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Geologic Map of the Gribbles Park Quadrangle, Park and Fremont Counties, Colorado

Description of Map Units, Previous Studies, Present Study, Geologic Setting, Structure, Volcanic Activity, Mineral Resources and References

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INTRODUCTION

The Gribbles Park quadrangle is located in southern Park County and northwestern Fremont County in the southern part of the Mosquito Range. This quadrangle includes an upland of rolling hills and grass land and sparse ponderosa forest at high elevation northeast of Salida, Colorado.

The oldest rocks exposed in the quadrangle are Proterozoic metamorphic and igneous rocks, which are overlain unconformably by Paleozoic sedimentary rocks, Tertiary volcanic and sedimentary rocks, and Quaternary alluvial and colluvial deposits. The Late Cretaceous Whitehorn Granodiorite intruded Paleozoic sedimentary rocks. Steep faults offset Proterozoic and Paleozoic rocks. The Weston-Pleasant Valley fault trends northward through the quadrangle; this fault was probably an active fault in part of late Paleozoic time and after Late Paleozoic time. Paleozoic rocks are folded into broad homoclinal sequences or are folded into moderate-scale anticlines and synclines. Late Cretaceous plutonic rocks and Tertiary volcanic and sedimentary rocks are cut by few faults. Tertiary volcanic rocks and volcanogenic sedimentary rocks cover Proterozoic and Paleozoic rocks over much of the quadrangle. Volcanic rocks are composed mainly of silicic welded tuff and air-fall tuff, but in the eastern part of the map area basaltic Tertiary flows cap mesas locally. Tertiary volcanogenic sedimentary rocks were deposited during eruption of silicic tuff, and were coeval with welded tuff and ash-flow tuff deposits. Tertiary units are truncated by Pleistocene pediment deposits, and alluvial and colluvial deposits occur in most drainages

PREVIOUS STUDIES

Numerous geologic studies in the vicinity of the Gribbles Park quadrangle, most dating from the two decades 1960 to 1980, established the regional geologic framework. Reports on regional stratigraphic studies of lower and middle Paleozoic rocks by Campbell (1972), Conley (1972), Gerhard (1972), Nadeau (1972), and Ross and Tweto (1980) established the regional stratigraphic sequence and regional lithofacies relations for those rocks. Upper Paleozoic rocks were studied in the region of the Gribbles Park quadrangle by Peel (1971), Pierce (1969, 1972), De Voto (1971, 1972, 1980a, 1980b), and De Voto and Peel (1972), and these reports defined the local stratigraphic sequence and integrated it with regional stratigraphy. Wrucke (1974) described the Late Cretaceous Whitehorn Granodiorite, the main plutonic body in the map area, and determined that the pluton was a laccolith. Welded tuff of the Wall Mountain Tuff was described by Chapin and Lowell (1979) as a valley-fill deposit. Epis and Chapin (1974) described the Badger Creek Tuff and the Gribbles Park Tuff that occur in the eastern part of the map area.

A series of geologic maps by the U.S. Geological Survey, all at a scale of 1:62,500, described relations among Proterozoic and Paleozoic successions, Cretaceous plutonic rocks, Tertiary intermediate and silicic volcanic rocks, and Quaternary deposits in the region of the Gribbles Park quadrangle. Wrucke and Dings (1979) published an open-file map of the Cameron Mountain quadrangle (scale 1:62,500), which included the Gribbles Park 7.5-minute quadrangle. Taylor and others (1975) published a geologic map of the Howard quadrangle (scale 1:62,500), which borders the Cameron Mountain 15-minute quadrangle of Wrucke and Dings (1979) on the south. The Black Mountain quadrangle (scale 1:62,500), mapped by Epis and others (1979a), adjoins the Gribbles Park 7.5-minute quadrangle on the east, and the Guffey 15-minute quadrangle (Epis and others, 1979b) borders the Gribbles Park 7.5-minute quadrangle at its the northeast corner. The geology of the Gribbles Park quadrangle is shown in a generalized form in the western part of the Pueblo 1° X 2° quadrangle (Scott and others, 1978).

De Voto (1971) published a geologic map of the Antero Reservoir quadrangle (scale 1:62,500), which borders the Gribbles Park quadrangle (scale 1:24,000) on the north; an extensive discussion of the geologic history of the South Park region accompanied his geologic map.

The Colorado Geological Survey began a 1:24,000 scale geological mapping in this area in 1996. Two geologic maps have been published prior to the Gribbles Park quadrangle: Salida East (Wallace and others, 1997); Cameron Mountain; (Wallace and Lawson, 1998). Figure 1 shows a generalized geological map and the location of the quadrangles in this mapping program.

PRESENT STUDY

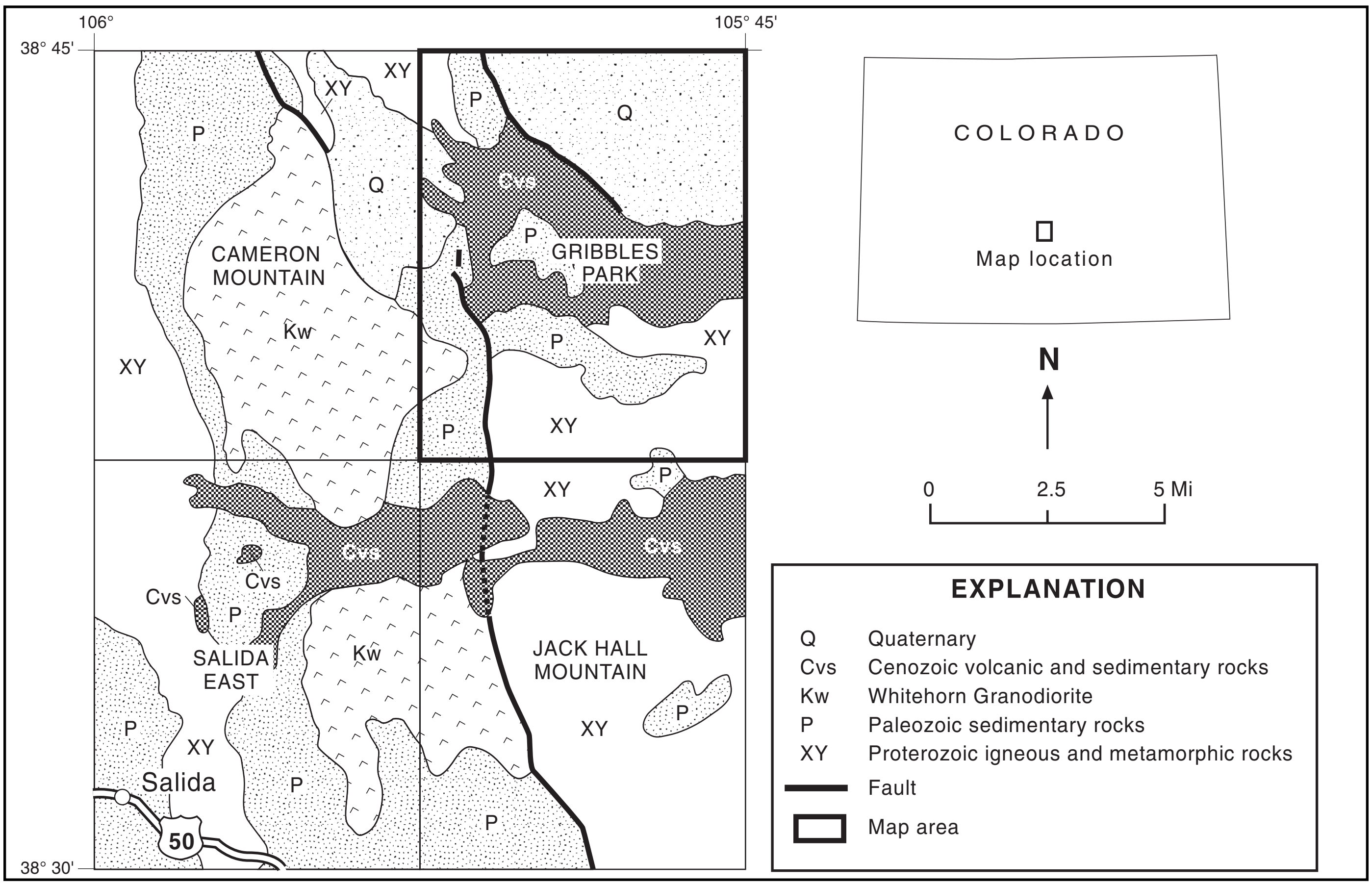

Figure 1. Location of Gribbles Park quadrangle.

The present study focuses on geologic mapping of the Gribbles Park quadrangle at a scale 1:24,000. Most geologic mapping was completed in June and July, 1998. C.A. Wallace and Allison D. Lawson mapped the Phanerozoic terrane. Wallace compiled the geologic map of the Phanerozoic terrane, prepared cross sections, and wrote much of the explanatory text. Proterozoic rocks were mapped, compiled, and described by James A. Cappa. Rock names in this report are field terms: sedimentary rocks are named according to the scheme proposed by Pettijohn (1957), metamorphic rocks names follow the system proposed by Best (1982), and volcanic and igneous rocks were named according to the I.U.G.S classifications proposed by Streckeisen (1973, 1978).

GEOLOGIC SETTING

Proterozoic rocks consist mainly of igneous rocks and lesser amounts of metamorphic rocks. Regionally, the metamorphic rocks are divided into two groups: strongly foliated rocks and slightly foliated rocks. The strongly foliated group consists primarily of mafic and felsic gneiss, schist, phyllite, and gneissic granodiorite. The slightly foliated rocks are composed of gabbro, bimodal metavolcanic rocks, and meta-quartzite. The contact between the Proterozoic strongly foliated and slightly foliated groups is abrupt, occurring over a few tens of meters. The two groups may have been differentiated along a sharp metamorphic gradient related to the intrusion of a Proterozoic granodioritic batholith.

Proterozoic igneous rocks in the region consist of granodiorite and quartz monzonite batholiths that intrude the older metamorphic series. Locally Proterozoic rocks that underlie Upper Cambrian clastic rocks are intensely weathered: a saprolitic zone may occur in Proterozoic rocks where mafic rocks were weathered before Late Cambrian time.

The Paleozoic sequence is about 1,045 m thick in the southern part of the map area where the succession is the thickest. At the base, in ascending order, is the Manitou Limestone (Lower Ordovician), Harding Quartzite (Middle Ordovician), Fremont Dolomite (Upper and Middle Ordovician), Chaffee Formation (Upper Devonian), Leadville Limestone (Lower Mississippian), Kerber Formation (Pennsylvanian), Sharpsdale Formation (Pennsylvanian), Minturn Formation (Pennsyl-vanian), and Sangre de Cristo Formation (Pennsyl-vanian and Permian). Most of the lower Paleozoic units are separated by disconformities that represent long periods of nondeposition, or long periods of deposition and later erosion. Ordovician, Devonian, and Mississippian rocks were deposited in a shallow-marine environment. Pennsylvanian rock units are conformable or intertonguing and were deposited without unconformities in the north-northwest-trending Central Colorado Trough, and depositional environments alternated between marine and continental conditions.

The Manitou Limestone (Lower Ordovician) is the oldest Paleozoic unit exposed in the Gribbles Park quadrangle, but in the adjoining Salida East and Cameron Mountain quadrangles, the Sawatch Quartzite (Upper Cambrian) occurs locally below the Manitou Limestone. Disconformably above the Manitou Limestone is the Harding Quartzite, which at some places is a quartzite breccia. Overlying the Harding Quartzite on a disconformable contact is the Fremont Dolomite (Upper and Middle Ordovician). The Chaffee Formation (Upper Devonian) disconformably overlies the Fremont Dolomite, and in most of the Gribbles Park quadrangle the Chaffee Formation is represented only by the Dyer Dolomite Member, which occurs at the top of the formation. The Parting Quartzite Member of the Chaffee Formation occurs only in the western and northwestern part of the Gribbles Park 7.5-minute quadrangle. The Leadville Limestone (Lower Mississippian) disconformably overlies the Chaffee Formation.

Above the Leadville Limestone in the region of the Gribbles Park quadrangle a complex sequence of clastic rocks that formed two cyclic repetitions of marine to continental sequences in a north-northwest-trending, fault-bounded arm of the Pennsylvanian-Permian interior seaway, known as the Central Colorado Trough (De Voto, 1972). In the Gribbles Park quadrangle, which contains rocks preserved along the eastern margin of the Central Colorado Trough, the stratigraphic succession consists of alternating continental and marine deposits. In the southern part of the Central Colorado Trough, the base of the first depositional cycle is represented by the transitional marine and continental Kerber Formation. The Kerber is overlain by the Sharpsdale Formation, which is mainly a continental deposit. The second depositional cycle in this seaway is represented by the predominantly marine Minturn Formation and the overlying member one of the Sangre de Cristo Formation, a continental deposit. Regionally, a third cycle in the seaway is represented by member two of the Sangre de Cristo Formation, a marine unit, and by member three of the Sangre de Cristo Formation, continental unit, but this third cycle is absent in the Gribbles Park quadrangle. The cyclic repetition of marine and non-marine strata was controlled by syndepositional tectonism on the Weston-Pleasant Valley fault, part of which is exposed in the Gribbles Park quadrangle (De Voto, 1972; De Voto and Peel, 1972; Wrucke and Dings, 1979).

The Whitehorn Granodiorite (Upper Cretaceous) is a laccolith that intruded Paleozoic rocks. The border zones of the pluton are fine-grained porphyries, whereas interior parts of the pluton are uniformly fine- and medium-grained. Only the northeastern part of the laccolith is exposed in the Gribbles Park quadrangle.

Tertiary units are mainly volcanic rocks of basaltic and silicic composition and upper Tertiary sedimentary rocks and gravel. The Mountain Tuff (late Eocene) is a rhyolite ash-flow tuff that occurs as remnants in the map area. Silicic ignimbrites from the Thirtynine Mile volcanic field formed the Badger Creek Tuff (late Eocene) and the Gribbles Park Tuff (early Oligocene) that occur as erosional patches in the Gribbles Park quadrangle. The Antero Formation is a water-laid tuff that is correlative with the non-welded part of the Badger Creek Tuff. Basalt lava flows in the eastern part of the map area are probably Miocene in age. The Miocene Wagon Tongue Formation is a continental, lacustrine, volcanogenic sediment.

