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Geologic Map of the Salida East Quadrangle, Chaffee and Fremont Counties, Colorado

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CONTENTS

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INTRODUCTION

The Salida East quadrangle is located in southeastern Chaffee County and western Fremont County in the southern end of the Mosquito Range. This quadrangle includes the eastern part of the City of Salida and the upland terrane north of Salida.

The oldest rocks in the quadrangle are Proterozoic metamorphic and igneous rocks overlain unconformably by Paleozoic sedimentary rocks, Tertiary volcanic and sedimentary rocks, and Quaternary glaciofluvial and stream deposits. The Late Cretaceous Whitehorn Granodiorite intruded Paleozoic sedimentary units. Steep faults offset Proterozoic and Paleozoic rocks and some Paleozoic rocks are overturned, but Late Cretaceous plutonic rocks and Tertiary volcanic and sedimentary rocks are cut by few faults. Tertiary volcanic rocks are composed mainly of silicic welded tuffs and air-fall tuffs, but north of Salida andesitic and basaltic Tertiary lahar breccia, flow breccia, and dense flows occur locally. Tertiary sedimentary rocks post-date volcanic rocks and dip toward the south and southwest; faults border the Arkansas River Valley and separate Tertiary sedimentary rocks from older rocks. Tertiary units are truncated by Pleistocene outwash deposits, the oldest of which form terraces high above recent alluvium in the Arkansas River Valley.

PREVIOUS STUDIES

Numerous geologic studies in the vicinity of the Salida East 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), and the reports and maps that resulted determined the local stratigraphic sequence and integrated the local succession into the regional stratigraphic and lithofacies pattern. 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. 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 Salida East quadrangle. Wrucke and Dings (1979) published an open-file map of the Cameron Mountain quadrangle (scale 1:62,500), which includes the Salida East quadrangle. Taylor and others (1975) published a geologic map of the Howard quadrangle (scale 1:62,500), which borders the Cameron Mountain quadrangle on the south. The Black Mountain quadrangle (scale 1:62,500) of Epis and others (1979a) adjoins the Cameron Mountain quadrangle on the east, and the Guffey 15-minute quadrangle (Epis and others, 1979b) borders the Cameron Mountain quadrangle to the northeast. The geology of the Salida East quadrangle is shown in a generalized form in the western part of the Pueblo 1° X 2° quadrangle (Scott and others, 1978).

PRESENT STUDY

The present study focuses on geologic mapping of the Salida East quadrangle at a scale 1:24,000. Most geologic mapping was completed in July and August 1996, and field checking was completed in October 1996. 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 by James A. Cappa, C.A. Wallace, Allison D. Lawson, and Jonathan M. Zook; Cappa compiled the geologic map of the Proterozoic terrane from that work. 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 Strekeisen (1973, 1978).

GEOLOGIC SETTING

Proterozoic rocks consist mainly of metamorphic and a lesser amount of igneous rocks. They are divided into two groups: strongly foliated rocks and slightly foliated rocks. The strongly foliated group consists primarily of mafic and felsic gneiss, schist and phyllite, and gneissic granodiorite. The gneisses resemble other mafic and felsic gneisses in Colorado that have a metamorphic age of about 1.7 Ga. The slightly foliated rocks are composed of gabbro, metabasalt, and metaquartzite. Both units contain pegmatite intrusive bodies; however, the pegmatites in the strongly foliated rocks are much more abundant, much larger in size, and, generally, have cross-cutting relationships with the foliation. The slightly foliated rocks contain only rare pegmatites that cannot be mapped at this map scale and, generally, are concordant with the foliation or bedding. The contacts between the Proterozoic groups are 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 that occurs north of the Salida East quadrangle, or they may be two distinct units of different ages. Proterozoic rocks that underlie Upper Cambrian clastic rocks are intensely weathered: a saprolitic zone occurs in Proterozoic rocks where mafic rocks were weathered before Upper Cambrian time.

The Paleozoic sequence is about 2,400 m thick. At the base is the Sawatch Quartzite (Upper Cambrian), which in ascending order, is overlain by 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 (Pennsylvanian), and Sangre de Cristo Formation (Pennsylvanian-Permian). Most of the lower Paleozoic units are separated by disconformities that represent long periods of nondeposition or deposition and later erosion in shallow marine depositional environments. Most of the upper Paleozoic units are conformable or intertonguing and were deposited continuously in a narrow north-northwest-trending graben that alternated between marine and continental environments.

Above the Leadville Limestone in the region of the Salida East quadrangle is a sequence of clastic rocks that form cyclic repetitions of marine to continental sequences formed in a north-northwest-trending, fault-bounded arm of the Pennsylvanian-Permian interior seaway, known as the Central Colorado Trough (De Voto, 1972). At the base of the first depositional cycle in this seaway is the Kerber Formation, which is a predominantly marine and deltaic unit overlain by the Sharpsdale Formation, which is mainly a continental deposit. The second depositional cycle in the seaway is represented by the predominantly marine Minturn Formation and the overlying member one of the Sangre de Cristo Formation, a continental deposit. The base of the third cycle in the seaway is represented by member two of the Sangre de Cristo Formation, a marine deposit, and by member three, a continental deposit at the top of the cycle. Only the base of the third cycle occurs along the eastern edge of the Salida East quadrangle. The cyclic repetition of marine and non-marine strata was controlled by syndepositional tectonics of bounding faults located east and west of the Salida East quadrangle (De Voto, 1972; De Voto and Peel, 1972).

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.

Tertiary units are mainly volcanic rocks of intermediate and silicic composition and upper Tertiary sedimentary rocks and gravel. Basalt and andesite lava flows, lahars, and air-fall tuff, latite flows, rhyodacite flows, and rhyolite ash-flow tuffs and air-fall tuffs range in age from 36 Ma to 19 Ma (Oligocene-Miocene). The Dry Union Formation (Miocene-Pliocene) is a sedimentary sequence that may be partly gradational with volcanic rocks and shows prominent local provenance.

Quaternary units are mainly glacial and interglacial deposits. The oldest Quaternary units occur at the highest elevations and younger units occur at successively lower elevations. Eolian deposits are common in drainages, and deposits of colluvium and alluvium formed in modern drainages during Holocene time. Quaternary deposits consist of gravel, sand, and mudstone deposited in glacial, fluvial, colluvial, and eolian environments during Pleistocene and Holocene time. Wrucke and Dings (1979) identified several glacial deposits that formed terraces and they used the position above modern alluvial surfaces to establish an age sequence. Most of these old glacial remnants occur on terraces in the Arkansas River Valley. Our nomenclature for Quaternary deposits in the Salida East quadrangle uses a relative time scale suggested by Kirkham (Colorado Geological Survey, written commun., 1997). According to Kirkham, the scheme used by Wrucke and Dings (1979) that related continental glacial events to alpine deposits is not justified, so a purely relative scale is best applied to deposits in terraces in the map area. We mapped till and outwash deposits at The Crater, Big Baldy Mountain, and in a drainage along the eastern border of the map, and we separated colluvium from alluvium in modern drainages.

STRUCTURE

The principal structures in the map area are steeply dipping normal and reverse faults that trend north-northwest and northeast and locally occurring medium-scale anticlines and synclines. Most faults are steep normal faults of small separation that offset Proterozoic and Paleozoic rocks. Cambrian to Mississippian sedimentary rocks are more intensely faulted than overlying Pennsylvanian and Permian sedimentary rocks. The Arkansas River Valley is bounded by a steep fault that separates Proterozoic and volcanic rocks from Tertiary conglomerate and sandstone of the Dry Union Formation.

The Salida East quadrangle is located in the southern part of the Central Colorado Trough of De Voto (1972) and the southern part of the "Colorado Sag" as described by (Ross and Tweto, 1980). North-northwest trending faults parallel the trend of the central and southern part of the "Colorado Sag". The north-northwest and northeast orientation of the faults in the map area parallels that of principal faults in nearby Proterozoic terranes (Tweto, 1980) and parallels principal bounding faults of source terranes for Paleozoic rocks east and south of the map area. The north-northwest-striking faults in the map area are parallel to the Weston-Pleasant Valley fault east of the map area and the Kerber-Crestone fault south of the map area.

Many of the north-northwest-trending faults originated in Early and Middle Proterozoic time. The north-northwest 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 Proterozoic 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) 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). The influence of north-northwest-striking faults on Laramide tectonism in the Salida East quadrangle is not known because Mesozoic sedimentary rocks are absent, but extension that characterized formation of the Rio Grande rift during Miocene and Pliocene time is recorded on some faults in the map area.

In the Salida East quadrangle, north-northwest-trending faults were active during Pennsylvanian time (De Voto, 1972). Most separation on north-northwest-striking faults in the map area postdates lithification and subsequent exposure of the Leadville Limestone at the surface. The prominent silicified zone that formed at the top of the Leadville Limestone when the limestone was exposed to erosion between Mississippian and Pennsylvanian time is offset by faults of this intersecting set. Some of these faults may have been reactivated after Paleozoic time, but these faults had no slip after about 70 Ma when the Whitehorn Granodiorite was intruded because the laccolith truncates all faults that cut Paleozoic rocks.

Fewer faults were mapped in Proterozoic rocks than in Paleozoic rocks, but this disparity is likely the result of a more detailed stratigraphic system in Paleozoic rocks than in Proterozoic rocks rather than from a real difference in the abundance of faults. Many small-scale faults that separate Cambrian to Devonian rocks do not appear to continue into Pennsylvanian and Permian rocks, but a detailed stratigraphy is not available in Pennsylvanian and Permian rocks that might locate faults of small separation.

A prominent fault east and northeast of Tenderfoot Hill offsets Proterozoic rocks, Tertiary volcanic rocks, and rocks of the lower Dry Union Formation east and northeast of Tenderfoot Hill. This fault appears to be range-bounding and has a strike is similar to the trend of faults that controlled erosion and deposition in the Central Colorado Trough (De Voto, 1972). The strike is similar to faults that bound the Rio Grande rift. This fault juxtaposes Oligocene volcanic rocks against the Miocene-Pliocene Dry Union Formation and may be related to Neogene extension in the northernmost part of the Rio Grande rift.

The few folds shown in the map area are medium-scale structures in Proterozoic and Paleozoic rocks. Large-scale folds probably occur in Proterozoic rocks, but stratigraphic markers were not identified that would permit tracing these structures. Overturned lower Paleozoic rocks north of Cottonwood Gulch in the central part of the map area probably result from rotation of fault blocks rather than from overturned limbs of folds. Gentle east-trending folds occur in Pennsylvanian rocks in the central part of the map area north of Crater Creek where faults have not been identified. The west flank of a large-scale syncline occurs in the southeastern corner of the quadrangle where it deforms the Sangre de Cristo Formation.

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 caused erosion of rock units in the map area, and an easterly flowing paleovalley, the Gribbles Run Paleovalley of Chapin and Lowell (1979), drained from west to east across the northern part of the map area before the Wall Mountain Tuff was erupted (Early Oligocene). This paleovalley was part of a larger drainage system that trended southeast according to Chapin and Lowell (1979).

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DESCRIPTION OF MAP UNITS

QUATERNARY DEPOSITS

af **Artificial fill (latest Holocene)**—Fill and waste rock deposited by humans during construction and mining operations. Artificial fill is composed mostly of unsorted silt, sand, and rock fragments.

Qa **Alluvium (late Holocene)**—Alluvium is common in most drainages where Holocene streams have downcut older colluvial deposits. These nonconsolidated, interbedded, lenticular layers of poorly sorted, matrix- and framework-supported boulder and cobble gravel deposits containing rounded, sub-rounded, and sub-angular clasts in a matrix of pebbles, sand, silt, and clay occur in active stream channels. Stratification is generally crude. Braided channels are common on the flat alluvial surfaces. Stream courses contain numerous abandoned channels 1 to 2 m above active channels.

Qta **Talus (late Holocene)**—One talus deposit, on the south side of Longs Gulch, is shown on the map. Smaller talus deposits occur locally below cliffs of Harding Quartzite and Parting Quartzite, but these were too small to show on the map. The talus deposit that occurs in Longs Gulch is composed of angular boulders and cobbles of Harding Quartzite that are about 0.5 m in diameter and form a rubbly deposit below the cliff face.

