminal and/or recessional moraines.

Tarryall Creek Placer Mines of the Tarryall Creek District

The Tarryall Creek Placer operation was similar to the Fairplay Placer operation in that gravels of glacio-fluvial origin were exploited for their auriferous content immediately downstream/down-ice from terminal and/or recessional moraines.

COAL MINES IN CRETACEOUS ROCKS

King (Cole) Mine of the Como District

Location

The King (Cole) Mines were the most prolific coal producers in the South Park Region and are located in S1/2 section 2, T. 9 S., R. 76 W. and N1/2 section 11, T. 9 S., R. 76 W., 1.5–3.0 miles southeast of Como (Washburne, 1910).

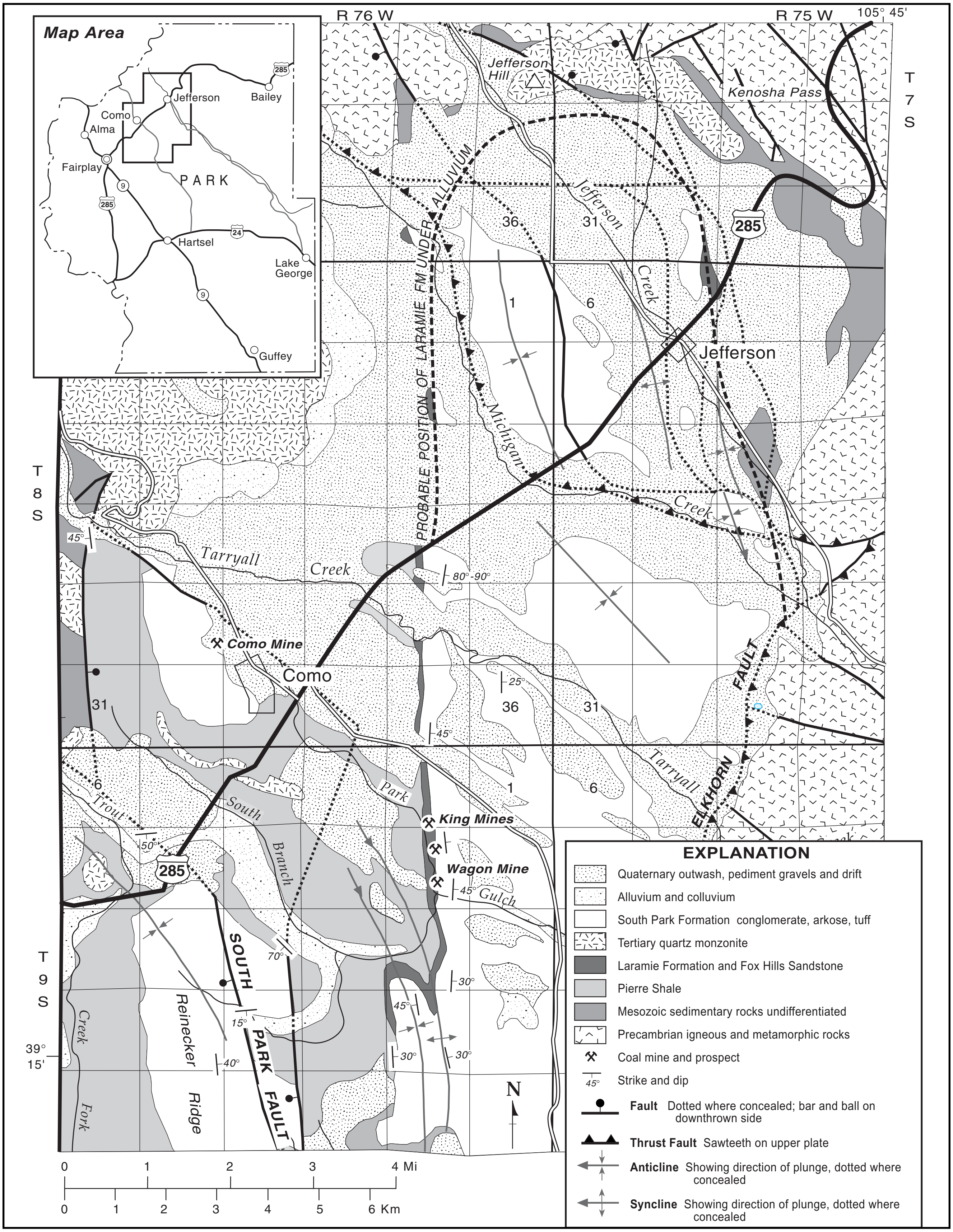


Figure 10. Distribution of the coal-bearing Laramie Formation in the South Park area, Park County, Colorado (modified from Washburne, 1910).

History, Production, and Grade

Production statistics are obscure, but in 1885 the No. 1 Mine produced 58,997 tons of coal. All mining was terminated in 1893 (Washburne, 1910).

Form of Deposit and Composition of Ores

Three coal beds were exploited in the King (Cole) Mine. The upper two beds varied from 4 feet to 6 feet thick and the lower bed ranged from 7 feet to 40 feet thick, averaging 7–8 feet thick (Figure 10). Maximum thickness of the coal extended for a length of over 1,000 feet and is related to shearing and crumpling. The lower coal bed occurs at the base of the Cretaceous Laramie Formation and rests directly on the Fox Hill Sandstone; the middle coal bed is located 175–187 feet above the lower coal bed in sections 2 and 23; T. 9 S., R. 76 W. The upper coal bed lies 175–221 feet above the middle coal bed (Washburne, 1910).

Structural and Stratigraphic Controls

The coal beds are contained within a coal measure (cyclothem) of the Cretaceous Laramie Formation (Washburne, 1910).

MINERAL DEPOSIT TYPES OF EAST-CENTRAL PARK COUNTY

Mineral commodities of east-central Park County are included in a variety of metallic and non-metallic deposit types, hosted in Proterozoic rocks. These are: 1) tungsten- and copper-zinc skarns with associated tin, molybdenum, uranium, and gold localized by stratigraphy and, at some locations, faulting; 2) greisen-hosted beryllium deposits, with attendant lead, zinc, arsenic, molybdenum, iron, copper, tungsten, uranium, tin, and gold; 3) pegmatite-hosted commodities (beryllium, uranium, rare earth, and mica feldspar deposits); 4) vein occurrences containing combinations of gold, silver, copper, lead, zinc, molybdenum, tungsten, uranium, and fluorite.

TUNGSTEN AND COPPER-ZINC SKARNS (TARRYALL SPRINGS, MOUNTAINDALE, PULVER, AND LAKE GEORGE DISTRICTS)

At least 23 tungsten and four copper-zinc skarns are hosted by Proterozoic granitoid, gneiss, and schist in east central southeast Park County (Heinrich, 1981). Mineralogic textures in both types of deposits tend to be granoblastic (non-foliated). Although tabular lensoid veins are sometimes present, stratabound tungsten skarns are the most abundant. Stratabound deposits are localized in calc-silicate gneiss occurring in thin layers, lenses, and pods in the biotite, sillimanite, and amphibolite gneiss, the most predominant Early Proterozoic gneiss known as the “Idaho Springs Formation” (Figure 11).

Conversely, copper-zinc and copper skarns are uncommon in calc-silicate-bearing lithologies, but are most typical in amphibolite and, to lesser extent, anthophyllite- or gederite-cordierite gneiss, sillimanite gneiss, and biotite gneiss (Figure 12). They are also partly controlled by faulting. Other rock types hosting skarns include impure marble, calcite-wollastonite gneiss, hornblende-diopside gneiss, and hornblendite (Heinrich, 1981).

Most deposits are unrelated to igneous contacts and are the product of metasomatic processes associated with regional metamorphism. However, in some deposits, the metal-bearing layers occur adjacent to intrusions of gray pegmatite and associated quartz pods. These deposits may constitute true contact metasomatic tactites (Hawley, 1969). Ore controls with regard to tungsten skarns appear to be nearly stratigraphic, whereas those with respect to copper-zinc skarns appear to be controlled by both stratigraphy and faults (Heinrich, 1981).

Tungsten skarns that occur in strongly stratabound, disseminated scheelite and powellite have been exploited from east-central Park County. Skarns in southeast Park County have yielded mostly copper and zinc. In the copper and zinc skarns, the copper minerals are mostly bornite, but also include chalcopyrite, chalcocite, and covellite; the zinc occurs as sphalerite (Heinrich, 1981). More rarely, molybdenite is present and tin, uranium, and gold minerals have also been identified at some locations (Heinrich, 1981).

Gangue minerals within the skarn bodies consist of garnet, epidote, zoisite, clinozoisite, wollastonite, vesuvianite, diopside, quartz, calcite, and more rarely the manganese silicates, bustamite and rhodonite. These skarn bodies form irregular masses, boudins, and stubby lenses that may be only a few tens of feet in length (Heinrich, 1981). However, copper-zinc skarns locally are as long as 1,000 feet and as wide as of 150 feet, with down dip extensions several hundred feet long (Heinrich, 1981).

PEGMATITE-HOSTED COMMODITIES (TARRYALL SPRINGS, MOUNTAINDALE, PULVER-LAKE GEORGE DISTRICT)

Pegmatite bodies host a diverse variety of economic minerals and are found primarily in east central and southeast Park County. They occur in Proterozoic gneiss and granite. The deposits are classified by the minerals exploited, including beryllium, uranium, columbium-tantalum, and rare-earth minerals, as well as muscovite, microcline, and plagioclase. Many pegmatite bodies contain more than one economic commodity. In terms of size, most pegmatites are small tabular or lenticular bodies that vary from a few tens of feet in width up to several hundred feet in length. Many are zoned, and exhibit concentric mineralogic and/or textural shells which may comprise a border, wall, or intermediate zone formed about a central core (Hanley and others, 1950). The zones commonly consist of the following (Figure 13): 1) microcline-quartz or quartz (the core zone); 2) plagioclase-muscovite-quartz ± microcline (the intermediate zone); 3) plagioclase-quartz-microcline ± muscovite ± biotite (the wall zone); and 4) fine-grained equivalents of wall zone minerals (the border zone). The economic minerals typically exhibit a strong preference for a particular zone. For example, beryllium and columbium-tantalum minerals are most common in the intermediate zone whereas lithium- bearing minerals usually occur in the core. In other instances certain minerals occur as hydrothermal replacements within pre-existing zones or along fractures. The types of pegmatites present in east-central Park County are briefly discussed by commodity.

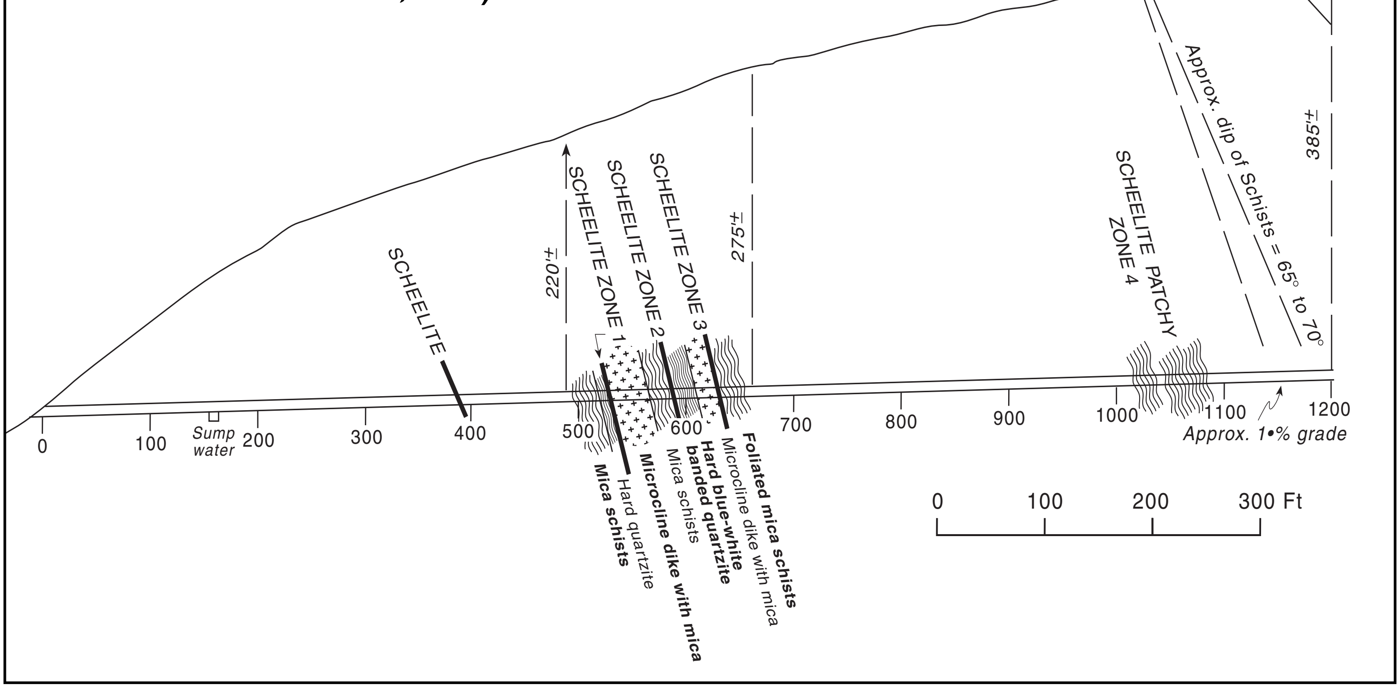
PEGMATITE-HOSTED BERYLLIUM (TARRYALL SPRINGS, MOUNTAINDALE, PULVER-LAKE GEORGE DISTRICT)

Pegmatite-hosted beryllium deposits occur in granite gneiss and other Proterozoic rocks. In addition to beryllium as beryl; the deposits also contain tantalum, niobium, and columbium as columbite and tantalite.

PEGMATITE-HOSTED BERYLLIUM, RARE EARTH MINERALS, URANIUM (TARRYALL SPRINGS, MOUNTAINDALE, PULVER-LAKE GEORGE DISTRICT)

In east-central Park County, pegmatite-hosted rare-earth deposits are composed of non-zoned lenticular pegmatite a few tens of feet wide and about 100 feet long. Hosts include granite gneiss, the Pikes Peak Granite, and other Proterozoic rocks. At some locations, yttrium is the primary commodity and occurs in lenses of yttrofluorite (a hydrothermal replacement of feldspar). Other commodities present in the deposits include beryllium, fluorine, feldspar, rare-earth

Figure 11. Section of St. Joe tungsten mine, Park County, Colorado (modified from Prommel and Hoskins, 1953).



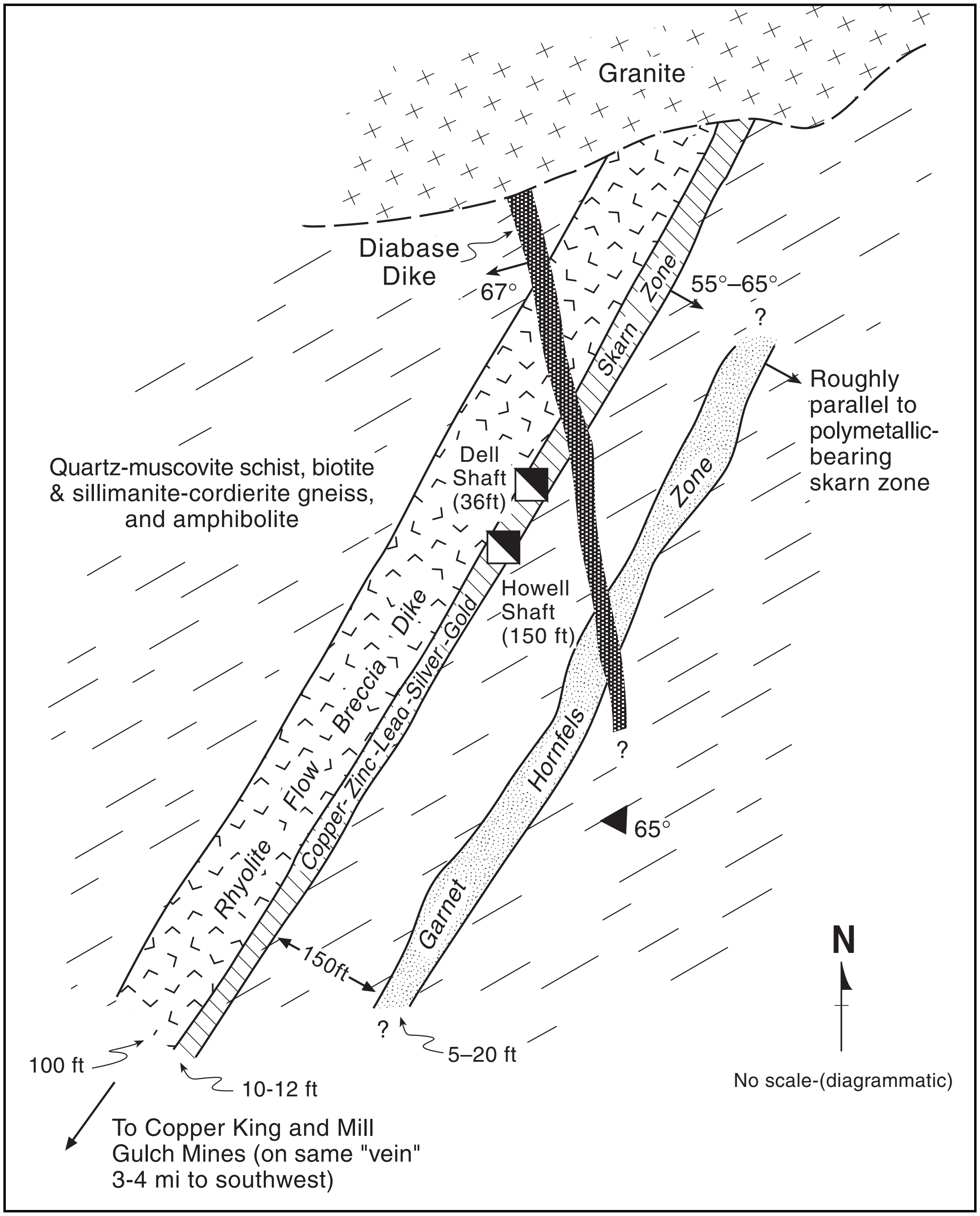


Figure 12. Geologic map of the Betty (Lone Chimney) copper-zinc-lead-silver-gold mine, Park County, Colorado (modified from Eckel, 1932).

minerals, and thorium. Minerals include beryl, orthoclase, quartz, gadolinite, yttrofluorite, allanite, monazite, xenotime, microcline, and molybdenite. At other locations tantalum, niobium, and columbium as columbite and tantalite are also present. Uranium and thorium as thorite occur in some pegmatite bodies within the middle Proterozoic Pikes Peak Granite. Faults, fractures, and fissures may localize mineralization.

PEGMATITE-HOSTED MICA-FELDSPAR (PULVER-LAKE GEORGE DISTRICT)

Numerous small pegmatite bodies, both barren types and those containing metallic and rare-earth minerals, occur in the Pulver-Lake George district in east-central Park County, They have been exploited for microcline and muscovite.