Quaternary units are mainly pediment and alluvial gravels and rare landslide deposits. The oldest Quaternary units occur at the highest elevations and younger units occur at successively lower elevations. Deposits of colluvium and alluvium formed in modern drainages during late Quaternary time and these deposits consist of gravel, sand, silt, and clay. Rare landslides form unsorted rubble in the southern part of the map area. Our nomenclature for Quaternary deposits in the Gribbles Park quadrangle uses a relative time scale suggested by R.M. Kirkham (Colorado Geological Survey, written commun., 1997). According to Kirkham a purely relative scale is best applied to surficial deposits in the map area, because correlation of surficial deposits to continental glacial events requires more detailed study than has been accomplished for this report.

STRUCTURE

The principal structures in the map area are steeply dipping normal and reverse faults that trend north, northwest, and east, and anticlines and synclines of local extent. Most faults are steep normal faults that offset Proterozoic and Paleozoic rocks. Cambrian to Mississippian sedimentary rocks are more intensely faulted than overlying Pennsylvanian and Permian sedimentary rocks. The Weston-Pleasant Valley fault strikes north in the southwestern part of the quadrangle, but this fault cannot be traced north of Antelope Gulch.

The Gribbles Park quadrangle is located in the southern part of the Central Colorado Trough of De Voto (1972), which is synonymous with and the southern part of the “Colorado Sag” as described by Ross and Tweto (1980). Regionally, bounding faults of the Central Colorado Trough trend north-northwest, but the segment of the Weston-Pleasant Valley fault in the Gribbles Park quadrangle strikes north.

Many of the northwest- and north-trending faults in this region originated in Early and Middle Proterozoic time. The orientation of the faults in lower and upper Paleozoic strata may have been controlled by rejuvenated slip on these older faults. Many of these faults produced highlands adjacent to shallow basins (Tweto, 1980) and controlled erosion and sedimentation since Pro-terozoic time (Tweto, 1980; Ross and Tweto, 1980).

The main regional tectonic elements that influenced sedimentation during Paleozoic time are: (1) the Sawatch anticline of De Voto (1972), which is located west of the map area; (2) the Colorado Front Range and the Apishapa highlands to the east (Ross and Tweto, 1980), which are equivalent to the Front Range and Wet Mountains anticlines of De Voto (1972); (3) the Uncompaghre and San Luis Valley uplifts to the southwest (De Voto, 1972; Ross and Tweto, 1980); and (4) the Central Colorado Trough, which extended northwest between the Uncompaghre uplift to the southwest and the Front Range-Apishapa uplift to the northeast (De Voto, 1972).

In the region of the Gribbles Park quadrangle, north-northwest-trending faults were active during Pennsylvanian time (De Voto, 1972; Wallace and others, 1997; Wallace and Lawson, 1998). The Weston-Pleasant Valley fault was active during deposition of Pennsylvanian strata (De Voto, 1980), and in the Gribbles Park quadrangle this fault was active after Paleozoic time. The Weston- Pleasant Valley fault was not active after Oligocene time in the map area because the fault is covered by deposits of the Antero Formation that show no offset. The influence of north- and northwest-striking faults on Laramide tectonism in the Gribbles Park quadrangle is not known because Mesozoic sedimentary rocks are absent. The northwest-striking Rye Slough fault, in the northern part of the map area, shows normal offset in Miocene beds of the Wagon Tongue Formation; the northwest strike and post-Miocene age of this fault suggests that slip on this fault may be related to extension in the Rio Grande rift.

Most folds in the Gribbles Park quadrangle are medium-scale structures that deform Paleozoic rocks, but one large-scale anticline occurs in the southwestern part of the map area. The principal orientations of anticlines and synclines are north, northwest, northeast, and east. The large, northwest-trending anticline in the southwestern part of the map area is cut by the Weston-Pleasant Valley Fault. Medium-scale, east-west anticlines and synclines occur in lower Paleozoic rocks in the southern part of the map area, but in the central and northern part of the map area north- and northeast-trending anticlines and synclines occur in lower and upper Paleozoic rocks. Overturned lower Paleozoic rocks are adjacent to the Rye Slough fault, and tightly folded, locally overturned upper Paleozoic rocks occur west of the Weston-Pleasant Valley fault in the southwestern part of the map area.

During the period 70 to 36 Ma (Maastrichtian to Rupelian age) sedimentary, metamorphic, and plutonic rocks in the map area were uplifted and the southern part of the Central Colorado Trough, which received a large volume of sediment during Paleozoic time, became a source area for sediment during early Tertiary time. After emplacement and crystallization of the Whitehorn Granodiorite, which presumably was emplaced at shallow depth, uplift initiated erosion of rock units in the map area.

VOLCANIC ACTIVITY

After about 36 Ma several rhyolitic ash-flow tuffs were erupted from west of the map area, and from northeast of the Gribbles Park quadrangle. The Wall Mountain Tuff was erupted from the southern Sawatch Range northwest of Salida, Colorado, (Chapin and Lowell, 1979) at 36.64 ± 0.06 Ma (McIntosh and Chapin, 1994) and the ash-flow tuff flowed over a pre-existing topography that filled the Gribbles Park paleovalley (Chapin and Lowell, 1979). Eruptive activity from the Thirtynine Mile volcanic field produced the Badger Creek Tuff at 34.35 ± 0.09 Ma (McIntosh and Chapin, 1994) and the Gribbles Park Tuff at 32.76 ± 0.14 Ma (McIntosh and Chapin, 1994). Volcanic activity in the map area terminated after basalt pahoehoe flows were erupted in the northwest quadrant of the map area. Basalt breccia, which contains volcanic bombs, in the northern part of the basalt field may represent eruptive vents and fissures.

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EXPANDED DESCRIPTION OF MAP UNITS

QUATERNARY SURFICIAL DEPOSITS

Qac **Alluvium and colluvium (Holocene)—** Alluvium and colluvium is common in most drainages where Wrucke and Dings (1979) showed only alluvial deposits. In active stream channels, alluvium consists of nonconsolidated, interbedded, lenticular layers of poorly sorted, matrix- and framework-supported boulder, cobble, and pebble gravel deposits containing rounded, sub-rounded, and sub-angular clasts in a matrix of pebbles, sand, silt, and clay. Stratification is generally crude. Modern streams contain numerous abandoned channels that are 1 to 2 m above active braided channels. Modern stream channels are incised 1 to 5 m into interlayered alluvium and colluvium that is composed of tan and grayish-yellow-brown, fine-grained, nonconsolidated sediment and interbedded lenses of matrix-supported to clast-supported, angular cobbles and pebbles in a clayey and sandy matrix. Interlayered alluvium and colluvium is crudely stratified. Some lenses of coarse sediment in the interlayered alluvial and colluvial deposits are channel gravels that contain crossbeds and planar bedding.

Qao **Older Alluvium (Holocene and Pleistocene?)—**Older alluvial deposits occur in fans along Badger Creek in the northern part of the quadrangle near Rye Slough and Long Gulch. The older alluvium is composed of nonconsolidated, interbedded layers of silty clay, clayey silt, silt, silty sand, sand, and pebble, cobble, and boulder gravel. Boulders and cobbles are commonly angular and subangular. The alluvium forms prominent fan-shaped deposits where tributaries join Badger Creek. Older alluvial deposits predate alluvium and colluvium deposits (Qac) in Badger Creek.

Qls **Landslide deposits (Holocene and Pleistocene?)—**These are heterogeneous deposits of unsorted, non-stratified rock debris, gravel, sand, and silt.

Pediment deposits (Pleistocene)—Pediment deposits are composed of poorly stratified sand and silt that contain matrix-supported boulders, cobbles, and pebbles. Pediment surfaces and terrace remnants reach elevations of about 9,700 ft in the northeastern part of the map area. Clasts are composed of basalt, quartzite, cherty dolomite, red and olive-drab sandstone and siltstone, welded tuff, and vein quartz. Gravel composition reflects a strong local provenance. The terminology used in the Gribbles Park quadrangle is the same as that used in the Cameron Mountain quadrangle (scale 1:24,000). Pediment deposit three (Qp_3) in the Gribbles Park quadrangle is equivalent to Qsp_2 mapped by Wrucke and Dings (1979) in the Herring Park area; and Pediment deposit two (Qp_2) in this map area is equivalent to Qsp_2 mapped by Wrucke and Dings (1979) in the Herring Park area. Pediment deposit one (Qp_1) in the Gribbles Park quadrangle is equivalent to Qv of Wrucke and Dings (1979), which they equated to the Verdos Alluvium formed during the Yarmouth interglacial stage or the Kansan glaciation.

Qp_3 **Pediment deposit three—**Pediment deposit three is composed of poorly stratified sand and silt that contains matrix-supported boulders, cobbles, and pebbles. Boulders are subangular to angular and as large as 0.4 m in diameter. Upper surface is 3 to 9 m above alluvium and colluvium in adjacent drainages. Correlative deposits were mapped as T3 in the Salida East quadrangle (Wallace and others, 1997) and as Qp_3 in the Cameron Moun-tain quadrangle (Wallace and Lawson, 1998).

Qp_2 **Pediment deposit two—**Pediment deposit two is composed of poorly stratified sand and silt that contains matrix-supported boulders, cobbles, and pebbles. Boulders are angular and subangular. Upper surface is about 12 m above alluvium and colluvium in adjacent drainages. Correlative deposits were mapped as Qp_2 in the Cameron Mountain quadrangle (Wallace and Lawson, 1998), grouped with T3 by Wallace and others (1997) in the Salida East quadrangle, and as Qsp_1 by Wrucke and Dings (1979).

Wrucke and Dings (1979) suggested these deposits formed during the Yarmouth interglacial stage or the Kansan glaciation.

Qp_1 **Pediment deposit one—**Pediment deposit one is composed of poorly stratified gravel of pebbles, cobbles, and boulders in a silty and sandy matrix. Strongly developed grayish-red, grayish-brown, and red-brown soil marks the upper surface of the pediment; boulders, cobbles, and pebbles are weathered. Remnants of this pediment deposit reach an elevation of about 9,700 ft in the northeastern part of the map area. Correlative deposits were mapped as Qp_1 in the Cameron Mountain quadrangle (Wallace and Lawson, 1998), mapped as T2 in the Salida East quadrangle (Wallace and others, 1997), and as Qv by Wrucke and Dings (1997).

TERTIARY ROCKS AND DEPOSITS

Tb **Basalt (Miocene)—**Vesicular and non-vesicular, dense basalt porphyry contains olivine and hornblende in a matrix of glass and felted plagioclase microlites. Olivine phenocrysts occur as single crystals as large as 1 cm in diameter and as glomerophenocrysts that form crystal masses as large as 3 cm. Black hornblende crystals show strong resorption features and they are irregularly shaped, rounded, and pitted; hornblende crystals are generally 1 cm in length, but some crystals are 2.5-cm in length. Pahoehoe flows accumulated to a maximum thickness of about 85 m. Late-stage fissure eruption south of Herring Park, in the west-central part of the quadrangle, formed a scoria mound that contains volcanic bombs, which are commonly 30-cm long but may be 70 cm in length.

Tw **Wagon Tongue Formation (Miocene)—**Formation consists of semiconsolidated and nonconsolidated, poorly to moderately sorted, interbedded mudstone, siltstone, sandstone, granular and pebbly sandstone, and fine gravel. Gravel and sand beds have shallow channels at basal contacts and contain low-angle planar crossbeds. Beds of air-fall tuff are well indurated and contain quartz, feldspar, and biotite in a lithified matrix of ash. Formation is generally poorly exposed; thickness may be as much as 150 m. Subangular and angular pebbles, cobbles, and boulders commonly occur on the Wagon Tongue Formation, but these clasts are a lag deposit left by erosion of younger pediment deposits.

Tgp **Gribbles Park Tuff (Oligocene)—**Formation consists of ash-flow tuffs composed of moderate-gray, light-gray, pinkish-gray, brownish-gray, and reddish-gray rhyolite porphyry. Phenocrysts are quartz, chatoyant sanidine, and biotite. Volcanic rock fragments are common. Compound cooling units form moderately to densely welded, glassy tuff. This ash-flow tuff has an $argon^{40}/argon^{39}$ isotopic age of 32.76 ± 0.14 Ma (McIntosh and Chapin, 1994). The type locality is north of Gribbles Park in W ½ sec. 16 and E ½ sec. 17, T. 51 N., R. 11 E. (Epis and Chapin, 1974) Thickness at type locality in Gribbles Park quadrangle is about 100 m (Epis and Chapin, 1974).

Badger Creek Tuff (Oligocene)—Regionally this formation consists of a nonwelded tuff member (Tbcn) and a welded tuff member (Tbc); the nonwelded tuff is widespread in the Gribbles Park quadrangle.

Tbc **Welded tuff member—**Member is a light-gray, light-yellowish-gray, and light-reddish-gray quartz latite welded tuff. Unit contains abundant biotite and plagioclase phenocrysts and lesser amounts of sanidine and hornblende phenocrysts. Member also contains abundant light-pink and light-grayish-white pumice and lapilli and lithic fragments. Tuff is weakly foliated. Unit is about 25 m thick. An $argon^{40}/argon^{39}$ age on the Badger Creek welded tuff of 34.35 ± 0.09 Ma was obtained by McIntosh and Chapin (1994).

Tbcn **Nonwelded tuff member—**Member is a white, light-grayish-white, and light-gray, ash-flow and air-fall tuff that forms prominent hoodoos and easily eroded cliffs. Although most of unit is nonwelded ash-flow tuff, some slightly welded and moderately welded flow units occur in the upper part of the nonwelded tuff member in Badger Creek drainage. Member is composed of multiple flow units that are interbedded with air-fall tuff. Abundant volcanic rock fragments are a distinguishing feature of this unit. Member grades laterally into the Antero Formation in the western and northern part of the map area. The thickness of the nonwelded member of the Badger Creek Tuff is about 200 m in the Gribbles Park quadrangle and the tuff thins to about 90 m to the south in the Salida East quadrangle (Wallace and others, 1997). The nonwelded tuff member is same age as the welded tuff member.