Qls **Landslide deposits (late Holocene)**—Landslide deposits are rare in the Salida East quadrangle; one mass slope-failure is shown on the map in lower Ute Creek, where a small block of terrace five gravel slid onto the Holocene alluvial plain, and one rock slide occurs south of the Arkansas River in Proterozoic rocks.

Qes **Eolian sand and silt deposits (Holocene?)**—Eolian deposits are widespread in drainages throughout the quadrangle, and these light-tan, tan, and grayish-light-brown deposits are composed of a mixture of fine-grained sand and silt. Rare angular pebbles occur as isolated clasts in a fine-grained matrix, and most likely these pebbles were emplaced by slope-wash mechanisms. A thin layer of eolian silt and sand overlies colluvium at many places, but most are too thin and laterally discontinuous to show on the map. Eolian deposits clearly postdate formation of colluvial deposits and are downcut by modern alluvial channels.

Qc **Colluvium (Holocene)**—Colluvial deposits are shown in most drainages where Wrucke and Dings (1979) showed only alluvial deposits. The deposits that we mapped as colluvium are crudely stratified and are composed of tan and grayish-yellow-brown, fine-grained, nonconsolidated sediment and interbedded lenses of matrix-supported angular cobbles and pebbles in a clayey and sandy matrix. Some lenses are composed of framework-supported angular clasts surrounded by clayey and sandy material. Lenses of coarse debris preserve flat bedding. Colluvium predates alluvium because modern stream deposits have incised colluvial deposits in all drainages. Colluvium forms broad extensive benches that are 5 to 15 m or more above active stream channels.

Qao **Older Alluvium (lower Holocene)**—Older alluvial deposits occur in fans along the Arkansas River Valley in the southwestern part of the quadrangle and in Longs Gulch in the northwestern part of the map area. Nonconsolidated, interbedded layers of silty clay, clayey silt, silt, silty sand, and pebble, cobble, and boulder gravel form prominent fan-shaped deposits at the mouth of numerous gulches that drain toward the Arkansas River. Commonly boulders are angular and sub-angular. Older alluvial deposits postdate the youngest terraces (terrace five) because the older alluvial deposits overlap outwash gravel. Old alluvial gravel postdates colluvium in Longs Gulch where the alluvial material overlaps colluvium. Theses older alluvial deposits are being dissected by the youngest alluvial deposits in modern stream channels. Occurs 5 to 10 m above level of alluvium in active stream channels.

Qtu **Tufa (lower Holocene)**—A tufa deposit of tan, light-grayish-tan, light-grayish-yellow, and grayish-yellow, porous, banded, planar-laminated limestone occurs along the south border of the map area in the Arkansas River valley. Hot springs issued from the Leadville Limestone and calcite was deposited above a rubbly surface that occurs above the limestone. Taylor and others (1975) considered the tufa deposit to predate terrace one, which they equated to the Nussbaum(?) Alluvium, presumably deposited during the Nebraskan(?) glaciation, but field relations and isotopic data are lacking to support this assignment. The tufa deposit could be as young as late Pleistocene or Holocene in age.

Qty **Younger till (Pleistocene)**—Younger till occurs at The Crater in Crater Gulch and in Tombstone Gulch where small alpine glaciers formed. The younger till is composed of boulders, cobbles, and pebbles in a fine-grained matrix. This till is characterized by a prominent hummocky topography. Small cirque basins occur at the head of each younger till deposit.

Qto **Older till (Pleistocene)**—Older till occurs at The Crater in Crater Gulch and in Tombstone Gulch at places where Wrucke and Dings (1979) showed landslide deposits. The older till in Crater Gulch is a rampart of boulders, cobbles, and gravel in a fine-grained matrix that has the morphology of a terminal moraine. The older till in Tombstone Gulch consists of boulders, cobbles, and pebbles in a fine-grained matrix and has a subdued hummocky topography.

Qt_5 **Terrace five (Pleistocene)**—Poorly stratified lenticular silty sand, sand, pebbly sand, and sandy pebble gravel, sandy cobble gravel, pebbly cobble gravel, and sandy boulder gravel. Pebbles, cobbles and boulders sub-angular to rounded. Stratified and contains lenses of moderately sorted sand. Upper surface of terrace is about 12 m above alluvium in Arkansas River. Forms apron below terminal moraine in Crater Gulch.

Qt_4 **Terrace four (Pleistocene)**—Poorly stratified lenticular silty sand, sand, pebbly sand, and sandy pebble gravel, sandy cobble gravel, pebbly cobble gravel, and sandy boulder gravel. Pebbles, cobbles and boulders sub-angular to rounded. Stratified and contains lenses of moderately sorted sand. Forms terraces about 24 m above alluvium in Arkansas River.

Qt_3 **Terrace three (Pleistocene)**—Poorly stratified boulder, cobble, and pebble gravel in a sandy and silty matrix. Pediment surface and terrace remnants about 45 m or more above the Arkansas River. Occurs north of the Arkansas River in the southern part of the quadrangle. Wrucke and Dings (1979) thought these deposits formed during the Sangamon interglacial stage or the Illinoisian glaciation.

Qt_2 **Terrace two (Pleistocene)**—Sandy gravel that contains pebbles, cobbles, and boulders. Strongly developed grayish-red, grayish-brown, and red-brown soil marks the upper surface of the terrace. Forms terrace deposits 80 m above the Arkansas River in the southern part of the quadrangle. Wrucke and Dings (1979) suggested these deposits formed during the Yarmouth interglacial stage or the Kansan glaciation.

Qt_1 **Terrace one (Pleistocene)**—Poorly stratified and weathered boulder, cobble, and pebble gravel in a sandy matrix in terrace remnants 120–130 m above the Arkansas River 0.5 km east of and 3 km southeast of Salida. Wrucke and Dings (1979) suggested these deposits are Nebraskan? in age.

TERTIARY ROCK SAND DEPOSITS

Tg **Alluvial gravel (Pliocene?)**—Occurs only in the northeastern part of the map area near Jack Rabbit Hill where remnants of these deposits are preserved at elevations of about 3048 m (10,000 ft). Tertiary gravels are composed of rounded and well-rounded boulders and cobbles of mostly Prroterozic and lower Paleozoic rocks in a sandy and silty matrix. These deposits were probably more extensive than the small patches currently preserved in this area. Clasts of lower Paleozoic rocks may have been derived from the northwestern quadrant of this map area.

Tdu **Dry Union Formation (Pliocene to Miocene)**—Exposed in the southwestern part of the quadrangle. Moderate-gray, light-gray, yellowish-gray, and greenish-gray, poorly consolidated siltstone, sandstone, conglomerate, and breccia that contain lesser amounts of interbedded silty shale and laminated shale. Consists mainly of interbedded boulder, cobble, and pebble conglomerate, pebbly sandstone, sandstone, sandy siltstone, siltstone, shale, and claystone. Conglomerate and sandstone commonly fill channels between siltstone and sandstone beds and are fining-upward sequences that contain abundant crossbeds. Laminated and microlaminated shale and claystone are commonly truncated by coarse beds. Siltstone, shale, and claystone commonly contain plant debris. Breccia of local provenance is interbedded with sandstone, siltstone, and shale in the region northwest of Tenderfoot Hill where Wrucke and Dings (1979) showed a landslide deposit in the Cameron Mountain quadrangle. Two types of breccia occur where landslide deposits were mapped previously by Wrucke and Dings (1979):

1) Angular and sub-angular boulders, cobbles, and pebbles of silicic volcanic rocks occur in a sandy matrix of silicic volcanic fragments. The clasts were derived from exposures of the Wall Mountain Tuff and biotite latite that occur upslope and across a fault from the breccia. Interbedded with the breccia in channels are lenses and interbeds of crossbedded pebbly sand and lesser amounts of siltstone and shale.

2) Angular and sub-angular boulders, cobbles, and pebbles of andesite and basalt derived locally from flow breccia, dense, vesicular and nonvesicular andesite and basalt, lahar breccia, and mudflow breccia, all of which is well exposed in the Tenderfoot Hill area. The andesite and basalt breccia also contains lenses and interbeds of pebbly crossbedded sand, and laminated siltstone and shale. Despite the chaotic appearance of the breccias, crude bedding in the breccia and interbeds and lenses of finer grained sediment in the breccia indicate that these breccias are part of the Dry Union Formation, and the monolithic compositions record a strong local provenance. Clasts in the Dry Union Formation south of the Arkansas River are composed mainly of metamorphic rocks; these clasts were probably derived from Proterozoic rocks north of the river. The few strike and dip measurements obtained from the Dry Union Formation north and south of the Arkansas River show that the well-bedded parts of this unit dip southwest uniformly, and dips of 30° are common. These dips exceed initial dips common in fluvial depositional environments, so it is most likely that beds of the Dry Union Formation were deformed along range-bounding faults, some of which may be covered by younger deposits. Wrucke and Dings (1979) assigned a Pliocene to lower Miocene age to the Dry Union Formation, presumably based on mammalian fossils found in the southwestern corner of this map area. Only lower part of unit occurs in the map area (Wrucke and Dings, 1979).

Tr

Rhyodacite (Miocene)—Exposed in the central and south-central parts of the map area. Grayish-pink, light-gray, light-grayish-brown, and pinkish-brown, silicic, porphyritic lava flows are prominently flow banded. Phenocrysts of plagioclase are common and phenocrysts of biotite are less common. The prominent eutaxitic texture and lithophysae are characteristic features of this unit. Gas cavities are stretched parallel to the flow direction. The thickness of the rhyodacite is estimated at 50 to 60 m, but the flows are draped over a surface of substantial topographic relief, so accurate determination of thickness is not possible. Wrucke and Dings (1979) assigned a Miocene age for these flow rocks.

Tab

Andesite of Big Baldy Mountain (Miocene)—Dark-gray, black, and purplish-black aphanitic, porphyritic and slightly porphyritic andesite and basalt breccia and dense, nonvesicular fractured andesite and basalt. Plagioclase phenocrysts are prominent. Resistant-weathering andesite exposures are isolated on hilltops, and this unit forms bodies that are most likely vertical and near-vertical plugs rather than representing remnants of formerly extensive flows. According to Lowell (1971) this unit is probably of Miocene age.

Twa

Andesite of Waugh Mountain (Miocene)—Dark-gray, greenish-black, and dark-greenish-brown, locally vesicular andesite and basalt flows (Wrucke and Dings, 1979). The only occurrence of this unit is in the southeastern corner of the map area where the andesite is a cliff-forming unit that overlies units of the Minturn and Sangre de Cristo Formations. Dense flows and flow breccias predominate in this unit where it occurs in the quadrangle. Epis and Chapin (1974) reported an isotopic age of 19 Ma for this unit.

Tan **Andesite and basalt (Oligocene)**—Exposed in a restricted area north of Salida along Spiral Drive and Tenderfoot Hill. Andesite and basalt forms an interlayered sequence of pahoehoe flows, aa flows, lahar breccias, and mudflow breccias. Pahoehoe flows are composed of dark-gray and black, nonvesicular and vesicular, dense, nonporphyritic and slightly porphyritic andesite and basalt. Aa flows contain angular blocks of dark-gray and black, vesicular and non-vesicular andesite and basalt in a fine-grained vesicular and nonvesicular fine-grained and glassy matrix. Blocks are as much as 1 m in diameter in aa flows. Lahar breccias are composed of angular blocks of dark-gray, black, and dark-red, vesicular and nonvesicular andesite and basalt in a matrix of dark-red, dark-gray, and black fine-grained, poorly to moderately consolidated ash and pumice. The basal contact of lahar breccia is commonly a channeled contact, and the breccia is generally composed of fine-grained ash and volcanic fragments that contains few pebble-, cobble-, or boulder-sized clasts. This basal zone probably represents the lower laminar flow layer of an individual flow unit. Mudflow breccias are composed of angular, sub-angular, and sub-rounded, dark-gray, black, and dark-red clasts of vesicular and nonvesicular andesite and basalt, and rare clasts of sedimentary and metamorphic rocks. Clasts range from pebble to boulder size. Matrix-supported and clast-supported mudflow breccias have channeled contacts at the base.

