



CORRELATION OF MAP UNITS

Qp	Qoo	Holocene	QUATERNARY
Qs	Qos	Pleistocene	
Qm	Qms	Pliocene and Miocene	
Ql	Qls	Oligocene	
Tm	Tms	Tertiary	TERTIARY
Tkda	Tkds	Paleocene	
Ki	Kis	Upper Cretaceous	CRETACEOUS
Kj	Kjs	Lower Cretaceous	
Jm	Jms	Upper Jurassic	JURASSIC
Jl	Jls	Triassic	
Pm	Pms	Permian	PERMIAN
Pp	Pps	Pennsylvanian	
Cm	Cms	Cambrian	PRECAMBRIAN Y
Yp	Yps	1.04 billion years	
Xp	Xps	1.44 billion years	
Xc	Xcs	1.72 billion years	
Xm	Xms	1.72 billion years	PRECAMBRIAN X
Xl	Xls	1.72 billion years	

GEOLOGIC UNITS OF THE FRONT RANGE URBAN CORRIDOR—A RECORD OF HISTORY

The geographic distribution of the geologic units of the Front Range Urban Corridor reflects their ages and history, the oldest rocks forming the mountains and the youngest units occurring as an extensive surficial cover above the bedrock in the eastern parts of the Corridor and adjacent to major streams. Consolidated rocks younger than those of the mountains form the hogbacks and foothills that border the mountain front.

The history of events recorded by these units spans perhaps the billion years, for the oldest rocks of the mountains may be that old. The ancient granites, schists, and quartzites were intruded three times by molten rock material (magmas) that solidified into granitic rock at 1.7 billion, 1.4 billion, and 1 billion years ago. These old crystalline rocks (all more than a billion years old), which form the mountains of the Front Range Urban Corridor, were broken long ago by planes of movement or faults along which the rocks in many places were greatly sheared or crushed in wide zones.

Ancient mountains that were formed during the creation of these ancient rocks were worn down to an essentially flat surface by 300 million years (m.y.) ago; however, the record of events between a billion and 300 m.y. is missing in the Denver area. Near Colorado Springs the record takes us back to about 500 m.y. and indicates that for most of the time until 300 m.y. the region lay beneath the sea.

Between 300 m.y. ago and 67 m.y. ago, this region experienced two more invasions of the sea, the last one perhaps lasting about 30-50 million years. A great pile of sedimentary rocks about 10,000 feet thick accumulated during this period, most of it laid down on the floor of that last sea.

About 67 m.y. ago, the present mountains began to be uplifted, bending the sedimentary rocks at their flanks sharply as those on the crest were carried upward. The cretal areas were eroded as they rose, and the erosional debris was carried to the flanks of the mountains where it was deposited to form a great plain that soon was covered by vegetation. Volcanoes erupted along breaks or faults that formed the mountain front, and these volcanic materials were added to the growing pile of sediments. The mountains continued to rise, and the ancient core rocks were uncovered by erosion, and sediments continued to be deposited eastward until about 7 m.y. ago. Then, because of uplift of the entire region, including the Great Plains, the streams east of the mountains began to cut down through the pile of sediments they had deposited, and to excavate and carry away great volumes of material. The South Platte River at Denver now probably is 1,500-2,000 feet below the level of the former top of that huge pile of sediments.

During the Great Ice Age of the last two or three million years, a series of successively lower land surfaces or pediments were formed and finally the valleys were entrenched and the streams confined. During the peak of the wet glacial periods the swollen streams cut their valleys more actively, but, as the climate became drier and the stream volumes were reduced, the streams on the plain were able to transport their loads and the valleys were partially refilled with sediment. Each successively younger stage of valley cutting tended to be deeper than the earlier one, with one exception, and the deposits of the last glacial and early interglacial streams were left as terrace remnants along the younger valleys. Winds whipping across these valleys carried sand and silt eastward and southwestward and dropped it over much of the greater Denver area to form a widespread thick cover of sand and loess that now covers the bedrock of older sedimentary formations over much of the Denver area.

Because the preserved remnants of sediments deposited during the last few million years are progressively higher topographically with increasing age, height of a deposit above present stream level is a rough measure of age. Another measure of relative age is the degree of development of the soil profile that has formed on its surface. Because stream gradients are not uniform, relative height above stream level may be different in different stream valleys and at different distances downstream in the same valley. And, because of climatic, lithologic, and structural differences, soil profile development will vary considerably with altitude, latitude, and position relative to the mountains. These important criteria for determining units of similar lithology and texture, but of different ages, therefore, must be used with judgment and caution.