Ta

Antero Formation (Oligocene)—Formation is a light-grayish-white, light-gray, pale-greenish-gray, thinly bedded, laminated, water-laid tuff, and interbedded, light-grayish-white and light-gray, crossbedded, tuffaceous sandstone and sandy pebble and cobble conglomerate. The sandstone forms thick beds and lenticular channels in water-laid tuff. The formation interfingers with nonwelded member of Badger Creek Tuff (Epis and Chapin, 1974). This unit forms prominent white cliffs in western and central parts of quadrangle and is about 60 m thick.

Ttm

Thirtynine Mile Andesite (Oligocene)— The formation is poorly sorted, black, greenish-black, and reddish-black, pyroxene-bearing andesite breccia of Epis and Chapin (1974). This unit occurs only along northeastern boundary of Gribbles Park quadrangle where it forms a poorly exposed rubble in the region of Rye Slough.

Twm

Wall Mountain Tuff (late Eocene)—The oldest Tertiary volcanic unit exposed in the Gribbles Park quadrangle is the Wall Mountain Tuff (Epis and Chapin, 1974). The Wall Mountain Tuff is a welded rhyolite ash-flow tuff exposed in widely scattered patches in the south, southwestern, and western parts of the quadrangle. The Wall Mountain Tuff is predominantly eutaxitic in texture and is moderately to densely welded, although no pattern in the distribution of different degrees of welding was determined from our mapping. The degree of welding varies from pumice-rich flow bands to densely welded glassy tuff. The welded tuff is mostly light-gray, moderate-gray, light-brownish-gray, and grayish-red rhyolite that contains prominent sanidine and plagioclase phenocrysts (Epis and Chapin, 1974). McIntosh and Chapin (1994) reported an argon^{40}/argon^{39} age of 36.64 ± 0.06 Ma for the Wall Mountain Tuff. Flow foliation in glassy welded tuff is prominent. Chapin and Lowell (1979) identified the caldera source of the Wall Mountain Tuff in the southern part of the Sawatch Range, northwest of Salida, Colorado. Chapin and Lowell (1979) described primary and secondary deformation structures from the Wall Mountain Tuff in the Gribbles Run paleovalley where this glassy tuff formed a single cooling unit that slid and folded into the paleovalley as the plastic and mobile tuff degassed and compacted. The sparse exposures of the Wall Mountain Tuff in the Gribbles Park quadrangle do not permit reconstruction of pre-eruption topography, so flow foliation in the tuff cannot be directly linked to deformation mechanisms described by Chapin and Lowell (1979). Regionally the thickness of the Wall Mountain Tuff varies markedly, and it has a maximum thickness of more than 150 m (Epis and Chapin, 1974).

MESOZOIC ROCKS

Kw

Whitehorn Granodiorite (Late Cretaceous)— The only Mesozoic rock unit in the Gribbles Park quadrangle is the Late Cretaceous Whitehorn Granodiorite, which was described by Wrucke (1974). The Whitehorn Granodiorite is a large laccolith that occupies large parts of the adjoining Salida East, Cameron Mountain, and Jack Hall Mountain quadrangles (Wrucke and Dings, 1974; Wallace and others, 1997; Wallace and Lawson, 1998). The Whitehorn Granodiorite occurs in a small area in the southwestern part of the Gribbles Park quadrangle where the laccolith intrudes the Pennsylvanian Minturn and lower Sangre de Cristo Formation. The basal contact of the laccolith is not exposed in the map area; the upper contact appears to dip gently eastward near Everett Cow Camp, but as the contact is traced to the southwest the contact appears to steepen. Dikes occur locally along the contact of granodiorite and sedimentary rocks. In the map area the Whitehorn Granodiorite is a fine- and medium-grained, equigranular and hypidiomorphic-seriate, biotite granodiorite that contains varietal hornblende and pyroxene. The basal and upper contacts of the laccolith generally have a prominent porphyritic texture and contain plagioclase crystals, 1 to 5 mm long, in a fine-grained equigranular or aphanitic matrix. Reddish-black and black hornfels, greenish-black and blackish-green hornfels, and light-green, green, and grayish-green calc-silicate hornfels formed from contact metamorphism at the contact between the laccolith and Pennsylvanian clastic and carbonate rocks. Biotite- and plagioclase-rich xenoliths are locally common along borders. May be weakly foliated near contacts. Wrucke (1974) reported a potassium-argon age of 70.0 ± 2.6 Ma from biotite for the Whitehorn Granodiorite. McDowell (1971) reported concordant potassium-argon ages of 70.4 ± 2.1 Ma from biotite and 69.4 ± 2.1 Ma from hornblende for the age of intrusion.

PALEOZOIC ROCKS

Sangre de Cristo Formation (Lower Permian and Upper Pennsylvanian)— This formation overlies the Minturn Formation on a gradational contact. Pierce (1969) subdivided the Sangre de Cristo Formation into four informal units, and DeVoto and Peel subdivided the Sangre de Cristo Formation into upper and lower members in the northern Sangre de Cristo Range and the southern Mosquito Range. De Voto and Peel (1972) also estimated that the Sangre de Cristo Formation totaled about 4,570 m in thickness. Only the lowest member, member one, of the four regionally recognized informal members is present in the Gribbles Park quadrangle.

Psc$_1$

Member one (Upper Pennsylvanian)— This member overlies the Minturn Formation on a gradational contact in which red, coarse-grained beds intertongue with black and olive-drab shale, siltstone, fine-grained sandstone, and carbonate beds of the Minturn Formation. The basal member of the Sangre de Cristo Formation is composed mainly of grayish-red and reddish-gray, coarse-grained to granular arkose, subarkose, and orthoquartzite, and arkose conglomerate, and lesser amounts of dark-grayish-red and purplish-red micaceous siltstone, and dark-red, silty, micaceous shale. Member one is equivalent to unit 4 of Pierce (1969). Grayish-red and reddish-gray, coarse-grained arkose, pebbly arkosic conglomerate, and medium- and fine-grained arkose form composite bedding units that generally range between 60 cm and 15 m thick. Polymict conglomerate beds are generally matrix-supported and composed of subangular to subrounded, granitic, metamorphic, and sedimentary clasts. Channeled bases of these composite bedding units commonly overlie the fine-grained upper parts of fining-upward sequences. Within coarse-grained zones channeled contacts are common among multiple co-sets of cross-beds. In the adjacent Salida East quadrangle, Wallace and others (1997) described an ideal fining-upward sequence as composed of coarse-grained, pebbly and granular arkose overlain by grayish-red beds of medium- and fine-grained arkose, siltstone, and less common red silty shale at the top. In the Salida East quadrangle many fining-upward sequences were incomplete and coarse-grained basal parts of fining-upward sequences occurred on medium-grained sequences where the siltstone and shale tops of the sequences were eliminated, but metamorphism and poor exposures in the Gribbles Park quadrangle mask these sedimentologic features. Primary sedimentary structures in the coarse-grained rocks are large- and medium-scale trough and planar crossbeds that form multiple co-sets, channels, shale-chip conglomerates, and dispersed pebble conglomerate. In medium- and fine-grained arkose and subarkose, primary structures are predominantly small-scale trough and planar crossbeds, shallow channels, ripple cross-lamination, climbing ripples, cuspate and linguoid ripples, rib-and-furrow structures, parting lineation, and planar lamination. Primary bedding structures in siltstone and silty shale beds at the tops of fining-upward sequences are predominantly ripple cross-lamination, planar lamination, flasers, and microlamination. Secondary sedimentary structures are rare and poorly exposed. Some rare, thin lenticular beds of olive-drab, dark-greenish-gray, dark-gray, and moderate-gray, fine-grained sandstone, siltstone, and shale are interbedded with the dominant red-bed sequence in member one of the Sangre de Cristo Formation; these fine-grained intervals are generally less than 1 m thick and form hornfels near the Whitehorn Granodiorite. The top of member one is not exposed in the Gribbles Park quadrangle, and this member is a minimum of 300 m thick in the south-western corner of the map area.

IPm

Minturn Formation (Middle Pennsylvanian)—This formation regionally overlies the Sharpsdale Formation on a gradational and conformable contact, but the contact is poorly exposed in the Gribbles Park quadrangle. The Minturn Formation is composed mainly of dark-gray, gray, olive-drab, grayish-green, greenish-gray, and black fine-grained, arkose, feldspathic sandstone, siltstone, shale, and less common limestone and dolomite. The unit is estimated to be about 550 m thick in the southern part of the map area. Gray, grayish-green, and olive-drab sandstone beds are fine grained and flaggy weathering. Sandstone beds contain planar lamination, ripple cross-lamination, low-amplitude hummocky crossbeds, and shallow channels. Dark-gray and olive-drab siltstone is planar laminated and microlaminated and contains ripple cross-lamination. Some beds of olive-drab and grayish-green, medium- and coarse-grained arkose occur interbedded with finer grained rocks in the lower part of the Minturn, and shale and siltstone beds occur more commonly in the middle and upper parts of this unit. Limestone beds are thin, laminated and microlaminated, black and dark-gray, fetid micrite. Commonly limestone beds are 1 to 15 cm thick and are interbedded with black and dark-gray, silty shale; zones of interbedded limestone and shale form bedding units that are 1 to 3 m thick, but some individual limestone beds are as thick as 1 m. Limestone beds are not as common in the Minturn Formation as in the Kerber Formation. Near the top of the Minturn Formation, grayish-red, micaceous silty shale and some fine- and medium-grained arkose beds are interbedded with more characteristic olive-drab, grayish-green, dark-gray, and black micaceous shale, silty shale, and siltstone of the Minturn Formation. The black, micaceous, shale bed containing casts of salt crystals that occurs at the contact with the overlying Sangre de Cristo Formation in the Salida East quadrangle could not be identified in the metamorphosed rocks in the Gribbles Park quadrangle.

IPs

Sharpsdale Formation (Middle Pennsylvanian)—The Sharpsdale Formation overlies the Kerber Formation on a contact that appears gradational and conformable. The Sharpsdale Formation is composed mainly of grayish-red and reddish-gray, coarse-grained arkose, pebbly and granular arkose, subarkose, and orthoquartzite interbedded with grayish-red and reddish-gray, medium- and fine-grained, feldspathic sandstone and lesser amounts of dark-red, micaceous siltstone and purplish-red, silty, micaceous and shale. This formation is estimated to be about 150 m thick in the southern part of the map area. Grayish-red, purplish-red, and bright-grayish-red, coarse-grained arkose, pebbly arkose, and medium- and fine-grained arkose of the Sharpsdale Formation form composite bedding units that generally range between 60 cm to 15 m thick. Channeled bases of these composite bedding units commonly overlie the fine-grained upper parts of fining-upward sequences. Within coarse-grained zones channeled contacts are common among multiple co-sets of crossbeds. An ideal fining-upward sequence is composed of coarse-grained, pebbly and granular arkose overlain by grayish-red beds of medium- and fine-grained arkose, siltstone, and less common red silty shale at the top. Primary sedimentary structures in the coarse-grained rocks are large- and medium-scale trough and planar crossbeds that form multiple co-sets, channels, shale-chip conglomerates, and dispersed pebble conglomerate. In medium- and fine-grained arkose and subarkose, primary structures are predominantly small-scale trough and planar crossbeds, shallow channels, ripple cross-lamination, climbing ripples, cuspate and linguoid ripples, rib-and-furrow structures, and planar lamination. Siltstone and silty shale beds at the tops of fining-upward sequences are dominated by ripple cross-lamination, planar lamination, flasers, and microlamination. Some intervals in the Sharpsdale are olive-drab and grayish-green, tan- and rusty-weathering, medium- and coarse-grained arkose, pebbly arkose, and arkose conglomerate; these bleached and reduced intervals are generally less than 15 m thick. Arkose beds within the olive-drab and rustyweathering intervals commonly have channeled basal contacts and contain common medium- and large-scale planar and trough crossbeds. Calcite, dolomite, and ankerite occur as cement in these olive-drab and rusty-weathering intervals, and malachite and azurite occur as replacement masses in these coarse-grained rocks. Presumably the secondary copper-bearing minerals were altered from diagenetic sulfide minerals in fresh rock. The contact between the Sharpsdale and Kerber Formations is located differently in the Salida East and Gribbles Park quadrangles. In the Salida East quadrangle a zone of distinctive grayish-green and gray limestone beds occurs in the base of the Sharpsdale and uppermost Kerber Formations, and the base of the Sharpsdale is located where gray-colored shale, siltstone, arkose, and limestone of the Kerber is replaced by red-colored pebbly arkose of the Sharpsdale Formation. In the Gribbles Park quadrangle these distinctive bright-grayish-green and gray limestone beds do not extend upward to the contact between the Kerber and Sharpsdale Formations; the contact between the Kerber and Sharpsdale Formations in the Gribbles Park quadrangle is placed at the uppermost tan-weathering limestone in the Kerber Formation.