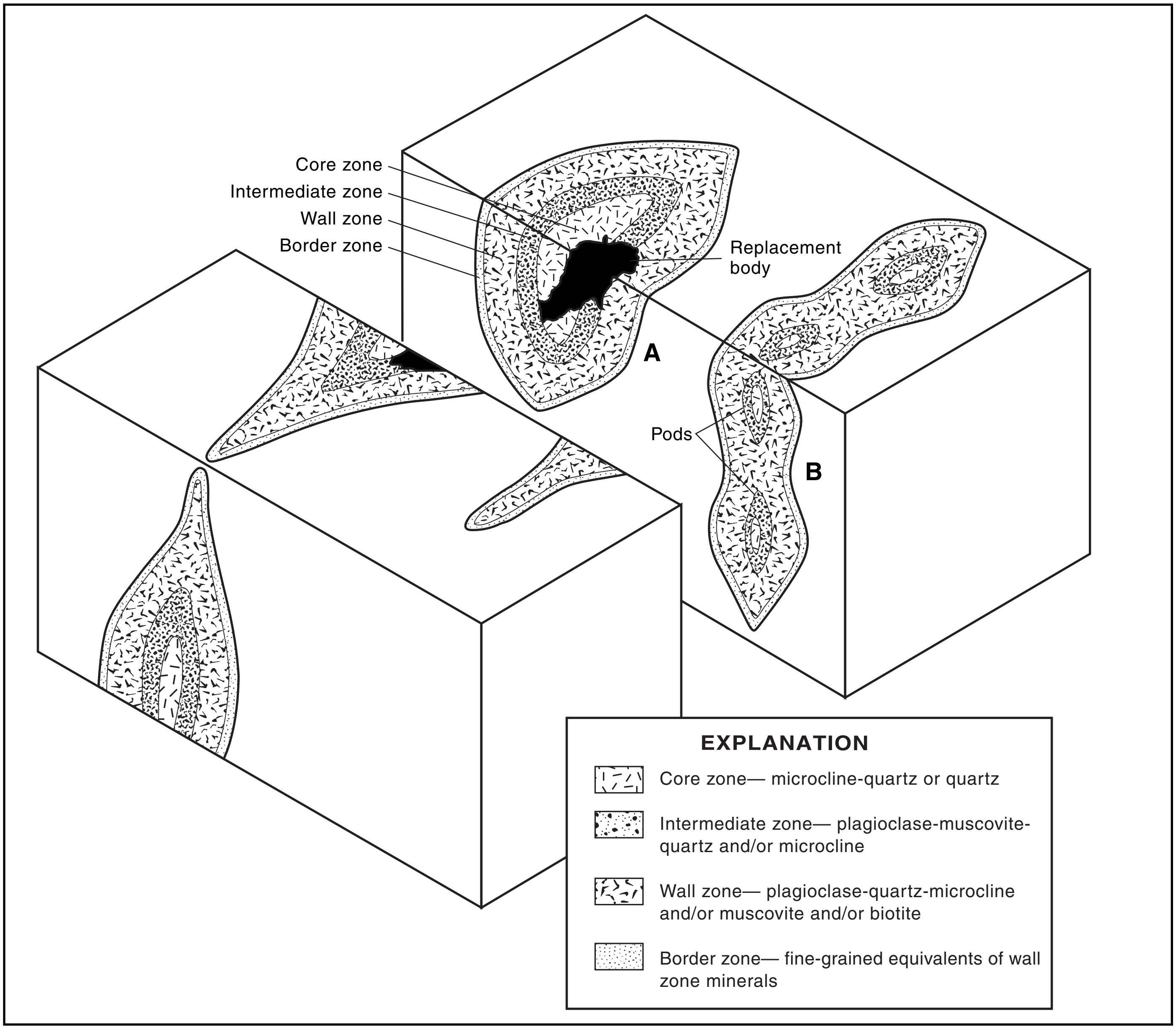


Figure 13. Idealized zoning within pegmatite bodies (from Hanley, Heinrich, and Page, 1950).

NON-PEGMATITE-HOSTED BERYLLIUM (TARRYALL SPRINGS, MOUNTAINDALE, PULVER-LAKE GEORGE DISTRICT)

Non-pegmatite-hosted beryllium deposits typically occur as greisens within, or near, the middle Proterozoic Redskin Granite, which ranges from aplite to granite porphyry (Figure 14). Greisen walls are comprised primarily of widely varying proportions of quartz, muscovite, and topaz, but some also contain fluorite and traces of lithium and tin (Hawley and Griffits, 1968; Hawley, 1969). A prominent hematitic aureole may be present where greisens are developed in granitic rocks older than Redskin Granite or Pikes Peak Granite. Faults and fractures within greisenized granitic rocks appear to be the primary ore controls, although certain lithologic contacts and units of favorable composition are also important in localizing mineralization. Mineralized bodies are varied in form and include clustered pipes, veins, cupolas, pods, and irregular lenses. The primary ore minerals are beryl and bertrandite. Beryl occurs as well-crystallized hexagonal crystals and massive anhedral poikiloblastic (a large grain of a mineral that encompasses older

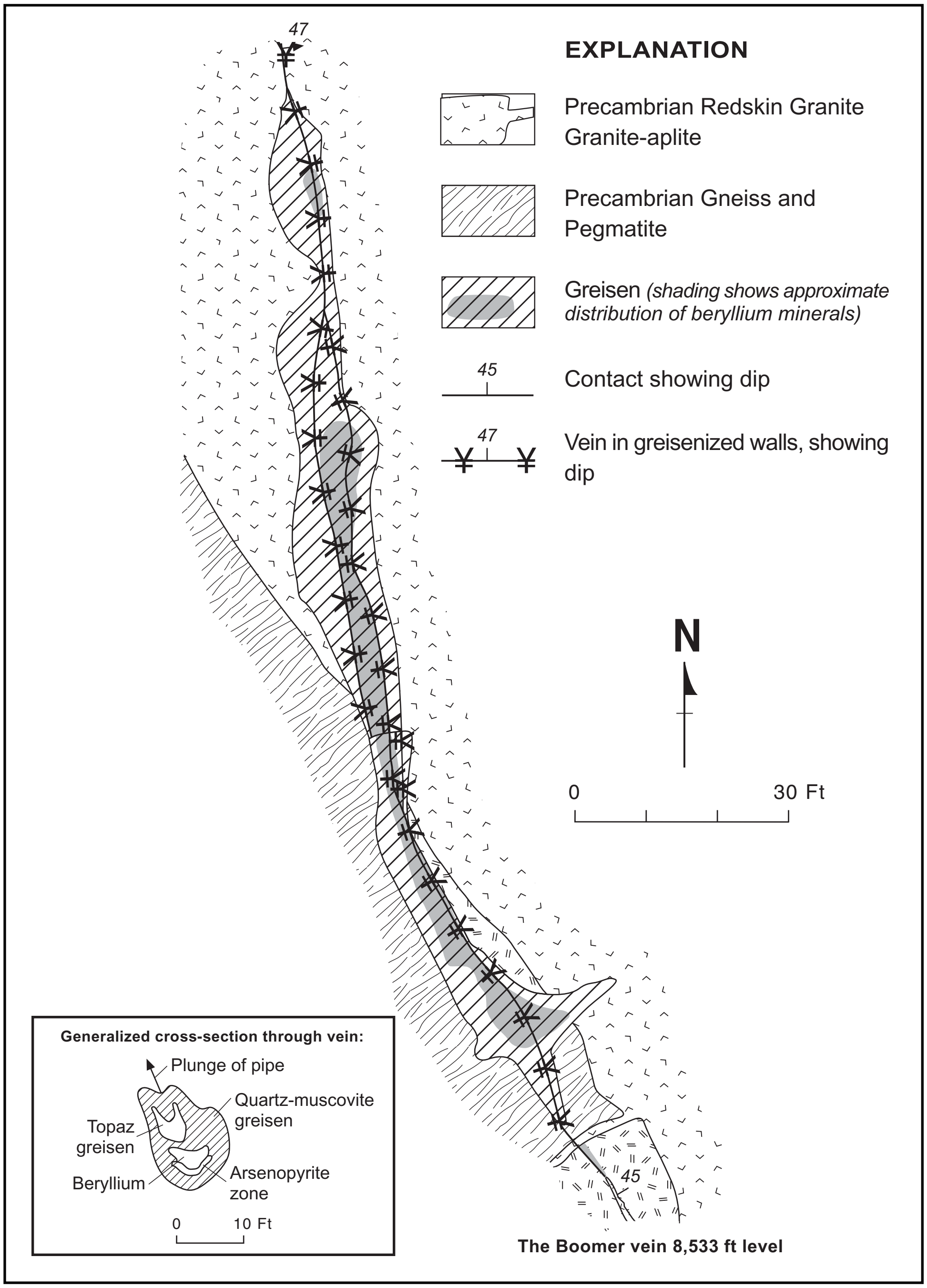


Figure 14. Boomer non-pegmatitic-hosted beryllium mine, Mountaindale district, Park County, Colorado (from Hawley, 1969). Refer to Plate 1 for map location.

crystals) grains in sharp-walled veins within greisenized rocks, whereas bertrandite occurs as abundant disseminated grains and veinlets within podiform or pipelike bodies within micaceous greisens. Both types of bodies grade into barren greisen. Euclase, galena, sphalerite, arsenopyrite, molybdenite, pyrite, chalcopyrite, covellite, wolframite, uraninite, pitchblende, and cassiterite are also present, but are usually concentrated in small ore shoots adjacent to the main beryllium deposits (Hawley and Griffits, 1968; Hawley, 1969). Masses of galena contain 0.3–0.7 percent silver, 0.3–1.5 percent bismuth and 0.007–0.700 percent copper; samples analyzed in 1959–1968 showed 150 parts per million (ppm) silver, 30 ppm beryllium, 15,000 ppm copper, 15,000 ppm lead, 150 ppm tin, 1,500 ppm tungsten, 300 ppm zinc. Anomalous amounts of niobium, lithium, and rubidium are also present (Hawley and Griffits, 1968). Gangue minerals include quartz, muscovite, topaz, fluorite, and siderite.

COPPER-GOLD-SILVER (TARRYALL SPRINGS, MOUNTAINDALE, PULVER-LAKE GEORGE DISTRICT)

Fissure veins in the district locally contain gold, silver, chalcopyrite, covellite, galena, scheelite, and molybdenite. Gangue minerals include quartz, muscovite, topaz, fluorite, and siderite. Mineralization is localized by fissures, contacts, and favorable rock units within middle Proterozoic granite-aplite, porphyritic granite, granite, pegmatite, and the Silver Plume(?) Quartz Monzonite. Extensive greisenization is locally present, and suggests a genetic link with the greisen-hosted beryllium deposits (Hawley, 1969).

FLUORITE (REYNOLDS SWITCH, PULVER-LAKE GEORGE DISTRICT)

Fluorite occurs in en-echelon northwest-striking, northeast-dipping veins and fissures, and as replacement bodies within granite and limestone host rock.

TYPICAL MINES OF EAST-CENTRAL PARK COUNTY

The detailed descriptions are of the most productive mines in east-central Park County, and are organized by deposit type.

TUNGSTEN SKARNS

St. Joe Tungsten Mine of Tarryall Springs District

Location

The St. Joe Mine is located on the St. Joe Claim Group and consists of the St. Joe, Scheelite No. 1 and Scheelite No. 2 claims (Prommel, 1953) located in the NW 1/4, SE1/4, SW1/4, section 6, T. 12 S., R. 72 W. and in northern section 7, T. 2 S., R. 72 W. All of the claims occur on the north side of U.S. Highway 24 in the western portion of the Tarryall Springs district a short distance east of Wilkerson Pass.

History, Production, and Grade

Workings consist of a several pits, three shallow shafts, and a 1,200 foot-long adit (Prommel, 1953; Belser, 1956; Heinrich, 1981). The portal of the adit is located at the northern extent of the St. Joe claim and was driven northward under the Scheelite No. 1 and 2 claims. The adit was excavated to explore the prominent east-west-trending pegmatite dikes that stretch at least 1,000 feet east the tunnel site (Prommel, 1953). An incomplete channel sample collected over a two-foot interval within a lime silicate layer that occurs 528 feet from the portal yielded a grade of 0.28 percent WO_3 (Prommel, 1953). As of 1956, no tungsten ore had been shipped (Belser, 1956).

Form of Deposit and Composition of Ores

Scheelite occurs as parallel bands in three lime-silicate layers 2–3 feet thick that strike N 85 E and dip about 7 degree to the north. The bands parallel the trend of the enclosing schist and gneiss (Prommel, 1953; Belser, 1956). Scheelite also occurs as irregularly distributed small crystals, grains, flakes, and thin coatings associated with garnet, epidote, and quartz in bedrock that occurs between the lime-silicate layers containing the concentrated tungsten mineralization (Prommel, 1953). A zone consisting of disseminated scheelite occurs within a siliceous garnetized zone within a mica schist (Belser, 1956; Heinrich 1981). These layers and zones occur in four layers north of the portal of the St. Joe Tunnel (Figure 11) (Belser, 1956), and consist of: Zone 1, located 528 feet from the portal and 223 feet below the surface, following the south side of a 36 foot-thick pegmatite dike; Zone 2, located 588 feet from the portal and midway between the 36 foot-thick pegmatite dike to the south and a another 16 foot-thick pegmatite dike located further to the north; Zone 3, located 608 feet from the portal and following the north wall of the 16 foot.-thick pegmatite dike; and Zone 4, located 1,030 feet from the portal and 350 feet below the surface and consisting of scattered scheelite within a 6-foot wide zone in siliceous and garnetiferous mica schist.

Wallrock Alteration

Metasomatism has resulted in the formation of a typical calc-silicate skarn mineral assemblage consisting of highly altered, extremely siliceous, garnet-epidote-quartz-chlorite rocks (Heinrich, 1981).

Structural and Stratigraphic Controls

Stratigraphic ore controls consist of calc-silicate layers present within early Proterozoic gneiss and schist formerly assigned to the Idaho Springs Formation (Heinrich, 1981). Scheelite is concentrated in skarns near the pegmatite dikes (Belser, 1956; Heinrich, 1981).

Gilley Ranch Tungsten Deposit of Tarryall Springs District

Location

Gilley Ranch deposit is located in northeast Tarryall Springs district in the E1/2 section 32, T. 11 S., R. 71 W., about 2 miles east of Colorado State Highway 77 (Heinrich, 1981).

History, Production, and Grade

A 5 foot-thick zone is reported to average one percent WO_3 at the bottom of a 50-foot shaft and a 75-foot drift (Belser, 1956).

Form of Deposit and Composition of Ores

Northeast-striking, nearly vertically dipping, calc-silicate gneiss is host to tabular, lensoid to podiform, tungsten-bearing skarn bodies that follow the schistosity of the enclosing biotite gneiss. The skarn is composed of quartz, garnet, epidote, and vesuvianite (Heinrich, 1981). Tungsten occurs as crystals, grains, flakes and coatings of scheelite. Gold is also present. Wollastonite and clinozoisite, as well as chlorite, have been reported by some workers.

Wallrock Alteration

Metasomatism has resulted in a typical calc-silicate skarn mineral assemblage.

Structural and Stratigraphic Controls

Gneissic calc-silicate layers within biotite and hornblende gneiss of early Proterozoic age are the stratigraphic controls for tungsten mineralization. Scheelite is concentrated in skarns near bodies of gray pegmatite and related quartz pods.

Jasper Queen Tungsten Mine of Pulver-Lake George District

Location
Jasper Queen Mine is located in the SE1/4, section 2, T. 12 S., R. 72 W.

History, Production, and Grade
The deposit was mined during World War II by the Hayden Mining Company. At that time, 3,700 pounds of ore averaging 1.3 percent WO_3 was shipped; 14 tons of material, assaying 0.62 percent WO_3, was stockpiled at Boulder, Colorado. Workings consist of a short shaft, two trenches, and 10 shallow pits (Heinrich, 1981).

Form of Deposit and Composition of Ores
Ore bodies consist of skarn lenses that are mineralized with scheelite, minor molybdenite, and copper sulfides within a gangue of garnet, quartz, epidote, and vesuvianite (Heinrich, 1981). Wollastonite and clinozoisite have also been reported. The largest skarn bodies measure 15–20 feet in length, 10–12 feet in thickness, and 5–10 feet in width, and occur within 25-100 foot-thick calc-silicate layers that strike N 15 E.

Wallrock Alteration
Metasomatism has resulted in a calc-silicate skarn mineral assemblage.

Structural and Stratigraphic Controls
Primary ore controls for tungsten mineralization are calc-silicate layers within the early Proterozoic gneiss and amphibolite (Heinrich, 1981).

COPPER-ZINC SKARNS

Most of the prominent copper-zinc skarns are located in southeast Park County in the Guffey district. At least one skarn is located in east-central Park County.

Blue Mountain Zinc-Copper Mine of Florissant-Fish Creek District

Location
Blue Mountain Zinc-Copper Mine is located in NW1/4, NE1/4, section 8, T. 13 S., R. 71 E.

History, Production, and Grade
Unknown production took place from a short adit in the Blue Mountain Zinc-Copper Mine.

Form of Deposit and Composition of Ores
Sillimanite-cordierite gneiss enclosed by biotite gneiss is host to copper and zinc as disseminated chalcopyrite and sphalerite. Gangue minerals include muscovite and magnetite. Mineralization is restricted to a narrow zone consisting of lensoid, tabular, (pegmatite?) pods oriented parallel to the vertical, north-south foliation of the gneiss (Heinrich, 1981). The gneiss is part of a roof pendant, or megaxenolith, in early Proterozoic metamorphic rocks within the middle Proterozoic Pikes Peak Granite. Thus, it is unlikely that the deposit possesses any significant down-dip extent.

Wallrock Alteration
Wallrock at the Blue Mountain Zinc-Copper Mine is migmatized.

Structural and Stratigraphic Controls
Early Proterozoic host rocks are finely banded blue-gray gneiss with layers of: 1) sillimanite-quartz ± biotite; 2) quartz; and 3) cordierite-quartz. These layers are strongly migmatized by leucogranite (Heinrich, 1981). Chalcopyrite is disseminated in the sillimanite-cordierite gneiss that is surrounded by biotite gneiss. Middle Proterozoic Pikes Peak Granite surrounds the "island" of metamorphic rocks.

PEGMATITE-HOSTED BERYLLIUM

Big Horn Sheep Pegmatite-Hosted Beryllium Mine of Tarryall Springs District

Location
Big Horn Sheep Mine is located in the W1/2 section 20, T. 11 S., R. 73 W.

History, Production, and Grade
At least 10 tons of beryl have been produced from a side hill cut and two open pits at the Big Horn Sheep Pegmatite-Hosted Mine (Meeves and others, 1966).

Form of Deposit and Composition of Ores
The Big Horn Sheep deposit is a north-trending Proterozoic pegmatite containing beryllium, tantalum, and niobium as beryl, columbite, and tantalite (Meeves and others, 1966). Granite gneiss encloses the body.

Wallrock Alteration
There is no wallrock alteration reported from the Big Horn Sheep deposit.

Structural and Stratigraphic Controls
Factors controlling the localization of mineralization have not been reported.

NON-PEGMATITE-HOSTED BERYLLIUM

Black Prince Non-Pegmatite-Hosted Beryllium of Tarryall Springs District

Location
The Black Prince Mine is located in the center of SE1/4, NW1/4, SW1/4, section 11, T. 11 S., R. 72 W., about 1,700 feet north-northeast of the Redskin Mine.

History, Production, and Grade
As of 1969, no beryllium ore had been produced. Some sulfide ore was mined and shipped in about 1930 (Hawley, 1969). Developmental work on the property consists of a shaft over 68 feet deep (re-collared in 1961), a caved shaft, and several open cuts. Workings occur over a 200 feet-long and 100 feet-wide area (over 20,000 square feet).