Badger Creek Tuff (Oligocene)—Consists of a lower nonwelded tuff member, and an upper welded tuff member.

Tbc **Welded tuff member**—The welded tuff member is a resistant-weathering unit of light-gray, light-yellowish-gray, and light-reddish-gray quartz latite that forms subdued cliff faces and hills. The degree of welding varies in this member from slightly welded to glassy, although no pattern in the degree of welding was determined from our mapping. Phenocrysts of plagioclase and biotite are prominent, and sanidine and hornblende are less common. The welded-tuff member is distinguished from all other tuff units in the quadrangle because of the abundant fragments of light-grayish white and light-pink pumice and lapilli and dark-red, reddish-gray, dark-gray, and black fragments of glassy and aphanitic volcanic rocks. In the northern part of the quadrangle the welded-tuff unit directly overlies upper Paleozoic sedimentary rocks and the Whitehorn Granodiorite; the nonwelded unit is thin or absent below the welded tuff. The welded tuff is more than 120 m thick in the north-central part of the quadrangle where the thickest accumulation of ash-flow tuff filled the Waugh Mountain paleovalley, which was located by Wrucke and Dings (1979) in the northeast quadrant of the map area.

Tbcn **Nonwelded tuff member**—Brightly colored, easily eroded ash-flow and air-fall tuff that forms prominent hoodoos and color bands of light-grayish-white, white, grayish-orange, light-grayish-yellow, and light-grayish-red, nonwelded ash-flow tuff. Composed of multiple flow units. Air-fall tuff is a minor component. This unit is composed primarily of pumice; volcanic rock fragments are rare. The thickness ranges from a few feet of nonwelded tuff at some places to more than 90 m in the Cottonwood Creek drainage near Rick Mountain.

Tbl **Biotite latite (Oligocene)**—Unit is exposed north of Tenderfoot Hill (north of Salida) where small patches of prominently flow-banded, light-gray, light-lavender-gray, and light-pinkish-gray porphyry are preserved. This distinctive porphyry contains abundant plagioclase phenocrysts that are 4 to 7 mm in length and lesser amounts of biotite phenocrysts. Wrucke and Dings (1979) gave a Miocene age for this biotite latite, but they cited no isotopic ages to support this determination.

Twm **Wall Mountain Tuff (Oligocene)**—The oldest Tertiary volcanic unit exposed in the Salida East quadrangle is the Wall Mountain Tuff (Oligocene) (Wrucke and Dings, 1979), which is a welded rhyolite ash-flow tuff exposed in widely scattered patches of small areal extent. 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 welded tuff is mostly light-gray, moderate-gray, light-brownish-gray, and grayish-red rhyolite that contains prominent sanidine and plagioclase phenocrysts (Wrucke and Dings, 1979). Epis and Chapin (1974) reported that J.D Obradovich (U.S. Geological Survey, commun. to Epis and Chapin, 1973) determined isotopic ages of 34.7 ± 0.7 Ma and 36.2 ± 0.8 Ma from sanidine, and 35.7 ± 0.8 Ma from biotite; they regarded the age of about 36 Ma to be a reliable estimate of the eruption time for the Wall Mountain Tuff. Flow foliation in glassy welded tuff is prominent, and in exposures northeast of Tenderfoot Hill, north of Salida, the welded tuff is folded on a mesoscopic scale. 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 distal edges of the Wall Mountain Tuff in the Salida East quadrangle do not permit reconstruction of pre-eruption topography, so the folds in the tuff cannot be directly linked to deformation mechanisms described by Chapin and Lowell (1979), although post-emplacement folds could have resulted from a similar mechanism.

MESOZOIC ROCKS

Kw

Whitehorn Granodiorite (Late Cretaceous)— The only Mesozoic rock unit in the Salida East quadrangle is the Late Cretaceous Whitehorn Granodiorite, which was described by Wrucke (1974). The Whitehorn Granodiorite is formed from numerous stocks and a large laccolith in the eastern half of the quadrangle that intruded Pennsylvanian and Permian marine and continental rocks units (Wrucke and Dings, 1979). The basal contact of the laccolith is best exposed in the westernmost exposures of the main body where the contact dips gently eastward at about 35(. Small stocks that penetrated lower and middle Paleozoic rocks west of the main body have steeply dipping contacts that suggest these stocks are mostly vertical and are likely feeders to the main body. A small stock 2.4 km east of Salida has a syenogabbro border phase, and it too may be a feeder to the main body. Most of the Whitehorn Granodiorite is a fine- and medium-grained, equigranular and hypidiomorphic-seriate, biotite granodiorite that contains varietal hornblende and pyroxene. Biotite- and plagioclase-rich xenoliths are locally common along borders in some places. 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. Generally the granodiorite is not foliated, and poorly defined foliation occurs only near borders of the laccolith. Country rocks at the basal contact of the laccolith are little metamorphosed, whereas overlying country rocks are prominently contact metamorphosed as a result of upward migration of heat and fluids from the magma. Wrucke (1974) reported a potassium-argon age of 70.0 ± 2.6 Ma from biotite for the Whitehorn Granodiorite. McDowell (1971) reported concordant ages of 70.4 ± 2.1 Ma from biotite and 69.4 ± 2.1 Ma from hornblende for the age of intrusion.

PALEOZOIC ROCKS

PIPs

Sangre de Cristo Formation (Lower Permian and Upper Pennsylvanian)— Overlies the Minturn Formation on a gradational contact. Pierce (1969) and De Voto and Peel (1972) subdivided the Sangre de Cristo Formation into five informal units in the northern Sangre de Cristo Range and the southern Mosquito Range, and De Voto and Peel (1972) estimated that the Sangre de Cristo Formation totaled about 4,570 m thick. The lower three members of the five regionally recognized members are present in the Salida East quadrangle and total about 950m in thickness. From the base upward, these subdivisions are member one, member two, and member three.

Ps_3

Member three (Lower Permian)—Only the lower 122 m of the member is present in the quadrangle. Exposed only in the southeastern corner of the map area. The base of member three has a gradational contact with underlying member two and is equivalent to unit 6 of the basal part of the upper member of the Sangre de Cristo Formation of Pierce (1969). Member three is composed of grayish-red and reddish-gray, pebbly and granular coarse-grained arkose, subarkose, and orthoquartzite interbedded with grayish-red and reddish-gray, medium- and fine-grained feldspathic sandstone and lesser amounts of micaceous, dark-red siltstone and dark-red, silty, micaceous shale. Polymict conglomerate beds in member 3 are similar in composition and texture to conglomerates of member one, and bedding characteristics and primary bedding structures in member 3 are also similar to those of member one. Thin, lenticular beds of olive-drab, dark-greenish-gray, and grayish-black fine-grained sandstone, siltstone, and shale interbedded with the dominant red-bed sequence that occur in member one do not occur in the basal beds of member three in the East Salida quadrangle, but these beds occur higher in the stratigraphic section east of the Salida East quadrangle.

$\mathrm{P}\mathbb{P}s_2$

Member two (Lower Permian and Upper Pennsylvanian)—Mainly a fine-grained unit composed of olive-drab, grayish-green, dark-gray, greenish-black, and black micaceous shale, siltstone, and fine-grained sandstone, and rare interbeds of moderate-gray limestone, dolomite, and gypsum. Member two is equivalent to unit 5 of the lower member of the Sangre de Cristo Formation of Pierce (1969). Member two is about 305 m thick in the Salida East quadrangle. Siltstone and sandstone beds are generally between 2 to 30 cm thick and contain planar lamination, ripple cross-lamination, parting lineation, shallow channels, and small-scale planar lamination. Generally the siltstone and sandstone beds are fining-upward sequences capped by silty, micaceous black shale. Limestone, dolomite, and gypsum beds occur at the base of this member, and these beds range in thickness between 30 cm and 2 m. Limestone and dolomite beds are impure argillaceous and silty micrite that is laminated or mottled. Mottled, dark-gray gypsum beds containing some silt and sand grains occur at the base of member two.

$\mathbb{P}s_1$

Member one (Upper Pennsylvanian)—Overlies the Minturn Formation on a gradational contact in which red, coarse-grained beds intertongue with black and olive-drab shale, siltstone, and fine-grained sandstone of the Minturn. The basal member of the Sangre de Cristo Formation is composed mainly of grayish-red, coarse-grained arkose and pebbly and granular arkose, 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), which formed the lower part of his lower member of the Sangre de Cristo Formation. Coarse-grained arkose, pebbly arkosic conglomerate, coarse-grained arkose, 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 sub-angular to sub-rounded, 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 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. Many fining-upward sequences are incomplete and coarse-grained basal parts of fining-upward sequences occur on medium-grained sequences where the siltstone and shale tops of the sequences have been eliminated. 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 predominantly ripple cross-lamination, planar lamination, flasers, and microlamination. Rare secondary sedimentary structures in the sandstone beds are deformed and overturned crossbeds and load casts. Some fine-grained intervals in member one of the Sangre de Cristo Formation are olive-drab, grayish-green, dark-gray, and moderate-gray fine-grained sandstone, siltstone, and shale; these fine-grained intervals are generally less than 1 m thick. Sandstone beds within these dark-colored, fine-grained intervals commonly have channeled basal contacts, and sandstone beds contain common medium- and small-scale ripple cross-lamination. Fine-grained sulfide minerals occur in sandstone and siltstone beds within these fine-grained intervals, and pyrite, chalcopyrite, and possibly bornite minerals appear to be interstitial diagenetic minerals. At the top of member one, gypsum beds are interbedded with grayish-red, coarse-grained arkose, medium- and fine-grained arkose, dark-red siltstone, and shale. Generally, dark- and moderate-gray gypsum beds are 30 cm to 2 m thick.

IPm

Minturn Formation (Middle Pennsylvanian)—Overlies the Sharpsdale Formation on a gradational and conformable contact. The Minturn is composed mainly of dark-gray, gray, olive-drab, grayish-green, greenish-gray, and black fine-grained sandstone, siltstone, shale, and less common limestone and dolomite. The unit is about 550 m thick in 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 more common in the upper part of the Minturn Formation. Near the top of the Minturn Formation, red, micaceous silty shale and some fine- and medium-grained sandstone beds are interbedded with more characteristic olive-drab, grayish-green, dark-gray, and black micaceous shale, silty shale, and siltstone of the Minturn Formation. A black micaceous shale bed that contains casts of salt crystals occurs at the contact with the overlying Sangre de Cristo Formation.

IPs

Sharpsdale Formation (Middle Pennsylvanian)—Overlies the Kerber Formation on a contact that appears gradational and conformable. Composed mainly of grayish-red and reddish-gray, coarse-grained arkose and 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. The Sharpsdale Formation is about 335 m thick in 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. In the lower part of the Sharpsdale Formation, coarse-grained basal parts of fining-upward sequences occur on medium-grained sequences, and the siltstone and shale tops of the sequences have been eliminated. In the upper part of the Sharpsdale, complete fining-upward sequences are common, and the thickness of the lower coarse-grained part of the sequence is less, or the coarse-grained pebbly arkose is absent. 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. Rare secondary sedimentary structures in the sandstone beds are deformed and overturned crossbeds and load casts; secondary structures in the siltstone and shale are convolute lamination and small-scale load casts. At some places, the base of the Sharpsdale contains rare interbeds of grayish-green and gray limestone; these interbeds disappear within about 45 m of the basal contact. Some fine-grained intervals in the Sharpsdale are olive-drab, grayish-green, dark-gray, and moderate-gray fine-grained sandstone, siltstone, and shale; these fine-grained intervals are generally less than 1 m thick. Sandstone beds within these dark-colored, fine-grained intervals commonly have channeled basal contacts and contain common medium- and small-scale ripple cross-lamination. Fine-grained sulfide minerals occur in sandstone and siltstone beds within these fine-grained intervals, and pyrite, chalcopyrite, and possibly bornite appear to be interstitial diagenetic minerals.