IPk

Kerber Formation (Lower Pennsylvanian)— The Kerber Formation disconformably overlies the Leadville Limestone. The Kerber Formation is about 122 m thick in the southern part of the Gribbles Park quadrangle, but the deformed sequence shown in cross section B-B′ may be as thick as 330 m. In the Gribbles Park quadrangle the Kerber Formation is mainly a red-bed sequence, in contrast to the dominant green-bed sequence in the Salida East and Cameron Mountain quadrangles. The great difference in rock colors notwithstanding, the Kerber is composed of a unique combination of coarse-grained conglomeratic arkose, medium- and coarse-grained arkose, shale, siltstone, and limestone, and rare dolomite that is duplicated by no other unit in the region. Burbank (1932, p. 13) used the name “Kerber” for a sequence of carbonaceous black shale, siltstone, and brown sandstone that separate red coarse-grained rocks (Sharpsdale Formation) from limestone of the Leadville Limestone at Kerber Creek, southwest of Salida, Colorado. De Voto and Peel (1972) described detailed lithofacies variations in the Kerber Formation from the Arkansas River Valley, described lateral stratigraphic relations with the Belden Formation, and discussed vertical stratigraphic relations with the Sharpsdale Formation. Wrucke and Dings (1979) and Taylor and others (1975) applied the name “Belden Formation” to this stratigraphic interval, but, as pointed out by De Voto and Peel (1972), the Belden Formation is primarily a fine-grained carbonaceous shale and the Kerber Formation contains a significant component of coarse-grained arkose, conglomerate, and sandstone, so the term “Belden” is not properly applied to the latter rocks. In the Gribbles Park quadrangle the Kerber Formation is composed mostly of grayish-red, reddish-gray, moderate-red, fine-, medium-, and coarse-grained arkose, and arkose conglomerate interbedded with micaceous siltstone and shale, and reddish-gray, gray, pinkish-gray, and grayish-green limestone, and rare beds of dolomite and gypsum. The Kerber Formation also contains interbedded grayish-green, olive-drab, olive-gray, moderate-gray, dark-greenish-gray, coarse-grained arkose, conglomeratic arkose and subarkose, medium- and fine-grained arkose, siltstone, and shale. Grayish-black, moderate-gray limestone and rare dolomite occur as interbeds in olive-drab and grayish-green rocks; reddish-gray, pinkish-gray, and light-brownish-gray and tan-weathering limestone and rare dolomite occur interbedded with red rocks at the top. Coarse- and medium-grained conglomeratic arkose is a dominant rock type in the Kerber Formation, and it occurs in composite beds that are as thick as 15 m. Coarse-grained zones are separated by zones of medium- and fine-grained arkose, siltstone, or shale that commonly are 3 to 10 m thick. Coarse-grained rocks are most abundant near the base of the Kerber Formation and some coarse arkoses are calcite cemented. Coarse-grained sedimentation units are fining-upward sequences capped by fine-grained sandstone or siltstone. Fine-grained sedimentation units are fining-upward sequences capped by dark-colored shale. Dark-gray and black limestone beds in the Kerber Formation are fine-grained, argillaceous, mottled or laminated, fetid micrite; limestone beds are generally 12 cm to 3 m thick. Some limestone beds contain brachiopods and trilobite fragments. Limestone interbeds are common in the middle and near the top of the Kerber in the Gribbles Park quadrangle, but to the southwest and west in the Salida East and Cameron Mountain quadrangles limestones are most common near the top of the Kerber. In the west-central and southern parts of the Gribbles Park quadrangle limestone beds in the upper part of the Kerber are commonly fossiliferous, and a distinctive thin, mottled, nodular, bright-grayish-green limestone beds. In the Gribbles Park quadrangle a brachiopod coquina occurs in upper Kerber in distinctive bright-grayish-green limestone beds. Gray and tan-weathering dolomite beds occur rarely in the Kerber Formation. Primary sedimentary structures in the coarse-grained rocks are predominantly large-scale and medium-scale planar and trough crossbeds, channels, ripple cross-lamination, rib-and-furrow structures, cuspate and linguoid ripple marks, climbing ripples, and planar lamination that forms parting lineation. Shallow channels occur at the base of coarse-grained, conglomeratic sandstone beds. Primary sedimentary structures in the fine-grained rocks are ripple cross-lamination, rib-and-furrow structures, climbing ripples, ripple marks, planar lamination, microlamination, and water-expulsion structures. Conglomeratic and sandy units have coarse-grained rocks at the base and become finer grained upward. Contacts between the upper part of a fine-grained sequence and the lower part of a coarse-grained sequence are generally channeled. The distinctive bright-grayish-green limestone beds in the upper Kerber is a regional marker bed that was used as a key to separation of the Kerber, Sharpsdale, Belden, and Minturn Formations. In the adjoining Salida East and Cameron Mountain quadrangles (Wallace and others, 1997; Wallace and Lawson, 1998) distinctive bright-grayish-green limestone beds extend across the upper contact of the Kerber into lower beds of the Sharpsdale Formation, but in the Gribbles Park quadrangle these distinctive limestone beds occur only in the upper part of the Kerber. The upper contact of the Kerber Formation appears to be gradational with the overlying Sharpsdale Formation.

Ml **Leadville Limestone (Lower Mississippian)—** The Leadville Limestone is a moderate-gray and dark-gray, massive-weathering, thinly bedded, micritic limestone and finely crystalline dolomite. Beds range in thickness from 7 cm to 2 m. Black laminated chert nodules and lenticular chert beds occur at some stratigraphic levels. The formation overlies the Dyer Dolomite Member of the Chaffee Formation on a disconformable contact. The Leadville Limestone varies in thickness from 91 m in the northern part of the quadrangle to about 37 m in the southern part of the map area; much of the thickness variation may result from post-lithification solution of limestone or from volume reduction related to solution and silicification of limestone. The base of the Leadville is channeled into the underlying Dyer Dolomite Member, and at some places shallow channels are filled with medium-grained orthoquartzite cemented by calcite. Sandy limestone, flat-pebble conglomerate, and limestone breccia occur in the shallow channels at the base of unit. Clasts of grayish-yellow, laminated and microlaminated dolomite, presumably derived from the Dyer Dolomite Member, occur in the basal sandstone beds of the Leadville at some places. In the Gribbles Park quadrangle most of the Leadville Limestone is composed of finely crystalline micrite and lesser amounts of dolomicrite, whereas in the Salida East and Cameron Mountain quadrangles, dolomicrite forms at least half of the unit (Wallace and others, 1997; Wallace and Lawson, 1998). Lenticular interbeds of biomicrite and oolitic limestone occur rarely in limestone in the Gribbles Park quadrangle. Some limestone and dolomite are mottled light gray and moderate gray. The two distinctive flaggy-weathering, thinly bedded, laminated, grayish-pink and grayish-red, flat-pebble conglomerate limestone zones that were prominent in the Salida East quadrangle (Wallace and others, 1997) are absent in the Gribbles Park quadrangle. Alteration of the Leadville consists of an early diagenetic event of dolomitization, and post-lithification events of solution and silicification, events that may have been sequential. Dolomite replaced beds of micrite resulting in interbedded dolomite and limestone zones that are 60 cm to 3 m thick. Dolomitization is uneven laterally and vertically so that much of the Leadville is mostly micrite at some places and thick zones of dolomicrite at other places. A solution event after lithification of the Leadville formed prominent caves and solution breccias in the upper part of this unit. This post-Mississippian solution event affected Mississippian limestones throughout much of the Cordillera and may have been related to a widespread silicification event in the Leadville Limestone. A chert breccia that was mapped at the top of the Leadville Limestone in the Salida East quadrangle (Wallace and others, 1997) was too thin to show as a map unit in the Gribbles Park quadrangle, but thin zones of chert occur at the top of the Leadville Limestone in the Badger Creek area. The zones of massive replacement chert and chert breccias that occur at several stratigraphic levels in the Salida East quadrangle (Wallace and others, 1997) are absent in the Gribbles Park quadrangle. South of Cals Fork Gulch in the northwestern part of the Gribbles Park quadrangle, silica-cemented sandstone beds are interbedded with limestone near the top of the Leadville Limestone. The sandstone is mostly medium-grained, silica-cemented orthoquartzite, composed of rounded to well rounded grains. The occurrence of interbedded sandstone and limestone in the upper part of the Leadville Formation is unique in the region of the Gribbles Park quadrangle.

Chaffee Formation (Upper Devonian)— The Chaffee Formation rests disconformably on the Fremont Dolomite. The Chaffee Formation is divided into the Parting Quartzite Member at the base and the Dyer Dolomite Member at the top (Wrucke and Dings, 1979). Campbell (1972) applied group rank to the Chaffee and applied formation rank to the Parting Quartzite and Dyer Dolomite, and he subdivided the Parting and Dyer into several members on the basis of measured sections. Members could not be mapped separately at the map scale of 1:24,000, so we retain the nomenclature hierarchy of Wrucke and Dings (1979). The Chaffee Formation is resistant to weathering; however, because the units are thinly bedded, they are less resistant to weathering than the massive-weathering Fremont Dolomite below and the massive-weathering Leadville Limestone above, so the Chaffee Formation is a slope-forming unit between the two carbonate units. The Parting Quartzite Member is absent in the southern part of the Gribbles Park quadrangle.

Dcd

Dyer Dolomite Member—This member is a yellowish-gray, light-gray, and pale-yellowish-gray, laminated and microlaminated, finely crystalline and microcrystalline dolomite. Some beds of laminated yellowish-gray chert are interbedded with the dolomite. A zone of micaceous green shale and interbedded nodular dolomite occurs at the top of the Dyer Dolomite Member south of Cals Fork Gulch and south of Rye Slough, but the zone of green shale is absent south of Antelope Creek. The micaceous green shale at the top of the Dyer Dolomite Member is about 5 m thick. The dolomite is bioturbated and vuggy or massive weathering. Laminated dolomite beds are 1 to 5 cm thick. The Dyer Dolomite Member is about 95 m thick in the northern part of the map area and about 24 m thick in the southern part of this quadrangle.

Dcp

Parting Quartzite Member—This member is a light-gray, pale brownish-gray, light-grayish-red, and pinkish-gray, fine-grained, silica- or calcite-cemented, dense, flinty, conchoidal-fracturing orthoquartzite. The member occurs as a mappable unit north of Antelope Gulch and west of Badger Creek. Quartzite beds are generally 5 to 25 cm thick. Planar lamination, ripple cross-lamination, and rare planar crossbeds are the principal sedimentary structures, but are masked by recrystallization. Although interbeds of dolomite and shale occur in adjacent quadrangles, these rock types are absent in the thin exposures of the Parting in the map area. This unit is a maximum of about 24 m thick in the northern part of the quadrangle, and is absent in the southern part of the map area.

Of

Fremont Dolomite (Upper and Middle Ordovician)—The Fremont Dolomite overlies the Harding Quartzite on a disconformable contact. The Fremont Dolomite is a dark-, moderate-, and light-gray, massive-weathering, finely crystalline, fetid dolomite that contains echinoid debris and dolomitized coral. Trilobite and brachiopod fragments occur in the Salida East quadrangle, but these fossils were not found in the Gribbles Park quadrangle. The dolomite may be mottled light gray and dark gray, or it may be laminated and microlaminated. Beds are generally 5 cm to 1 m thick and bedding is poorly developed. This dolomite resists weathering and has a rough, uneven, sharply ridged weathering surface. The Fremont Dolomite is maximum of about 67 m thick in the Gribbles Park quadrangle.

Oh

Harding Quartzite (Middle Ordovician)— The Harding Quartzite overlies the Manitou Limestone on a disconformable contact.

The Harding Quartzite is a dark-reddish-gray, dark-grayish-orange, dark-grayish-red, light-gray, moderate-gray, and rusty-orange, fine- to medium-grained, well-sorted, silica-cemented, mottled orthoquartzite. The sandstone is completely cemented by silica, and it has the conchoidal fracture of a quartzite. This resistant-weathering unit is about 67 m thick at most places in the quadrangle. Quartzite beds range from 2.5 cm thick to about 20 cm thick, and they contain planar lamination and planar crossbeds, which mostly are obscured by pervasive replacement by diagenetic silica. Some quartzite beds locally contain bioturbation and abundant burrows. The unit is commonly brecciated and forms a framework-supported mass of angular fragments, some of which retain traces of original bedding. Angular clasts of rusty-colored, red, and orange quartzite form a breccia that represents the entire thickness of the Harding Quartzite at some places. Some exposures contain sandstone conglomerate at the base.

Om

Manitou Limestone (Lower Ordovician)— The Manitou Limestone overlies Proterozoic rocks. It is composed of dark-, moderate-, and light-gray, thin- to thick-bedded dolomite and cherty dolomite and rare beds of dark-gray limestone. The Manitou Limestone is about 73 m thick in the northern part of the map area and about 37 m thick in the southern part of the quadrangle. The formation contains little limestone and dolomitic limestone in the Gribbles Park quadrangle. Dolomite and limestone are laminated and mottled, and beds range between 2 cm and 1 m in thickness. A distinctive characteristic of the Manitou Limestone is the occurrence of black and light-grayish-white chert nodules and lenses in the dolomite. The chert is internally laminated and parallel to bedding. Silicified breccia of pebble- and cobble-sized laminated chert in a matrix of silicified dolomite occurs locally as lenses in the dolomite. These chert breccias are less common in the Gribbles Park quadrangle than in the Salida East quadrangle where the entire thickness of the Manitou Limestone can be composed of chert breccia (Wallace and others, 1997).

PROTEROZOIC ROCKS

Xqm

Quartz monzonite (Early Proterozoic)— This unit is a reddish-orange to red, fine- to medium-grained, granular biotite quartz monzonite, which is generally poorly exposed. Wrucke and Dings (1979) mapped much of this unit as a Middle Proterozoic age intrusive; however, field relationships with the Xvs unit and the presence of locally developed foliation indicate that this unit is primarily of Early Proterozoic age.

Xgd

Granodiorite (Early Proterozoic)—This unit is composed of gray, speckled, coarse- to very coarse-grained, strongly foliated granodiorite and granite gneiss. In places it contains augen of quartz and microcline feldspar up to 6 cm in length and minor amounts of muscovite and biotite. Foliation is well developed near the contact with older units. Exposures in the Gribbles Park quadrangle are limited to a few acres in the north-central part of the quadrangle and an extensive area in the south-central part of the quadrangle south of Gribbles Park adjacent to the Badger Creek drainage. The outcrops in this quadrangle are a portion of the strongly foliated border phase of a pluton that extends for approximately 60 km north of the quadrangle (Wrucke and Dings, 1979). A sample of six zircon fractions from the granodiorite in the adjacent Cameron Mountain quadrangle was dated by the uranium-lead method by Bickford and others (1989); the resultant age is 1672 $\pm$ 5 Ma.