Form of Deposit and Composition of Ores
Black Prince deposit is composed of clustered 2–10-feet diameter pipes, greisenized cupolas, pods, and irregular lenses (Hawley, 1969). These occur in middle Proterozoic Redskin Granite that consists of granite-aplite, porphyritic granite, and granite porphyry. Ore commodities include beryllium, lead, zinc, arsenic, molybdenum, iron, copper, tungsten, uranium, and tin; minerals include bertrandite, beryl, euclase, galena, sphalerite, arsenopyrite, molybdenite, pyrite, chalcopyrite, covellite, wolframite, uraninite, and cassiterite. Beryl occurs as hexagonal crystals and massive poikiloblastic grains. Masses of galena contain 0.3–0.7 percent silver, 0.3–1.5 percent bismuth and 0.007–0.700 percent copper; samples analyzed in 1959-1968 showed 150 ppm silver, 30 ppm beryllium, 15,000 ppm copper, 15,000 ppm lead, 150 ppm tin, 1,500 ppm tungsten, and 300 ppm zinc. Gangue minerals include quartz, muscovite, topaz, fluorite, and siderite.

Wallrock Alteration
Ore-hosting lithologies have undergone griesenization.
Structural and Stratigraphic Controls

The primary ore control is greisenized rock. Ore is further localized by fissures and northeast-striking fractures, contacts, and favorable rock units. Nearly all of the beryllium deposits occur in the granite-aplite or porphyritic granite facies of the greisen in Redskin Granite. Even those deposits not actually in the Redskin Granite are spatially and genetically related to it.

Redskin Non-Pegmatite-Hosted Beryllium Mine of Tarryall Springs District

Location
The Redskin Mine is located in the center of S1/2, SW1/4 SW1/4, SW1/4, section 11, T. 11 S., R. 72 W., on the east side of Redskin Gulch about 3,000 feet from its mouth.

History, Production, and Grade
The Redskin claims were originally located as a silver prospect. The mine was patented in 1901 and was developed for molybdenum prior to 1919. Uraninite was discovered in 1954, and beryllium was discovered in 1959. A small amount of molybdenum ore was shipped between 1913–1918 and a small quantity of beryllium ore was produced between 1959–1969. Sampling of outcrops and dumps by the U.S. Bureau of Mines in 1959–1960 yielded an average grade of 5.0 percent BeO (Meeves, 1966). Workings consist of an inclined shaft, stopes, open cuts, and prospects that occur over an area measuring 450 feet x 50 feet.

Form of Deposit and Composition of Ores
The Redskin deposit consists of three mineralized pipes within the greisenized phases of the middle Proterozoic Redskin Granite, which is composed of granite-aplite, porphyritic granite, granite, granite-aplite, and granite porphyry (Hawley, 1969). Much ore consists of small pods and irregular lenses localized by steeply dipping fractures within a portion of a greisenized pipe that plunges N 60 E. Also, two 2–10 foot-diameter pipes are clustered nearby to form the mine area. The ore zone contains beryllium, lead, zinc, arsenic, molybdenum, iron, copper, tungsten, uranium, and tin. Minerals include bertrandite, beryl, euclase, galena, sphalerite, arsenopyrite, molybdenite, pyrite, chalcopyrite, covellite, wolframite, uraninite, and cassiterite; gangue minerals include quartz, muscovite, topaz, fluorite, siderite (Hawley, 1969). Masses of galena contain 0.3–0.7 percent silver, 0.3–1.5 percent bismuth, 0.007-0.700 percent copper. Samples from the mine in 1919 contained as much as 10 percent MoS_2 , but averaged about 3.0 percent MoS_2. Samples taken in 1959–1969 assayed 1.5–150 ppm silver, 15–70,000 ppm beryllium, 15-700 ppm copper, 7–15,000 ppm molybdenum, 150–70,000 ppm lead, 70–300 ppm tin, 0–150 ppm tungsten, 70–150 ppm zinc.

Wallrock Alteration
Rocks hosting mineralization have undergone greisenization.

Structural and Stratigraphic Controls
The primary ore control is greisenization, with further localization of mineralization provided by fractures, fissures, contacts, and favorable rock units (Hawley, 1969). Nearly all of the beryllium deposits of the area occur in the granite-aplite or porphyritic granite facies of the greisenized phases of the Redskin Granite. Even those deposits not actually in the Redskin Granite are spatially and genetically related to the granite.

Boomer Non-Pegmatite-Hosted Beryllium Mine of Mountaindale District

Location
Boomer Mine is located in the southwest Lake George beryllium area in N1/2, NE1/4, NE1/4, SW1/4 section 21, T. 11 S., R. 72 W. (Figure 14) (Hawley, 1969).

History, Production, and Grade
Boomer Group claims were patented in 1905. In 1917 the mine was considered a molybdenum prospect, but there is no known production. The workings were

rehabilitated in 1955 as a uranium prospect, and in 1956 the mine began producing beryllium. Although the Boomer Mine is a small deposit, it is the most important and largest of its type found in the area to date. Between 1956–1965 it produced 3,000 tons of beryllium ore that contained 2.0–11.2 percent BeO and averaged 5.0 percent BeO (Hawley, 1969). Production figures includes 678 tons produced between 1956 and 1959 that contained 8.77 percent BeO. Workings consist of one main shaft and short, irregular levels interconnected by open stopes, raises, open cuts, and small glory holes. The main levels are at 8,556 feet, 8,533 feet, 8,516 feet, 8,494 feet, 8,486 feet, 8,440 feet, and 8,398 feet owing to the plunge of the orebody; several additional shallow shafts are present. Workings occur over an area measuring 380 feet x 360 feet x 185 feet (136,800 square feet).

Form of Deposit and Composition of Ores

The Boomer deposit is composed of plunging pipes, pods, irregular lenses, and high temperature veins that occur in discontinuous intersecting fractures within a shear zone along the southwest contact of a granite stock. Mineralized shear zones are also developed along other formational contacts (Meeves and others, 1966). Although ore bodies are separate at the surface, at depth it seems certain that they are interconnected, and form one large complex body localized by the combined influence of the Boomer Vein, fractures of the steep northeast-trending set, and the southern contact of the Boomer Cupola (Hawley, 1969). At least two pipes are exposed in the hanging wall of the Boomer Vein. Podiform shoots range from a few inches to few feet thick, and some are up to 10 feet thick. The largest orebody is 30 feet long, 40 feet wide along dip, and 10 feet thick (Meeves and others, 1966). The host for the ore structures includes the following (Hawley, 1969): 1) early Proterozoic granite; granite-aplite, granite porphyry of Redskin Granite; 2) middle Proterozoic granite-aplite, porphyritic granite; and pegmatite, amphibolite; 3) early Proterozoic gneiss. The granodiorite and the Silver Plume Granite also host beryllium minerals (Nelson-Moore and others, 1978). Nearly all ore at the Boomer Mine is found above 8,500 feet. Beryl is the chief component in all ore bodies except the Outhouse Lode, where bertrandite predominates. Ore commodities include beryllium, lead, zinc, arsenic, molybdenum, iron, copper, tungsten, uranium, tin; beryl, bertrandite, euclase, galena, sphalerite, arsenopyrite, molybdenite, pyrite, chalcopyrite, covellite, wolframite, uraninite, cassiterite, and silver. Beryl occurs as hexagonal crystals and massive poikioblastic grains (Hawley, 1969). Gangue minerals include quartz, muscovite, topaz, fluorite, and siderite. Pods of galena up to 6 inches in diameter contain 0.3-0.7 percent silver, 0.3–1.5 percent bismuth, and 0.007–0.700 percent copper.

Analyses of samples collected from 1959 to 1969 from the Boomer deposit are shown in Table 3.

Table 3. Geochemical analyses of samples collected from 1959 to 1969 from the Boomer deposit (Hawley, 1969).

Element	Percent
Beryllium	0.00015–6.2
Silver	0.00015–0.015
Copper	0.0007–3.0
Germanium	< 0.005–0.015
Lithium	0.009–0.12
Molybdenum	0.0007–0.03
Niobium	0.002–0.15
Lead	0.003–>10.0
Tin	0.0015–0.03
Tungsten	0–>10.0
Zinc	0.007–1.5
Uranium oxide (U_3O_8)	0.02-0.74

Wallrock Alteration

Wallrocks have been extensively altered to greisen containing mostly quartz and muscovite, but topaz and/or fluorite-rich varieties also occur (Hawley, 1969). However, the beryllium content and greisen alteration decrease rapidly away from the veins and pods of ore; thus, enclosing rocks only a few feet distant exhibit few effects from the mineralizing event (Meeves and others, 1966).

Structural and Stratigraphic Controls

Primary ore controls are greisen rocks, and deposits are localized by fractures and fissures (especially northeast- and northwest-trending fracture sets), contacts, favorable rock units, and the Boomer Vein (Hawley, 1969). Commonly, mineralized shear zones are developed along formational contacts (Figure 14). Nearly all of the beryllium deposits occur in the granite-aplite or porphyritic granite facies of the greisenized Redskin Granite.

PEGMATITE-HOSTED RARE EARTH MINERALS

Teller-Meyers Pegmatite-Hosted Rare Earth Minerals Mine of Pulver-Lake George District

Location

The Teller (Meyers) Mine is located in the NE1/4 section 31, T. 12 S., R. 71 W.

History, Production, and Grade
The Teller (Meyers) Mine produced 5,000 pounds of rare-earth elements as the mineral gadolinite and 10,000 pounds fluorite as yttrofluorite from two open cuts (Meeves and others, 1966).

Form of Deposit and Composition of Ores
The Teller (Meyers) Mine deposit is a yttrium-bearing non-zoned lenticular pegmatite, 25 feet wide and 100 feet long that strikes N 52 W and is hosted by granite schist of the Pikes Peak Granite (Meeves and others, 1966; Glass and others, 1958). Yttrium, which occurs with fluorite minerals as lenses mainly in the northern portion of the pegmatite, is apparently a hydrothermal replacement of feldspar. The most abundant yttrium minerals are allanite, gadolinite, monzanite, and xenotime. Other commodities present include fluorine, feldspar, beryllium, and thorium as yttrofluorite, orthoclase, quartz, microcline, and molybdenite.

Wallrock Alteration
Wallrock alteration at the Teller-Meyers Mine has not been described.

Structural and Stratigraphic Controls
Shear zones localized along formational contacts control the emplacement of some pegmatites. (Meeves and others, 1966).

URANIUM

Gold Star Greisen-Hosted Uranium Mine of Tarryall Springs District

Location
Gold Star Mine is located in the center, N1/2, NE1/4, SE1/4, SW1/4, section 23, T. 11 S., R. 72 W.

History, Production, and Grade
Although there has been no reported production, geochemical sampling has yielded the following results: 0.06–3.21 percent U_3O_8 (average of 4 samples: 0.925 percent U_3O_8), 1–4 ppm silver, 20–49 ppm copper, 10-441 ppm lead, and 80–128 ppm zinc. The samples were presumably taken from a 6 foot-deep pit.

Form of Deposit and Composition of Ores
The deposit is a 400 foot-diameter circular greisen pipe containing uranium as uraninite, schoepite, curite, and soddyite (Nelson-Moore and others, 1978).

Wallrock Alteration
Wallrock alteration consists of migmatization, hydrothermal alteration, and secondary enrichment of the greisen pipe (Nelson-Moore and others, 1978).

Structural and Stratigraphic Controls
The greisen pipe is hosted by early Proterozoic gneiss, schist, and migmatite. A lithic breccia of possible volcanic origin is also present, as is middle Proterozoic quartz monzonite of the Redskin Granite. Faults and fractures provide a further locus for the mineralization.

Last Chance Vein-Type Uranium Mine of Tarryall Springs District

Location
Last Chance Mine is located in the S1/2, SW1/4, SW1/4, section 30; N1/2, NE1/4, NW1/4, NW1/4, Section 31, T. 11 S., R. 72 W.

History, Production, and Grade
Known production from 30 foot-deep pits and drifts total about one ton of ore containing 0.25 percent U_3O_8. Assays of 0.33 percent U_3O_8 and 0.8–2000 ppm equivalent uranium have also been reported (Nelson-Moore and others, 1978).

Form of Deposit and Composition of Ores
The Last Chance uranium deposit is a 2-mile long, 6-foot wide, autunite and meta-autunite- bearing quartz vein that trends N 30–50 W and dips 60–85 degrees to the west (Nelson-Moore and others, 1978).

Wallrock Alteration
Wallrock alteration at the Last Chance Mine has not been described.

Structural and Stratigraphic Controls
Mineralization is localized by faults, fissures, and fractures within a N 30 W-trending shear zone hosted by the middle Proterozoic Silver Plume Granite and early Proterozoic gneiss and metasedimentary rock.

Hilda May Pegmatite-Hosted Uranium Mine of Mountaindale District

Location
The Hilda May Mine is located in the NW1/4, NW1/4, SE1/4, NW1/4, section 22, T. 11 S., R. 72 W.

History, Production, and Grade
Unknown amounts of ore were produced from surface workings.

Form of Deposit and Composition of Ores
The deposit consists of uranium and thorium as thorite within a pegmatite body.

Wallrock Alteration
Wallrock alteration at the Hilda May Mine has not been described.

Structural and Stratigraphic Controls
Mineralization is hosted by a pegmatite body within the middle Proterozoic Pikes Peak Granite and is further localized by faults, fissures, and fractures.

HILLTOP PEGMATITE-HOSTED URANIUM MINE OF PULVER-LAKE GEORGE DISTRICT

LOCATION
The Hilltop Mine is located in SE1/4 section 12, T. 12 S., R. 72 W. (Nelson-Moore and others, 1978).

HISTORY, PRODUCTION, AND GRADE
An unknown amount of ore was produced from small workings consisting of one pit and one open cut (Nelson-Moore and others, 1978).

FORM OF DEPOSIT AND COMPOSITION OF ORES
The Hilltop deposit consists of uranium as autunite occurring within a zoned pegmatite body. Gangue minerals consist of quartz, biotite, muscovite, plagioclase, and orthoclase (Nelson-Moore and others, 1978).

WALLROCK ALTERATION
Wallrock alteration at the Hilltop Mine has not been described.

STRUCTURAL AND STRATIGRAPHIC CONTROLS
Mineralization is hosted by a pegmatite body occurring within the middle Proterozoic Pikes Pike Granite and is further localized by faults, fissures, and fractures (Nelson-Moore and others, 1978).

MICA AND FELDSPAR

HALSTEAD PEGMATITE-HOSTED MICA AND FELDSPAR MINE OF PULVER-LAKE GEORGE DISTRICT

LOCATION
The Halstead Mine is located in the SW1/4, NE1/4 section 22, T. 12 S., R. 72 W.

HISTORY, PRODUCTION, AND GRADE
Production from the Halstead Mine has not been reported.

FORM OF DEPOSIT AND COMPOSITION OF ORES
Microcline and muscovite occur within a typical pegmatite setting.

WALLROCK ALTERATION
Wallrock alteration at the Halstead Mine has not been described.

STRUCTURAL AND STRATIGRAPHIC CONTROLS
Mineralization occurs within a pegmatite body cutting Proterozoic magmatic gneiss.

VEIN-TYPE COPPER-GOLD-SILVER

APEX COPPER-GOLD MINE OF PULVER-LAKE GEORGE DISTRICT

LOCATION
The Apex Mine is located in the center of section 1, T. 12 S., R. 72 W.

HISTORY, PRODUCTION, AND GRADE
Crude ore and concentrates were reportedly produced at the end of 1921 from a 250-foot shaft and 450 feet of drifts and crosscuts, all developed on one level.

FORM OF DEPOSIT AND COMPOSITION OF ORES
The deposit consists of three fissure veins containing gold, silver, copper, lead, tungsten, and molybdenum; minerals include chalcopyrite, covellite, galena, scheelite, and molybdenite. Gangue minerals include quartz, muscovite, topaz, fluorite, and siderite. Masses of galena may contain 0.3–0.7 percent silver, 0.3–1.5 percent bismuth, and 0.007–0.700 percent copper.

WALLROCK ALTERATION
Alteration at the deposit consists of extensive greisenization.

STRUCTURAL AND STRATIGRAPHIC CONTROLS
Mineralization is localized by fissures, contacts, and favorable rock units within greisen of the middle Proterozoic granite-aplite, porphyritic granite, granite, pegmatite, and the Silver Plume(?) Quartz Monzonite.

FLUORITE

KYNER FLUORITE MINE OF PULVER-LAKE GEORGE DISTRICT

LOCATION
The Kyner Mine is located in section 28, T. 12 S., R. 71 W.

HISTORY, PRODUCTION, AND GRADE
Unknown amounts of ore were produced from a 110 foot-long open cut and from a drift of unknown length. Coarse fluorspar that was probably present in veins and fissures yielded a grade of 92–97 percent CaF_2 . Replacement ore had a grade of 37 percent CaF_2 (Argall, 1949).

FORM OF DEPOSIT AND COMPOSITION OF ORES
The Kyner Fluorite deposit consists of fissures, veins, and replacements within granite and limestone that occupied joints and en-echelon structures with strikes of N 30–45 W and dips of 70–80 degree to the northeast. The largest vein is about 20 feet thick (Argall, 1949).

WALLROCK ALTERATION
Wallrock alteration at the Kyner Fluorite Mine has not been described.

STRUCTURAL AND STRATIGRAPHIC CONTROLS
The presence of a granitoid intrusive apparently controls ore emplacement.

MINERAL DEPOSIT TYPES OF SOUTHEAST PARK COUNTY

Mineral commodities of southeast Park County include a variety of metallic and non-metallic deposit types that are hosted primarily in Proterozoic metamorphic rocks, but also include Paleozoic clastic and Cenozoic volcanic rocks. These include: 1) skarn deposits hosted by the early Proterozoic gneiss where it is intruded by early Proterozoic granitoid and related pegmatite; mineral commodities include tungsten and copper- zinc and minor to significant rare-earth elements, gold, silver, uranium, and thorium; 2) stratiform deposits of zinc, copper, cobalt, silver, and gold in Proterozoic schist, gneiss, and amphibolite. These deposits are similar to the copper-zinc skarns described by Heinrich (1981) and other authors; 3) vein deposits of tungsten, copper, gold, and silver in fractured zones within Proterozoic crystalline rocks. These may be related to the tungsten and copper-zinc skarns described by Heinrich (1981) and other authors; 4) Proterozoic pegmatite deposits containing gold, copper, and tungsten; 5), Proterozoic pegmatite deposits containing beryllium, uranium, and rare earth elements; 6) Proterozoic pegmatite deposits barren of metals but mined for feldspar, mica, and beryl; 7) stratabound Paleozoic and Cenozoic clastic- and volcaniclastic-hosted uranium and vanadium deposits; and 8) Tertiary volcanic-hosted pumice and manganese deposits.

TUNGSTEN-TIN SKARNS (GUFFEY DISTRICT)

Early Proterozoic age silicate gneiss units in the east central and southeastern portion of Park County are the dominant host rock for at least 23 tungsten skarn deposits (Heinrich, 1981). Stratabound granoblastic (non-foliated) deposits are present in the southeastern part of the county but are far more common in the central Park County. Tungsten skarns consist of irregular masses, boudins, stubby lenses, pods, and thin layers, which are often only a few tens of feet long; all of the preceding occur within biotite, sillimanite, and amphibolite gneiss sub units (Heinrich, 1981). Tabular lensoid veins are also present locally. Most of the deposits are the products of metasomatic processes associated with regional metamorphism although some constitute true igneous contact metasomatic tactites (Hawley, 1969). Ore controls for the tungsten skarns appear to be almost entirely stratigraphic (Heinrich, 1981).