IPk **Kerber Formation (Lower Pennsylvanian)**—Disconformably overlies the Leadville Limestone. The Kerber Formation is about 335 m thick in the map area. This formation is composed mostly of grayish-green, olive-drab, olive-gray, moderate-gray, and dark greenish-gray, coarse-grained arkose and conglomeratic arkose and subarkose, medium- and fine-grained arkose, siltstone, and shale. Black shale, black siltstone, moderate-gray limestone, and rare dolomite occur as interbeds in the olive-drab and grayish-green rocks. 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 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 is primarily a coarse-grained arkose, conglomerate, and sandstone, so the term "Belden" is not properly applied to the latter rocks. Coarse- and medium-grained conglomeratic arkose is the predominant rock type in the Kerber, 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 finer grained rocks, mostly olive-drab shale and siltstone and black shale, become more common upward in the sequence. Moderate-gray limestone interbeds are common near the top of the Kerber where limestone beds range between 1 to 5 m in thickness. De Voto and Peel (1972) indicated that three limestone beds occurred in the upper part of the Kerber Formation where they studied it, but apparently limestone beds are more common in the upper part of the Kerber north of the Arkansas River in the Salida East quadrangle than to the south where De Voto and Peel (1972) refined the description of the Kerber Formation. In the region of Midway Spring and to the north, numerous beds of limestone that are 1 to 5 m thick, many of which contain brachiopods and fragments of trilobites, occur locally near the base, in the middle, at the top of the formation. Limestone beds that occur near the top of the Kerber are commonly fossiliferous, and several thin mottled limestone beds that mark the top of the Kerber Formation are a distinctive bright grayish-green color. 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. Locally, black shale and olive-drab siltstone near the top of this unit contain salt-crystal casts. Conglomeratic and sandy units have coarse-grained rocks at the base and become finer grained upward. Dark-gray and black limestone beds that occur in the upper and lower 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 grayish-green limestone beds occur near the top of the formation. Contacts between the upper part of a fine-grained sequence and the lower part of a coarse-grained sequence are generally channeled contacts. The upper contact of the Kerber Formation appears to be gradational with the overlying Sharpsdale Formation because grayish-green coarse-grained conglomeratic arkose, olive-drab siltstone, and green and gray limestone beds of the Kerber Formation are interbedded with coarse-grained grayish-red arkose of the Sharpsdale 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 from 7 cm to 2 m. Grayish-pink and grayish-red beds occur in zones in the lower and upper parts of the Leadville; these zones are thinly bedded and flaggy, laminated and microlaminated, micritic limestone. Black laminated chert nodules and lenticular chert beds occur at some stratigraphic levels. Overlies the Dyer Dolomite Member of the Chaffee Formation on a disconformable contact. The Leadville Limestone varies in thickness to a maximum of about 78 m; much of the thickness variation results from post-lithification solution of limestone and from volume reduction that resulted from solution and silicification of limestone. The base of the Leadville is channeled into the underlying Dyer Dolomite Member, and the 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. Above the basal sandstone are several beds of calcareous sandstone that are interbedded with moderate- and dark-gray micrite. The sandstone beds above the basal unit are 2.5 to 30 cm thick, and they decrease in thickness upward; about 3 m above the base the sandstone beds are absent. Most of the Leadville Limestone is composed of interbedded zones of finely crystalline dolomite and micrite, with lenticular interbeds of biomicrite and oolitic limestone that occur sporadically through the sequence. Some limestone and dolomite are mottled light gray and moderate gray. In the lower third of this unit two distinctive flaggy-weathering, thinly bedded, laminated, grayish-pink and grayish-red limestone zones occur, but these zones are visible only in dry canyons and road cuts where outcrops are fresh. These grayish-pink and grayish-red, thinly bedded zones appear to develop in flat-pebble and flat-cobble conglomerates in which the laminated and microlaminated micrite forms a jumbled mass of sub-rounded clasts that range from 2.5 to 30 cm in length. The conglomerates are well displayed along some mining roads north of the Arkansas River and west of Wells Gulch in the southern part of the map area. In the southern part of the map area the flaggy zones become grayish purple and grayish red in color, and they form prominent color bands in the lower Leadville Limestone. 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 zones of micrite; the result is interbeds of dolomite and limestone that are 60 cm to 3 m thick, but dolomitization was 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 event of silicification in the Leadville limestone.

Mlc

Chert member—In much of the Salida East quadrangle a laterally extensive chert breccia has been mapped at the top of the Leadville Limestone. This prominent marker is composed of red, orange, grayish-red, grayish-yellow, brown, and reddish-brown, banded, vuggy, laminated and microlaminated chert and chert breccia. Most breccia clasts are angular and range from less than 2 to 15 cm in diameter. Laterally this upper marker is discontinuous, and it is not everywhere present below Pennsylvanian clastic rocks. At places where the chert zone is absent, limestone breccias and caves are common at the top of the Leadville Limestone, so the occurrence of solution breccias and the occurrence of chert that may have replaced solution breccias may be related events. Zones of massive replacement chert and chert breccias occur at several stratigraphic levels in the Leadville Limestone. These silicified zones are presumed to have formed at the same time as solution and replacement features at the top of the Leadville Limestone, after Early Mississippian and before Early Pennsylvanian time. The chert breccia zone at the top of the Leadville Limestone could represent the regolith interval mapped as the Molas Formation in southwestern and western Colorado (De Voto, 1980a).

Chaffee Formation (Upper Devonian)—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, but the units are thinly bedded; therefore, 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.

Dcd

Dyer Dolomite Member—Yellowish-gray, light-gray, and pale-yellowish-gray, laminated and microlaminated, finely crystalline and microcrystalline dolomite that contains some lenticular interbeds of light-grayish-green and light-greenish-gray shale and laminated yellowish-gray chert. The dolomite is bioturbated and vuggy or massive-weathering. Rare chert layers are interbedded with dolomite and range from 1 to 5 cm thick. The Dyer Dolomite Member is about 30 m thick.

Dcp

Parting Quartzite Member—Light-gray, pale brownish-gray, light-grayish-red, and pinkish-gray, fine-grained, silica-cemented, dense, flinty, conchoidal-fracturing orthoquartzite. Rare interbeds of dolomite and shale are 5 to 20 cm thick, and some pebbly and granular sandstone interbeds occur. Quartzite beds are generally 5 to 25 cm thick. Planar lamination and rare planar crossbeds are the principal sedimentary structures but are masked by recrystallization. Member is a silica-cemented, flinty, conchoidal-fracturing rock. At some places the Parting Quartzite Member is not densely cemented and the quartzite is friable. Breccia is common. The thickness of this unit ranges between 6 and 15 m, but some of the thickness variation could result from poor exposures or from weathering that resulted from lack of silica cement. In the southern part of the quadrangle the Parting Quartzite Member is well cemented, and forms a mass of quartzite that resists weathering.

Of

Fremont Dolomite (Upper and Middle Ordovician)—Overlies the Harding Quartzite on a disconformable contact. The Fremont Dolomite is a dark-, moderate-, and light-gray, massive-weathering, crystalline, fetid dolomite that contains echinoid debris and dolomitized coral in a fine-grained dolomite matrix. Trilobite and brachiopod fragments occur on some bedding planes. The dolomite may be mottled light-gray and dark-gray, or it is laminated and microlaminated. Rare black chert nodules are irregularly distributed through the dolomite. 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 about 61 m thick.

Oh **Harding Sandstone (Middle Ordovician)**—Overlies the Manitou Limestone on a disconformable contact. The Harding Sandstone 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 25 m thick at most places in the quadrangle. Quartzite beds range from 2.5 cm thick to about 20 cm thick. They contain planar lamination and planar crossbeds, which are obscured by pervasive replacement by diagenetic silica. Phosphatic bony plates of primitive fish occur locally. 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-, red-, and orange-colored quartzite form a breccia that represents the entire thickness of the Harding Quartzite at some places in the central and southern parts of the quadrangle. Some exposures contain sandstone conglomerate at the base.

Om **Manitou Limestone (Lower Ordovician)**—Overlies the Sawatch Quartzite or overlies Proterozoic rocks. Dark-, moderate-, and light-gray, thin- to thick-bedded dolomite and cherty dolomite and rare beds of dark-gray limestone that is about 37 m thick. Contains little limestone and dolomitic limestone in the Salida East 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. Commonly the unit is composed of a silicified breccia of pebble- and cobble-sized laminated chert in a matrix of silicified dolomite that, in some places, forms the entire thickness of the unit. Breccia also occurs as lenses in the dolomite. Silicified clasts are angular and as large as 15 cm in diameter. The breccia may have formed from: (1) silicification of a dolomite collapse breccia that resulted from solution of underlying evaporite, or (2) silicification of dolomite that formed massive chert, which later collapsed into voids created by dissolution of underlying evaporite. Weathering of silicified breccias produces large angular boulders that form prominent rubble fields downslope from exposures of the Manitou Limestone.

Ꞓs **Sawatch Quartzite (Upper Cambrian)**—Ranges between 7 cm and 3 m in thickness in the Salida East quadrangle, and it may be absent at some places. In general, the Sawatch is thicker in the northern part of the quadrangle, where this unit can be as thick as 3 m, than in the southern part along the Arkansas River where 7 to 20 cm is a common thickness. The Sawatch Quartzite is a light-gray, moderate-gray, light-grayish-yellow, fine- to medium-grained, well-sorted, silica-cemented orthoquartzite and pebbly orthoquartzite that contains planar crossbeds, ripple cross-lamination, and planar lamination at places where bedding is preserved. Commonly, however, brecciation has obliterated bedding in the Sawatch; silica-cemented breccias are framework-supported angular fragments of quartzite that range up to 5 cm in diameter in matrix of finely comminuted quartzite. Some breccia fragments retain original bedding traces. Pebbly quartzite contains sub-rounded and rounded quartz clasts. Below the Sawatch Formation Proterozoic rocks are severely weathered and leached.

PROTEROZOIC ROCK UNITS

STRONGLY FOLIATED ROCKS

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 the contact with older gneiss (unit Xgn). Exposures in the Salida East quadrangle are limited to a few acres in the north-central part of the quadrangle. 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).

Xgn

Gneiss (Early Proterozoic)—Predominantly dark-gray to black, fine- to medium-grained quartz-biotite-muscovite gneiss and lesser amounts of medium-grained amphibolite and fine-grained, light- to medium-gray feldspar-quartz-biotite gneiss. Commonly well foliated; contains local zones of migmatite and pegmatite. Includes lesser amounts of discontinuous garnet-biotite phyllite and schist up to 8 m thick containing copper carbonates and silicates. The gneiss contains some epidote as stringers and films along foliation planes. Primary minerals of the gneiss units include quartz, microcline, plagioclase, biotite, and muscovite. Dark-red garnet is found in the phyllitic units. Common accessories minerals include biotite, magnetite, muscovite, epidote, zircon, sphene, and allanite (Boardman, 1971). The quartz-biotite-muscovite gneiss contains approximately 70% strained quartz grains ranging in size from about 0.4 to 0.7 mm and rare plagioclase feldspar. The remainder of the gneiss is strongly foliated and contains biotite and muscovite ranging in size between 1.0 and 2.0 mm. Locally, some silicic zones in the gneiss contain less than 10% micas. Locally, the biotites are altered to chlorite. The feldspar-quartz-biotite gneiss contains approximately 60% feldspar, mostly microcline, ranging in size from 0.1 to 0.8 mm, 35% strained, very fine-grained quartz, and about 5% biotite. The amphibolites generally have obscure contact relations with the surrounding gneiss; however, they appear to be sills and dikes that are younger than and intrude the gneiss, as they are conspicuously not foliated. They contain about 60% hornblende ranging in size from 0.5 to 1.0 mm and about 40% plagioclase ranging between 0.5 to 1.5 mm. According to Boardman (1971) the amphibolites consist primarily of hornblende and plagioclase and lesser amounts of biotite, pyroxene (diopside), and quartz. Actinolite is found in altered zones.

SLIGHTLY FOLIATED ROCKS

Xb

Basalt (Early Proterozoic)—Dark-gray to black, predominately aphanitic to fine-grained basalt. Contains approximately 50% altered plagioclase crystals, 40% strongly pleochroic hornblende crystals after pyroxene, and 10% fine-grained chlorite. The plagioclase and hornblende are equigranular and range in size from less than 0.5 mm to, rarely, 2-4 mm. About half of the hornblende is very fine grained and occurs as radiating lath-like crystals throughout the basalt. Epidote and opaque minerals, probably magnetite, occur in trace amounts. Xenocrysts of quartz are rare. In Dead Goat Gulch the basalt is locally agglomeratic and vesicular. Breccias are common, and the basalt is often interbedded with fine-grained to coarse-grained clastic rocks.