Xg

Gabbro (Early Proterozoic)—This unit is a dark-gray to black, medium- to coarse-grained gabbro. Megascopically the rock contains light-orangish-tan crystals of plagioclase feldspar in a black aegerine-augite matrix. Contact relations with the surrounding rock units are generally obscured. The gabbro contains approximately 30 to 50 percent medium-grained (2–5 cm) labradorite (An_{50}–An_{60}) and 50 to 70 percent strongly pleochroic, prismatic, fine-grained (0.5–1.0 mm) crystals of aegerine-augite. A fine-grained phase of pyroxene occurs within a sub-ophitic texture of larger plagioclase crystals and along plagioclase fractures. In the Salida East quadrangle to the southwest the pyroxene crystals have been replaced by hornblende (Wallace and others, 1997). Chlorite and rare epidote occur as alteration products of the pyroxene. Opaque minerals, probably iron oxides and ilmenite, occur in trace amounts up to a few percent.

Xvs

Interbedded volcanic and sedimentary rocks (Early Proterozoic)—This unit is composed of interbedded tan, bimodal volcanic and volcaniclastic rocks, and moderate-gray to black, light-gray, and grayish-tan, fine-grained to very fine-grained quartzite, metasiltstone, and metagraywacke. The quartzite consists primarily of very fine quartz grains and up to 10 percent feldspar grains. Porphyroblasts of plagioclase up to 1 mm in size occur in some locations in the quadrangle and can constitute up to 20 percent of the quartzite. Poorly to moderately foliated chlorite and biotite can constitute from 5 to 30 percent of the quartzite. Glomeroporphyritic biotite occurs in association with magnetite grains. One sample examined with the petrographic microscope had highly birefringent needle- and lath-like minerals, probably sericite, along the suture zones of the quartz grains. Other accessory mineral constituents include garnet, zircon, and magnetite, probably of detrital origin. Crossbedding, graded couplets, microlamination, planar lamination, and ripple cross-lamination are commonly well preserved in quartzite, metasiltite, and metagraywacke. Locally the quartzite beds contain quartz veinlets that are 5 to 10 mm wide and contain rare pyrite. Epidote is common on fracture surfaces, in veinlets, and, rarely, as a replacement of chlorite. In the Salida East quadrangle detailed petrographic and stratigraphic studies by Boardman (1986) have demonstrated the presence of bimodal volcanic and volcaniclastic rocks in the Xvs unit. The Xvs rocks in the Gribbles Park quadrangle contain mostly metaquartzites and have a lesser amount of volcanic and volcaniclastic rocks. None of the basalt flows and felsic volcanic rocks so prominent in parts of the Salida East quadrangle are present in the Gribbles Park quadrangle. Four zircon fractions from a metadacite in the Xvs unit just east of Salida in the Salida East quadrangle were dated by the uranium-lead method by Bickford and others (1989) at 1728 $\pm$ 6 Ma.

MINERAL RESOURCES

Metallic mineral occurrences in the Gribbles Park quadrangle consist of metallic vein and replacement deposits in Proterozoic rocks and stratabound deposits in Paleozoic rocks. Industrial minerals occur at some places. Although mineral resource potential of these mineral occurrences has not been evaluated as part of this project, the mineral occurrences identified in the quadrangle are discussed briefly.

Vein and Replacement Mineral Deposits

A few minor vein and fracture-filling mineral deposits occur in the Proterozoic rocks of the Gribbles Park quadrangle. The most significant occurrence is shown on the map as sample 98JC005; it consists of one small, 5 by 3 m prospect pit. The host rock is a small unmapped body of gabbro, which has been cut by 15- to 20-cm-thick clear quartz veins and pegmatite. A green copper stain occurs on biotite layers in the gabbro. A grab sample of the mineralized biotite (sample 98JC005, table 1) contains 0.213 parts per million (ppm) gold, 14.2 ppm silver, 20,064 ppm copper, and 5,075 ppm zinc.

Paleozoic Stratabound Occurrences

Disseminated stratabound mineral deposits have been identified in upper Paleozoic rocks in the map area. These stratabound deposits resemble “red-bed” copper-uranium or copper-silver occurrences that are widespread in the western United States in rocks ranging in age from Middle Proterozoic to Cretaceous (Kirkham, 1989; Harrison, 1972; Connor and McNeal, 1988; Lindsey and Clark, 1995; Thorson and Hahn, 1995). Occurrences of highly anomalous amounts of copper, silver, lead, lithium, vanadium, and rare gold were identified from grab samples from the Kerber and Sharpsdale Formations in the map area (Table 1). The stratabound mineralized zones occur in chemically reduced zones of coarse-grained and conglomeratic arkose that are interbedded with conglomeratic, chemically oxidized arkose beds. Mineralized zones are commonly 20 cm to 2 m thick in rusty-weathering, grayish-tan, grayish-light-orange, and light-grayish-yellow, coarse-grained arkose and arkose conglomerate. These coarse-grained beds fill broad, shallow channels and trough and planar crossbeds are common

Table 1. Geochemical analyses of mineral occurrences in the Gribbles Park quadrangle. Analyses by Cone Geochemical, Inc., Lakewood, Colorado. Concentrations in brackets by atomic absorbtion method. All other analyses by partial digestion inductively coupled plasma method. [All concentrations in ppm except oxides and sulfur, which are in percent.]

Sample Number	Au	Ag	As	Cd	Co	Cu	Hg	Pb	Sb	Zn	Mo	Ni	B
98047		<0.5		<0.5	<1	82		25		3	2	2	<4
	[<0.001]	[0.3]	[2]				[0.25]		[<1]				
98161		4.1		<0.5	<1	16,769		19		27	<1	8	<4
	[<0.001]	[4.3]	[<1]				[0.22]		[<1]				
98192		<0.5		<0.5	<1	18		<10		81	<1	37	<4
	[<0.001]	[<0.2]	[4]				[0.11]		[<1]				
98204		<0.5		<0.5	<1	7		<10		7	<1	8	<4
	[<0.001]	[<0.2]	[3]				[0.09]		[<1]				
98273		<0.5		2.0	<1	64		24		55	3	14	<4
	[0.006]	[<0.2]	[114]				[0.33]		[<1]				
98276		1.8		<0.5	<1	1,251		991		195	16	15	<4
	[0.038]	[2.1]	[380]				[0.30]		[6]				
98280		0.9		<0.5	<1	24,005		<10		14	23	23	<4
	[0.008]	[1.3]	[1]				[0.04]		[2]				
98316		<0.5		<0.5	<1	1,264		41		23	2	10	<4
	[<0.001]	[.3]	[12]				[0.03]		[1]				
98352		<0.5		<0.5	<1	16		19		27	3	11	<4
	[<0.001]	[<0.2]	[7]				[0.05]		[<1]				
98353		5.2		<0.5	<1	9,899		<10		36	1	5	<4
	[<0.001]	[6.7]	[<0.1]				[0.17]		[<1]				
98354		10.1		<0.5	<1	18,002		<10		24	2	9	<4
	[<0.001]	[12.2]	[<1]				[0.57]		[<1]				
98355		<0.5		<0.5	<1	42		<10		39	<1	16	<4
	[<0.001]	[<0.2]	[1]				[0.03]		[1]				
98368		<0.5		<0.5	<1	26		13		18	5	6	<4
	[0.002]	[0.2]	[90]				[0.12]		[<1]				
98442		<0.5		<0.5	<1	29		<10		10	1	12	<4
	[0.005]	[0.2]	[2]				[0.05]		[<1]				
98JC013		<0.5		<0.5	<1	9		18		10	4	5	<4
	[<0.001]	[0.2]	[19]				[<0.01]		[<1]				
98JC005		13.9		0.8	<1	20,064		40		5,075	<1	3	<4
	[0.213]	[14.2]	[<1]				[0.29]		[<1]				
98JC015		<0.5		<0.5	<1	228		10		95	49	19	<4

(Table continues on next page)

in the arkose beds. Mineralized zones are overlain or underlain by red shale, red micaceous siltstone, red fine-, medium-, and coarse-grained arkose and arkose conglomerate. Stratabound mineral deposits occur mainly in rocks deposited in nearshore marine, deltaic, and paludal environments. Oxidizing fluids carrying dissolved metals moved through adjacent coarse-grained red beds deposited in fluvial, deltaic, and alluvial environments. Mineralized rock samples commonly show secondary hydrous copper-carbonate and manganese-oxide minerals on weathered surfaces. Mineralized beds were probably reduced zones, and the original minerals that contained copper and silver are likely to have been sulfide minerals such as chalcopyrite, chalcocite, and bornite. Typical red-bed copper and silver occurrences in reduced arkose and arkose conglomerate beds in the Sharpsdale Formation in the west-central part of the Gribbles Park quadrangle contain 16,769 ppm copper and 4.3 ppm silver (sample 98161) and 18,002 ppm copper and 12.2 ppm silver (sample 98354, table 1). Coarse-grained and pebbly, reduced arkose from the lower Minturn Formation

Table 1. Geochemical analyses of mineral occurrences in the Gribbles Park quadrangle (continued).

Sample Number	Be	Li	Mn	P	Sr	V	Al_2O_3	CaO	Fe_2O_3	K_2O	MgO	Na_2O	S
98047	<1	2	28	20	25	<1	0.11	0.12	0.34	0.01	<0.1	<0.01	0.02
98161	<1	30	63	86	74	23	9.15	0.13	0.51	0.87	1.15	1.92	0.05
98192	<1	54	2,353	478	108	39	5.64	23.81	6.88	0.12	3.53	0.02	0.01
98204	<1	6	43	6,535	19	52	2.77	2.26	14.68	0.70	0.12	0.01	0.01
98273	2	11	3,852	328	66	104	1.06	39.40	2.11	0.39	1.08	0.01	<0.1
98076	5	39	4,855	125	47	184	1.33	0.31	11.59	0.61	0.28	0.02	0.04
98280	2	21	193	636	111	66	12.16	0.43	3.54	2.63	3.22	2.66	0.03
98316	1	20	4,811	82	53	38	7.40	5.59	2.42	0.88	0.72	1.82	<0.1
98352	<1	28	402	43	8	11	3.96	1.40	2.11	0.07	0.04	0.03	2.1
98353	<1	28	1,406	53	82	18	7.06	1.90	0.69	0.41	1.52	1.92	0.04
98354	<1	24	1,018	28	83	25	7.10	0.63	0.89	0.68	1.28	1.94	0.06
98355	<1	34	1,957	214	154	28	3.89	40.42	4.64	0.25	1.36	0.03	0.02
98368	<1	80	30	106	53	12	1.01	0.10	1.05	0.26	0.07	0.03	0.01
98442	<1	154	86	<10	995	20	3.83	29.79	1.69	2.01	2.48	0.04	<0.1
98JC013	1	4	22	114	19	11	13.87	0.07	1.04	8.02	0.08	1.00	<0.1
98JC005	3	10	3,544	68	12	10	4.84	7.68	22.31	0.14	11.57	0.57	0.02
98JC015	20	21	443	2,147	61	256	5.85	0.42	728.60	1.06	0.38	0.31	<0.1

contains 24,005 ppm copper and 1.3 ppm silver (Table 1, sample 98280).

Paleoplacers occur in beds that contain stratabound minerals. Sand-sized heavy minerals form black streaks on bedding surfaces and on crossbed foresets in conglomeratic arkose beds. The heavy minerals are predominantly magnetite and ilmenite(?).

Lindsey and Clark (1995) described stratabound copper and uranium mineral occurrences in the Minturn and Sangre de Cristo Formations from the northern Sangre de Cristo Range southeast of the Gribbles Park quadrangle, and Wallace and others (1997) and Wallace and Lawson (1998) described stratabound mineral occurrences from the nearby Salida East and Cameron Mountain quadrangles. Table 2 shows concentrations in parts per million of anomalous elements of mineralized rocks from the Gribbles Park quadrangle for comparison to anomalous elements from mineralized beds in the northern Sangre de Cristo Range (Lindsey and Clark, 1995) and from mineralized strata of the Salida East and Cameron Mountain quadrangles. The depositional environ-

Table 2. Comparision of element concentrations in mineralized rocks from stratabound mineral occurrences in upper Paleozoic rocks from the northern Sangre de Cristo Range, and the Salida East, Cameron Mountain, and Gribbles Park quadrangles. [All concentrations given in parts per million, except Au where the concentrations are measured in parts

Element	Salida East quadrangle (Wallace and others, 1997)		Northern Sange de Cristo Range (Lindsey and Clark, 1995)		Cameron Mountain quadrangle (Wallace and Lawson, 1998)		Gribbles Park quadrangle (from table 1)	
	Median	Range	Median	Range	Median	Range	Median	Range
Ag	0.7	<.2–6.4	<1	<1–16	5.3	<0.5–17.0	2.04	<0.5–12.2
Au	<5(ppb)	<5–20	nr		0.02	0.001–0.078	0.0005	<0.001–0.038
As	3.6	<2–10	5.7	0.7–26	14.3	<5–31	44.15	<1–380
B	nr		52	10–150	15.5	<5–42	<4	<4
Ba	155	20–940	957	196–3,400	95.8	4–244	nr	
Co	10.6	4–32	16	6–34	12.3	<10–16	<1	<1
Cr	56	21–91	61	21–679	nr		nr	
Cu	1,649	<1–>10,000	161	2–8,500	19,515	74–53,085	5105.30	7–24,005
La	48	20–110	nr		nr		nr	
Mo	1.5	<1–6	5	<2-43	2.5	<1–7	4.43	<1–23
Ni	21	9–52	30	7-61	31.3	27–35	12.6	2–37
Pb	8.9	<2–22	51	5–7,480	7.25	1–18	85.9	<10–991
Sc	6.1	3–8	nr		<50	<50	nr	
Sr	121	16–865	nr		19	8–31	134.1	8–995
Th	nr		14.3	7.3–30.1	nr		nr	

ments are similar in each area, but some differences in element concentrations are apparent: (1) The concentration of arsenic and silver in samples from upper Paleozoic rocks is greater in the Gribbles Park and Cameron Mountain quadrangles than in the Salida East and northern Sangre de Cristo Range, (2) The concentration of lead in samples from upper Paleozoic rocks in the Gribbles Park quadrangle and in the northern Sangre de Cristo Range is greater than in samples from the Cameron Mountain and Salida East quadrangles, (3) The concentration of copper is greater in upper Paleozoic rocks in the Gribbles Park, Salida East, and Cameron Mountain quadrangles than in the northern Sangre de Cristo Range, and (4) The concentration of vanadium in upper Paleozoic rocks of the northern Sangre de Cristo Range is greater than concentrations of vanadium in the Salida East, Cameron Mountain, and Gribbles Park quadrangles. On the basis of this small area of sampling, the copper and silver concentrations appear to increase northeastward in upper Paleozoic rocks in the Central Colorado Trough.