The geologic units that constitute this record are described below from youngest (top) to oldest (bottom).

DESCRIPTION OF MAP UNITS OF THE GREATER DENVER AREA (Front Range Urban Corridor Sheet)

Qp	POST-PINEY CREEK AND PINEY CREEK ALLUVIUM (UPPER HOLOCENE)—Gravel, sand, silt, and clay of modern stream flood plains and slightly older low terraces less than 6.1 m (20 ft) above stream level. Deposits of Bear Creek, Clear Creek, Boulder Creek, and South Platte River are coarse, cobbly gravel near the mountain front, decrease in grain size downstream. In streams east of the South Platte River the deposits are mainly sand. Sand, silt, and clay compose the deposits in small streams and wetlands. Thickness generally less than 6 m. Minor source of sound aggregate.
Qoo	COLLIUM (UPPER HOLOCENE)—Generally unconsolidated material deposited on slopes by gravity and sheetwash. Thickness generally more than 1.5 m. Includes talus.
Qls	LANDSLIDE DEPOSITS (HOLOCENE TO MIDDLE? PLEISTOCENE)—Slumps, debris flows, earthflows, rockfall avalanche deposits, and similar large masses of locally derived debris moved downslope by gravity.
Qes	WINDBLOWN SAND (LOWER HOLOCENE TO UPPER PLEISTOCENE)—Gravel, sand, silt, and clay forming alluvial terrace deposits commonly 7.6 to 12.2 m above present stream level. Includes post-Piney Creek alluvium of Scott (1962, 1963a). Deposits of major streams west of South Platte River are more coarse-grained near the mountains. Deposits of streams east of South Platte River are mostly sand. Commonly less than 7.6 m thick. Source of sound aggregate.
Ql	LOESS (UPPER PLEISTOCENE)—Silt with lesser amounts of clay and sand deposited by wind, generally downslope from areas of windblown sand.
Qlo	LOUVERS ALLUVIUM (UPPER PLEISTOCENE)—Gravel, sand, silt, and clay forming terraces as much as 20 m above present stream. Base of deposit locally as much as 9 m below present stream level. Underlies much of Piney Creek and Broadway alluvium in channels of major streams. Contains some calcium carbonate (CaCO ₃) in upper part and is cross-stratified in upper 3.6 to 4.5 m. Major source of commercial sand and gravel.
Qs	SLOOUM ALLUVIUM (PLEISTOCENE)—Bouldery cobble gravel near mountain front, decreases in grain size eastward away from mountains. Much calcium carbonate (CaCO ₃) in upper part where not removed by erosion. Many unsorted stones. Thickness generally less than 7.6 m. Forms gently sloping surfaces 24 to 36 m above present streams.
Qv	VERDOS ALLUVIUM (PLEISTOCENE)—Bouldery cobble gravel near mountain front, decreases in grain size eastward away from mountains. Much calcium carbonate (CaCO ₃) in upper part where not removed by erosion. Contains many unsorted stones. Locally contains bed of volcanic ash thought to be about 600,000 years old. Thickness averages about 4.5 m. Forms gently sloping surfaces 61 to 76 m above present streams.

ROCKY FLATS ALLUVIUM (PLEISTOCENE)—Bouldery cobble gravel near mountains, decreases in grain size away from mountains. Very bouldery in Rocky Flats area north and south of Coal Creek. Much calcium carbonate (CaCO₃) in upper part where not removed by erosion. Contains many unsorted stones. Commonly less than 7.6 m thick but contains some thicker channels. Forms gently sloping surfaces about 107 m above present streams.

NESSIUM ALLUVIUM (PLEISTOCENE)—Bouldery cobble gravel, near mountain front at levels higher than Rocky Flats Alluvium. Contains much calcium carbonate (CaCO₃) 2-5 m thick.

HIGH LEVEL GRAVEL DEPOSITS (PLEISTOCENE TO OLGOCENE)—Rounded to subangular pebbles, cobbles, and boulders as much as 6 m in diameter in sandy matrix. Boulders chiefly granite. Smaller sized material consists of granite, gneiss, schist, amphibolite, and other Precambrian rocks. Caps spurs and ridges about 300 m above present streams.

CASTLE ROCK CONGLOMERATE (LOWER OLGOCENE)—Indurated bouldery cobbly gravel composed mostly of Precambrian rocks exposed to the Front Range, but also contains some Tertiary volcanic rocks. The sandy matrix of the conglomerate is well-cemented by silica, but basal part of deposit locally is less cemented and softer than the main part of the formation. Generally less than 15 m thick. In eastern part of mapped area includes mudstone, claystone, siltstone, and sandstone that contain volcanic ash.