The primary tungsten mineral is disseminated scheelite and powellite whereas copper, when present, occurs chiefly as bornite, but also as chalcopyrite, chalcocite, and covellite. Zinc occurs as sphalerite. Molybdenum, tin, uranium, and gold also have been identified at some occurrences (Heinrich, 1981). Gangue minerals include garnet, epidote, zoisite, clinozoisite, wollastonite, vesuvianite, diopside, quartz, calcite and locally bustamite and rhodonite.

ZINC-COPPER-COBALT-SILVER-GOLD SKARNS (GUFFEY DISTRICT)

Proterozoic granitoids, gneisses, and schists in the east-central and southeastern portion of Park County host at least four copper-zinc skarns (Heinrich, 1981). These generally occur as stratabound granoblastic bodies but some veins are also present. Copper-zinc and copper skarns show a marked affinity for amphibolites and, to a lesser extent, anthophyllite or gederite-cordierite gneiss, hornblende-diopside gneiss, and hornblendite (Heinrich, 1981). Faults also plays an important role in the localization of the ore deposits. Like tungsten skarns, most of the copper and copper-zinc skarns are unrelated to igneous contacts and owe their origin to metasomatic processes associated with regional metamorphism. However, true metasomatic tactites associated with igneous intrusions are also present (Hawley, 1969).

Skarns in southeast Park County have yielded predominantly copper and zinc. Copper occurs chiefly as bornite but also as chalcopyrite, chalcocite, and covellite. Zinc occurs as sphalerite. Tungsten, where present, occurs as disseminated scheelite and powellite. Molybdenum, tin, uranium, and gold also have been identified at some occurrences (Heinrich, 1981). Various combinations of garnet, epidote, zoisite, clinozoisite, wollastonite, vesuvianite diopside, quartz, calcite and locally bustamite and rhodonite comprise the gangue minerals. Unlike tungsten, which usually exhibit limited dimensions, copper zinc skarns locally are up to 1,000 feet long and 150 feet wide with down dip extensions of up to several hundred feet (Heinrich, 1981).

VEIN-TYPE TUNGSTEN-COPPER-GOLD-SILVER (GUFFEY DISTRICT)

This deposit type appears to be closely related to the tungsten and copper-zinc skarns and is discussed in the section on Mineral Deposits of East-Central Park County under the heading of Tungsten and Copper-Zinc Skarns.

PEGMATITE-HOSTED COMMODITIES

Pegmatite bodies host a diverse variety of economic minerals and are found primarily in east central and southeast Park County. They occur in Proterozoic gneiss and granite. The deposits are classified by the minerals exploited, including beryllium, uranium, columbium-tantalum, and rare-earth minerals, as well as muscovite, microcline, and plagioclase. Many pegmatite bodies contain more than one economic commodity. In terms of size, most pegmatites are small tabular or lenticular bodies that vary from a few tens of feet in width up to several hundred feet in length. Many are zoned, and exhibit concentric mineralogic and/or textural shells which may comprise a border, wall, or intermediate zone formed about a central core (Hanley and others, 1950). The zones commonly consist of the following (Figure 13): 1) microcline-quartz or quartz (the core zone); 2) plagioclase-muscovite-quartz ± microcline (the intermediate zone); 3) plagioclase-quartz-microcline ± muscovite ± biotite (the wall zone); and 4) fine-grained equivalents of wall zone minerals (the border zone). The economic minerals typically exhibit a strong preference for a particular zone. For example, beryllium and columbium-tantalum minerals are most common in the intermediate zone whereas lithium-bearing minerals usually occur in the core. In other instances certain minerals occur as hydrothermal replacements within pre-existing zones or along fractures. The types of pegmatites present in southeast Park County are briefly discussed by commodity.

PEGMATITE-HOSTED BERYLLIUM-URANIUM-RARE-EARTH MINERALS (GUFFEY DISTRICT)

Pegmatite bodies that contain beryllium, uranium, and rare-earth minerals occur in lensoid to podiform bodies that range in size up to 375 feet x 130 feet within Proterozoic granitic and gneissic host rocks. Economic commodities include niobium, bismuth, uranium, thorium, tantalum, beryllium, titanium, and tin; minerals include beryl, columbite, bismuthite, beyerite, monazite, and uranothorite. Bodies rich in rare-earth minerals contain euxenite, monazite, ilmenite, and allanite. Ore minerals typically occur between a core of massive quartz and microcline and a wallrock zone comprised of medium-grained quartz-microcline-plagioclase-muscovite-garnet. Some columbite samples contain 48.28 percent Cb_2O_5, 26.53 percent Ta_2O_5, 2.64 percent TiO_2, and 0.19 percent SnO_2. Gangue mineral include quartz, plagioclase, microcline, muscovite, garnet, schorlite, and apatite, and biotite, magnetite, and chlorite. Primary ore controls are the pegmatite body, with localization of mineralization by faults and fractures.

PEGMATITE-HOSTED COPPER-GOLD-TUNGSTEN (GUFFEY DISTRICT)

Disseminated chalcopyrite and bornite occur primarily in nonfoliated actinolite-clinozoisite-sphene-magnetite rock within pegmatite bodies, some of which are located only several hundred feet from a copper-zinc skarn.

PEGMATITE-HOSTED MICA-FELDSPAR (GUFFEY DISTRICT)

Numerous small pegmatite bodies that are both barren and that contain metallic and rare-earth minerals occur in southeast Park County. The deposits have been exploited for microcline and muscovite.

STRATABOUND VOLCANICLASTIC AND CLASTIC-HOSTED URANIUM (GUFFEY DISTRICT)

Uranium and vanadium occur within tabular bodies in sandstone, siltstone, poorly sorted arkosic gravel, and clay of the Pennsylvanian Minturn Formation and in rhyolitic ash-flow tuffs of the Oligocene Wall Mountain Tuff. Faults and fractures in permeable rocks provide the locus for mineralization.

VOLCANIC-HOSTED PUMICE AND MANGANESE (BLACK MOUNTAIN DISTRICT)

Concordant deposits of pumice and manganese are hosted by ash flow tuffs and andesitic flows of the upper member of the Oligocene Thirtynine Mile Andesite. The pumice probably formed as a result of the devitrification of glassy volcanic units that were subsequently mineralized with manganese from coeval volcanic processes.

TYPICAL MINES OF SOUTHEAST PARK COUNTY

TUNGSTEN SKARNS OF THE GUFFEY DISTRICT

B & G Tungsten Skarn Mine of the Guffey District

Location

The B & G Tungsten Mine is located in NW1/4, SE1/4, SE1/4, SW1/4 section 25, T. 14 S., R. 74 W.

History, Production, and Grade

B & G Tungsten Mine produced an unknown amount ore from two 15 feet-deep shafts; and 25 feet of workings.

Form of Deposit and Composition of Ores

The deposit is a skarn within the early Proterozoic gneiss intruded by a pegmatite. Low-grade tungsten as scheelite occurs as crystals, grains, flakes, and coatings in lensoid, tabular, pod-like bodies within northwest-striking, nearly vertically dipping,"veins" within calc-silicate layers (Belser, 1956,). These bodies or veins follow the schistosity of the enclosing Proterozoic schist, biotite, and migmatitic gneiss. Gangue minerals include garnet, epidote, chlorite, and quartz.

Wallrock Alteration
Rocks bordering the deposit are highly altered.

Structural and Stratigraphic Controls
Calc-silicate wallrock controls mineralization.

COPPER-ZINC SKARNS OF THE GUFFEY DISTRICT

Betty (Lone Chimney) Copper-Zinc-Lead-Silver-Gold Skarn

Location
The Betty Mine is located in W1/2, NW1/4, NE1/4 section 21, T. 15 S., R. 73 W., about a mile west of Currant Creek; Lone Chimney Mine is located section 16, T. 15 S., R. 73 W.

History, Production, and Grade
Workings are the 300-foot Howell Shaft with minor drifts and the 30-foot Dell Shaft with a 30-foot drift and a crosscut that followed the mineralized zone northeastward (Lovering and Goddard, 1950).

Form of Deposit and Composition of Ores
The mineralized zone is comprised of a skarn as much as 12 feet wide, formed from the recrystallization and metasomatism of the enclosing quartz-muscovite schist, biotite gneiss, sillimanite-cordierite gneiss, and amphibolite. A cupola of the early Proterozoic granite occurs south and north of the mine between the Currant Creek and Chumway Park Faults. According to Heinrich, (1981) skarn types include: 1), sillimanite-quartz-rock; 2) non-foliated pegmatoidal cordierite-sillimanite-quartz rock; 3) cordierite-quartz rock with both pegmatoidal and graphic phases; 4) cordierite-anthophyllite; 5) anthophyllite; 6) actinolite; and 7) gahnite-quartz pegmatoids as well as massive gahnite. Sulfide minerals consist of (in order of abundance) chalcopyrite, sphalerite, galena, pyrite, bornite, and covellite (Bever, 1953). Gangue minerals include calcite, epidote, magnetite, biotite, muscovite, chlorite, grossularite, hornblende, and gahnite (Heinrich, 1981). Eckel (1932) reported the presence of vesuvianite. Oxidation of primary copper sulfide minerals has produced malachite and azurite in near-surface rocks (Heinrich, 1981).

Wallrock Alteration
A typical assemblage of skarn minerals is present in the form of cordierite, quartz, calcite, garnet, anthophyllite, epidote, spinel, and sillimanite.

Structural and Stratigraphic Controls
Ore controls include fractures and dike-injected faults with strikes of N 42 E and dips of 6 degrees southeast that cut metamorphic foliation having a strike of N 22 E and a dip of 55–-65 degrees southeast (Figure 12) (Heinrich, 1981).

Copper Queen Copper-Zinc Mine of Guffey District

Location
The Copper Queen Mine is located in the NE1/4, SW1/4 section 21, T. 15 S., R. 73 W., on the north side of Thirtyone Mile Creek 1.5 miles west of its junction with Currant Creek (Colorado State Highway 9) (Heinrich, 1981). The Copper King Mine, a pegmatite-hosted deposit exhibiting similar mineralogy, occurs several hundred feet to the west.

History, Production, and Grade
Several adits have been developed on the property.

Form of Deposit and Composition of Ores
Disseminated chalcopyrite and bornite occur in anthophyllite skarns occurring within a 1,980 foot-wide body of biotite-sillimanite gneiss. The gneiss body is intruded by the early Proterozoic granite north and west of the mine and is nonconformably overlain by Tertiary rhyolite to the east.

Wallrock Alteration
Wallrock alteration consists of typical skarn minerals including garnet, epidote, chlorite, quartz, actinolite, clinozoisite, sphene, magnetite, and anthophyllite.

Structural and Stratigraphic Controls
Calc-silicate beds and faults and fractures control the distribution of mineralization.

Stratabound-Hosted Zinc-Copper-Cobalt-Silver-Gold Mine of Guffey District
These stratabound deposits are typified by the Betty (Lone Chimney) and Mill Gulch Mine and appear to be identical to the copper-zinc skarns described by Heinrich, 1981; Eckel, 1932; Lovering and Goddard, 1950; Bever, 1950; Belser, 1956; Hanley and others, 1950.

VEIN-TYPE COPPER-GOLD-SILVER

Vein-Type Copper-Gold-Silver Mines of Guffey District
These deposits include the so-called “veins” of Crescent Mine and appear be identical and/or related to the precious metal-bearing copper-zinc skarns described by Heinrich, 1981; Eckel, 1932; Lovering and Goddard, 1950; Bever, 1950; Belser, 1956; Hanley and others, 1950.

PEGMATITE-HOSTED BERYLLIUM-URANIUM-RARE-EARTH MINERALS, MICA-FELDSPAR

MEYERS RANCH PEGMATITE-HOSTED BERYLLIM-URANIUIM-RARE-EARTH MINERALS MINE OF GUFFEY DISTRICT

LOCATION

The Meyers Ranch Mine is located in NE1/4 section 31, T. 14 S., R. 73 W., about 15 miles northwest of Guffey.

HISTORY, PRODUCTION, AND GRADE

Minor production occurred during the 1930s and included 200 tons of feldspar, 150 tons of scrap mica, 25 tons of beryl, and one ton of columbite-tantalite (Hanley and others, 1950).

FORM OF DEPOSIT AND COMPOSITION OF ORES

The deposit is a 375 foot-long, 130 foot-wide, ovoid, lens-shaped hydrothermal replacement lode within a zoned pegmatite that strikes N 30 E within Proterozoic mafic granite and biotite gneiss. Zones within the body include (Hanley and others, 1950; Heinrich and Bever, 1957): 1) quartz-microcline pegmatite (the core zone); 2) quartz-muscovite-albite pegmatite containing accessory beryl, columbite, apatite, garnet, black tourmaline, and bismuth carbonate minerals (intermediate zone); 3) quartz-microcline-muscovite-plagioclase pegmatite with accessory plagioclase, garnet, and black tourmaline (the wall zone). Economic minerals lie between a core of massive quartz and microcline and a wall rock zone comprised of medium-grained quartz-microcline-plagioclase-muscovite-garnet. Niobium, bismuth, uranium, tantalum, feldspar, mica, beryllium, titanium, and tin are present in the ore zone as microcline, muscovite, beryl, columbite, bismuthite, beyerite, monazite, and uranothorite (Heinrich and Bever, 1957). A columbite sample analyzed 48.28 percent Cb_2O_5, 26.53 percent Ta_2O_5, 2.64 percent TiO_2, and 0.19 percent SnO_2. Gangue minerals include quartz, plagioclase, muscovite, garnet, schorlite, and apatite.

WALLROCK ALTERATION

The wallrock zone of the deposit is comprised of medium-grained quartzo-feldspathic minerals and is gradational with the country rock (Hanley and others, 1950).

STRUCTURAL AND STRATIGRAPHIC CONTROLS

The pegmatite trends N 30 E, dips inward on all sides, and is enclosed by granite gneiss. The primary ore controls are the pegmatite body itself, with further localization of mineralization by faults and fractures. In particular, the body has been shattered and fissured by a northwest-striking, southwest-dipping shear zone located near its center (Hanley and others, 1950).

PEGMATITE-HOSTED COPPER-GOLD-TUNGSTEN

COPPER KING PEGMATITE-HOSTED COPPER-GOLD-TUNGSTEN MINE OF GUFFEY DISTRICT

LOCATION

The Copper King Mine is located in the NE1/4, SW1/4 section 21, T. 15 S., R. 73 W., on the north side of Thirtyone Mile Creek 1.5 miles west of its junction with Currant Creek (Colorado State Highway 9) (Heinrich, 1981). The Copper Queen Mine, a skarn deposit exhibiting similar mineralogy, lies several hundred feet to the east.

HISTORY, PRODUCTION, AND GRADE

The Copper King deposit was mined for feldspar in the 1930s (Heinrich, 1981).

FORM OF DEPOSIT AND COMPOSITION OF ORES

The deposit is a narrow northeast-trending pegmatite body. Disseminated chalcopyrite and bornite occur primarily in nonfoliated actinolite-clinozoisite-sphene-magnetite rock.

WALLROCK ALTERATION

Wallrock alteration in the Copper King Mine has not been reported.

STRUCTURAL AND STRATIGRAPHIC CONTROLS

The Copper King deposit is localized within a pegmatite body and is enclosed by actinolite and anthophyllite schist that is locally impregnated with bornite (Hanley and others, 1950)

PEGMATITE-HOSTED URANIUM AND RARE-EARTH DEPOSITS

BAUMER PEGMATITE-HOSTED URANIUM AND RARE-EARTH MINERALS MINE OF GUFFEY DISTRICT

LOCATION

Baumer Mine is located in NW1/4, NE1/4 section 31, T. 15 S., R. 72 W. (Heinrich and Bever, 1957).

HISTORY, PRODUCTION, AND GRADE

Production from the mine has not been reported, but the workings are 45 feet long, 10 feet wide, and 6 feet deep (Heinrich and Bever, 1957).

FORM OF DEPOSIT AND COMPOSITION OF ORES

The deposit consists of a 60 feet-long and 15 feet-wide, northwest-plunging pod-like body within a vertical pegmatite that strikes N 35 W. The deposit contains uranium, thorium, and rare earth elements in euxenite, monazite, ilmenite, and allanite (Heinrich and Bever, 1957). Gangue minerals include microcline, plagioclase, quartz, biotite, magnetite, and chlorite. The pegmatite consists of two units: a wall zone of reddish microcline, white plagioclase (An13) and colorless quartz masses up to 4 inches long, and a core of quartz and light-red microcline with biotite altered to chlorite (Heinrich and Bever, 1957). Euxenite associated with minor monazite occurs mostly in the wall zone near the core. Radioactive ilmenite is enclosed in parallel sheaves of biotite in the core along its margins. Allanite in quartz pegmatite is cut by biotite blades.

Wallrock Alteration
Wallrock alteration has not been reported for the Baumer Mine.

Structural and Stratigraphic Controls
A mineralized granitic pegmatite intrudes the contact between Proterozoic biotite gneiss and biotite- sillimanite schist and controls the distribution of mineralization (Heinrich and Bever, 1957).

URANIUM

Goermer Stratabound Volcaniclastic andClastic-Hosted Uranium Mine of Guffey District

Location
The Goermer Mine is located in the N1/2, SW1/4 section 19, T. 15 S., R. 73 W.

History, Production, and Grade
Thirty tons of uranium-vanadium ore were produced from small surface workings in 1966 and were analyzed to contain 0.28 percent U_3O_8 and 0.59 percent V_2O_5.

Form of Deposit and Composition of Ores
Uranium and vanadium as autunite occurs within a tabular body hosted by sandstone, siltstone, poorly sorted arkosic gravel, and clay of the Pennsylvanian Minturn Formation and within a rhyolitic ash-flow tuff of the Oligocene Wall Mountain Tuff (Nelson-Moore and others, 1978). The tuff is similar to the nearby Echo Park Alluvium, which hosts large uranium deposits in the Tallahassee Creek district of Fremont County 10 miles south-southeast of the Goermer Mine (Nelson-Moore and others, 1978).

Wallrock Alteration
Wallrock alteration has not been reported for the Goermer Mine.

Structural and Stratigraphic Controls
Faults and fractures in permeable rocks provide the locus for mineralization.

MANGANESE AND PUMICE

Black Mountain Volcanic-Hosted Pumice and Manganese Mine of Black Mountain District

Location
The Black Mountain deposit is located in sections 29, 28, and 32; T. 15 S., R. 74 W.

History, Production, and Grade
No production is known from the surface workings. This deposit may comprise the largest pumice deposit in Colorado (Bush, 1951).

Form of Deposit and Composition of Ores
The deposit is a horizontal concordant body of pumice at least 18 feet thick which was probably derived from the devitrification of glassy volcanic units that were subsequently impregnated with manganese (Bush, 1951). The deposit may be part of a landslide deposit derived from volcanic rocks on adjoining slopes.

Wallrock Alteration
Devitrification is the only alteration reported (Bush, 1951).

Structural and Stratigraphic Controls
The Black Mountain deposit is hosted by the ash flow tuffs and andesitic flows of the upper member of the Oligocene Thirtynine Mile Andesite.

MINERAL DEPOSIT TYPES OF CENTRAL PARK COUNTY

Uranium and coal are the most common deposit types in central Park County; minor mineral deposits contain gold, lead-zinc, copper, tungsten, pegmatitic minerals, vermiculite, and barite. Detailed information on mineral deposits in this area is limited.