INDUSTRIAL MINERAL OCCURRENCES

Limestone

There are no reported limestone deposits that have been worked in the Gribbles Park quadrangle. The Leadville Limestone and other lower Paleozoic carbonate rocks have been quarried for chemical grade limestone and rip rap in other parts of Colorado.

Dimension stone

The Whitehorn Granodiorite is exposed in the southwestern corner of the Gribbles Park quadrangle. Although the granodiorite was quarried for dimension stone at several localities in the Salida East quadrangle (Wallace and others, 1997), no quarries were located in the Gribbles Park quadrangle.

Gravel

Gravel resources of unknown quality are available in pediment deposits that occur scattered along Badger Creek and that mantle large areas in the northeastern quadrant of the map area. Sand and Gravel deposits occur in the southern part of Badger Creek, but in most places the streams are too small to have produced significant sand and gravel deposits.

REFERENCES CITED

Best, M.G., 1982, Igneous and metamorphic petrology: San Francisco, W.H. Freeman and Co., 630 p.

Bickford, M.E., Schuster, R.D., and Boardman, S.J., 1989, U-Pb geochronolgy of the Proterozoic volcano-plutonic terrane in the Gunnison and Salida areas, Colorado, *in* Grambling, J.A., and Tewksbury, B.J., eds., Proterozoic geology of the southern Rocky Mountains: Geological Society of America Special Paper 235, p. 33–48.

Boardman, S.J., 1986, Early Proterozoic bimodal volcanic rocks in central Colorado, U.S.A.; Part 1, Petrography, stratigraphy, and depositional history: Precambrian Research, v. 34, p. 1–36.

Burbank, W.S., 1932, Geology and ore deposits of the Bonanza mining district, Colorado: U.S. Geological Survey Professional Paper 169, 166 p.

Campbell, J.A., 1972, Lower Paleozoic systems, White River plateau, *in* De Voto, R.H., ed., Paleozoic stratigraphy and structural evolution of Colorado: Quarterly of the Colorado School of Mines, v. 67, no. 4, p. 37–62.

Chapin, C.E., and Lowell, G.R., 1979, Primary and secondary flow structures in ash-flow tuffs of the Gribbles Run paleovalley, central Colorado, in Chapin, C.E., and Elston, W.E., eds., Ash-flow tuffs: Geological Society of America Special Paper 180, p. 137–154.

Conley, C.D., 1972, Depositional and diagenetic history of the Mississippian Leadville Formation, White River Plateau, Colorado, *in* De Voto, R.H., ed., Paleozoic stratigraphy and structural evolution of Colorado: Quarterly of the Colorado School of Mines, v. 67, no. 4, p. 103–135.

Connor, J.J., and McNeal, J.M., 1988, Geochemistry of mineralized quartzite beds in the Spokane Formation (Belt Supergroup), Rogers Pass area, Lewis and Clark County, Montana: U.S. Geological Survey Bulletin 1762, 17 p.

De Voto, R.H., 1971, Geologic history of South Park and Geology of the Antero Reservoir quadrangle, Colorado: Quarterly of the Colorado School of Mines, v. 66, no. 3, 90 p.

_______1972, Pennsylvanian and Permian stratigraphy and tectonism in central Colorado, *in* De Voto, R.H., ed., Paleozoic stratigraphy and structural evolution of Colorado: Quarterly of the Colorado School of Mines, v. 67, no. 4, p. 139–185.

_______1980a, Mississippian stratigraphy and history of Colorado, *in* Kent, H.C., and Porter, K.W., eds., Colorado geology: Denver, CO, Rocky Mountain Association of Geologists, p. 57–70.

_______1980b, Pennsylvanian stratigraphy and history of Colorado, in Kent, H.C., and Porter, K.W., eds., Colorado geology: Denver, CO, Rocky Mountain Association of Geologists, p. 71–101.

De Voto, R.H., and Peel, F.A., 1972, Pennsylvanian and Permian stratigraphy and structural history, northern Sangre de Cristo Range, *in* De Voto, R.H., ed., Paleozoic stratigraphy and structural evolution of Colorado: Quarterly of the Colorado School of Mines, v. 67, no. 4, p. 283–320.

Epis, R.C., and Chapin, C.E., 1974, Stratigraphic nomenclature of the Thirtynine Mile volcanic field, central Colorado: U.S. Geological Survey Bulletin 1395–C, 23 p.

Epis, R.C., Wobus, R.A., and Scott, G.R., 1979a, Geologic map of the Black Mountain quadrangle, Fremont and Park Counties, Colorado: U.S. Geological Survey Miscellaneous Investigations Series Map I–1195, scale 1:62,500.

_______1979b, Geologic map of the Guffey quadrangle, Park County, Colorado: U.S. Geological Survey Miscellaneous Investigations Series Map I–1180, scale 1:62,500.

Gerhard, L.C., 1972, Canadian depositional environments and paleotectonics, central Colorado, *in* De Voto, R.H., ed., Paleozoic stratigraphy and structural evolution of Colorado: Quarterly of the Colorado School of Mines, v. 67, no. 4, p. 1–36.

Harrison, J.E., 1972, Precambrian Belt basin of northwestern United States; Its geometry, sedimentation, and copper occurrences: Geological Society of America Bulletin, v. 83, p. 1215–1240.

Kirkham, R.V., 1989, Distribution, settings, and genesis of sediment-hosted stratiform copper deposits, *in* Boyle, R.W., Brown, A.C., Jefferson, C.W., Jowett, E.C., and Kirkham, R.V., eds., Sediment-hosted stratiform copper deposits: Geological Association of Canada Special Paper 36, p. 3–38.

Lindsey, D.A., and Clark, R.F., 1995, Copper and uranium in Pennsylvanian and Permian sedimentary rocks, northern Sangre de Cristo Range, Colorado: U.S. Geological Survey Bulletin 2216, 23 p.

McDowell, F.W., 1971, K/Ar ages of igneous rocks from western United States: Isochron/West, no. 2, p. 1–16.

McIntosh, W.C., and Chapin, C.E., 1994, Argon^{40}/argon^{39} geochronology of ignimbrites in the Thirtynine Mile volcanic field, Colorado, *in* Evanoff, E., compiler, Late Paleogene geology and paleoenvironments of central Colorado: Geological Society of American Field Trip Guidebook, Rocky Mountain Section Annual Meeting, Durango, Colorado, May 6–8, 1994, p. 23–26.

Nadeau, J.E., 1972, Mississippian stratigraphy of central Colorado, *in* De Voto, R.H., ed., Paleozoic stratigraphy and structural evolution of Colorado: Quarterly of the Colorado School of Mines, v. 67, no. 4, p. 77–101.

Peel, F.A., 1971, New interpretations of Pennsylvanian and Permian stratigraphy and structural history, northern Sangre de Cristo Range, Colorado: Golden, Colorado School of Mines, Master's. thesis, 75 p.

Pettijohn, F.J., 1957, Sedimentary rocks (2nd ed.): New York, Harper and Row, 718 p.

Pierce, Walter, 1969, Geology and the Pennsylvanian-Permian stratigraphy of the Howard area, Fremont County, Colorado: Golden, Colorado School of Mines, Master's thesis, 129 p.

_______1972, Permo-Pennsylvanian stratigraphy and history of the Howard area, Colorado [abs], *in* De Voto, R.H., ed., Paleozoic stratigraphy and structural evolution of Colorado: Quarterly of the Colorado School of Mines, v. 67, no. 4, p. 281.

Ross, R.J., and Tweto, Ogden, 1980, Lower Paleozoic sediments and tectonics in Colorado, *in* Kent, H.C., and Porter, K.W., eds., Colorado geology: Denver, Colo., Rocky Mountain Association of Geologists, p. 47–56.

Scott, G.R., Taylor, R.B., Epis, R.C., and Wobus, R.A, 1978, Geologic map of the Pueblo 1° X 2° quadrangle, south-central Colorado: U.S. Geological Survey Miscellaneous Investigations Series Map I–1022, scale 1:250,000.

Streckeisen, A.L., 1973, Classification and nomenclature recommended by the IUGS Subcommission on the systematics of igneous rocks: Geotimes, v. 18, no. 10, p. 26–30.

_______1978, Classification and nomenclature of volcanic rocks, lamprophyres, carbonatites, and melilitic rocks: Neues Jahrbuch fur Mineralogie, Abhandlungen 134, p. 1–14.

Taylor, R.B., Scott, G.R., and Wobus, R.A., 1975, Reconnaissance geologic map of the Howard quadrangle, central Colorado: U.S. Geological Survey Miscellaneous Investigations Series Map I-892, scale 1:62,500.

Thorson, J.P., and Hahn, G.A., 1995, Lisbon valley, a new open-pit copper deposit [abs]: Prospectors and Developers Convention, Toronto, Canada.

Tweto, Ogden, 1980, Tectonic history of Colorado, in Kent, H.C. and Porter, K.W., eds., Colorado geology: Denver, Colo., Rocky Mountain Association of Geologists, p. 5–9.

Wallace, C.A., Cappa, J.A., and Lawson, A.D., 1997, Geologic map of the Salida East quadrangle, Chaffee and Fremont Counties, Colorado: Colorado Geological Survey Open-File Report 97–6, 1:24,000 scale, 23 p.

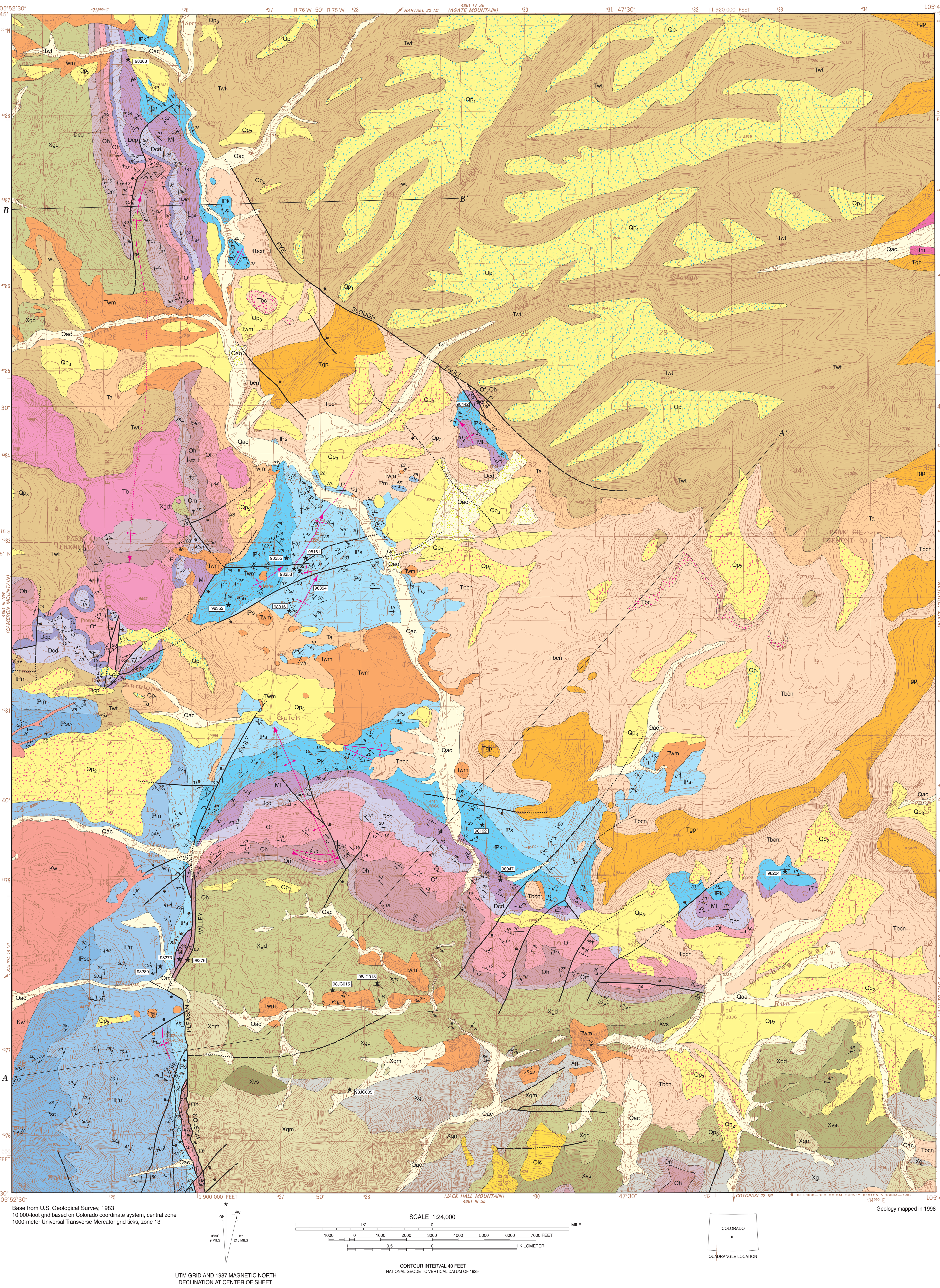
Wallace, C.A., and Lawson, A.D., 1998, Geologic map of the Cameron Mountain quadrangle, Chaffee, Park, and Fremont Counties, Colorado: Colorado Geological Survey Open File Report 98–4, 1:24,000 scale, 23 p.