Xg

Gabbro (Early Proterozoic)—Dark-gray to black, medium- to coarse-grained hornblende gabbro. Megascopically the rock contains light-orangish-tan crystals of plagioclase feldspar in a black hornblende matrix. Contact relations with the surrounding rock units are generally obscured. The gabbro contains approximately 30 to 50% medium-grained (2–5 cm) labradorite (An^{50}–An^{60}) and 50 to 70% strongly pleochroic, prismatic, medium-grained crystals of hornblende after pyroxene. A fine-grained phase of hornblende occurs within a sub-ophitic texture of larger plagioclase crystals and along plagioclase fractures. Chlorite and rare epidote occur as an alteration product of the hornblende. 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 felsic volcanic rocks, dark-gray and black basalt flows, and medium-gray to black, light-gray, and grayish-tan, fine-grained to very fine-grained quartzites, metasiltstones, and metagraywacke. The quartzites consist primarily of very fine quartz grains and up to 10% feldspar grains. Poorly to moderately foliated chlorite and, rarely, biotite can constitute from 5 to 30%. 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 and magnetite, both probably of detrital origin. Crossbedding and other sedimentary structures such as graded couplets, microlamination, planar lamination and ripple cross-lamination are often well preserved. Locally the quartzites contain 5 to 10 mm quartz veinlets containing rare pyrite. Epidote is common on fracture surfaces, in veinlets, and, rarely, replacing chlorite. A sample of the well-bedded quartzite collected about 1,000 feet east of the confluence of Longfellow Gulch and the Arkansas River may contain finely disseminated organic material along the bedding planes. Basalt similar to that in map unit Xb is found interbedded with sedimentary rocks throughout this unit. The basalt is aphanitic to fine grained, porphyritic, and massive or vesicular. Vesicles are filled with carbonate minerals or are vadose. In welle xposed outcrops , basalt flows comprise about 50% of the map unit. In Dead Horse Gulch the unit contains interbedded, dark-grayish green lithic graywacke containing sub-angular to sub-rounded clasts of basalt and hornblende crystals up to 5 cm in length. Locally the unit includes dikes and sills of felsic (rhyodacite) composition. Contacts are covered, and the dikes and sills are too small to be shown at the map scale. The rhyodacite contains coarse-grained, extremely altered phenocrysts of potassium feldspar and coarse-grained biotite phenocrysts largely altered to chlorite. The matrix is a fine-grained mass of birefringent clay minerals. Fine-grained magnetite octahedra comprise 1 to 2% of the rhyodacite.

Xmgd

Granodiorite of Methodist Mountain (Early Proterozoic)—Medium-gray, massive, fine- to medium-grained granodiorite consisting chiefly of quartz, oligoclase, microcline, biotite, and hornblende. Exposed in a small area just south of Cleora along the southern edge of the quadrangle (Wrucke and Dings, 1979).

Xp

Pegmatite (Early Proterozoic)—Pegmatite occurs in both the strongly foliated gneiss and to a much lesser extent in the slightly foliated rocks. They are described here only because they are unfoliated. In the strongly foliated gneiss (unit Xgn), pegmatites are common, they are of significant size (up to a few hundred meters long), and they generally have cross-cutting relationships with the foliation. Pegmatites in the weakly foliated rocks are rare, tend to be of insignificant size, up to 0.5 m thick and perhaps 10 m long, and generally are concordant with foliation or bedding. The pegmatites consist primarily of large crystals of quartz, microcline, albite, muscovite, and occasional biotite, garnet, beryl, and magnetite. They are zoned or unzoned.

Mineral occurrences in the Salida East quadrangle consist of metallic vein and replacement deposits in Proterozoic and Tertiary volcanic rocks, stratabound deposits in Paleozoic rocks, and industrial mineral deposits of feldspar, mica, beryl, columbite-tantalum, limestone, dimension stone, and gravel. Mineral resource potential of these mineral occurrences has not been evaluated as part of this project, but the mineral occurrences identified in the quadrangle are discussed briefly.

VEIN AND REPLACEMENT MINERAL DEPOSITS

CLEORA DISTRICT

The Cleora district is located in the southern part of the map area along the Arkansas River about 1.5 kilometer southeast of the southern edge of Salida. Copper and tungsten mineralization are associated with quartz veins in fractures within Proterozoic gabbro (unit Xg).

The most significant mine in the district was the Stockton Mine. The prospect contains nine northeasterly-striking veins. The mine was first worked in the 1870s for copper. During World War I scheelite was recognized and approximately two tons of ore were produced during World War II. No other prospect has any recorded production (Belser, 1956).

At the Grandview Mine scheelite, cuproscheelite, and cuprotungstite were found as clasts in a fault breccia. The breccia was observed to be flat-lying and about 15 m thick (Tweto, 1960).

Scheelite, pyrite, and chalcopyrite occur in the quartz veins and in the vein margins of all the Cleora district mineral occurrences. Scheelite has also been observed associated with a grossularite-vesuvianite-diopside skarn in the dump material of the Stockton Mine (Boardman, 1971; Heinrich, 1981). Supergene malachite and chrysocolla are commonly found in the surface exposures. Bornite has also been reported (Tweto, 1960).

Scapolite, an alteration product of the plagioclase in the gabbro, occurs within the quartz veins, in the vein margin and selvage, and up to several meters away from the veins. Scapolite occurs as slender prisms up to one cm in length in the vein margin. In the altered gabbro, the scapolite occurs as disseminated gray-white euhedral crystals. According to Boardman (1971), the scapolite contains about equal amounts of Ca and Na, reflecting the plagioclase composition of the gabbro. Grab samples from three of the mine dumps of the Cleora district are weakly anomalous in gold, copper, and tungsten (see Table 1).

TURRET DISTRICT

The main part of the Turret district is located 1.5 kilometers north of the Salida East quadrangle in sec. 28, T. 51 N., R. 9 E. Very little geological and historical information is available on this district. Gold mineralization in the main part of the Turret district is confined to northeast-trending quartz veins in Proterozoic granodiorite (Bhutta, 1954). The occurrences in the Railroad Gulch and Longs Gulch area of the Salida East quadrangle are quartz-pyrite veins, fracture-fillings, and stratabound disseminations in Proterozoic gneiss and phyllite.

From 1881 through 1897, a narrow gauge railroad operated from the Calumet Mine, about 3.5 km east of Turret, through Railroad Gulch and down to the main line in the Arkansas River valley. The rail line was washed out in 1897 and was officially abandoned in 1923 (J. Huffman, oral commun., 1996). The mines in Railroad Gulch were probably developed and abandoned about this same period of time.

ISOLATED OCCURRENCES

There is a small tungsten-manganese occurrence at the Sage prospect located in the SW 1/4 sec. 24, T. 50 N., R. 9 E., just about 400 meters east of The Crater. The host rock is brecciated Badger Creek Tuff. The Mineral Resource Data System (MRDS) database (U.S. Geological Survey) reports a Mn value of 12% and a WO_3 value of 0.67%.

Magnetite is a common accessory mineral in the Xvs unit and has been described as a disseminated deposit in Cottonwood Creek (sec. 34, T. 50 N., R. 9 E.) approximately 1.5 km east of Tenderfoot Hill (Harrer and Tesch, 1959).

The Iron King hematite deposit located in sec. 2 , T. 50 N., R. 9 E. is a small irregular replacement body along a fault in the Leadville Limestone. The MRDS database describes the following geochemical data as typical of the deposit: 30.2% Fe, 0.13% P, 0.39% S, 40.8 % Si, and 0.2% Mn. In 1936 an assay for gold ran $60.00 per ton. There is no reported production. There are, however, reports that the deposit was mined for gold and silver and used as flux in a local smelter until the 1920s.

PROTEROZOIC STRATAFORM OCCURRENCES

In the N½NW¼NE¼ sec. 8, T. 51 N., R. 9 E. on the south side of Longs Gulch there is an inclined shaft along an east-northeast trending zone of visible malachite and chrysocolla mineralization in a dark-gray, friable, garnet-biotite phyllite. Several Bonus pegmatites prospect sites occur in this vicinity. One of the Bonus pegmatite prospects occurs just about 20 m to the north of this shaft. The phyllite zone is about 8 m thick and appears to persist for 30 to 35 m along strike. Quartz segregations in the phyllite range from 2 to 10 cm in width and have lengths of 1 to 1.5 m. A grab sample of phyllite (see Table 1) yielded 1.34 ppm gold, 8 ppm silver, >10,000 ppm copper, and anomalous nickel, vanadium, and zinc.

PALEOZOIC STRATABOUND OCCURRENCES

Disseminated stratabound mineral deposits have been identified in upper Paleozoic rocks in the map area, and these 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, zinc, lead, barium, chromium, and vanadium, and rare gold were identified from grab samples from the Sharpsdale, Minturn, and Sangre de Cristo Formations in the map area (Table 1). The stratabound mineralized zones occur in chemically reduced zones of fine-grained clastic rock interbedded with coarse-grained and conglomeratic, chemically oxidized beds. Mineralized zones are commonly 2 cm to 20 cm thick in dark-gray, moderate-gray, greenish-gray, fine-grained sandstone, siltstone, and shale. Mineralized zones are overlain or underlain by coarse-grained red beds. 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 rocks deposited in fluvial, deltaic, and alluvial environments. Rock samples commonly show secondary hydrous-copper-carbonate minerals on weathered surfaces. Nonweathered rock contains silt-sized grains of pyrite, chalcopyrite, and possible grains of chalcocite and bornite.

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 Salida East quadrangle. The deposits they described are similar in many respects to those described here. Table 2 shows concentrations in parts per million of anomalous elements of mineralized rocks from the Salida East quadrangle and from the northern Sangre de Cristo Range (Lindsey and Clark, 1995). The depositional environments are similar in each area, but some differences in element concentrations are apparent: 1) The concentrations of arsenic, barium, molybdenum, lead, uranium, and vanadium are lower in upper Paleozoic rocks in the Salida East quadrangle than in the Sangre de Cristo Range, and 2) The concentrations of copper and zinc are higher in upper Paleozoic rocks in the Salida East quadrangle than in the northern Sangre de Cristo Range. The difference in the concentration of uranium may be related to the apparent lesser amounts of carbonaceous material in the Minturn and Sangre de Cristo Formations in this map area than in the same rocks in the northern Sangre de Cristo Range, but differences in concentrations of arsenic, barium, molybdenum, lead, copper, and zinc have no obvious explanation. A single highly anomalous concentration of 20 ppb gold in sample 96864 is the only relatively high concentration of gold found to occur in these stratabound mineral occurrences (Table 1).

Sample 96860 is from a paleoplacer at the base of the Sangre de Cristo Formation. This sample contained concentrations of sand-sized heavy minerals on bedding surfaces and on crossbed foresets. The heavy minerals are predominantly magnetite and ilmenite(?). This sample contains relatively high concentrations of chromium, iron, and vanadium, and relatively high concentrations of copper and manganese, but gold concentrations are below 5 ppb.

Three grab samples of chert (Table 1, samples 96141, 96689, and 96775) from the upper part of the Leadville Limestone were analyzed for disseminated gold. One sample contained a gold concentration of 10 ppb. The process of silicification of carbonate rocks may transport and deposit gold in chert.

INDUSTRIAL MINERAL OCCURRENCES

PEGMATITE MINERALS

There are several large pegmatite bodies within the Proterozoic gneiss (unit Xgn) some of which are up to 300 m in length and 15 m wide and are shown on the map as discrete units. There are many other pegmatite bodies too small to be shown on the map. The pegmatites along Railroad Gulch, mostly in the S½ sec. 34, T. 51 N., R. 9 E., are grouped together and are known as the Rock King prospects. These prospects produced small amounts of albite, microcline, muscovite, beryl, columbite, and tantalite. Euhedral, blue-green beryl crystals up 30 cm in diameter and 2.7 meters in length have been reported from the Rock King prospects (Hanley and others, 1950). Production reported by Boardman (1971) was just over 3,000 pounds during 1943 and 1944.