WALL MOUNTAIN TUFF (LOWER OLGOCENE)—Light gray fine-grained siliceous volcanic rock (74 percent silica). Most of the rock composed of deformed glass shards. Part of once-continuous ash-flow sheet that originated more than 160 km to the southwest. Probably less than 15 m thick in this area. Age about 35 m.y. (Leatt, Scott, and Obradovich, 1969). Has been used for crushed-rock aggregate for roads and has been quarried for use as building stone.

GREEN MOUNTAIN CONGLOMERATE (PALEOCENE)—Conglomerate, sandstone, siltstone, and claystone forming upper part of Green Mountain. Thickness about 198 m. Contains pollen and spore fossils of Paleocene age in lower 137 m (Scott, 1972).

DAWSON AND ARAPAHO FORMATIONS (PALEOCENE TO UPPER CRETACEOUS)—Sandstone, siltstone, claystone, and conglomerate. Where unit underlies the Denver Formation, it is called the Arapaho Formation. Where Denver Formation intertongues and pinches out to the south and east, the unit is called the Dawson Formation. Forms most of bedrock between Denver and Colorado Springs. As much as 610 m thick (Scott and Wobus, 1973). A conglomerate at the base of the Arapaho Formation is an important aquifer in the Denver area.

DENVER FORMATION (PALEOCENE AND UPPER CRETACEOUS)—Claystone, siltstone, sandstone, and conglomerate composed primarily of altered andesitic (volcanic) debris. Claystone and siltstone partly altered to montmorillonitic clay. Underlies most of Denver metropolitan area. Montmorillonitic clay swells when wet, and causes damage to buildings, roads, and other structures. Thickness 280 m.

SHOSHONITE (LOWER PALEOCENE)—Dark-gray porphyritic lava flows capped North and South Table Mountains and forming dikes near Balcon Reservoir (also includes Flagstaff Mountain sill near Boulder, dated at 64 m.y. by Hobbit and Larson, 1975). Includes Table Mountain Shoshonite (Scott, 1972) and monzonite and tuff of Van Horn (1972). These flows recognized in North Table Mountain and two flows recognized in South Table Mountain. Total thickness of flows about 73 m. Age of middle flow probably is 63-64 m.y. (Scott, 1972) and age of Balcon Reservoir intrusion is 62 m.y. (Hobbit and Larson, 1975).

LARAMIE FORMATION (UPPER CRETACEOUS)—Shale, claystone, siltstone, and sandstone containing coal beds, mainly in the lower part. Thickness variable but as much as 230 m. Source of coal, brick clay, refractory clay.

FOX HILLS SANDSTONE (UPPER CRETACEOUS)—Sandstone and interbedded shale that in many places contains marine mollusks. Forms sandstone ridges locally in areas of steeply dipping beds from the mountain front that stand up between topographically lower areas of Pierre Shale and Laramie Formation. The Fox Hills Sandstone is an important aquifer.

PIERRE SHALE (UPPER CRETACEOUS)—Olive-gray marine shale and interbedded sandstone. Thick sandstone (the Hygiene Sandstone Member) about 375 m above sea level. Thickness variable but locally more than 2,134 m (7,000 ft) thick. Bentonite beds in Pierre Shale have swelling properties that cause damage to roads, foundations, and other structures. Pierre Shale has been utilized as a source of clay for brick, tile, and expanded aggregate.

NORRARA FORMATION (UPPER CRETACEOUS)—Consists of an upper unit, the Smoky Hill Shale Member composed of interbedded soft calcareous shale and thin layers of limestone, about 122 to 152 m thick, and a lower unit, the Fort Hays Limestone Member composed of gray and dense limestone beds, about 9 to 12.2 m thick. Has been used as a source of cement rock and smaller limestone.

CARLE SHALE, GREENHORN LIMESTONE, AND GRANDS SHALE (BENTON GROUP, UNDIFFERENTIATED UPPER CRETACEOUS)—Consists of interbedded shale, sandstone, and limestone (the Carle Shale), a middle limestone formation (the Greenhorn Limestone), and a lower gray to black shale unit (the Grand S shale). Total thickness of the group is about 91 to 152 m.

DAKOTA GROUP (LOWER CRETACEOUS)—Consists of an upper interbedded sandstone and shale unit (the South Platte Formation) about 61 to 91 m thick, and a lower conglomeratic sandstone formation (the Lytle Formation) about 12 to 24 m thick. Forms the most prominent hogback ridge along mountain front, the so-called "Dakota hogback." The South Platte Formation contains refractory clay.