Wrucke, C.T., 1974, The Whitehorn Granodiorite of the Arkansas Valley in central Colorado: U.S. Geological Survey Bulletin 1394–H, 8 p.

Wrucke, C.T., and Dings, M.G., 1979, Geologic map of the Cameron Mountain quadrangle, Colorado: U.S. Geological Survey Open-File Report 79–660, scale 1:62,500.

COLORADO GEOLOGICAL SURVEY
DEPARTMENT OF NATURAL RESOURCES
DENVER, COLORADO

OPEN FILE MAP 99-3
GEOLOGIC MAP OF THE GRIBBLES PARK QUADRANGLE
PARK AND FREMONT COUNTIES, COLORADO
Booklet accompanies map



CONDENSED DESCRIPTION OF MAP UNITS

The complete description of map units and references is in the accompanying pamphlet.

QUATERNARY SURFICIAL DEPOSITS

Qac **Alluvium and colluvium (Holocene)**—In active stream channels alluvium consists of nonconsolidated, inter-bedded, lenticular layers of silty clay, clayey silt, silt, silty sand, sand, and framework-supported boulder, cobble, and pebble gravel deposits. Includes modern braided channel alluvial deposits in most drainages. Streams have incised into interlayered alluvium and colluvium that consists of lenticular layers of tan and grayish-yellow-brown clayey silt, silty sand, sand, pebbly and cobbly silt and sand, and silty and sandy gravel; stratification is generally crude

Qao **Older Alluvium (Holocene and Pleistocene?)**—Nonconsolidated interbedded layers of silty clay, clayey silt, silt, silty sand, sand, and pebble, cobble, and boulder gravel. Commonly boulders are angular and subangular. Occurs as fans near Rye Slough and Long Gulch where tributaries join Badger Creek

Qls **Landslide deposits (Holocene and Pleistocene?)**—Heterogeneous, deposits of unsorted, non-stratified rock debris, gravel, sand, and silt

Pediment deposits (Pleistocene)

Qp_3 **Pediment deposit three**—Poorly stratified boulder, cobble, and pebble gravel in sandy and silty matrix. Boulders are angular and subangular. Pediment sur-face 3 to 9 m above alluvium and colluvium in adja-cent drainages. Correlative deposits mapped as Qp_3 in Cameron Mountain quadrangle and as T_3 in Salida East quadrangle

Qp_2 **Pediment deposit two**—Poorly stratified boulder, cobble, and pebble gravel in sandy and silty matrix. Boulders are angular and subangular. Upper surface of pediment about 12 m above alluvium and colluvium in adjacent drainages. Correlative deposits mapped as Qp_2 in the Cameron Mountain quadrangle and grouped with T_3 in the Salida East quadrangle

Qp_1 **Pediment deposit one**—Poorly stratified boulder, cobble, and pebble gravel in sandy and silty matrix. Strongly developed grayish-red, grayish-brown, and red-brown soil marks the upper surface of the pediment; boulders, cobbles and pebbles are weathered. Remnants of pediment reach an elevation of about 9,700 ft in the northwestern part of the Gribbles Park quadrangle. Correlative deposits mapped as Qp_1 in the Cameron Mountain quadrangle and as T_2 in the Salida East quadrangle

TERTIARY ROCKS AND DEPOSITS

Tb **Basalt (Miocene)**—Vesicular and non-vesicular, dense basalt porphyry that contains olivine and hornblende in matrix of glass and felted plagioclase microlites. Olivine phenocrysts are as large as 1 cm in diameter and glomerophenocrysts are as large as 3 cm. Black horn-blende phenocrysts as large as 2.5 cm in length. Pa-hoehoe flows accumulated to a thickness of about 85 m. Late-stage fissure eruption south of Herring Park formed a scoria mound that contains volcanic bombs

Twt **Wagon Tongue Formation (Miocene)**—Semiconsolidated and nonconsolidated, poorly to moderately sorted, interbedded mudstone, siltstone, sandstone, granular and pebbly sandstone, and fine gravel. Gravel and sand beds have shallow channels at basal contacts and contain low-angle planar crossbeds. Beds of air-fall tuff are well indurated and contain quartz, feldspar, and biotite in a lithified matrix of ash. Subangular and angular pebbles, cobbles, and boulders form a lag over the Wagon Tongue Formation from eroded pediment deposits

Tgp **Gribbles Park Tuff (Oligocene)**—Ash-flow tuffs composed of moderate-gray, light-gray, pinkish-gray, brownish-gray, and reddish-gray rhyolite porphyry. Phenocrysts are quartz, chatoyant sanidine, and biotite. Volcanic rock fragments are common. Compound cooling units form moderately to densely welded, glassy tuff

Badger Creek Tuff (Oligocene)—Regionally consists of a welded tuff member (Tbc) and a nonwelded tuff member (Tbcn); the nonwelded tuff is widespread in Gribbles Park quadrangle

Tbc **Welded tuff member**—Light-gray, light-yellowish-gray, and light-reddish-gray quartz latite welded tuff. Unit contains abundant biotite and plagioclase phenocrysts and lesser amounts of sanidine and hornblende phenocrysts. Also contains abundant light-pink and light-grayish-white pumice and lapilli and lithic fragments. Weakly foliated

Tbcn **Nonwelded tuff member**—White, light-grayish-white, and light-gray, ash-flow and air-fall tuff that forms prominent hoodoos and easily eroded cliffs. Most of unit is nonwelded ash-flow tuff; some slightly welded and moderately welded flow units occur in upper reaches of Badger Creek. Composed of multiple flow units. Abundant volcanic rock fragments are a distinguishing feature of unit. Grades laterally into Antero Formation in western and northern part of map area (Epis and Chapin, 1974)

Ta **Antero Formation (Oligocene)**—Light-grayish-white, light-gray, pale-greenish-gray, thinly bedded, laminated, water-laid tuff, and interbedded, light-grayish-white and light-gray, crossbedded, tuffaceous sandstone and sandy pebble and cobble conglomerate. Sandstone forms thick beds and lenticular channels in water-laid tuff. Interfingers with nonwelded member of Badger Creek Tuff (Epis and Chapin, 1974). Forms prominent white cliffs in western and central parts of quadrangle

Ttm **Thirtynine Mile Andesite (Oligocene)**—Poorly sorted, black, greenish-black, and reddish-black, pyroxene-bearing andesite breccia of Epis and Chapin (1974). Occurs only along northeastern boundary of Gribbles Park quadrangle where it forms poorly exposed rubble in the vicinity of Rye Slough

Twm **Wall Mountain Tuff (late Eocene)**—Light-gray, moderate-gray, light-brownish-gray, and grayish-red, eutaxitic, welded, rhyolite ash-flow tuff that contains prominent sanidine and plagioclase phenocrysts. Flow foliation in glassy welded tuff is prominent, and degree of weld-ing varies in map area from pumice-rich flow bands to densely welded glassy tuff.

MESOZOIC ROCKS

Kw **Whitehorn Granodiorite (Late Cretaceous)**—Fine- and medium-grained, equigranular and hypidiomorphic-seriate, biotite granodiorite. Contains varietal hornblende and pyroxene. Border phases are commonly porphyritic and contain plagioclase crystals, 1 to 5 mm long, in a fine-grained equigranular or aphanitic matrix. Biotite- and plagioclase-rich xenoliths locally common along borders. May be weakly foliated near contacts. Occurs only in southwestern part of Gribbles Park quadrangle where the laccolith intrudes the Penn-sylvanian Minturn and member one of the Sangre de Cristo Formation

PALEOZOIC ROCKS

Sangre de Cristo Formation (Lower Permian and Upper Pennsylvanian)—Overlies the Minturn Formation on a gradational contact. Pierce (1969) subdivided the Sangre de Cristo Formation into four informal units and De Voto and Peel subdivided the Sangre de Cristo Form-ation into upper and lower members in the northern Sangre de Cristo Range and southern Mosquito Range. Only the lowest member, member one, of the four regionally recognized informal members of Pierce (1969) is present in the Gribbles Park quadrangle

$IPsc_1$ **Member one (Upper Pennsylvanian)**—Grayish-red arkose, subarkose, and orthoquartzite interbedded with grayish-red and reddish-gray, pebbly arkose conglomerate and lesser amounts of dark-grayish-red and purplish-red, micaceous siltstone and dark-red, silty, micaceous shale. Polymict conglomerate beds are generally matrix-supported and composed of subangular to subrounded, granitic, metamorphic, and sedimentary clasts. Rare, thin, lenticular beds of olive-drab, dark-greenish-gray, and dark-gray, and moderate-gray, fine-grained sandstone, siltstone, and shale interbedded with dominant red-bed sequence. Trough and planar crossbeds and channeled basal contacts are common in coarse-grained rocks. Trough and planar cross-beds, ripple cross-lamination, cuspate and linguoid ripples, climbing ripples, rib-and-furrow structure, shallow channels, and parting lineation are common in medium- and fine-grained arkose and subarkose beds

IPm **Minturn Formation (Middle Pennsylvanian)**—Mainly dark-gray, gray, olive-drab, grayish-green, greenish-gray, and black, fine-grained arkose, feldspathic siltstone, silty shale, shale, and less common limestone and dolomite. Gray, grayish-green, and olive-drab sandstone beds are fine grained and flaggy weathering. Sandstone beds contain planar lamination, ripple cross lamination, low-amplitude hummocky crossbeds, and shallow channels. Dark-gray and olive-drab siltstone is planar laminated and microlaminated and contains ripple cross-lamination. Some beds of olive-drab and grayish-green, medium- and coarse-grained arkose occur interbedded with finer grained rocks in lower part of Minturn; shale and siltstone beds occur more commonly in the middle and upper parts of this unit. Limestone beds are thin, laminated and micro-laminated, black and dark-gray, fetid micrite. Com-monly limestone beds are 1 to 15 cm thick and are inter-bedded with black and dark-gray, silty shale; zones of interbedded limestone and shale form bedding units that are 1 to 3 m thick, but some individual limestone beds are as thick as 1 m. Grayish-red, micaceous silty shale and some fine- and medium-grained arkose beds are interbedded with more characteristic olive-drab, grayish-green, dark- gray, and black micaceous shale, silty shale, and siltstone near the top of the Minturn Formation

IPs **Sharpsdale Formation (Middle Pennsylvanian)**—Mainly grayish-red and reddish-gray, coarse-grained arkose, pebbly and granular arkose, subarkose, and orthoquartzite interbedded with grayish-red and reddish-gray, medium- and fine-grained, feldspathic sandstone and lesser amounts of dark-red, micaceous siltstone and purplish-red, silty, micaceous shale. Grayish-red, purplish-red, and bright-grayish-red, coarse-grained arkose, pebbly arkose, and medium- and fine-grained arkose form composite bedding units that generally range between 60 cm to 15 m thick. Channeled bases of these composite bedding units commonly overlie fine-grained upper parts of fining-upward sequences. Primary sedimentary structures are large-, medium-, and small-scale trough and planar crossbeds, channels, shale-chip conglomerates, dispersed pebble conglomerate, ripple cross-lamination, climbing ripples, cuspate and linguoid ripples, rib-and-furrow structures, planar lamination, flasers, and microlamination. Some intervals in the Sharpsdale are olive-drab and grayish-green, tan- and rusty-weathering, medium- and coarse-grained arkose, pebbly arkose, and arkose conglomerate; these bleached and reduced intervals are generally less than 15 m thick. Calcite, dolomite, and ankerite occur as cement in these olive-drab and rusty-weathering intervals, and malachite and azurite occur as replacement minerals, which are probably alteration products from sulfides. In the Gribbles Park quadrangle the contact between Kerber Formation and Sharpsdale Formation is placed at uppermost tan-weathering limestone in the Kerber

IPk **Kerber Formation (Lower Pennsylvanian)**—Mainly grayish-red, reddish-gray, moderate-red, fine-, medium-, and coarse-grained arkose, arkose conglomerate, interbedded with micaceous siltstone and shale, and reddish-gray, gray, pinkish-gray, and grayish-green limestone, and rare beds of dolomite and gypsum. The Kerber Formation also contains interbedded grayish-green, olive-drab, olive-gray, moderate-gray, dark-greenish-gray, coarse-grained arkose, conglomeratic arkose and subarkose, medium- and fine-grained arkose, siltstone, and shale. Grayish-black, moderate-gray limestone, and rare dolomite occur as interbeds in olive-drab and grayish-green rocks, and reddish-gray, pinkish-gray, and light-brownish-gray limestone and rare dolomite occur interbedded with red rocks at the top. Coarse-grained sedimentation units are fining-upward sequences capped by fine-grained sandstone or siltstone. Fine-grained sedimentation units are fining-upward sequences capped by dark-colored shale. Primary sedimentary structures are trough and planar crossbeds, ripple cross-lamination, planar lamination, rib-and-furrow structures, parting lineation, ripple cross-lamination, climbing ripples, planar lamination, cuspate and linguoid ripple marks, channels, microlamination, and water-expulsion structures Shale and siltstone are laminated and microlaminated. Dark-gray and black limestone beds that occur in the lower and upper parts of the Kerber Formation are fine-grained, argillaceous, mottled or laminated, fetid micrite that are generally 12 cm to 3 m thick. Several limestone beds contain brachiopods and trilobite fragments, and some rare thin limestone beds near the top are brachiopod coquina. Distinctive bright-grayish- green limestone beds occur near the top of the Kerber Formation

Ml **Leadville Limestone (Lower Mississippian)**— Moderate-gray and dark-gray, massive-weathering, thinly-bedded, micritic limestone and finely crystalline dolomite. Beds range in thickness between 7 cm and 2 m. Sandy limestone, flat-pebble conglomerate, and limestone breccia occur in shallow channels at the base. Black laminated chert nodules and lenticular beds occur at some stratigraphic levels. South of Cals Fork Gulch in northwestern part of quadrangle, silica-cemented sandstone beds are interbedded with limestone near top of formation. Sandstone is mostly medium-grained, silica-cemented orthoquartzite composed of rounded to well-rounded grains

Chaffee Formation (Upper Devonian)—Consists of Dyer Dolomite Member at top and Parting Quartzite Member at base

Dcd **Dyer Dolomite Member**—Yellowish-gray, light-gray, and pale-yellowish-gray dolomite. Finely crystalline and microcrystalline, laminated and micro-laminated, or bioturbated, and flaggy or massive weathering. Some beds of laminated yellowish- gray chert are interbedded with dolomite. A zone of micaceous green shale and interbedded nodular dolomite occurs at the top of the Dyer Dolomite Member in northern part of quadrangle.