The Riegel pegmatite prospects are located along the north side of Longs Gulch, mostly in sec. 3, T. 50 N., R. 9 E. Feldspar, mica, and beryl are the reported ore minerals. There is no reported production.

The Bonus and Shirley group of pegmatites are mostly located on the ridges on the south side of Longs Gulch in sec. 6, 7, and 8, T. 50 N., R. 9 E. Ore minerals in these pegmatites include beryl, columbite-tantalite, muscovite, and microcline. Niobium has also been reported from these pegmatites. Only about 20 tons of ore were produced from these pegmatites through 1974.

LIMESTONE

There are no reported limestone deposits that have been worked in the Salida East 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 was quarried for dimension stone at several localities marked on the Salida East quadrangle topographic map. The medium-grained texture, salt and pepper color, and relative lack of joints in this granodiorite make it an attractive dimension stone. At some of the bigger quarry sites, some of the old works still remain. During 1996 some of the Whitehorn Granodiorite was quarried and used for crushed and decorative stone.

GRAVEL

Sand and gravel resources are available along most of the major drainages in the quadrangle. Significant resources occur along the Arkansas River in the southwestern part of quadrangle.

Belser, C., 1956, Tungsten potential in Chaffee, Fremont, Gunnison, Lake, Larimer, Park, and Summit Counties, Colorado: U.S. Bureau of Mines Information Circular 7748, 31 p.

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

Bhutta, M.A., 1954, Geology of the Salida area, Chaffee and Fremont Counties, Colorado: Golden, Colorado School of Mines, Ph.D. dissertation, 173 p.

Boardman, S.J., 1971, Precambrian geology and mineral deposits of the Salida area, Chaffee County, Colorado: Ann Arbor, University of Michigan, Ph.D. dissertation, 131 p.

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., 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.

Hanley, J.B., Heinrich, E.W., and Page, L.R., 1950, Pegmatite investigations in Colorado, Wyoming, and Utah, 1942–1944: U.S. Geological Survey Professional Paper 227, 125 p.

Harrer, C.M., and Tesch, W.J., Jr., 1959, Reconnaissance of iron occurrences in Colorado: U.S. Bureau of Mines Circular 7918, 82 p.

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.

Heinrich, E.W., 1981, Precambrian tungsten and copper-zinc skarns of south-central Colorado: Colorado Geological Survey Resource Series 21, 115 p.

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.
Lowell, G.R., 1971, Cenozoic geology of the Arkansas Hills region of the southern Mosquito Range, central Colorado in San Luis basin, Colorado: New Mexico Geological Society Guidebook, 22nd Field Conference, 1971, p. 209–217.
McDowell, F.W., 1971, K/Ar ages of igneous rocks from western United States: Isochron/West, no. 2, p. 1–16.
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, M.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, M.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, 1960, Scheelite in the Precambrian gneisses of Colorado: Economic Geology, v. 55, p. 1406–1428.
_____ 1980, Tectonic history of Colorado, *in* Kent, H.C. and Porter, K.W., eds., Colorado geology: Denver, CO, Rocky Mountain Association of Geologists, p. 5–9.
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.

Table 1. Geochemical analyses of mineral occurrences on Salida East quadrangle. See map for location of samples. Analyses by Chemex Labs, Inc. Gold analyses by fire assay and atomic absorption. All other analyses by inductivly coupled plasma method.

SAMPLE NUMBER	Au ppb	Ag ppm	Al %	As ppm	Ba ppm	Be ppm	Bi ppm	Ca %	Cd ppm	Co ppm	Cr ppm	Cu ppm	Fe %	Ga ppm	Hg ppm	K %
96141	<5	<0.2	5.25	10	30	0.5	<2	0.96	<0.05	32	60	383	7.19	<10	<1	0.15
96213	<5															
96365	<5	<0.2	3.47	8	60	0.5	<2	0.26	<0.05	17	86	2,350	4.25	<10	<1	0.23
96689	<5															
96775	10															
96781A	<5	<0.2	2.26	<2	100	0.5	<2	4.11	<0.05	7	61	47	2.14	<10	<1	0.65
96781B	<5	<0.2	2.46	<2	70	0.5	<2	6.70	<0.05	8	41	3	2.91	<10	<1	0.87
96781C	<5	<0.2	2.33	<2	940	0.5	<2	2.06	<0.05	7	51	<1	3.13	<10	<1	0.65
96781D	<5	<0.2	2.71	<2	150	0.5	<2	2.29	<0.05	11	57	151	2.88	<10	<1	0.70
96791	<5	6.4	1.99	<2	70	1.5	Intf.	0.35	<0.05	10	54	>10,000	1.91	<10	<1	0.47
96860	<5	<0.2	1.36	<2	320	0.5	<2	0.24	<0.05	13	164	31	9.43	<10	<1	0.13
96863	<5	<0.2	1.39	<2	160	1.5	<2	>15.00	<0.05	4	21	989	0.71	<10	<1	0.57
96864	20	<0.2	1.30	<2	70	0.5	<2	7.96	<0.05	6	55	1,330	1.31	<10	<1	0.39
96865A	<5	<0.2	2.14	6	40	1.5	<2	0.40	<0.05	7	43	408	2.81	10	<1	0.24
96865B	<5	<0.2	2.16	<2	20	0.5	<2	0.33	<0.05	7	91	2,470	2.72	<10	<1	0.14
C6-6	1,340	8.2	1.57	<2	100	<0.5	Intf.	0.69	1.00	57	100	>10,000	5.64	<10	<1	0.16
C6-19	<5	<0.2	0.15	2	60	<0.5	<2	0.09	<0.05	4	114	3	3.41	<10	<1	0.14
C6-46	<5	<0.2	0.50	2	40	<0.5	<2	0.08	<0.05	1	132	55	0.65	<10	<1	0.29
C6-63	90	0.4	1.24	12	20	<0.5	Intf.	1.17	<0.05	19	238	>10,000	2.21	<10	<1	0.07
C6-64	170	0.4	2.47	2	240	<0.5	<2	1.32	<0.05	59	104	3,660	3.92	<10	<1	0.84
C6-65	95	1.0	0.19	56	10	0.5	<2	2.54	<0.05	6	183	467	7.44	<10	<1	0.03

Table 1. Continued.

SAMPLE NUMBER	La ppm	Mg %	Mn ppm	Mo ppm	Na %	Ni ppm	P ppm	Pb ppm	Sb ppm	Sc ppm	Sr ppm	Ti %	Tl ppm	U ppm	V ppm	W ppm	Zn ppm
96141	30	3.04	540	<1	<0.01	52	500	20	<2	5	15	<0.01	<10	<10	32	<10	176
96213																	
96365	50	2.16	295	<1	0.01	45	980	20	<2	3	15	<0.01	<10	<10	30	<10	102
96689																	
96775																	
96781A	<40	3.08	565	<1	0.02	17	670	2	<2	7	46	0.07	<10	<10	41	<10	56
96781B	<40	4.77	700	<1	0.02	21	440	<2	<2	7	81	0.06	<10	<10	35	<10	60
96781C	<30	2.65	330	<1	0.01	17	680	<2	<2	8	67	0.07	<10	<10	48	<10	48
96781D	<20	3.44	340	<1	0.01	18	510	12	<2	7	56	0.08	<10	<10	46	<10	206
96791	<70	1.71	365	6	0.03	18	Intf.	10	<2	7	22	0.05	<10	30	51	<10	56
96860	<60	1.07	190	<1	0.01	9	840	6	<2	3	16	0.06	<10	<10	148	<10	26
96863	<40	2.87	1,815	<1	0.03	11	1,800	2	<2	3	865	0.01	<10	<10	12	<10	44
96864	<60	2.95	1,395	<1	0.04	9	1,130	2	<2	7	105	0.02	<10	<10	51	<10	46
96865A	<110	1.96	210	1	0.01	13	1,360	22	<2	7	43	0.01	<10	<10	32	<10	910
96865B	<40	1.90	290	3	0.03	13	1,110	4	<2	5	16	<0.01	<10	<10	48	<10	68
C6-6	<10	1.34	320	3	0.06	41	Intf.	4	<2	5	10	0.05	<10	<10	122	<10	224
C6-19	<80	0.03	710	4	0.01	8	50	2	<2	2	9	<0.01	<10	<10	5	<10	10
C6-46	<30	0.14	40	<1	0.05	3	210	10	<2	1	6	0.01	<10	<10	8	<10	14
C6-63	<10	0.27	230	1	0.22	20	Intf.	6	<2	3	67	0.03	<10	10	37	30	38
C6-64	<10	1.51	750	<1	0.16	34	310	4	<2	7	98	0.12	<10	<10	86	<10	64
C6-65	<10	0.06	680	<1	<0.01	6	20	36	4	1	37	<0.01	<10	<10	38	30	26

Abbreviations: ppm, parts per million; ppb, parts per billion; intf., interference.

Table 2. Comparison of element concentrations in mineralized rocks from stratabound mineral occurrences in upper Paleozoic rocks from the Salida East quadrangle and the northern Sangre de Cristo Range.

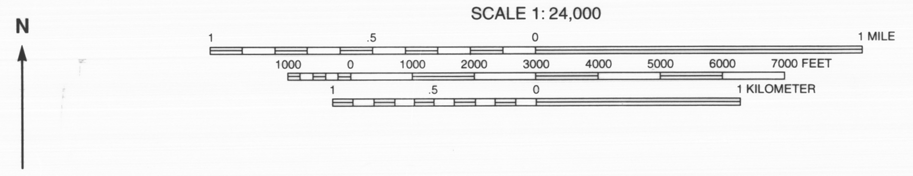
Salida East quadrangle (From Table 1)			Northern Sangre de Cristo Range (Lindsey and Clark, 1995)		
Element	Median, ppm	Range, ppm	Element	Median, ppm	Range, ppm
Ag	0.7	<0.2–6.4	Ag	<1	<1–16
Au	(ppb) <5	<5–20	Au	NR	
As	3.6	<2–10	As	5.7	0.7–26
B	NR		B	52	10–150
Ba	155	20–940	Ba	957	196–3,400
Co	10.6	4–32	Co	16	6–34
Cr	56	21–91	Cr	61	21–679
Cu	1,649	<1–>10,000	Cu	161	2–8,500
La	48	20–110	La	NR	
Mo	1.5	<1–6	Mo	5	<2–43
Ni	21	9–52	Ni	30	7–61
Pb	8.9	<2–22	Pb	51	5–7,480
Sc	6.1	3–8	Sc	NR	
Sr	121	16–865	Sr	NR	
Th	NR		Th	14.3	7.3–30.1
U	<10	<10–30	U	52.7	3.55–1,080
V	39	12–51	V	110	38–1,730

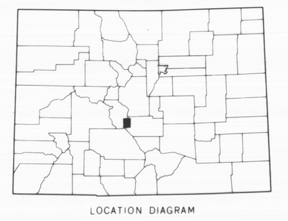
COLORADO GEOLOGICAL SURVEY
DIVISION OF MINERALS AND GEOLOGY
DEPARTMENT OF NATURAL RESOURCES

OPEN FILE MAP 97-6
GEOLOGIC MAP OF THE SALIDA EAST QUADRANGLE
CHAFFEE AND FREMONT COUNTIES, COLORADO
Booklet accompanies map

Base from U.S. Geological Survey, 1983

SCALE 1:24,000





Geology mapped in 1996

CONDENSED DESCRIPTION OF MAP UNITS

For a more complete description, see accompanying pamphlet.