MORRISON AND RALSTON CREEK FORMATIONS (UPPER JURASSIC)—Red and variegated claystone and siltstone, gray and interbedded brown and yellowish-gray sandstone, minor interbeds of limestone and gypsum. Combined thickness about 122 m.

MORRISON, RALSTON CREEK, AND LYONS FORMATIONS, UNDIFFERENTIATED (UPPER JURASSIC TO UPPER PERMIAN)

LYONS SANDSTONE (PERMIAN)—Yellowish-gray to reddish-brown cross-bedded sandstone, conglomeratic near the top. Thickness about 58 m.

LYONS SANDSTONE AND FOUNTAIN FORMATION, UNDIFFERENTIATED

FOUNTAIN FORMATION (LOWER PERMIAN TO MIDDLE PENNSYLVANIAN)—Reddish-brown arkosic conglomerate and pebbly sandstone containing thin layers of dark reddish-brown shale. Forms red gneiss and monuments at Bear Rocks and Rockborough Park and flatlands west and southwest of Boulder. Thickness 512 to 610 m.

UNNAMED ROCKS (CAMBRIAN)—Represented on this map only by sandstone dikes thought to be equivalent to the Upper Cambrian Sawatch Quartzite (Scott, 1963b, p. 5).

PIKES PEAK GRANITE (PRECAMBRIAN Y)—White to orange-pink biotite or biotite-hornblende granite, granodiorite, and quartz-monzonite. Weathers to disaggregated mass of constituent minerals (called gneiss). Age about 1.04 billion years (Helge and others, 1967, p. 551).

PEGMATITE (PRECAMBRIAN Y AND X)—Very coarse-grained granitic rock in lenses, dikes, and irregular-shaped bodies. Composed mainly of quartz, feldspar, and mica. Some pegmatites have been mined for feldspar, scrap mica, and beryl.

SILVER PLUME QUARTZ MONZONITE (PRECAMBRIAN Y)—Coarse-grained to fairly fine-grained muscovite-biotite quartz monzonite. Locally foliated. Age about 1.44 billion years (Helge, 1969).

QUARTZ MONZONITE (PRECAMBRIAN X)—Light-brown to gray, fine-grained quartz monzonite with scattered biotite and muscovite flakes. Slightly younger than the Boulder Creek Granodiorite.

BOULDER CREEK GRANODIORITE (PRECAMBRIAN X)—Medium-baked and white medium- to coarse-grained, foliated granodiorite, locally porphyritic and may include some quartz monzonite. Age about 1.72 billion years (Helge and others, 1967, p. 565).

QUARTZITE (PRECAMBRIAN X)—White, reddish-gray, and black fine- to coarse-grained conglomeratic quartzite and some interbedded schist. Quartzites well-bedded and very hard.

SCHIST (PRECAMBRIAN X)—Silver-gray to dark-gray, well-foliated fine- to medium-grained mica schist, garnetiferous schist, sillimanitic schist, migmatitic biotite gneiss and actinolite, and other schistose lithologies. Commonly associated with gneiss and migmatite.

GNEISS (PRECAMBRIAN X)—Composed primarily of gray medium-grained foliated gneiss, consisting mainly of quartz, plagioclase, and biotite, and foliated micaceous schist. Includes large areas of migmatite and migmatitic gneiss near major bodies of Pikes Peak Granite, Silver Plume Quartz Monzonite, and Boulder Creek Granodiorite, as well as garnet, sillimanite, and cordierite-bearing gneisses.

FELSIC GNEISS (PRECAMBRIAN X)—Light-colored gneiss characterized by a predominance of quartz and feldspar. Biotite commonly forms less than 10 percent of the rock. Interspersed biotite-gneiss, hornblende gneiss, or amphibolite are locally abundant. Locally contains abundant sillimanite (20 to 30 percent of the rock).

AMPHIBOLITE, HORNBLLENDE, AND RELATED ROCKS (PRECAMBRIAN X)—Dark-colored rocks composed mainly of hornblende, quartz, plagioclase, biotite, and clinopyroxene in varying amounts. Commonly consists of interbedded hornblende gneiss, amphibolite, and other gneisses, including calc-alcic gneiss. Amounts of amphibolite and hornblende in unit not uniform but always sufficient to give an unusually dark appearance.

Base compiled by U.S. Geological Survey in 1972 from 1:250,000 quadrangle sheet 1985-1986. Limited revision from aerial photographs since 1971.

50,000-foot grid based on Colorado coordinate system, central area 5000-meter Universal Transverse Mercator grid 1983, zone 13, shown in blue.

Mean elevations are shown in parentheses.

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