Dcp **Parting Quartzite Member**—Light-gray, light-grayish-red, pale-brownish-gray, and pinkish-gray, fine-grained, silica-or calcite-cemented, dense, flinty, conchoidal-fracturing orthoquartzite. Quartzite beds are 5 to 25 cm thick. Occurs as mappable unit north of Antelope Gulch and west of Badger Creek. Planar lamination, ripple cross-lamination, and rare planar crossbeds locally present

Of **Fremont Dolomite (Upper and Middle Ordovician)**— Dark-moderate-, and light-gray, fine-grained, fossiliferous dolomite. Mottled light gray and dark gray or laminated and microlaminated. Resistant weathering dolomite forms beds 5 cm to 1 m thick. Fossils are dolomitized coral and fragments of echinoids

Oh **Harding Quartzite (Middle Ordovician)**— Dark-reddish-gray, dark-grayish-orange, dark-grayish-red, light-gray, moderate-gray, and rusty-orange, fine- and medium-grained, well-sorted mottled orthoquartzite. Quartzite beds range from 2.5 cm to about 20 cm thick. Primary bedding structures are planar lamination and planar crossbeds. Locally, bedding and primary sedimentary structures are obscured by pervasive replacement by diagenetic silica. Burrows and bioturbated quartzite occur locally. The dense, conchoidal-weathering quartzite is commonly brecciated. Some exposures contain sandstone conglomerate at the base

Om **Manitou Limestone (Lower Ordovician)**—Dark-, moderate-, and light-gray, thin- to thick-bedded dolo-mite and cherty dolomite that contains rare beds of dark-gray limestone. Dolomite and limestone are lam-inated and mottled, and beds range between 2 cm to 1 m in thickness. Laminated black and light-grayish- white chert lenses and nodules occur parallel to bedding planes. Breccia is composed of pebble- and cobble- sized laminated chert in a matrix of silicified dolomite; breccia occurs as lenses in the dolomite. Chert breccia is less common in Gribbles Park quadrangle than in Salida East quadrangle where breccia can form entire thickness of Manitou Limestone

PROTEROZOIC ROCKS

Xqm **Quartz monzonite (Early Proterozoic)**—Reddish-orange to red, fine-to medium-grained, granular biotite quartz monzonite. Generally poorly exposed. Wrucke and Dings (1979) mapped much of this unit as a Middle Proterozoic age intrusive; however, field relations with the Xvs unit and the presence of locally developed foliation indicate that this unit is primarily of Early Proterozoic age

Xgd **Granodiorite (Early Proterozoic)**—Gray, speckled, coarse- to very coarse-grained, strongly foliated granodiorite and granite gneiss. In places contains augen of quartz and microcline feldspar up to 6 cm in length and minor amounts of muscovite and biotite. Foliation is well developed near contact with older units. Outcrops in quadrangle are a portion of the strongly foliated border phase of a pluton that extends for approx-imately 60 km north of quadrangle (Wrucke and Dings, 1979). Six zircon fractions from the granodiorite in adjacent Cameron Mountain quadrangle yielded a uranium-lead age of 1,672 ± 5 Ma (Bickford and others, 1989)

Xg **Gabbro (Early Proterozoic)**—Dark-gray to black, medium- to coarse-grained gabbro. Megascopically, contains light-orangish-tan crystals of plagioclase feldspar in a black aegerine-augite matrix. Contact relations with surrounding rock units are generally obscured. Chlorite and rare epidote occur as alteration products of pyroxene. Opaque minerals, probably iron oxides and ilmenite, occur in trace amounts up to a few percent

Xvs **Interbedded volcanic and sedimentary rocks (Early Proterozoic)**—Interbedded, tan, bimodal volcanic and volcaniclastic rocks, and medium-gray to black, light-gray, and grayish-tan, fine-grained to very fine-grained quartzite, metasiltstone, and metagraywacke. Quartzite consists primarily of very fine quartz grains and up to 10 percent feldspar grains. Porphyroblasts of pla-gioclase up to 1 mm in size occur in some locations in quadrangle and can constitute up to 20 percent of the rock. Poorly to moderately foliated chlorite and biotite can constitute from 5 to 30 percent. Cross-bedding and other sedimentary structures such as graded couplets, microlamination, planar lamination, and ripple cross-lamination are commonly well preserved. Four zircon fractions from a metadacite in the Xvs unit just east of Salida in the Salida East quadrangle yielded a uranium-lead of 1,728 ± 6 Ma (Bickford and others, 1989)

MAP SYMBOLS

Contact—Dashed where inferred and dotted where covered by younger deposits

Fault—Dashed where approximately located and dotted where covered by younger deposits. Ball and bar on downthrown block

Anticline—Trace of axial surface. Dashed where approximately located and dotted where covered by younger deposits. Large arrow shows direction of plunge and small arrows show direction of dip away from the axial trace

Syncline—Trace of axial surface. Dashed where approximately located and dotted where covered by younger deposits. Large arrow shows direction of plunge and small arrows show direction of dip toward the axial trace

Strike and dip of beds

20 **Inclined**

Vertical

20 **Overturned**

Strike and dip of foliation in metamorphic rocks

35 **Inclined**

35 **Strike and dip of foliation in volcanic rocks**

Adit

Spring

★ 97200 **Sample location and sample number**—See Tables 1 and 2

A——A′ **Alignment of cross section**

CORRELATION OF MAP UNITS

Map units	Epoch	Period
Qac, Qao, Qls	Holocene	QUATERNARY
UNCONFORMITY		
Qp_3, Qp_2, Qp_1	Pleistocene	QUATERNARY
UNCONFORMITY		
Tb	Miocene	TERTIARY
UNCONFORMITY		
Twt	Miocene	TERTIARY
UNCONFORMITY		
Tgp	Oligocene	TERTIARY
UNCONFORMITY		
Tbc, Tbcn, Ta	Oligocene	TERTIARY
UNCONFORMITY		
Ttm	Oligocene	TERTIARY
UNCONFORMITY		
Twm	Late Eocene	TERTIARY
UNCONFORMITY		
Kw	Late Cretaceous	CRETACEOUS
UNCONFORMITY		
$IPsc_1$	Late Pennsylvanian	PENNSYLVANIAN
IPm, IPs	Middle Pennsylvanian	PENNSYLVANIAN
IPk	Early Pennsylvanian	PENNSYLVANIAN
UNCONFORMITY		
Ml	Early Mississippian	MISSISSIPPIAN
UNCONFORMITY		
Dcd, Dcp	Late Devonian	DEVONIAN
UNCONFORMITY		
Of	Late Ordovician	ORDOVICIAN
UNCONFORMITY		
Oh	Middle Ordovician	ORDOVICIAN
UNCONFORMITY		
Om	Early Ordovician	ORDOVICIAN
UNCONFORMITY		
Xqm	Early Proterozoic	PROTEROZOIC
UNCONFORMITY		
Xgd, Xvs, Xg	Early Proterozoic	PROTEROZOIC

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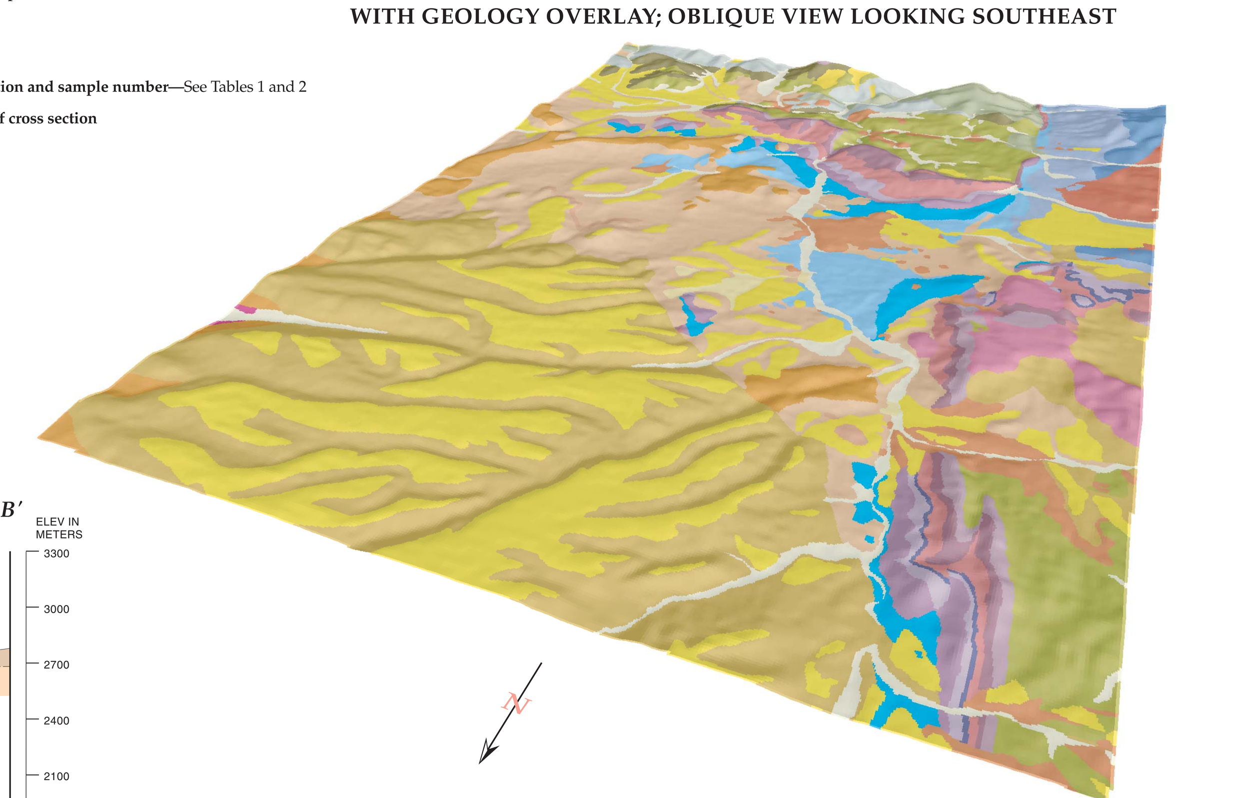
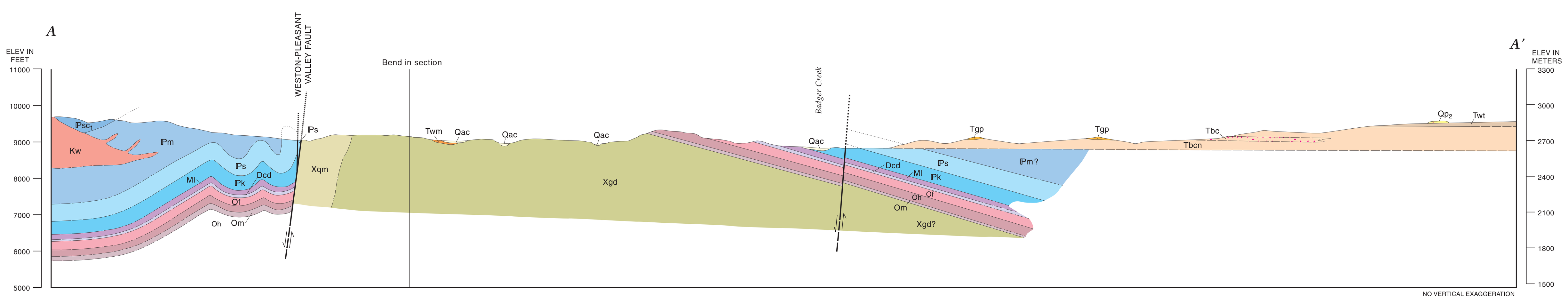
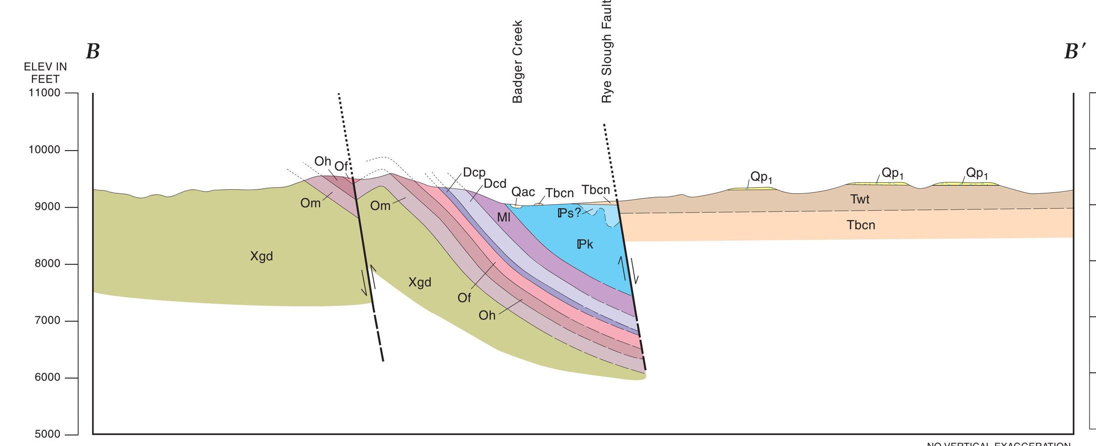
Denver, Colorado

SHADED-RELIEF MAP OF THE GRIBBLES PARK QUADRANGLE WITH GEOLOGY OVERLAY; OBLIQUE VIEW LOOKING SOUTHEAST







GEOLOGIC MAP OF THE GRIBBLES PARK QUADRANGLE, PARK AND FREMONT COUNTIES, COLORADO

By C. A. Wallace, James A. Cappa, and Allison D. Lawson

1999