QUATERNARY DEPOSITS AND ROCK UNITS

af — **Artificial fill (latest Holocene)**—Fill and waste rock deposited by humans during construction and mining operations. Artificial fill is composd mostly of unsorted silt, sand, and rock fragments

Qa — **Alluvium (late Holocene)**—Nonconsolidated interbedded lenticular layers of silty clay, clayey silt, silt, silty sand, sand, and sandy pebble and cobble gravel in active stream channels. Braided streams are common and contain numerous abandoned channels 1 to 2 m above the active channels

Qta — **Talus deposits (late Holocene?)**—Angular boulders and cobbles that form a rubbly deposit below cliff faces of the Harding Sandstone on the south side of Longs Gulch in northern part of quadrangle

Qls — **Landslide deposits (late Holocene)**—Earth-slip and mass-wasting deposits of local extent. Mapped only in lower Ute Creek

Qes — **Eolian sand and silt deposits (Holocene?)**—Light-tan, tan, and grayish-light-brown, fine-grained sand and silt, silty sand, and sandy pebble lag deposits that cover colluvium deposits and are downcut by modern alluvial channels

Qc — **Colluvium (Holocene)**—Lenticular layers of tan and grayish-yellow-brown clayey silt, silty sand, sand, pebbly and cobbly silt and sand, and silty and sandy gravel 5 to 15 m above active stream channels

Qao — **Older alluvium (lower Holocene)**—Nonconsolidated interbedded layers of silty clay, clayey silt, silt, silty sand, sand, and pebble, cobble, and boulder gravel 5 to 10 m above level of alluvium in active stream channels. Boulders are commonly angular and sub-angular

Qtu — **Tufa (Pleistocene to lower Holocene?)**—Tan, light-grayish-tan, light-grayish-yellow, and grayish-yellow, porous, banded planar-laminated limestone

Qty — **Younger till (Pleistocene)**—Composed of boulders, cobbles, and pebbles in a fine-grained matrix. Characterized by a prominent hummocky topography

Qto — **Older till (Pleistocene)**—Composed of boulders, cobbles, and gravel in a fine-grained matrix. Has a subdued hummocky topography or the morphology of a terminal moraine

Qt_5 — **Terrace five (Pleistocene)**—Poorly stratified lenticular silty sand, sand, pebbly sand, and sandy pebble gravel, sandy cobble gravel, pebbly cobble gravel, and sandy boulder gravel. Pebbles, cobbles, and boulders sub-angular to rounded. Upper surface is about 12 m above Holocene alluvium of Arkansas River

Qt_4 — **Terrace four (Pleistocene)**—Poorly stratified lenticular silty sand, sand, pebbly sand, and sandy pebble gravel, sandy cobble gravel, pebbly cobble gravel, and sandy boulder gravel. Pebbles, cobbles, and boulders sub-angular to rounded. Upper surface about 24 m above alluvium of Arkansas River

Qt_3 — **Terrace three (Pleistocene)**—Poorly stratified boulder, cobble, and pebble gravel in sandy and silty matrix. Pediment surface and terrace remnants about 45 m above Quaternary alluvium of Arkansas River. Occurs north of Arkansas River in southern part of quadrangle

Qt_2 — **Terrace two (Pleistocene)**—Poorly stratified boulder, cobble, and pebble gravel in sandy and silty matrix. Grayish-red and grayish brown soil marks upper surface of the terrace. Terraces and pediment deposits occur about 80 m above Quaternary alluvium of Arkansas River in the southern part of the quadrangle

Qt_1 — **Terrace one (Pleistocene)**—Poorly stratified boulder, cobble, and pebble gravel in sandy and silty matrix. Clasts are weathered. Terrace remnants and alluvial surface 120 to 130 m above Quaternary alluvium in the Arkansas River. Occurs south of Arkansas River

TERTIARY SEDIMENTARY AND VOLCANIC UNITS

Tg — **Alluvial gravel (Pliocene?)**—Rounded and well-rounded boulders, cobbles, and pebbles in a sandy and silty matrix. Clasts consist mostly of Proterozoic and lower Paleozoic rocks. Maximum diameter of boulders about 0.5 m. Exposed as isolated small patches at several places in the northeastern part of the quadrangle

Tdu — **Dry Union Formation (lower Pliocene to upper Miocene)**—Moderate-gray, light-gray, yellowish-gray, and greenish-gray, poorly consolidated siltstone, sandstone, conglomerate, and breccia that contains lesser amounts of interbedded silty shale and laminated shale. Pebble and cobble conglomerate occurs as lenticular beds that fill channels between siltstone and sandstone beds. Locally conglomerate is of unique provenance near exposures of volcanic rocks and Proterozoic metamorphic rocks. Only lower part of unit occurs in the map area (Wrucke and Dings, 1979)

Tr — **Rhyodacite (Miocene)**—Grayish-pink, light-gray, light-grayish-brown, and pinkish-brown, prominently banded, eutaxitic, silicic porphyritic lava flows. Glassy groundmass contains microlites and abundant phenocrysts of plagioclase and less abundant phenocrysts of biotite. Lithophysae prominent in some layers

Tab — **Andesite of Big Baldy Mountain (Miocene)**—Dark-gray, black, and purplish-black, aphanitic and porphyritic breccia and dense nonvesicular andesite and basalt. Plagioclase phenocrysts are prominent

Twa — **Andesite of Waugh Mountain (Miocene)**—Dark-gray, greenish-black, and dark-greenish-brown, locally vesicular andesite and basalt flows. Occurs only in southeastern part of map area (Wrucke and Dings, 1979)

Tan — **Andesite and basalt (Oligocene)**—Dark-gray, black, grayish-black, and dark-greenish-black, aphanitic, porphyritic, vesicular and nonvesicular basalt and andesite flows. Interbedded pahoehoe and aa flows, lahar breccia, and mudflows. Occurs only north of Salida

Badger Creek Tuff (Oligocene)

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. Some welded tuff is massive and some is glassy and has a prominent eutaxitic texture

Tbcn — **Nonwelded tuff member**—Light-grayish-white, white, grayish-orange, light-grayish-red, light-grayish-yellow, pumice-rich, non-welded ash-flow tuff, and minor air-fall tuff. Composed of multiple flows and forms prominent hoodoos. Locally occurs below the welded tuff member

Tbl — **Biotite latite (Oligocene)**—Light-gray, light-lavender-gray, and light-pinkish-gray latite porphyry. Prominently flow banded. Contains abundant plagioclase phenocrysts that are 4 to 7 mm in length and lesser amounts of biotite phenocrysts. Occurs north of Salida

Twm — **Wall Mountain Tuff (Oligocene)**—Light-gray, moderate-gray, light-brownish-gray, and grayish-red eutaxitic welded rhyolite ash-flow tuff that contains prominent sanidine and plagioclase phenocrysts (Wrucke and Dings, 1979). Flow foliation in glassy welded tuff is prominent, and degree of welding varies in map area from pumice-rich flow bands to densely welded glassy tuff

CRETACEOUS 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. Small stock 2.4 km east of Salida has a syenogabbro border phase. Biotite- and plagioclase-rich xenoliths locally common along borders at some places. May be weakly foliated near contacts

PALEOZOIC SEDIMENTARY ROCKS

P[P]s — **Sangre de Cristo Formation (Lower Permian and Upper Pennsylvanian)**—Regionally four informal units were subdivided in the lower (units 4 and 5) and upper members (units 6 and 7) of the Sangre de Cristo Formation by Pierce (1969). The boundary between the Pennsylvanian and Permian periods probably occurs in unit 5 (De Voto and Peel, 1972). Below, unit 4 of Peel is equivalent to member one, unit 5 is equivalent to member two, and unit 6 is equivalent to member 3 (Peel, 1969)

Ps_3 — **Member three (Lower Permian)**—Grayish-red and reddish-gray, pebbly and granular coarse-grained 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 dark-red, silty, micaceous shale. Polymict conglomerate beds are generally matrix-supported and composed of sub-angular to sub-rounded, granitic, metamorphic, and sedimentary clasts. Rare, thin, lenticular beds of olive-drab, dark-greenish-gray, and grayish-black fine-grained sandstone, siltstone, and shale are interbedded with dominant red-bed sequence. Trough crossbeds and channeled basal contacts are common in sandstone. Planar crossbeds, ripple cross-lamination, cuspate and linguoid ripples, climbing ripples, and parting lineation are common in medium- and fine-grained sandstone beds

$P[P]s_2$ — **Member two (Lower Permian and Upper Pennsylvanian)**—Olive-drab, grayish-green, dark-gray, greenish-black, and black fine-grained sandstone, argillaceous siltstone, and silty shale that contains rare interbeds of moderate-gray limestone and dolomite and gray gypsum. Sandstone and siltstone beds range from 2 to 30 cm thick and are fining-upward sequences commonly capped by argillaceous siltstone and shale. Primary sedimentary structures are most common in fine-grained sandstone and siltstone; structures consist of shallow channels, small-scale planar crossbeds, ripple cross-lamination, planar lamination, and water-expulsion structures. Limestone, dolomite, and gypsum beds occur at the base of this member; these beds range in thickness between 30 cm and 2 m

$[P]s_1$ — **Member one (Upper Pennsylvanian)**—Grayish-red and reddish-gray, pebbly and granular coarse-grained arkose, subarkose, and orthoquartzite interbedded with grayish-red and reddish-gray, medium- and fine-grained feldspathic sandstone 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 sub-angular to sub-rounded, granitic, metamorphic, and sedimentary clasts. Rare, thin, lenticular beds of olive-drab, dark-greenish-gray, and grayish-black fine-grained sandstone, siltstone, and shale interbedded with dominant red-bed sequence. Trough crossbeds and channeled basal contacts are common in sandstone. Planar crossbeds, ripple cross-lamination, cuspate and linguoid ripples, climbing ripples, parting lineation, are common in medium- and fine-grained sandstone beds

[P]m — **Minturn Formation (Middle Pennsylvanian)**—Dark-gray, gray, olive-drab, grayish-green, greenish-gray, and black fine-grained feldspathic sandstone, argillaceous and micaceous siltstone, and silty micaceous shale that form composite beds that range between 1- to 10-m thick. Sandstone and sandy siltstone are more common in the lower part of the unit, and siltstone and shale are more common in the upper part of the unit. Sedimentation units are fining-upward sequences that are capped by dark-colored shale. Primary sedimentary structures are small-scale planar crossbeds, ripple cross-lamination, planar lamination, and rib-and-furrow structures. Shallow channels occur at the base of some sandstone beds. Siltstone and shale are laminated and microlaminated, and some beds contain abundant plant fragments and some beds in the upper part of the formation are impure coal. Rare dark-gray and black limestone beds are fine-grained, argillaceous, fetid micrite that are generally 2- to 15-cm thick

[P]s — **Sharpsdale Formation (Middle Pennsylvanian)**—Grayish-red and reddish-gray, pebbly and granular coarse-grained arkose, subarkose, and orthoquartzite interbedded with grayish-red and reddish-gray, medium and fine-grained feldspathic sandstone and lesser amounts of micaceous, dark-red siltstone, and purplish-red, silty, micaceous shale. Pebbles and granules generally form framework-supported lenses composed of sub-angular to sub-rounded, granitic, metamorphic, and sedimentary clasts. Conglomeratic beds commonly fill shallow channels at the base of fining-upward sequences. Rare, thin, lenticular beds of olive-drab, dark-greenish-gray, and grayish-black, fine-grained sandstone, siltstone, and shale are interbedded with red-beds. Trough crossbeds and channeled basal contacts are common in sandstone. Planar crossbeds, ripple cross-lamination, cuspate and linguoid ripples, climbing ripples, parting lineation are common in medium- and fine-grained sandstone beds

[P]k — **Kerber Formation (Lower Pennsylvanian)**—Grayish-green, olive-drab, greenish-brown, and olive brown, conglomeratic coarse-grained arkose and subarkose interbedded with medium- and fine-grained sandstone, argillaceous and micaceous siltstone, silty micaceous shale, and moderate-gray biomicritic limestone that occurs at the lower and upper parts of the unit. 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 in coarse-grained rocks are trough and planar crossbeds, ripple cross-lamination, planar lamination, rib-and-furrow structures, and parting lineation. Shallow channels occur at the base of coarse-grained, conglomeratic sandstone beds. Primary sedimentary structures in fine-grained sandstone are ripple cross-lamination, climbing ripples, planar lamination, and ripple marks. Siltstone and shale 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 and 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 occurs in shallow channels at the base. Grayish-pink and grayish-red beds occur in zones in the lower and upper parts of the Leadville Limestone, and these zones are thinly bedded and flaggy, laminated and microlaminated, micritic limestone. Black laminated chert nodules and lenticular beds occur at some stratigraphic levels