VOLCANIC-HOSTED LEAD-ZINC (HARTSEL DISTRICT)

Lead and zinc minerals occur in ash and lahar deposits of the Oligocene Antero Formation.

PROTEROZIC-HOSTED GOLD-VERMICULITE (HARTSEL DISTRICT)

Vermiculite, gold, and titanium occurrences are hosted by granite, schist, and basic rocks.

VOLCANIC-HOSTED URANIUM (HARTSEL EXTENDED-BATH-GARO DISTRICT)

Uranium mineralization (autunite?) occurs in an irregular shear zone traversing breccia deposits of the lower member of the Oligocene Thirtynine Mile Andesite. Gangue minerals include pyroxene, hornblende, and biotite.

SEDIMENT-HOSTED URANIUM (BATH DISTRICT)

Uranium as autunite occurs within irregular, tabular bodies hosted by permeable sandstone units of the Tertiary Florissant Lake Beds. The deposits here probably resulted from uranium-laden oxidizing ground waters reacting with organic material or other reductants; this caused the dissolved uranium to precipitate thus creating epigenetic mineral deposits similar to those in roll front-type uranium deposits.

TUNGSTEN-COPPER SKARNS (HARTSEL DISTRICT)

Tungsten-copper skarn deposits here are practically identical to those occurring in east central Park County. Calc-silicate layers (called veins in the older literature) within early Proterozoic age biotite and migmatite gneiss units are the chief hosts for the granoblastic (nonfoliated) deposits (Heinrich, 1981). The bodies consist of lensoid to podiform masses and thin layers, which are often only a few tens of feet long. True veins may exist locally. Most of the deposits are the product of metasomatic processes associated with regional metamorphism, although some may constitute true igneous contact metasomatic tactites (Hawley, 1969). Ore controls appear to be dominantly stratigraphic (Heinrich, 1981). Scheelite is the primary tungsten mineral and occurs as disseminated crystals, grains, flakes, and coatings. Copper occurs as diurleite, but may also be present as bornite, chalcopyrite, chalcocite, and covellite. Zinc, where present, occurs as sphalerite. Molybdenum, tin, uranium, and gold minerals are similar to these recorded in east-central Park County skarn deposits. Gangue minerals include garnet, epidote, chlorite, quartz, and vesuvianite.

PEGMATITE-HOSTED RARE-EARTH MINERALS, THORIUM, AND BERYL (HARTSEL DISTRICT)

Monazite, beryl, schorlite, tantalite, euxenite, microcline, muscovite, and columbite are hosted by small pegmatite bodies in Proterozoic migmatitic biotite gneiss. Fractures within these bodies provide further localization for mineralization.

BARITE (HARTSEL DISTRICT)

Barite occurs in both bedding replacement deposits and in fracture-controlled vein deposits within limestone host rocks of the Pennsylvanian Maroon Formation.

COAL (HARTSEL EXTENDED DISTRICT)

In the Hartsel extended district, thin beds of coal occur in the Cretaceous Laramie Formation, but only attain minable thickness in the northwestern part of Park County in the vicinity of Como.

TYPICAL MINES OF CENTRAL PARK COUNTY

VOLCANIC-HOSTED LEAD-ZINC MINE OF HARTSEL DISTRICT

UNNAMED LEAD-ZINC MINE

LOCATION

An unnamed lead-zinc mine is located in the SE $^1/_4$ section 12, T. 13 S., R. 75 W.

HISTORY, PRODUCTION, AND GRADE

Production information from the unnamed lead-zinc mine is unreported.

FORM OF DEPOSIT AND COMPOSITION OF ORES

No information on the deposit have been reported.

WALLROCK ALTERATION

Wallrock alteration has not been reported for the unnamed mine.

STRUCTURAL AND STRATIGRAPHIC CONTROLS

The mine is hosted by water-laid ash and lahar deposits, which are interlayered with platy siltstone, shale, limestone, and ash-flow tuff deposits of the 2,000 foot-thick Oligocene Antero Formation (Epis and others, 1979).

PROTEROZOIC-HOSTED GOLD PROSPECT OF HARTSEL DISTRICT

UNNAMED GOLD PROSPECT OF HARTSEL DISTRICT

LOCATION

An unnamed gold prospect on Spinney Mountain is located in the SE $^1/_4$ section 24, T. 12 S., R. 74 W.

HISTORY, PRODUCTION, AND GRADE

Production from the unnamed gold prospect has not been reported.

FORM OF DEPOSIT AND COMPOSITION OF ORES

Vermiculite, gold, and titanium occur in an unknown deposit mode.

Wallrock Alteration
Wallrock alteration has not been reported for the unnamed gold mine.

Structural and Stratigraphic Controls
Mineralization is hosted by granite, schist, and unspecified mafic rocks contained within a unit mapped as early Proterozoic granodiorite (Epis and others, 1979). Vermiculite is an alteration product of the granodiorite.

VOLCANIC-HOSTED URANIUM-GOLD MINES OF HARTSEL EXTENDED-BATH-GARO DISTRICTS

Balfour Uranium-Gold Mine of Hartsel District

Location
The Balfour Mine is located in the SW1/4, SE1/4 section 17, T. 13 S., R. 74 W.

History, Production, and Grade
Minor, but unreported, production occurred from underground workings in the Balfour Mine.

Form of Deposit and Composition of Ores
The Balfour deposit occurs in an irregular shear zone occurring in the lower member of the Thirtynine Mile Andesite (Epis and others, 1979). The ore mineral is probably autunite; gangue minerals include pyroxene, hornblende, and biotite.

Wallrock Alteration
Wallrock alteration has not been reported for the Balfour Mine.

Structural and Stratigraphic Controls
Fractures and faults, probably related to the north-northwest-trending Currant Creek Fault Zone located 0.25 miles to the southwest, localize mineralization within the lower member of the Oligocene Thirtynine Mile Andesite (Epis and others, 1979). This unit is comprised of purple, gray, brown, and black, chaotically stratified, unsorted, well-indurated breccia. Although the unit is generally nonvesicular pyroxene andesite, it also contains minor hornblende- and biotite-bearing andesite.

SEDIMENT-HOSTED URANIUIM MINE OF BATH DISTRICT

Carson Uranium Mine of Bath District

Location
The Carson Mine is located in the center of E1/2, E1/2, SW1/4 section 19, T. 13 S., R. 76 W.

History, Production, and Grade
Limited production took place at the Carson Mine from underground workings and bulldozer trenches (Nelson-Moore and others, 1978).

Form of Deposit and Composition of Ores
Uranium as autunite occurs within irregular, tabular bodies hosted by sandstone and in small fractures in volcanic rocks (Nelson-Moore and others, 1978).

Wallrock Alteration
Wallrock alteration has not been reported for the Carson Mine.

Structural and Stratigraphic Controls
The Carson uranium deposit is the result of uranium-bearing oxidized ground waters reacting with reductants within favorable permeable sandstone and tuff units of the Tertiary Florissant Lake Beds and Oligocene Tallahassee Creek Conglomerate and in fractures within an unnamed trachyte unit (Nelson-Moore and others, 1978).

TUNGSTEN-COPPER SKARNS OF HARTSEL DISTRICT

School Section Tungsten Prospect of Hartsel District

Location
The School Section Tungsten Prospect is located in the N1/2, NW1/4 section 36, T. 14 S., R. 74 W.

History, Production, and Grade
No production has been recorded, but two 15-foot shafts and 5 surface cuts up to 25 feet long and 12 feet deep comprise the workings (Heinrich, 1981). A sample from the deepest cut contains 0.84 percent WO_3 for an interval of 16 feet (Belser, 1956).

Form of Deposit and Composition of Ores
The School Section Tungsten prospect is a skarn deposit resulting from intrusion by Proterozoic pegmatite masses. Tungsten and copper as scheelite and diurleite occur in lensoid, tabular, pod-like, bodies within north to northwest-striking, vertical, "veins" of calc-silicate. Scheelite occurs as crystals, grains, flakes, and coatings. Gangue minerals include garnet, epidote, chlorite, quartz, and vesuvianite (Heinrich, 1981).

Wallrock Alteration
Wallrock alteration has not been reported for the School Section Prospect.

Structural and Stratigraphic Controls
The mineralized skarn zone occurs between two north-striking pegmatite dikes (Heinrich, 1981). Host rocks

are calc-silicate layers in early Proterozoic schist, biotite gneiss, and migmatitic gneiss (Epis and others, 1979).

PEGMATITE-HOSTED RARE-EARTH MINERALS, THORIUM, AND BERYL MINE OF HARTSEL DISTRICT

East-West Pegmatite Rare-Earth Minerals-Beryllium-Thorium Mine of Hartsel District

Location

The East-West Mine is located in the center, S1/2 section 25, T. 14 S., R. 74 W.

History, Production, and Grade

A small amount of feldspar (microcline?) and possibly muscovite was produced during the 1950s.

Form of Deposit and Composition of Ores

Monazite, beryl, schorlite, tantalite, euxenite, microcline, muscovite, and columbite are hosted within a small pegmatite body occurring in a Proterozoic migmatitic biotite gneiss (Bever, 1953; Heinrich and Bever, 1957).

Wallrock Alteration

Wallrock alteration has not been reported for the East-West Mine.

Structural and Stratigraphic Controls

Mineralization occurs within a pegmatite body and is further localized by fractures.

BARITE MINE OF HARTSEL DISTRICT

Unamed Barite Mine of Hartsel District

Location

An unnamed barite prospect is located approximately two miles southwest of Hartsel in the NW1/4, NW1/4 section 18, T. 12 S., R. 75 W.

History, Production, and Grade

Fifteen pits up to 10 feet deep are present (Howland, 1936). Production information has not been reported.

Form of Deposit and Composition of Ores

The deposit, in addition to barite veins, consists of porous light blue to white barite crystal aggregates intermixed with limonite and clay that occur as irregular replacement masses that roughly parallel bedding; both mineralization types are stratabound within an isolated limestone horizon occurring in a redbed sequence. No sulfides have been observed (Howland, 1936). Veins are 1–2 feet wide, vein-like layers 6 inches to 3 feet thick are enlarged along bedding through selective replacement (Howland, 1936; Brobst, 1957). The light-blue color of the barite may be due to irradiation by radium chloride residing in radioactive vanadium minerals like those observed at the same stratigraphic horizon approximately 8 miles north of the barite prospect.

Wallrock Alteration

Wallrock alteration has not been reported for the unnamed mine.

Structural and Stratigraphic Controls

A combination of fractures and favorable beds within a 9-foot thick, white, fine-grained, gypsiferous limestone that is overlain by red shale and sandstone control the distribution of mineralization. These units occur within a small structural basin and are part of the Permian and Pennsylvanian Maroon Formation (Howland, 1936).

VERMICULITE MINE OF HARTSEL DISTRICT

Spinney Mountain Vermiculite Mine of Hartsel District

Location

The Spinney Mountain Mine is located in section 13, T. 12 S., R. 74 W.

History, Production, and Grade

The deposit is exposed in an outcrop that measures 20 feet by 40 feet; no production has been reported (Bush, 1951).

Form of Deposit and Composition of Ores

The deposit appears to be stratiform within hornblende-biotite schist (Bush, 1951).

Wallrock Alteration

The deposit is an alteration product of both hornblende and biotite present in mafic rocks (Bush, 1951).

Structural and Stratigraphic Controls

The deposit is hosted by Proterozoic hornblende-biotite and quartz-biotite schist (Bush, 1951) mapped as Proterozoic Granodiorite by Epis and others (1979).

COAL MINE OF HARTSEL EXTENDED DISTRICT

Myner's Coal Prospect of Hartsel Extended District

Location

Myner's prospect is located in NW1/4, NE1/4 section 28, T. 11 S., R. 75 W.

History, Production, and Grade

There has been no known production from the Myner's coal prospect.

Form of Deposit and Composition of Ores

The deposit consists of 12 inches of coal, which extend for an unreported length (Washburne, 1910).

Wallrock Alteration

There is no alteration present in the Myner's coal prospect.

Structural and Stratigraphic Controls

The deposit is hosted by the Cretaceous Laramie Formation (Washburne, 1910).

MINERAL DEPOSIT TYPES OF SOUTHWEST PARK COUNTY

The only mineral commodities reported as possibly existing in southwest Park County are stratabound "redbed-type" copper-silver occurrences in the Herring Creek area near the Fremont County line.

STRATABOUND CLASTIC-HOSTED COPPER-SILVER DEPOSIT

In the Herring Creek area in southwest Park County and northwest Fremont County, the Lower Pennsylvanian Kerber Formation and Middle Pennsylvanian Sharpsdale Formation locally contain elevated amounts of copper, silver, lead, lithium, vanadium, and rarely gold (Wallace and others, 1999). These anomalous values are hosted within chemically reduced zones of coarse-grained and conglomeratic arkose beds that are interbedded with chemically oxidized conglomeratic arkose beds that filling channels and troughs, which are bounded above and below by red shale, red micaceous siltstone, red fine-, medium-, and coarse-grained arkose and arkose conglomerate. The original copper and silver-bearing minerals probably consisted of disseminated chalcopyrite, chalcocite, and bornite. Mineralized zones are 0.67–6.50 feet thick and are stratabound within rocks deposited in marine, deltaic, and paludal environments. Hydrous copper-carbonate and manganese-oxide minerals are present on the weathered surfaces of the mineralized beds. Concentrations of 16,769–18,002 ppm copper and 4.3–12.2 ppm silver were recorded from the Sharpsdale Formation in $E^{1}/_{2}$ section 2, T. 51 N., R. 10 E., about 0.25 miles south of the Park-Fremont County line. It is probable that the same mineralization extends into section 36, T. 15 S., R. 76 W. in Park County, where the Sharpsdale Formation crops out (Wallace and others, 1999). The lower portion of the Middle Pennsylvanian Minturn Formation also hosts stratabound mineralization along a growth fault and has concentrations of up to 24,005 ppm copper and 1.3 ppm silver about three miles south-southwest of the Herring Creek area (Wallace and others, 1999).

MINERAL RESOURCE INFORMATION FOR THE DISTRICTS

[COMPILED FROM THE MINERAL RESOURCE DATA SYSTEM (MRDS) DATABASE]

A summary of the individual deposits occurring within the Alma Placer, Buckskin, Consolidated Montgomery, Horseshoe, Mosquito, and Pennsylvania subdistricts, herein considered part of the Greater Alma district, are arranged by commodity and then listed alphabetically, and depicted by reference number on Plate 1 (Table 4, Appendix A). The majority of these and all mines and prospects in Park County were compiled from the USGS Mineral Resource Data System (MRDS) database and their locations were plotted on both topographic and geological base maps. Bases were derived by compilation of the Denver (Bryant and others, 1981), Pueblo (Scott and others, 1978), Montrose (Tweto and others, 1976), and Leadville (Tweto and others, 1978) 1° x 2° geologic quadrangle maps. Following the descriptions of workings within the Greater Alma district, data from other Park County mineral districts, mines, and prospects are listed alphabetically by district or subdistrict name.

GREATER ALMA DISTRICT

Summary

The Greater Alma district, including the Alma Placers, Consolidated Montgomery, Buckskin, Horseshoe, Mosquito, and Pennsylvania subdistricts, is located on the east slope of the Mosquito Range in northwest Park County. The Greater Alma district occupies all of T. 8, 9 S., R. 78, 79 W., east of the crest of the Mosquito Range, and is host to both lode and placer deposits of gold and silver and lode deposits of lead, zinc, copper, and tungsten. Some lead and zinc have been recovered from a few placer operations. However, the district is best known for its prolific gold-silver-lead vein and fissure-type deposits occurring adjacent to the London Fault and in placer gold workings near Alma and Fairplay. The Alma and Fairplay placer deposits are localized within a relatively limited area as rich concentrations of gold in medium- to coarse-glacial outwash gravel overlying shale (Vanderwilt, 1947). Nuggets up to several ounces in size were recovered.

Stratabound ("bedded") manto and vein lead-zinc deposits, with subordinate to significant gold and silver, occur over a wide stratigraphic range. Host rocks include Cambrian Peerless Shale, Ordovician Manitou Limestone, Devonian Parting Quartzite, and, most notably, the Mississippian Leadville Limestone. Additionally, lead-zinc-silver-gold vein and fault-fissure deposits of modest size occur in the Cambrian Sawatch Quartzite, and tungsten occurrences are associated with copper, lead, manganese, and fluorite occur in the Cambrian Sawatch Quartzite and in Proterozoic granitoid rocks. Partial production statistics of each of the subdistricts within the Greater Alma district are summarized in Table 4.

Alma Placers Subdistrict of the Greater Alma District

Alma Placers are located 0.25–0.50 miles northeast of Alma on the east side of the South Platte River in T. 9 S., R. 77, 78 W. (Vanderwilt, 1947). Thus, they straddle the boundary between the Beaver Creek district and the Buckskin subdistrict of the Greater Alma district. Rich concentrations of gold occur over a relatively restricted area within medium- to coarse-grained glacial outwash gravels that rest on shale bedrock. Although some of the gravels may be fluvial in origin, most lie within a secondary terminal moraine related to the Wisconsin Stage of glaciation (Vanderwilt, 1947). Table 5 summarizes production the Alma Placers.

Buckskin Subdistrict of the Greater Alma District

Buckskin subdistrict, sometimes referred to as the Buckskin Joe district, was settled and prospected about 1861 (Heyl, 1964). It occupies most of T. 9 S., R. 78 W. and wraps around the Pennsylvania and Horseshoe districts located in the central and southern parts of the township, respectively. In this paper, they are considered subdistricts within the Greater Alma district. Principal ores are gold, gold-silver, lead-silver, and, locally, zinc. Deposit types in the Buckskin subdistrict include (Vanderwilt, 1947): 1),"bedded replacement" (manto-type) deposits of lead-zinc-silver in the Mississippian Leadville Limestone; 2) vein-type deposits of silver-gold-lead- copper in the Devonian Parting Quartzite; 3) vein- and fissure-type deposits of

Table 5. Placer recovery of precious metals from Alma placer mines, 1859–1998 (U.S. Bureau of Mines Yearbooks). NA—data not available.

Year	Placer Gold (oz)	Placer Silver (oz)
1859–1932	NA	NA
1932	37	7
1933	84	19
1934	1,046	208
1935	3,007	612
1936	2,272	457
1937	2,321	472
1938	3,213	662
1939	3,154	663
1940	2,013	426
1941	2,699	568
1942	413	83
1943	6	1
1945	4	1
1946–1952	(Included with Fairplay production figures)	
1953	2	1
1954		
1955		
1956–1998	NA	NA
TOTAL	20,271	4,180

Table 4. Recovered metals from lode and placer mines within sub-districts of the greater Alma district, 1859–1998 (U.S. Bureau of Mines Yearbooks). NA—data not available.

Subdistrict	Total Gold (oz)	Total Silver (oz)	Copper (lb)	Lead (lb)	Zinc (lb)
Alma Placers	20,271	4,180	0	0	0
Buckskin	19,782	131,219	364,250	1,449,650	9,006,300
Consolidated Montgomery	5,768	79,131	38,100	201,240	82,200
Horseshoe	28	13,856	1,800	497,700	0
Mosquito	570,296	446,698	663,150	14,474,510	598,000
Pennsylvania	NA	NA	NA	NA	NA
1859–1998 Total Production	616,145	675,084	1,067,300	16,623,100	9,686,500

lead-zinc-copper and, locally barite, in the Cambrian Sawatch Quartzite and Peerless Shale and in the Ordovician Manitou Limestone and Mississippian Leadville Limestone; 4) pods, lenses, and veins of gold-silver-lead-zinc-copper in Cambrian and Ordovician carbonate and quartzite; and 5), placer gold and silver deposits in fluvial and glacial gravel (Tables, 6, 7).

