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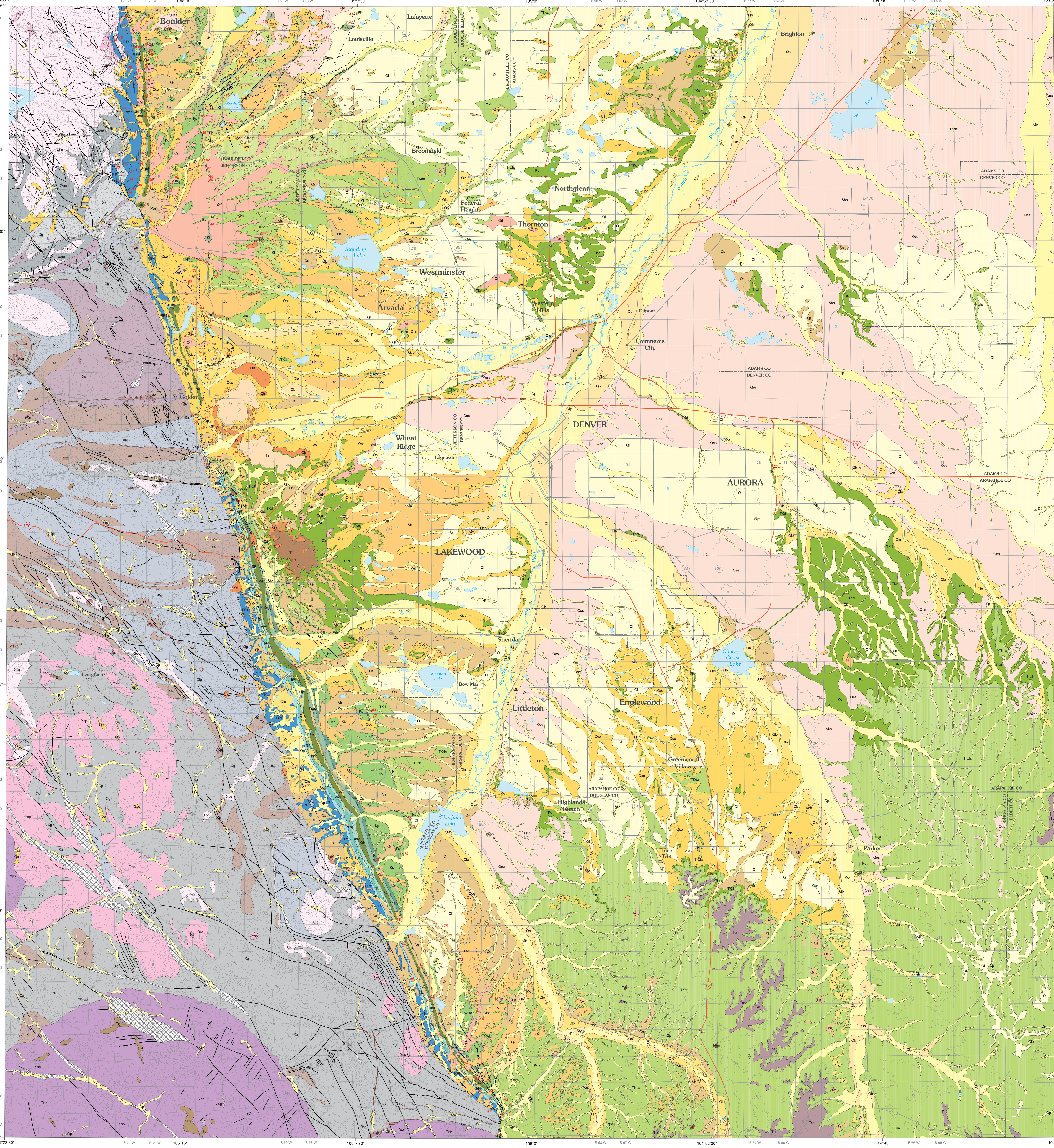

Base from U.S. Geological Survey, Digital Line Graphs (PLSS and Hypsography), 1995
County boundaries from Colorado Department of Local Affairs, 2001
Major highways and roads from NTAD 2001, U.S. Department of Transportation
Universal Transverse Mercator projection, zone 13, 1927 North American Datum

SCALE 1:100 000
CONTOUR INTERVAL 50 METERS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Geology compiled in 1973—1977
Spatial database by Theodore R. Brandt and Kyle E. Murray
Digital cartography by Theodore R. Brandt
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A SPATIAL DATABASE OF BEDDING ATTITUDES