Mlc — **Chert member**—Red, orange, grayish-red, reddish-brown, grayish-yellow, brown, and reddish-brown, banded, vuggy chert at the top of the Leadville Limestone

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

Dcd — **Dyer Dolomite Member**—Yellowish-gray, light-gray, and pale-yellowish gray dolomite. Dolomite is finely crystalline and microcrystalline, laminated and microlaminated, or bioturbated, and flaggy or massive-weathering. Some beds of laminated yellowish-gray chert are interbedded with dolomite. Lenticular interbeds of light-grayish-green and light-greenish-gray shale are interbedded with dolomite

Dcp — **Parting Quartzite Member**—Light-gray, light-grayish-red, pale-brownish-gray, and pinkish-gray, fine-grained, silica-cemented, dense, flinty, conchoidal-fracturing orthoquartzite. Some thin beds of dolomitic quartzite interbedded with thinly bedded and massive quartzite. Breccia is common. Sedimentary structures are masked by extensive recrystallization. Planar lamination and ripple cross lamination are preserved in some parts of the Parting Quartzite

Of — **Fremont Dolomite (Upper and Middle Ordovician)**—Dark-, moderate-, and light-gray, fine-grained, fossiliferous dolomite. Mottled in light-gray and dark-gray colors and laminated and microlaminated. Massive-weathering beds are 25-cm to 3-m thick. Contains rare black chert nodules. Fossils are dolomitized coral and fragments of brachiopods, trilobites, and echinoids

Oh — **Harding Sandstone (Middle Ordovician)**—Dark-reddish-gray, dark-grayish-orange, dark-grayish-red, light-gray, moderate-gray, and rusty orange, fine- and medium-grained, well-sorted orthoquartzite. Bedding and primary sedimentary structures obscured by pervasive replacement by diagenetic silica. 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 dolomite that contains a few beds of dark-gray limestone. Dolomite and limestone are laminated 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, and breccia occurs as lenses in the dolomite; at some places chert breccia forms the entire thickness of the Manitou Limestone

€s — **Sawatch Quartzite (Upper Cambrian)**—Light-gray, moderate-gray, and light-grayish-yellow, fine- and medium-grained, well-sorted, silica-cemented orthoquartzite and pebbly orthoquartzite. Pebbly quartzite contains sub-rounded and rounded vein-quartz clasts. The quartzite is massive weathering and bedding and primary sedimentary structures are commonly obscured by pervasive silica cementation. Faint crossbeds and ripple cross-lamination preserved at some places. Quartzite is commonly brecciated

PROTEROZOIC ROCKS

STRONGLY FOLIATED ROCKS

Xgd — **Granodiorite (Early Proterozoic)**—Gray, speckled, coarse- to very coarse-grained, prominently foliated granodiorite gneiss. Locally contains augen of quartz and feldspar as long as 6 cm. Foliation well developed near the contact with older gneiss (unit Xgn). Exposures in Salida East quadrangle are the prominently foliated border phase of a pluton that extends north of the quadrangle approximately 60 km. (Wrucke and Dings, 1979)

Xgn — **Gneiss (Early Proterozoic)**—Predominantly dark-gray to black, fine- to medium-grained quartz-biotite-muscovite gneiss that contains lesser amounts of amphibolite and light- to medium-gray feldspar-quartz-biotite gneiss. Commonly well foliated, and locally contains zones of migmatite and pegmatite. Gneiss contains epidote stringers and films on foliation planes. Some discontinuous zones of garnet-biotite phyllite are as thick as 8 m and contain copper carbonate and silicate minerals. Common accessory minerals include biotite, muscovite, magnetite, epidote, zircon, sphene, and allanite (Boardman, 1971). Amphibolite bodies are not foliated and appear to be sills and dikes that intrude gneisses. According to Boardman (1971) amphibolite consists of primary hornblende and plagioclase and lesser amounts of biotite, pyroxene (diopside), and quartz. Actinolite occurs in zones of altered amphibolite

SLIGHTLY FOLIATED ROCKS

Xb — **Basalt (Early Proterozoic)**—Dark-gray to black, predominately aphanitic to fine-grained basalt. Contains altered plagioclase crystals, strongly pleochroic hornblende crystals after pyroxene, and fine-grained chlorite. The plagioclase and hornblende are equigranular and range in size from less than 0.5 mm to, rarely, 2–4 mm. About half of the hornblende is very fine grained and occurs as radiating lath-like crystals throughout the basalt. Epidote and opaque minerals, probably magnetite, occur in trace amounts. In Dead Goat Gulch basalt is locally agglomeratic and vesicular. Breccias are common

Xg — **Gabbro (Early Proterozoic)**—Dark-gray to black, medium- to coarse-grained hornblende gabbro. Megascopically the rock contains light-orangish-tan crystals of plagioclase feldspar in a black hornblende matrix. Contact relations with the surrounding rock units are generally obscured. Contains medium-grained (2–5 cm) labradorite (An50–An60) and strongly pleochroic, prismatic, medium-grained crystals of hornblende after pyroxene. Chlorite and epidote occur in trace amounts as alteration products of the hornblende

Xvs — **Interbedded volcanic and sedimentary rocks (Early Proterozoic)**—Interbedded tan felsic volcanic rocks, dark-gray and black basalt, and medium-gray, light-gray, grayish-tan, and black, fine-grained to very fine-grained metaquartzite, metasiltstone, and metagraywacke. In sedimentary rocks graded couplets, ripple cross-lamination, small-scale crossbeds, planar lamination, and microlamination are prominent. Interbedded felsic volcanic rocks may preserve phenocrysts of quartz and feldspar. Interbedded basalt is aphanitic to fine grained, porphyritic, and massive or vesicular. Vesicles are filled with carbonate minerals or are vadose. Quartz veinlets occur locally and are 5 to 10 mm wide. Epidote is common on fracture and joint surfaces. In Dead Horse Gulch the sequence contains interbedded, dark-grayish-green lithic graywacke that contains sub-angular and sub-rounded clasts of basalt and hornblende crystals as long as 5 cm in length

Xmgd — **Granodiorite of Methodist Mountain (Early Proterozoic)**—Medium-gray, fine- to medium-grained granodiorite. Only exposed in a small area south of Cleora on the southern edge of the quadrangle

Xp — **Pegmatite (Early Proterozoic)**—Consists mainly of large crystals of quartz, microcline, albite, muscovite, and accessory biotite, garnet, beryl, and magnetite. Pegmatite bodies are zoned or unzoned. Masses of pegmatite range in diameter from 0.1 m to several tens of meters wide and several hundred meters long. Pegmatites commonly intrude the strongly foliated gneiss, and some of pegmatites form irregular bodies as long as 500 m. Pegmatite bodies rarely intrude slightly foliated rocks, range in length from 0.5 m to 10 m, and are too small to appear on the map

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

25 **Inclined**

Vertical

Overturned

Strike and dip of foliation in metamorphic rocks

35 **Inclined**

Vertical

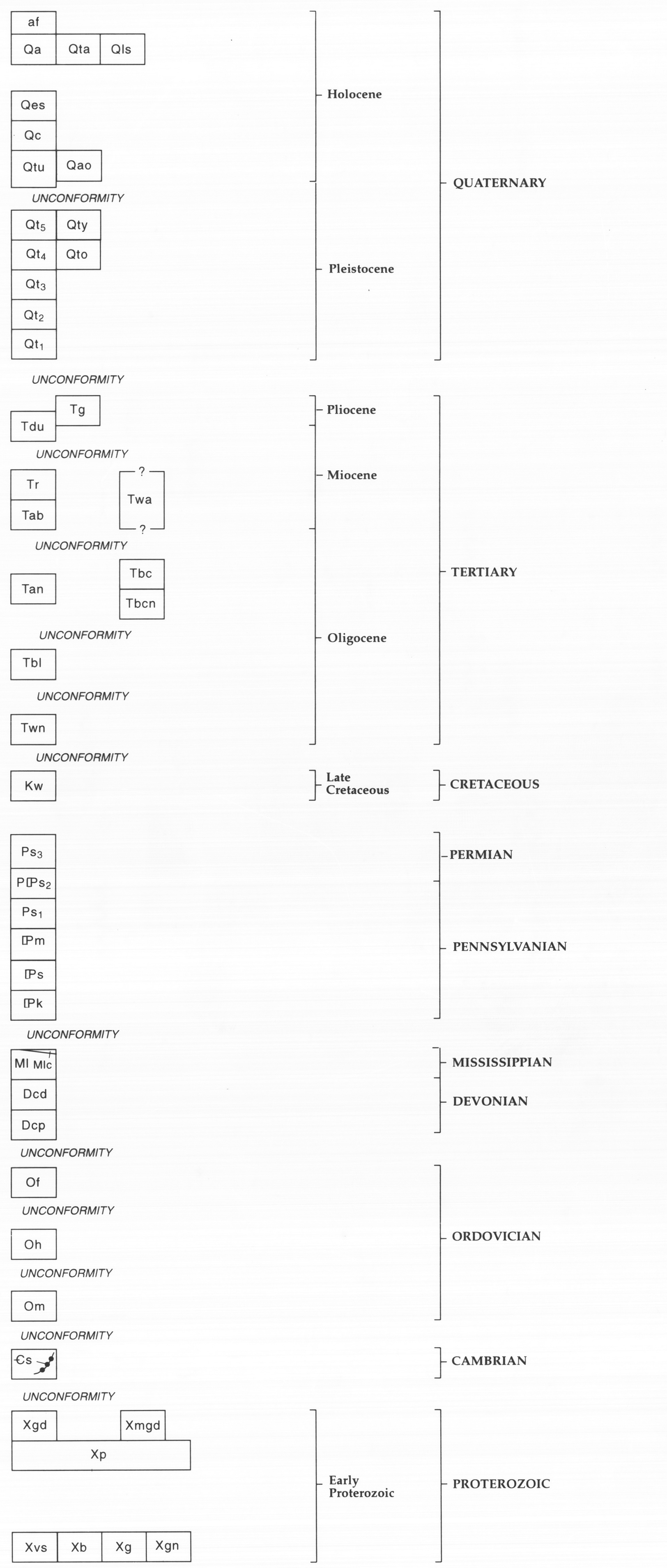
45 **Strike and dip of foliation in volcanic rocks**

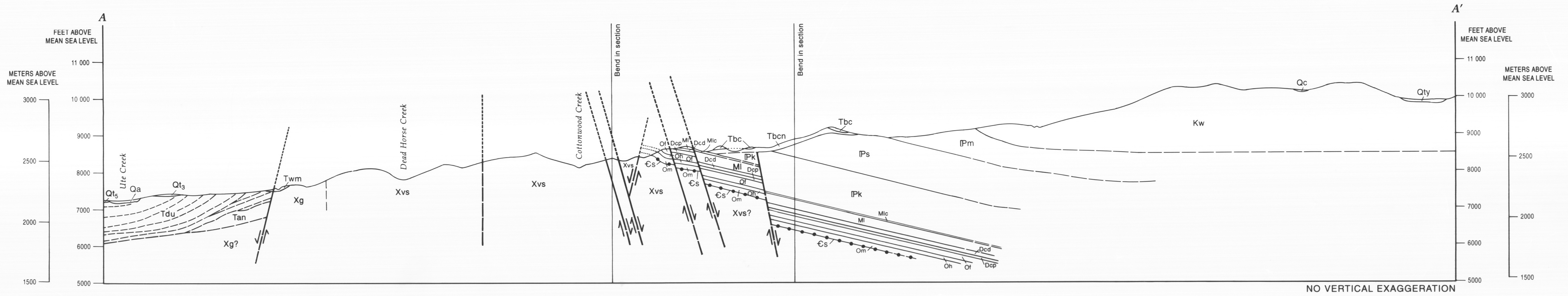
Form lines that show approximate trends of beds in subsurface. Used only on cross section A–A'

Adit

96861 **Sample location and sample number**—See Tables 1 and 2

CORRELATION OF MAP UNITS





GEOLOGIC MAP OF THE SALIDA EAST QUADRANGLE, CHAFFEE AND FREMONT COUNTIES, COLORADO

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

1997