Consolidated Montgomery Subdistrict, Greater Alma District

Consolidated Montgomery subdistrict occupies all of T.8S., R.78, 79W. on the east side of the Mosquito Range. Mines and prospects within the Consolidated Montgomery subdistrict exploited the following deposit types: 1) veins of gold-silver-lead-zinc in Proterozoic granite and schist; 2) manto bodies of silver-gold-zinc in the Devonian Parting Quartzite; 3) manto bodies of silver-lead-copper in the Mississippian Leadville Limestone; 4) sulfide-bearing quartz veins of tungsten containing minor gold, lead, zinc, silver, and copper; 5) veins of uranium in the Proterozoic granite and early Proterozoic schist; 6) copper-lead-zinc in an unknown, but probably vein-type, mode in an unknown host; 7) molybdenum of unknown mode in an unknown host; and 8) placer gold. Auriferous veins

Table 6. Lode vs. placer recovery of precious metals from Buckskin subdistrict mines, 1859–1998 (U.S. Bureau of Mines Yearbooks). NA—data not available.

Year	Lode Gold (oz)	Placer Gold (oz)	Total Gold (oz)	Lode Silver (oz)	Placer Silver (oz)	Total Silver (oz)
1859–1931	NA	NA	NA	NA	NA	NA
1932	21	1	22	39	0	39
1933	79	0	79	220	0	220
1934	1,178	8	1,186	5,052	0	5,052
1935	350	17	367	1,017	3	1,020
1936	114	0	114	1,437	0	1,437
1937	545	13	558	2,305	3	2,308
1938	304	9	313	993	1	994
1939	22	16	38	408	3	411
1940	1,112	15	1,127	6,594	3	6,597
1941	1,059	15	1,074	6,584	3	6,587
1942	1,445	2	1,447	9,696	0	9,696
1943	1,762	0	1,762	11,676	0	11,676
1944	1,467	0	1,467	12,008	0	12,008
1945	1,041	0	1,041	9,682	0	9,682
1946	930	21	951	6,651	5	6,656
1947	847	3	850	7,981	1	7,982
1948	554	0	554	4,458	0	4,458
1949	NA	NA	1,398	NA	NA	10,109
1950	NA	NA	1,250	NA	NA	7,142
1951	NA	NA	1,500 (est)	NA	NA	7,000
1952	NA	NA	2,019	NA	NA	6,193
1953	1,454	3	1,457	7,603	1	7,604
1954	448	0	448	3,446	0	3,446
1955	0	0	0	317	0	317
1956	30	0	30	462	0	462
1957	230	0	230	2,123	0	2,123
1958–1998	NA	NA	NA	NA	NA	NA
Total	14,992	123	19,782	100,782	23	131,219

Table 7. Recovered metals from Buckskin subdistrict lode and placer mines, 1859–1998 (U.S. Bureau of Mines Yearbooks). NA—data not available.

Year	Gold (oz)	Silver (oz)	Copper (lb)	Lead (lb)	Zinc (lb)
1859–1931	NA	NA	NA	NA	NA
1932	22	39	0	0	0
1933	79	220	1,000	1,800	0
1934	1,186	5,052	19,100	100	0
1935	367	1,020	0	4,750	0
1936	114	1,437	400	1,700	0
1937	558	2,308	1,800	26,900	0
1938	313	994	150	20,400	0
1939	38	411	700	6,800	0
1940	1,127	6,597	26,400	75,000	711,000
1941	1,074	6,587	21,600	81,600	614,000
1942	1,447	9,696	27,800	118,200	906,600
1943	1,762	11,676	42,000	163,000	941,900
1944	1,467	12,008	35,400	121,000	886,000
1945	1,041	9,682	24,600	98,400	707,000
1946	951	6,656	15,400	98,100	648,000
1947	850	7,982	15,000	104,700	648,600
1948	554	4,458	2,000	66,000	254,000
1949	1,398	10,109	1,000	167,000	365,000
1950	1,250	7,142	27,100	48,500	498,000
1951	1,500 est	7,000	27,800	59,200	486,000
1952	2,019	6,193	30,000	64,000	456,000
1953	1,457	7,604	26,000	66,000	550,000
1954	448	3,446	8,900	28,000	198,000
1955	0	317	1,300	1,600	0
1956	30	462	1,400	6,200	18,400
1957	230	2,123	7,400	20,700	117,800
1958–1998	NA	NA	NA	NA	NA
Total	19,782	131,219	364,250	1,449,650	9,006,300

and fracture zones were the most productive deposit types in the Consolidated Montgomery subdistrict. Partial production for the Consolidated Montgomery subdistrict is summarized in Tables 8 and 9.

HORSESHOE SUBDISTRICT OF THE GREATER ALMA DISTRICT

Horseshoe subdistrict was discovered about 1875 and was most active during 1883-1892, 1900–1916, and 1920–1923 (Behre, 1953). Horseshoe subdistrict is located in the southern portion of T. 9 S., R. 78 W. near the London Fault at the head of Fourmile Creek, about 10 miles west of Fairplay. Primary commodities exploited are lead and silver, with subordinate gold, copper, and zinc. The commodities were hosted by vein, fissure-filling, and replacement (manto-type) bodies occurring within Paleozoic carbonate formations, chiefly the Mississippian Leadville Limestone and Ordovician Manitou Limestone. Metal-bearing veins are also present in the underlying Proterozoic rocks, but are not economic. Placer gold has also been exploited at several locations in the Horseshoe subdistrict. Partial production records of the lode mines and

Table 8. Lode vs. placer recovery of precious metals from the Consolidated Montgomery subdistrict mines, 1859–1998 (U.S. Bureau of Mines Yearbooks). NA—data not available.

Year	Lode Gold (oz)	Placer Gold (oz)	Total Gold (oz)	Lode Silver (oz)	Placer Silver (oz)	Total Silver (oz)
1859–1931	NA	NA	NA	NA	NA	NA
1932	106	2	108	14	0	14
1933	428	0	428	1,551	0	1,551
1934	64	2	66	2,337	0	2,337
1935	447	0	447	1,312	0	1,312
1936	157	0	157	400	0	400
1937	288	4	292	16,195	1	16,196
1938	278	39	317	29,015	8	29,023
1939	929	8	937	3,132	3	3,135
1940	1,093	0	1,093	7,972	0	7,972
1941	407	5	412	1,727	3	1,730
1942	735	0	735	4,306	0	4,306
1943	359	0	359	2,416	0	2,416
1944	193	0	193	1,042	0	1,042
1945						
1946	39	0	39	3,079	0	3,079
1947	7	0	7	833	0	833
1948	20	0	20	609	0	609
1949	NA	NA	3	NA	NA	1,244
1950	NA	NA	39	NA	NA	516
1951	NA	NA	55	NA	NA	1,232
1952	NA	NA	NA	NA	NA	NA
1953	10	0	10	53	0	53
1954	0	0	0	11	0	11
1955	19	0	19	57	0	57
1956	32	0	32	63	0	63
1957–1998	NA	NA	NA	NA	NA	NA
Total	5,611	60	5,768	76,124	15	79,131

Table 9. Recovered metals from Consolidated Montgomery subdistrict lode and placer mines, 1859–1998 (U.S. Bureau of Mines Yearbooks). NA—data not available.

Year	Total Gold (oz)	Total Silver (oz)	Copper (lb)	Lead (lb)	Zinc (lb)
1859–1931	NA	NA	NA	NA	NA
1932	108	14	0	0	0
1933	428	1,551	100	900	0
1934	66	2,337	500	6,500	0
1935	447	1,312	0	3,800	0
1936	157	400	400	3,800	0
1937	292	16,196	100	5,240	0
1938	317	29,023	0	0	0
1939	937	3,135	500	1,000	0
1940	1,093	7,972	3,700	400	0
1941	412	1,730	1,500	800	0
1942	735	4,306	18,400	1,800	0
1943	359	2,416	4,400	15,000	21,100
1944	193	1,042	5,000	1,000	10,600
1945	NA	NA	NA	NA	NA
1946	39	3,079	0	0	0
1947	7	833	300	15,000	9,200
1948	20	609	0	0	0
1949	3	1,244	0	52,000	0
1950	39	516	400	28,100	2,000
1951	55	1,232	2,200	63,600	34,000
1952	NA	NA	NA	NA	NA
1953	10	53	0	0	0
1954	0	11	0	1,300	0
1955	19	57	300	900	4,000
1956	32	63	300	100	1,300
1957–1998	NA	NA	NA	NA	NA
Total	5,768	79,131	38,100	201,240	82,200

prospects within the Horseshoe subdistrict are summarized in Table 10.

Mosquito Subdistrict of the Greater Alma District

Mosquito subdistrict, within the Greater Alma district in this report, abuts the crest of the Mosquito Range and covers the western tier of sections 6, 7, 18, 19, 30, and 31, T. 9 S., R. 78 W. and the eastern tier of sections 1, 12, 13, 24, 25, and 36, T. 9 S., R. 79 W. The area lies five to seven miles west of Alma. Vein-type gold-lead-silver-zinc minerals are hosted by both Proterozoic crystalline rock and Paleozoic sedimentary rock. Mineral deposits are widespread within Paleozoic sedimentary rock, and they account for the primary production from the subdistrict. Specific deposit types and hosts include the following: 1) veins and fault/fissure-fillings of gold-silver-lead in a zone of the Pennsylvanian Minturn Formation intercalated with sills of Tertiary (?) porphyries; 2) mantos and veins of lead-zinc-silver in the Mississippian Leadville Limestone; 3) fissure-filling lead-zinc in the Mississippian Leadville Limestone; 4) vein-type uranium in the Proterozoic granite, gneiss, and schist; and 5) placer gold. Production statistics for the lode and placer mines of the Mosquito subdistrict are summarized in Tables 11 and 12.

A capsule description of the individual deposits occurring within the Alma Placer, Buckskin, Consolidated Montgomery, Horseshoe, Mosquito, and Pennsylvania subdistricts, herein considered part of the Greater Alma district, are arranged by commodity and then listed alphabetically and depicted by reference number on Plate 1 (Appendix A).

Table 10. Recovered metals from the Horseshoe subdistrict lode mines, 1859–1998 (U.S. Bureau of Mines Yearbooks). NA—data not available.

Year	Total Gold (oz)	Total Silver (oz)	Copper (lb)	Lead (lb)	Zinc (lb)
1859–1931	NA	NA	NA	NA	NA
1932	12	28	0	300	0
1933	0	9	0	1,000	0
1938	0	147	0	3,000	0
1940	0	114	0	2,000	0
1941	NA	NA	NA	NA	NA
1942	NA	NA	NA	NA	NA
1943	NA	NA	NA	NA	NA
1944	NA	NA	NA	NA	NA
1945	NA	NA	NA	NA	NA
1946	NA	NA	NA	NA	NA
1947	NA	NA	NA	NA	NA
1948	3	1,033	0	36,000	0
1949	NA	NA	NA	NA	NA
1950	2	999	300	37,200	0
1951	NA	NA	NA	NA	NA
1952	NA	NA	NA	NA	NA
1953	NA	NA	NA	NA	NA
1954	0	105	0	5,600	0
1955	NA	NA	NA	NA	NA
1956	NA	NA	NA	NA	NA
1957	11	11,421	1,500	412,600	0
1958–1998	NA	NA	NA	NA	NA
Total	28	13,856	1,800	497,700	0

BATH DISTRICT

Bath district is located in southeast Park County from one to six miles south of the south shore of Antero Reservoir. The district occupies T. 13 S., R. 76 W. and extends north into T. 12 S., R. 76 W. There are no known base- and precious- metal deposits in the Bath district. Uranium deposits are hosted by Tertiary clastic sedimentary rocks. Substantial Quaternary gravel deposits are present.

BEAVER CREEK DISTRICT

Beaver Creek district includes all but the extreme southern part of T. 9 N., R. 77 W. and most of the southern half of T. 8 S., R. 77 W. The district is located near the confluence of Beaver Creek and the South Platte River, and lies adjacent to the Alma and Tarryall Creek districts. Beaver Creek drains the southern and western slopes of Mount Silverheels about 10 miles north of Fairplay. The district is best known for its placer gold mines, which are hosted by Wisconsin Stage morainal outwash gravels associated with the South Platte Glacier in South Platte Valley. This glacier scoured the gold from deposits located on the eastern slopes of the Mosquito Range. Other metallic deposit types within the district include auriferous-cupiferous veins in the Mississippian Leadville Limestone. Non-metallic commodities include deposits of sand, gravel, and clay. Table 13 summarizes the production of precious metals from the district between 1859 to 1998.

BLACK MOUNTAIN DISTRICT

Black Mountain district is located in the south-central portion of the county in T. 15 S., R. 74 W. Deposits of uranium and manganese are hosted in volcanic breccia and tuff of Tertiary age. Some deposits of pumice are also present.

Table 11. Lode vs. placer recovery of precious metals from the Mosquito subdistrict mines, 1859–1998 (U.S. Bureau of Mines Yearbooks). NA—data not available.

Year	Lode Gold (oz)	Placer Gold (oz)	Total Gold (oz)	Lode Silver (oz)	Placer Silver (oz)	Total Silver (oz)
1859–1931	NA	NA	NA	NA	NA	NA
1932	125,440	0	125,440	63,103	0	63,103
1933	59,375	0	59,375	35,120	0	35,120
1934	82,658	1	82,659	53,698	0	53,698
1935	66,330	16	66,346	59,125	0	59,125
1936	52,663	20	52,683	47,844	4	47,848
1937	44,443	20	44,463	42,059	6	42,065
1938	33,526	18	33,544	25,891	4	25,895
1939	33,638	0	33,638	33,317	0	33,317
1940	26,731	0	26,731	32,680	0	32,680
1941	22,940	0	22,940	18,924	0	18,924
1942	15,009	0	15,009	9,152	0	9,152
1943	6,298	0	6,298	7,501	0	7,501
1944	622	0	622	2,776	0	2,776
1945	128	0	128	284	0	284
1946	49	0	49	2,708	0	2,708
1947	167	0	167	9,460	0	9,460
1948	43	0	43	229	0	229
1949	NA	NA	107	NA	NA	1,907
1950	NA	NA	12	NA	NA	179
1951	NA	NA	27	NA	NA	21
1952	NA	NA	NA	NA	NA	NA
1953	NA	NA	NA	NA	NA	NA
1954	10	0	10	241	0	241
1955	3	0	3	197	0	197
1956	2	0	2	268	0	268
1957–1998	NA	NA	NA	NA	NA	NA
Total	570,075	75	570,296	444,577	14	446,698

Table 12. Recovered metals from the Mosquito subdistrict lode and placer mines, 1859–1998 (U.S. Bureau of Mines Yearbooks). NA—data not available.

Year	Total Gold (oz)	Total Silver (oz)	Copper (lb)	Lead (lb)	Zinc (lb)
1859–1931	NA	NA	NA	NA	NA
1932	125,440	63,103	60,300	1,614,700	0
1933	59,375	35,120	69,400	1,313,000	0
1934	82,659	53,698	52,500	2,619,200	0
1935	66,346	59,125	92,000	1,899,950	0
1936	52,683	47,848	24,200	1,628,500	0
1937	44,463	42,065	65,100	1,238,660	6,000
1938	33,544	25,895	54,850	814,600	0
1939	33,638	33,317	67,700	1,069,200	0
1940	26,731	32,680	54,900	843,400	0
1941	22,940	18,924	55,000	655,400	0
1942	15,009	9,152	32,200	423,600	5,400
1943	6,298	7,501	21,200	222,000	161,400
1944	622	2,776	3,800	36,000	106,400
1945	128	284	200	3,500	0
1946	49	2,708	900	20,300	35,000
1947	167	9,460	3,300	40,600	106,800
1948	43	229	0	2,000	26,000
1949	107	1,907	5,000	19,000	141,000
1950	12	179	200	2,200	10,000
1951	27	21	0	1,200	0
1952	NA	NA	NA	NA	NA
1953	NA	NA	NA	NA	NA
1954	10	241	300	1,100	0
1955	3	197	100	3,500	0
1956	2	268	0	2,900	0
1957–1998	NA	NA	NA	NA	NA
TOTAL	570,296	446,698	663,150	14,474,510	598,000

BUFFALO PEAKS DISTRICT

Buffalo Peaks district is located in southwest Park County in T. 12 S., R. 78 W., and straddles the crest of the Mosquito Range and extending into Chaffee County to the southwest. Vein-type uranium deposits are the only deposits reported from the district.

COMO DISTRICT

Como district is centered about Como in northwest Park County. The district is located in T. 8 & 9 S., R. 75 and 76 W. but is only loosely defined. Although numerous placer gold deposits are present, the district is best known for its inactive coal mines that occur 0.5–7.0 miles northwest, west, northeast, southeast, and south of Como. The collieries operated in 1870–1905 and form the most productive portion of the South Park Coal Field, which occupies a faulted syncline about 20 miles long and 4 miles wide (Vanderwilt, 1947). The coal is hosted by the Cretaceous Laramie Formation and occurs in three principal beds that are 5–12 feet thick and separated by thick barren strata (Washburne, 1910; Vanderwilt, 1947). Washburne (1910) estimated mineable reserves at approximately

Table 13. Lode vs. placer recovery of precious metals from Beaver Creek district mines, 1859–1998 (U.S. Bureau of Mines Yearbooks). NA—data not available.

Year	Lode Gold (oz)	Placer Gold (oz)	Total Gold (oz)	Lode Silver (oz)	Placer Silver (oz)	Total Silver (oz)
1859–1998	NA	NA	NA	NA	NA	NA
1932	4	11	15	4	3	7
1933	0	5	5	0	0	0
1934	0	22	22	0	3	3
1935	0	44	44	0	4	4
1936	0	462	462	0	93	93
1937	0	336	336	0	71	71
1938	0	403	403	0	87	87
1939	0	4,300	4300	0	903	903
1940	0	5,459	5459	0	1,170	1170
1941	0	3,313	3313	0	713	713
1942	0	1,936	1936	0	422	422
1943	NA	NA	NA	NA	NA	NA
1944	0	2	2	0	0	0
1945	0	19	19	0	6	6
1946	NA	NA	NA	NA	NA	NA
1947	0	9	9	0	2	2
1948	0	11	11	0	3	3
1949	NA	NA	NA	NA	NA	NA
1950	NA	NA	NA	NA	NA	NA
1951	NA	NA	NA	NA	NA	NA
1952	NA	NA	NA	NA	NA	NA
1953	0	1	1	0	1	1
1954–1998	NA	NA	NA	NA	NA	NA
Total	4	16,333	16,337	4	3,481	3,485

18 million tons. More recent work estimated that 135 million tons of coal are present above a depth of 3,000 feet (unpublished report, 1980, Colorado Division of Minerals and Geology). The coal is bituminous grade and, although locally very thick, may exhibit lensing and 45-degree dips, which make mining difficult and expensive (Vanderwilt, 1947).

FAIRPLAY DISTRICT

Fairplay district is in west-central Park County, occupies the southern area of T. 9 S., R. 77 W. and all of T. 10 S., R. 77 W. The district is contiguous with the Beaver Creek district to the north. The district is best known for large placer gold mines that are hosted by glacial moraines and outwash gravels derived from the eastern slope of the Mosquito Range. These include the Fairplay and Cincinnati Placers that were located southeast and west of town, respectively, on the South Platte River. These placers were exploited by large bucketline-dredge operations. Tables 14 and 15 summarize the partial production of base and precious metals made from the Fairplay district.

Table 14. Lode vs. placer recovery of precious metals from the Fairplay district mines, 1859–1998 (U.S. Bureau of Mines Yearbooks). NA—data not available.

Year	Lode Gold (oz)	Placer Gold (oz)	Total Gold (oz)	Lode Silver (oz)	Placer Silver (oz)	Total Silver (oz)
1859–1931	NA	NA	NA	NA	NA	NA
1932	0	63	63	0	15	15
1933	0	119	119	0	21	21
1934	0	142	142	0	28	28
1935	0	601	601	0	128	128
1936	0	149	149	0	31	31
1937	0	123	123	0	27	27
1938	0	167	167	0	36	36
1939	50	0	50	0	50	50
1940	0	1,165	1165	0	246	246
1941	0	10,171	10171	0	2,022	2,022
1942	0	13,853	13853	0	2,738	2,738
1943	0	8	8	0	3	3
1944	0	2	2	0	0	0
1945	0	7,338	7338	0	1,284	1,284
1946	0	19,043	19,043	0	3,515	3,515
1947	0	11,775	11,775	0	2,358	2,358
1948	0	8,489	8,489	0	1,535	1,535
1949	NA	NA	8,697	NA	NA	1,569
1950	NA	NA	15,018	NA	NA	2,527
1951	NA	NA	11,684 (est)	NA	NA	1,868 (est)
1952	Shutdown 1/15/52					
1953	NA	NA	NA	NA	NA	NA
1954	0	49	49	0	9	9
1955	0	7	7	0	2	2
1956	0	6	6	0	1	1
1957	0	6	6	0	1	1
1958–1998	NA	NA	NA	NA	NA	NA
Total			97,041	0		18,146

Table 15. Recovered metals from the Fairplay district lode and placer mines, 1859–1998 (U.S. Bureau of Mines Yearbooks). NA—data not available.

Year	Total Gold (oz)	Total Silver (oz)	Copper (lb)	Lead (lb)	Zinc (lb)
1859–1931	NA	NA	NA	NA	NA
1932	63	15	0		
1933	119	21	0		
1934	142	28	0		
1935	601	128	0		
1936	149	31	0		
1937	123	27	0		
1938	167	36	0		
1939	50	50	0		
1940	1165	246	100	1,000	0
1941	10171	2,022			
1942	13853	2,738	0		
1943	8	3	0		
1944	2	0	0		
1945	7338	1,284	0		
1946	19,043	3,515	0	0	0
1947	11,775	2,358	0	0	0
1948	8,489	1,535	0	0	0
1949	8,697	1,569	0	0	0
1950	15,018	2,527	0	0	0
1951	11,684 (est)	1,868 (est)	0	0	0
1952					
1953	NA	NA	NA	NA	NA
1954	49	9	0	0	0
1955	7	2	0	0	0
1956	6	1	0	0	0
1957	6	1	0	0	0
1958–1998	NA	NA	NA	NA	NA
Total	97,041	18,146	100	1,000	0

FOURMILE DISTRICT

(For summary see Guffey district.)

GARO DISTRICT

Garo district is located 0.5 to 1.5 miles south of the village of Garo in section 16, T. 11 S., R. 76 W. and currently consists of a single group of uranium-vanadium-radium-copper bodies hosted by sandstones of the Pennsylvanian Maroon Formation. These are localized at fault intersections.

GUFFEY (FRESHWATER) DISTRICT

Guffey district; which includes the poorly defined Fourmile, Freshwater, Alhambra, and Red Ruth districts; occupies T. 14, 15 S., R. 72, 73 W. The mines and prospects are composed of diverse lode deposits that include:

1) skarn and vein deposits of tungsten and copper-zinc, with minor to significant occurrences of rare-earth minerals, gold, silver, uranium, and thorium hosted by the Proterozoic-gneiss where it is intruded by Proterozoic-granitoid and pegmatite;
2) vein deposits of copper, gold, and silver in fractured zones within Proterozoic crystalline rocks;
3) stratiform deposits of zinc, copper, cobalt, silver, and gold in Proterozoic schist, gneiss, and amphibolite;
4) stratabound Paleozoic clastic-hosted uranium and vanadium deposits;
5) stratabound Tertiary volcaniclastic-hosted uranium and vanadium deposits;
6) Proterozoic pegmatite deposits containing gold, copper, and tungsten;
7) Proterozoic pegmatite deposits containing uranium and rare earth elements;
8) Proterozoic pegmatite deposits mined for feldspar, mica, and beryl barren of metals; and
9) Tertiary volcanic- hosted pumice and manganese deposits. Production was minor (Table 16).

HALLS GULCH (HALLS VALLEY) DISTRICT

Halls Gulch district is located in northwest Park County and abuts the Continental Divide. The district occupies T. 6 S., R. 75 W. and T. 6 S., R. 76 W. It is comprised of both placer gold and vein-type base- and precious-metal lode deposits hosted by Proterozoic schist and gneiss. Commodities include gold, silver, lead, copper, and zinc. Bismuth is present in some of the veins. Mineral assemblages at the various mines include tetrahedrite, chalcopyrite, and a variable amount of gold and silver associated with a gangue of barite, quartz, and dolomite. Other mines produced lead-silver ore with low gold content. Descriptions for individual deposits have not been recorded. Production data is not available for most commodity types. Partial production records for the lode deposits of the Halls Gulch district are summarized in Table 17.

HARTSEL DISTRICT

The Hartsel district is located in south-central Park County in T. 12 S., R. 75 W.; T. 13 S., R. 74 W.; T. 14 S.,

Table 16. Recovered metals from the Guffey district lode mines, 1859–1998 (U.S. Bureau of Mines Yearbooks). NA—data not available.

Year	Total Gold (oz)	Total Silver (oz)	Copper (lb)	Lead (lb)	Zinc (lb)
1859–1931	NA	NA	NA	NA	NA
1932	NA	NA	NA	NA	NA
1933	NA	NA	NA	NA	NA
1934	NA	NA	NA	NA	NA
1935	NA	NA	NA	NA	NA
1936	NA	NA	NA	NA	NA
1937	NA	NA	NA	NA	NA
1938	NA	NA	NA	NA	NA
1939	NA	NA	NA	NA	NA
1940	NA	NA	NA	NA	NA
1941	NA	NA	NA	NA	NA
1942	NA	NA	NA	NA	NA
1943	NA	NA	NA	NA	NA
1944	NA	NA	NA	NA	NA
1945	NA	NA	NA	NA	NA
1946	6	37	700	3,600	0
1947	0	49	2,200	0	0
1948	NA	NA	NA	NA	NA
1949	NA	NA	NA	NA	NA
1950	NA	NA	NA	NA	NA
1951	NA	NA	NA	NA	NA
1952	NA	NA	NA	NA	NA
1953	NA	NA	NA	NA	NA
1954	NA	NA	NA	NA	NA
1955	1	74	4,300	0	0
1956	2	101	4,800	400	0
1957–1960					
1961–1998	NA	NA	NA	NA	NA
Total	9	261	12,000	4,000	0

R. 74 W; extensions of the district are in T. 12 S., R. 74 W. Diverse deposit types are present.

IRON HILL DISTRICT

The Iron Hill district is located in west-central Park County in SW1/4, T. 10 S., R. 78 W. and NW1/4, T. 11 S., R. 78 W. along the crest of the Mosquito Range. Lead-zinc deposits of unknown deposit type occur in carbonate rock.

KENOSHA PASS (JEFFERSON) DISTRICT

The Kenosha Pass (Jefferson) district in T. 7 S., R. 75 W. in north-central Park County. Uranium-hosted deposits in Proterozoic granitoid and Mesozoic sedimentary rocks and small fluorspar veins in Proterozoic crystalline rock are present in the district. Coal is present in at least one location. Mines and prospects of the Kenosha Pass (Jefferson) district are located on Plate 1.

LAKE GEORGE (BADGER FLATS)-PULVER DISTRICT

The Lake George (Badger Flats) Pulver district in east-central Park County is located three to nine miles west of the Jefferson County boundary. The district is in T. 12 and 13 S., R. 72 W. and W1/2, T. 12 and 13 S., R. 71 W. Deposits include a large number of tungsten-bearing skarns in Proterozoic metasedimentary rocks and veins containing combinations of gold, silver, copper, lead, molybdenum, tungsten, uranium, and fluorite in Proterozoic granitoid and foliated metamorphic rock. Some pegmatite bodies have been exploited for uranium and rare-earth minerals.

MICANITE (GUFFEY-FOURMILE) DISTRICT

The Micanite district is located in southeast Park County in SW1/2, T. 15 S., R. 72 W. about 5 miles southwest of the Freshwater-Guffey Post Office and less than two miles north of the Fremont County boundary. The district contains beryllium-bearing pegmatite bodies.

Table 17. Recovered metals from the Halls Gulch district lode mines, 1859–1998 (U.S. Bureau of Mines Yearbooks). NA—data not available.

Year	Total Gold (oz)	Total Silver (oz)	Copper (lb)	Lead (lb)	Zinc (lb)
1859–1932	NA	NA	NA	NA	NA
1933	18	3,580	11,500	2,600	0
1934	1	127	0	0	0
1937	0	172	0	1,200	0
1938	0	0	0	0	0
1939	0	50	100	1,000	0
1940	0	21	0	1,200	0
1941	1	111	900	200	0
1942–1998	NA	NA	NA	NA	NA
Total	20	4,061	12,500	6,200	0

MICHIGAN CREEK DISTRICT

The Michigan Creek district is composed of placer gold deposits occurring in T. 7 S., R. 7 W. and T. 8 S., R. 75 W.

MOUNTAINDALE DISTRICT

The Mountaindale district is located in east-central Park County in sections 20, 21, and 22, T. 11 S., R. 72 W. It is surrounded by the Tarryall Springs district. The dominant deposit types are vein-, fissure-, and greisenized pipe- deposits hosted in Proterozoic granitoid. The deposits were mined for beryllium, but also contained minor lead, zinc, arsenic, molybdenum, iron, copper, tungsten, uranium, tin, and gold. Pegmatite- and vein-hosted uranium deposits are also present. Minerals include beryl, bertrandite, euclase, galena, sphalerite, arsenopyrite, molybdenite, pyrite, chalcopyrite, covellite, wolframite, uraninite, and cassiterite.

PLATTE RANCH DISTRICT

The Platte Ranch district is located in the S1/2, T. 10 S., R. 77 W. and T. 11 S., R. 77 W. The deposit includes placer gold and sand and gravel deposits.

PULVER DISTRICT

Because boundaries of the Pulver district are poorly defined it has been combined with the Lake George (Badger Flats) district in this report. Zinc-copper-lead-gold mineralization in unknown deposit types are hosted by Proterozoic granite and schist near Pulver, about 10 miles west of Lake George.

SACRAMENTO DISTRICT

The Sacramento district is located about 8 to 11 miles southwest of Fairplay in N1/2, T. 10 S., R. 78 W. between Mosquito Creek and Fourmile Creek. The London Fault is the dominant structural feature in the area. In addition to placer gold, base- and precious-metal veins deposits occur in both Proterozoic and Paleozoic rocks; the most promising prospects occur in the Mississippian Leadville Limestone.

SHAWNEE DISTRICT

The Shawnee district is located in northeastern Park County in T. 7 S., R. 73 W. The district contains several uranium deposits in veins and shear zones within Proterozoic metamorphic rocks.

SOUTH PARK DISTRICT

The South Park district is located in central Park County in T. 10 and 11 S., R. 74 and 75 W. Tertiary sedimentary and volcaniclastic rocks host a stratabound uranium deposit; some mineralization also occurs in the underlying Proterozoic granitoid rocks.

SOUTH PLATTE PEGMATITE DISTRICT

The South Platte district in northeast Park County lies south of Bailey in T. 8 S., R. 72 W. The South Platte district contains Proterozoic-hosted pegmatite rocks and deposits of feldspar, monzonite, titanium, rare-earth elements, and gem topaz.

TARRYALL CREEK DISTRICT

The Tarryall Creek district is in the upper Tarryall Creek drainage basin on the southeast side of the Continental Divide in T. 7 and 8 S., R. 77 W. The district extends eastward into T. 8 S., R. 76 W. Tarryall Creek originates on the eastern slope of Mount Silverheels and flows southeast across South Park. Placer gold is the main commodity of the district, but some base metals have also been recovered from placer operations (Vanderwilt, 1947). Additionally, an extensive area of ubiquitous fracture and fissure-controlled pyrite-quartz-gold veins and attendant weak lead, zinc, and copper mineralization is associated with a zone of contact metamorphism produced by the Montgomery Gulch Stock. Table 18 summarizes precious-metal production from Tarryall Creek district.

TARRYALL SPRINGS DISTRICT

The Tarryall Springs district is located 1 to 11 miles west and 7 to 11 miles northwest and southwest of Lake George in T. 11 S., R. 72 W. and portions of T. 11 S., R. 71 W. and T. 11 S., R. 73 W. Tungsten has been exploited and is hosted in tabular, lensoid vein and skarn deposits in Proterozoic granitoid and schist. Copper occurs as bornite, chalcopyrite, chalcocite, and covellite; zinc occurs as sphalerite. Lesser amounts of molybdenum occur as molybdenite (Heinrich, 1981). Tin, uranium, gold, and manganese silicates, bustamite and rhodonite have also been identified. Skarn bodies consisting primarily of garnet, epidote, zoisite, clinozoisite, wollastonite, vesuvianite, diopside, quartz, and calcite form irregular masses, boudins, and stubby lenses which are often only a few tens of feet long. Commonly, disseminated scheelite, which is the only tungsten mineral, is stratabound in calc-silicate layers occurring within biotite gneiss adjacent to gray pegmatite bodies and associated quartz pods. Other rock types hosting skarns include impure marble, calcite-wollastonite gneiss, hornblende-diopside gneiss, amphibolite, and hornblendeite (Heinrich, 1981). Other deposits within the district include zoned pegmatite bodies that have been mined for their high content of uranium and rare-earth elements. Uranium deposits are present in fractures, veins, and pipes in Proterozoic crystalline rocks. Fluorite veins have been locally exploited.

Table 18. Lode vs. placer recovery of precious metals from the Tarryall Creek district mines, 1859–1998 (U.S. Bureau of Mines Yearbooks). NA—data not available.

Year	Lode Gold (oz)	Placer Gold (oz)	Total Gold (oz)	Lode Silver (oz)	Placer Silver (oz)	Total Silver (oz)
1859–1931	NA	NA	NA	NA	NA	NA
1932	0	53	53	0	7	7
1933	0	39	39	0	6	6
1934	19	737	756	0	57	57
1935	26	1,122	1148	0	93	93
1936	0	431	431	0	36	36
1937	0	642	642	0	53	53
1938	0	730	730	0	59	59
1939	8	729	737	22	56	78
1940	6	814	820	4	90	94
1941	13	5,064	5077	0	578	578
1942	0	3,977	3977	0	433	433
1943	NA	NA	NA	NA	NA	NA
1944	NA	NA	NA	NA	NA	NA
1945	NA	NA	NA	NA	NA	NA
1946	NA	NA	NA	NA	NA	NA
1947	0	2,315	2,315	0	206	206
1948	NA	NA	NA	NA	NA	NA
1949	NA	NA	NA	NA	NA	NA
1950	NA	NA	NA	NA	NA	NA
1951	NA	NA	NA	NA	NA	NA
1952	NA	NA	NA	NA	NA	NA
1953	NA	NA	NA	NA	NA	NA
1954	NA	NA	NA	NA	NA	NA
1955	NA	NA	NA	NA	NA	NA
1956	NA	NA	NA	NA	NA	NA
1957	0	17	17	0	2	2
1958–1998	NA	NA	NA	NA	NA	NA
Total	72	16,670	16,742	26	1676	1702

UNNAMED DISTRICT

Sand and gravel in the vicinity of Antero Reservoir constitute the only deposits occurring within a location that does not have a formal or informal name.

WESTON PASS DISTRICT

The Weston Pass district was probably discovered about 1890 and was most active in 1900–1905 and 1912–1916 (Behre, 1932). It is located 22 miles northwest of Fairplay in T. 11 S., R. 79 W. at the crest of the Mosquito Range separating Lake and Park Counties. Mining was limited to one mile on either side of the divide. Stratabound lead-zinc replacement bodies up to 10 feet thick contain 22–40 percent zinc, 5–18 percent lead, and 0.3–3.0 opt silver. They occur within the "Blue" Member of the Mississippian Leadville Limestone about 170 feet above the base (Heyl, 1964). The mineralized zone trends northwest for approximately 6,800 feet within a narrow open syncline whose northeastern limb is multiply faulted. Mines include the Ruby, Cincinnati, and Colin Campbell.

WILKERSON PASS DISTRICT

Wilkerson Pass is located in T. 11 and 12 S., R. 73 W., which adjoins southwest Tarryall Springs and northwest Lake George (Badger Flats) districts. The deposits are located in Proterozoic-hosted pegmatite mined for feldspar and mica; some contain uranium.

Coal Resources

The South Park Coal Field contains over 135 million tons of coal within the north-south exposure of sandstones and shales of the Cretaceous Laramie Formation.(Unpublished report, Colorado Division of Minerals and Geology, 1980). Of this total, 32 million tons are within 1,000 feet of the surface (Del Rio, 1969). The field covers approximately 8 square miles and covers portions of the Como, Hartsel, and Jefferson districts. At least three bituminous to sub-bituminous coal beds, generally ranging between two and eight feet thick, are present in the northern part of the field where the Laramie Formation crops out around the northern nose of the doubly-plunging Michigan Syncline (Wyant and Rogers, 1976). Folding has locally caused coal beds to attain a thickness of 40 feet. The only commercial production (1870 to 1905) was in the Como district. Here an undetermined amount of coal was produced from the Como Group, King Cole, and Wagon Mines (Washburne, 1910). In 1885 the King Cole Mine produced 58,997 tons of coal. A few miles to the south of the southern terminus of the Michigan Syncline, the Laramie Formation crops out around the edge of a small-unnamed syncline. Here the presence of at least two coal beds up to one foot thick is indicated by poor outcrop and coal rubble.

Petroleum Resources

Park County contains South Park Basin, one of three intermontane valleys in Colorado. This basin is a faulted syncline bounded by the Mosquito Fault east of the Sawatch Uplift along the western perimeter of the Basin and the Elkhorn Thrust along the eastern edge of the Front Range. (Plate 2) Pull-apart wrench faulting during the early phases of the Laramide Orogeny formed the basin. This major period of deformation separated the basin into two distinct north-south trending sub-basins. The asymmetrically shaped eastern sub-basin consists of Mesozoic and Tertiary sedimentary and volcanic rocks exceeding 15,000 feet thick. The axis underlies the westward-directed Elkhorn Thrust, whose upper plate is composed of Proterozoic basement rock. The western sub-basin is block faulted and has a thick section of east-dipping Paleozoic strata flanking Proterozoic rocks of the Mosquito Range to the west. The western sub-basin is separated from the eastern sub-basin by the Hayden Lineament.

South Park Basin has two distinct petroleum regimes. The eastern sub-basin is a Cretaceous system with source rocks in the Pierre and Niobrara Formations and potential petroleum reservoirs in the Jurassic Garo Sandstone, Cretaceous Dakota Sandstone, fractured Niobrara limey shale, and the Fox Hills Sandstone.

Twenty-five exploratory wells have been drilled in the eastern sub-basin since the early 1930s. Thirteen wells were drilled on the Hartsel Anticline located in the southern part of the sub-basin. In 1934, South Park Oil Company drilled and completed No. 1 State, the first well drilled in the County, located in SW1/4 section 16, T. 11 S., R. 75 W. The well drilled into a Cretaceous sandstone, and records indicate that over 5,000 barrels of oil were produced. Since 1934, McDannald Oil, Wycomo, Tennessee Gas, Shell Oil, Burton Hawks, Amoco Production Company, and Hunt Oil have drilled exploratory wells in this sub-basin, but there was no commercial production.

The Hunt Oil Company test well (NE1/4 section 17, T. 10 S., R. 75 W.) was a sub-thrust test on the east side of the eastern sub-basin. The well was spudded east of the trace of the Elkhorn thrust. The well drilled through 8,000 feet of Proterozoic rocks above the Elkhorn Thrust, and continued below the Thrust through a Cretaceous section, reaching a final depth in basal Dakota Sandstone at 12,768 feet. Hunt Oil Company abandoned the well in December 1998.

The McMurray Company reentered the Hunt well on August 16, 1999; they set a whipstock in the old hole at 10,118 feet, and drilled to 11,376 feet. They then set 5.5 inch casing to a depth of 11,360 feet to production test the fractured Pierre Shale. The well is currently shut-in. McMurray Company has not released information on the results of the testing program.

The western sub-basin has over 10,000 feet of Permian and Pennsylvanian strata (Belden and Maroon Formations) not present in the eastern sub-basin. The western sub-basin is unexplored for oil or gas. Promising source rock, the Belden Shale, reached maturity prior to folding associated with the Laramide Orogeny. There are several unproven reservoirs, including the Coffman Sandstone, arkosic sand beds in the Minturn Formation, and the Mississippian Leadville Limestone, all showing oil staining and residues that remain untested.

The county has minor geothermal resources when compared to the area of the Arkansas River Valley of Chaffee County just a few miles west of the western border of Park County. There is one geothermal occurrence, Hartsel Hot Springs, in Park County.

The most prominent and active hot springs in Park County are the Hartsel Hot Springs located south of the small town of Hartsel (Plate 1). This area was once a thriving resort. George and others (1920) report that "a good bath house, and a good hotel accommodate the patients and other guests". They reported a temperature of 134° F (57°C) and a flow rate of 2.5 to 3.0 gallons per minute. Barrett and Pearl (1978) examined Hartsel Hot Springs and listed two source springs, describing the springs and facilities as unused. They suggested that the springs were emanating from the Morrison Formation and that the proximity of the South Park Fault (0.5 miles to the south) was related to the hot springs. The temperature of the springs was reported to range from 45° to 52°C, and the flow of the two springs combined was 107 gallons per minute.

Hartsel Hot Springs was examined by the Colorado Geological Survey in 1993 (Cappa and Hemborg, 1995). The buildings shown in Barrett and Pearl (1978, their Figure 48) had disappeared and the site was in crumbling disrepair. The flow rate was difficult to measure owing to swampy conditions, but was estimated to be greater than 80 gallons per minute. Geochemistry of the Hartsel Hot Springs is shown in Table 19-below.

Table 19. Geochemistry of Hartsel Hot Springs (Cappa and Hemborg, 1995)

		Concentration (parts per million)					
Location	**Na**	**K**	**Ca**	**Mg**	**Fe**	**HCO_3**	**SO_4**
Spring A	680	33	120	20	0.17	479	320
Spring B	663	31	114	22	0.49	458	323

Areas of Mineral Potential

Areas of Park County possessing the greatest potential for the discovery new mineral deposits coincide with those areas where currently idle or abandoned mines and/or undeveloped prospects exist (Plate 1) These may be reactivated in the future, if the economic climate and/or metal prices change. While the discovery of a new deposit not previously known cannot be discounted, it is most probable that a new deposit will be developed within a mile of an existing mine or prospect. Further exploration in and around known mineral deposits frequently results in the identification of commercially viable reserves and/or the discovery of unknown deposits which were uneconomic at the time of past exploration. Examples of recent reactivated or new discoveries in the United States include:

- the large number of medium- to large-size discoveries of low-grade disseminated gold deposits near of "mined-out" small, moderate- to high-grade, precious metal mines and prospects in Nevada.
- the reactivation of the Jerome Mine (Arizona) and the Pend O'Reille Mine (Washington) for zinc.
- the discovery of the Magmont West lead orebody about one miles west of the prolific Viburnum Trend (New Lead Belt)(Southeast Missouri).
- the reactivation of the abandoned Berkley open-pit copper mine by a private entrepreneur in Butte, Montana.
- the discovery and on-going development of the Crown Jewel Deposit for gold near many abandoned small mines and prospects in Washington.

At least 50,000 ounces of gold in drill-indicated reserves (averaging 0.4 opt gold) reportedly exist at the London Mine (Charles Spielman, former mining engineer at the London Mine, personal communication, 1999). Other mines in Park County may also have small, but significant, base- and precious-metal deposits that could become minable deposits in the future.

In the next 10 to 30 years, mining operations in the County are likely to be undertaken by small- to moderate-sized companies that typically re-open existing mines and exploit previously recognized reserves that were of insufficient grade to mine in the past. Previously unidentified extensions may be found through drifting or longhole drilling. Discovery of deep new deposits through large-scale systematic drilling cannot be ruled out if metal prices increase. Some prospective areas in Park County are (Figure 5):

- the area bordering the strike-length of the London Fault. This area has above-average potential for new discoveries of vein-type gold-silver-lead-copper from historically productive and other stratigraphic horizons , especially within 0.2 miles southwest side of the fault between Mosquito Peak and Sheep Mountain;
- an area extending from south of Sacramento Creek to one mile south of Sheep Mountain, extending one mile to the east and east-northeast on the eastern side of the fault. This area has substantial potential for the delineation of manto (stratabound) silver-lead-zinc-copper deposits. Prospective hosts include the Mississippian Leadville Limestone and other Paleozoic carbonate units;
- an area that ranges about 1 mile southwest and northwest of the Sherman Fault. This area has potential for hosting blind manto (stratabound) silver-lead-zinc-copper deposits in the Leadville Limestone and other limestone-dolomite units. Although the prominent Hilltop Mine is located southwest side, the distribution of similar mines on the opposite (northeast) side of the nearby London Fault suggests that the northeast side of the Sherman Fault may also have high potential for the discovery of new deposits. The currently idle Sherman Mine is located about one mile north of the northern terminus of the Sherman Fault. The Leadville Corporation has holdings covering 7 square miles surrounding the Hilltop-Sherman Mines, and will probably reactivate them and develop new deposits if silver prices continue to

rise (John Gasper, President, Leadville Corporation; personal communication, 1999).

- the area near Mt. Lincoln and Mt. Bross encompasses the Russia, Moose, and Dolly Varden silver-lead-zinc-copper mines, which were among the largest of their type in Park County. This area may host additional deposits in Mississippian and other Paleozoic carbonate rocks.
- an area extending several miles east of the Cooper Gulch Fault includes the Paris, Phillips, and Orphan Boy Mines, which formerly exploited vein-type gold from the Cambrian Sawatch Quartzite and silver-lead-zinc-copper from the Mississippian Leadville Limestone at the Hock Hocking Mine. There is moderate potential for the discovery of extensions in this area.
- an area immediately east of the Alma Depot on High Park Ridge, between the South Platte River and Beaver Creek Placers. Old newspaper accounts (The Park County Bulletin: March 20, 1903; August 18, 1905) report the occurrence of "rich" gold-bearing float in this area. A few prospects yielded 20–30 opt silver; the Pennsylvanian Minturn Formation is probably the host rock for vein-type mineralization.
- in addition to vein-type mineralization in Late Paleozoic clastic rock, the deeper unexposed carbonate units (e.g, Leadville Limestone) may be prospective for stratabound silver-lead-zinc-copper deposits.
- several areas on the South Platte River between the old Fairplay and Alma Placers have not been exploited by large-scale operations and may be prospective for future gold dredging or dry-land placer operations. An area downstream of the Fairplay placer may also hold additional potential.
- the Tarryall Springs, Mountaindale, and northern half of the Pulver-Lake George districts (section 11, T. 12 S., R. 72 W.) in east-central Park County have substantial potential for the discovery of new tungsten skarns and beryllium-bearing pegmatites, and associated copper, zinc, lead, gold, silver, and uranium.
- the southwestern part of the Guffey district (T. 15 S., R. 73 W.) in southeast Park County hosts both tungsten- and copper-zinc-skarn deposits and some beryllium-bearing pegmatites. These deposits might be reactivated pending favorable commodity prices. The skarns locally carry by-product gold and silver, and pegmatite deposits could be uraniferous. The potential for the discovery of new deposits is high.
- in southwest Park County in the Herring Creek area (section 36, T. 15 S., R. 76 W.), the Lower to Middle Pennsylvanian Kerber, Sharpsdale, and Minturn Formations were found to contain anomalous concentrations of copper, silver, lead, vanadium, and lithium (Wallace and others, 1999). There is good potential for the discovery of significant copper-silver deposits similar to those in the Nacimiento Mine, New Mexico, and the Creta Mine, southwest Oklahoma.

IDENTIFIED PHYSICAL HAZARDS

(FROM COLORADO DIVISION OF MINERALS AND GEOLOGY)

The Colorado Division of Minerals and Geology reported that more than 60 abandoned underground mine sites in Park County pose hazards, ranging from environmentally degraded sites to physically dangerous sites. These mine hazards include, but are not limited to, open vertical shafts and stopes, open adits, collapsing workings, and significant ground subsidence above near-surface underground workings. These districts and their associated mines and prospects are concentrated in the northwest and, to fewer sites are present in east-central and southwest Park County. The abandoned sites include the Greater Alma, Como, Tarryall Springs-Lake George, and Guffey-Black Mountain districts. Over 225 shafts and adits are shown on U.S. Geological Survey 7.5-minute topographic maps in the northwest quadrant of Park County (Table 20).

Additionally, there are numerous prospect pits that could be hazardous. In a recent inventory of U.S. Forest Service lands in Colorado (including water-quality data), the Colorado Geological Survey reported that 3,623 of 11,307 mine sites (32 percent) range from potentially hazardous to extremely dangerous (Colorado Geological Survey, 1999 Rocktalk, April, 1999. The percentage may be higher on adjoining and/or enclosed (patented) private lands, where past operations were typically larger than those on unpatented public lands. The sites identified by the Colorado Division of Minerals and Geology as possessing extreme or significant hazards are shown in Table 21.

Table 20. Number of physical mine hazards in Park County, Colorado.

Quadrangle	Number of Physical Hazards
Alma Quadrangle	115
Climax Quadrangle	57
Mount Sherman Quadrangle	24
Fairplay West Quadrangle	14
Fairplay East Quadrangle	7
Como Quadrangle	6
Breckenridge Quadrangle	1

ACID DRAINAGE

Most base- and precious-metal mines (particularly those in northwest Park County) exploited ores that contained a high proportion of sulfide minerals, either as primary constituents or as gangue. These minerals include, but are not limited to, pyrite (iron sulfide), galena (lead sulfide), sphalerite (zinc sulfide), chalcopyrite (copper sulfide), and molybdenite (molybdenum sulfide). When these minerals are exposed to air or groundwater in abandoned mine workings and atmospheric water on their associated dumps, they decompose and generate sulphuric acid and heavy-metal chemical compounds that can subsequently migrate into streams and the water table. Since many of the old mines are located high on the mountain (in some cases, above timberline) and extend hundreds or thousands of feet into the subsurface, infiltration of polluted mine waters into local and regional groundwater aquifers is likely. Therefore, when water wells are drilled near old mines, the water needs to be rigorously tested for sulphur-, heavy-metal, and other toxic-chemical content.

Metal contamination can be associated with hidden, as yet unrecognized, deposits that have never been mined. Thus, when water for human or animal consumption is sought in areas of mineral deposits, caution should be exercised.

Table 21. Mine sites in Park County that exhibit various degrees of significant hazards (Colorado Division of Minerals and Geology).

Mine	District	Sec.	Twp.	Rng.	Hazard Rating	Comments
Como West Prospect	Como District	2	98S	76W	Extreme Danger	open vertical shaft
King Mine and vicinity	Como District		29S	76W	ExtremeDanger	open vertical shafts and subsidence
Wilkerson Pass Mine	Hartsel l		12S	75W	Extreme Danger	open vertical shafts w/caving collars
Boomer Lode #1	Tarryall Springs	?	?	?	Extreme Danger	open vertical shaft w/caving collar
Boomer Lode #2	Tarryall Springs	8	11S	72W	Extreme Danger	open vertical shafts w/caving collars
Johnson's Mine	Tarryall Springs	11	11S	73W	Extreme Danger	open vertical shafts and adits
St. Joe Tunnel	Lake George	5&6	12S	72W	Dangerous	open vertical shafts
Scheelite Prospects	Tarryall Springs	34	11S	72W	Dangerous	open vertical shafts w/caving collars
Unnamed	Lake George	1	12S	73W	Extreme Danger	open vertical shafts w/caving collars
Pulver Gulch Pegmatite Mines	Lake George	13	12S	72W	Potential Danger	open vertical shafts
Fluorite Mine	Tarryall Springs	6	11S	72W	Potential Danger	fenced vertical shaftColorado
Feldspar Mine	Guffey	32	15S	72W	Not Significant	open adits
Cabin Gulch	Guffey	21	15S	73W	Potential Danger	fenced vertical
Shaft Poyner Ranch Prospects	Bath	19	13S	75W	Not Significant	prospects
Trout Creek Prospects	Bath	20	13S	76W	NotSignificant	
Threemile Gulch	Hartsel Extended	17&20	11S	75W	Not Significant	prospects
Unnamed	Hartsel l	8	12S	75W	Not Significant	prospects
Middle Fork	South Platte Garo	6	11S	76W	Not Significant	prospects and gravel pit
Shafthouse Mine	Tarryall Springs		10S	72W	Potential Danger	partially sealed vertical shaft
Watrous Gulch Mine	Iron Hill Extended	9	11S	78W	Dangerous	open vertical shaft w/caving collar
Unnamed	Fairplay	14	10S	77W	Not Significant	gravel pit
Kurt Claim	Buckskin	33	9S	78W	Potential Danger	open adits
Little Johnny Claims	Sacramento	4	10S	78W	Potential Danger	open adits and prospects
Barco Mine	Sacramento	4	10S	78W	Not Significant	
Dauntless Mine	Mosquito?				Potential Danger	open vertical shafts and adits
Hilltop Mine	Horseshoe				Not Significant	open vertical shafts behind gates
Peerless Mine	Mosquito?				Potential Danger	open vertical shafts and adits
Ruby Mine	Weston Pass?				Dangerous	open vertical shafts and adits
Como West Prospect A	Como District	1	98S	6W	Not Significant	
Mammoth Mine	Consolidated Montgomery	14	8S	78W	Potential Danger	open adits
Magnolia Mine	Consolidated Montgomery	11	8S	78W	Dangerous	open vertical shafts and stope
Magnolia Mill Site	Consolidated Montgomery	14	8S	78W	Dangerous	open vertical shaft and adit
Morning Glory/Morning Star	Consolidated Montgomery	34	8S	78W	Potential Danger	open adits
Mineral Park Mine	Consolidated Montgomery	35	8S	78W	Extreme Danger	open vertical shaft
Unknown Mine	Consolidated Montgomery	3	8S	78W	Not Significant	
Dolly Varden Mine	Consolidated Montgomery	27	8S	78W	Not Significant	partially open adit
Unknown Mine	Buckskin		39S	78W	Potential Danger	open adit
Security Mine	Buckskin		39S	78W	Potential Danger	open vertical shaft and adits
Buckskin Joe	Buckskin		39S	78W	Dangerous	open adits and subsidence

Table 21. Continued.

Mine	District	Sec.	Twp.	Rng.	Hazard Rating	Comments
Mascotte Tunnel	Buckskin	10	9S	78W	Potential Danger	open adit
Russia Mine	Consolidated Montgomery	15&16	8S	78W	Potential Danger	open and collapsed adits and shafts
Mt. Bross Mine	Consolidated Montgomery	21	8S	78W	Not Significant	collapsed or iced-shut adits
Paris Mine	Buckskin		39S	78W	Dangerous	open vertical shafts
Unknown Mine	Buckskin		99S	78W	Potential Danger	open adits and shafts
Orphan Boy Mine	Buckskin		9S7	8W	Dangerous	open vertical shafts and adits
Orphan BoyMine	Pennsylvania1		59S	78W	Potential Danger	open vertical shafts and adits
Unknown Mine	Pennsylvania	1	69S	78W	Dangerous	open vertical shafts w/caving collars
Sweet Home Mine	ConsolidatedMontgomery	33	8S	78W	Potential Danger	open vertical shafts and adits
Unknown Mine	Buckskin		99S	78W	Potential Danger	open adits
North London Mine	Mosquito				Not Significant	collapsed shafts and sealed adits
Unnamed Mine	Mosquito?				Not Significant	open adit
Kite Lake Area Mines	Mosquito?				Potential Danger	open adits
Unknown Mine	Buckskin		89S	78W	Not Significant	collapsed adits
Unknown Mine	Mosquito		69S	78W	Potential Danger	open and collapsed shafts and adits
North London Mill	Mosquito		69S	78W	Degradation	silted streams
American Mine	Mosquito		79S	78W	Dangerous	open adits and vertical stopes
Jefferson Mine	Jefferson	3	27S	75W	Not Significant	water-filled adit
North Star	Consolidated Montgomery	3	8S	78W	Not Significant	ice-filled adit
Missouri & Whale Mines	Halls Valley	14	6S	76W	Degradation	collapsed adits

HEAVY-METAL TOXICITY

Historic mining in Park County exploited numerous mineral species that contained moderately to highly toxic metals and compounds that now reside on mine dumps, mill tailings, unmined ores, and in groundwater. These metals are potentially harmful to humans and animals, by direct contact, ingestion of solutes in water or edible plants, and inhalation of contaminated dust. Toxic metals found in some common primary ore or associated gangue minerals at Park County Mines include: lead (galena, cerussite), copper (chalcopyrite, bornite, covellite, malachite, azurite, chrysocolla, and tetrahedrite), tungsten (scheelite, huebnerite, wolframite, and powellite), molybdenum (molybdenite), tin (cassiterite), bismuth (bismuthite), uranium (various uranium minerals), thorium (various thorium minerals), radium (various radium minerals), manganese (rhodochrosite, rhodonite, and wad), rare-earth elements (columbite, tantalite, niobium, xenotime, yttrofluorite, monazite, illmenite, allanite, and samarskite), and beryllium (beryl and bertrandite).

Uranium, thorium, and radium ores were mined in at least 34 locations in northwest, central, east-central, and southeast Park County. The most notable sites were in the Garo, Guffey, Hartsel, Tarryall Springs-Lake George districts and the Mosquito subdistrict of the Greater Alma district. Radiation hazards are posed by direct contact with residual ores and dump and mill tailings, as well as from the production and accumulation of radon gas and seepage into groundwater. Radioactive minerals found in Park County deposits include uraninite, coffinite, pitchblende, carnotite, autunite, torbernite, uranophane, tyuyamunite, and monazite, and minerals that contain thorium and radium.

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