Compiled By

Theodore R. Brandt, David W. Moore, and Kyle E. Murray

2003

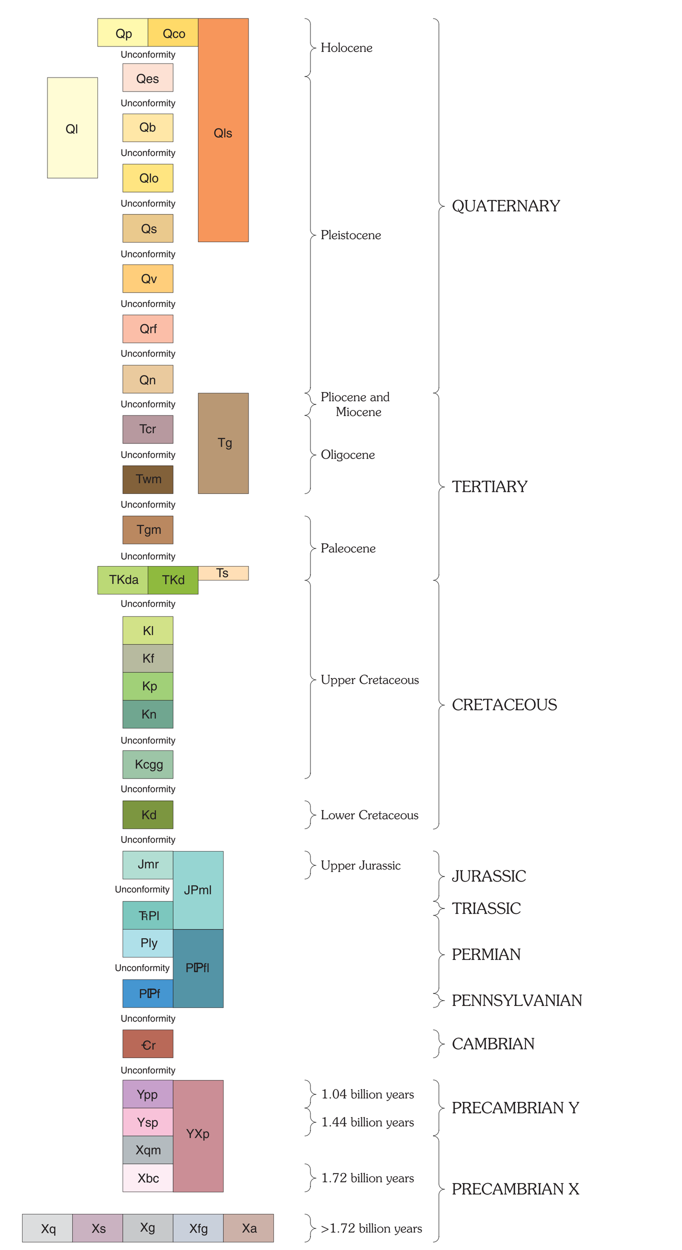
to accompany

GEOLOGIC MAP OF THE GREATER DENVER AREA, FRONT RANGE URBAN CORRIDOR, COLORADO

By

Donald E. Trimble and Michael N. Machette

CORRELATION OF MAP UNITS



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 two billion years, for the oldest rocks of the mountains may be that old. The ancient gneisses, schists, and quartzites were intruded three times by molten rock material (magma) 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.

Ancestral mountains that were formed during the creation of these ancient rocks were worn down to an essential 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 that period, most of it laid down of the floor of that last vast 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 crestal 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 at the mountain front, and these volcanic materials were added to the growing pile of sediments. The mountains continued to rise intermittently, the ancient core rocks were unroofed 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 until 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 plains were less 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 late 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 southeastward and dropped it over much of the greater Denver area to form a wide-spread thick cover of sand and loess that now conceals 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 of a deposit is the degree of development of the soil profile that has formed on its surface. Because stream sediments 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 textural differences, soil profile development will vary considerably with altitude, latitude, and position relative to the mountains. These important criteria for discriminating 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 from youngest (top) to oldest (bottom).

DESCRIPTION OF MAP UNITS

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 above stream level. Deposits of Bear Creek, Clear Creek, and 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, deposits are mainly sand. Sand, silt, and clay compose the deposits in small streams and tributaries. Thickness generally less than 6 m. Minor source of sound aggregate

Qco COLLUVIUM (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)—Fine to medium sand derived mainly from alluvium of major streams and distributed east and southeast of source area by wind

Qb BROADWAY ALLUVIUM (UPPER PLEISTOCENE)—Gravel, sand, silt, and clay forming alluvial terrace deposits commonly 7.6 to 12.2 m above present stream level. Includes pre-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 downwind from areas of windblown sand

Qlo LOUVIERS ALLUVIUM (UPPER PLEISTOCENE)—Gravel, sand, silt, and clay forming terraces as much as 20 m above present streams. Base of deposit locally as much as 9 m below present stream level. Underlies much of Piney Creek and Broadway Alluviums in channels of major streams. Contains some calcium carbonate ($CaCO_3$) in upper part and is iron-stained in upper 3.6 to 4.5 m. Major source of commercial sand and gravel

Qs SLOCUM 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 unsound 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 when not removed by erosion. Contains many unsound 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

Qrf ROCKY FLATS ALLUVIUM (PLEISTOCENE)—Bouldery cobble gravel near mountain front, decreases in grain size eastward away from mountains. Very bouldery in Rocky Flats area north and south of Coal Creek. Much calcium carbonate ($CaCO_3$) in upper part when not removed by erosion. Contains many weathered stones. Commonly about 4.5 m thick but contains some thicker channels. Forms gently sloping surfaces about 107 m above present streams

Qn NUSSBAUM ALLUVIUM (PLEISTOCENE)—Bouldery cobble gravel; near mountain front at levels higher than Rocky Flats Alluvium. Contains much calcium carbonate ($CaCO_3$). 2-5 m thick

Tg HIGH-LEVEL GRAVEL DEPOSITS (PLIOCENE TO OLIGOCENE)— 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

Tcr CASTLE ROCK CONGLOMERATE (LOWER OLIGOCENE)—Indurated bouldery cobbly gravel composed mostly of Precambrian rocks exposed in the Front Range, but also contains some chert and Tertiary volcanic rocks. The sandy matrix of the conglomerate is well-cemented by silica, but basal part of deposits 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

Twm WALL MOUNTAIN TUFF (LOWER OLIGOCENE)—Light-gray fine-grained silicic-volcanic rock (74 percent silica). Most of the rock composed of devitrified 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. (Izett, Scott, and Obradovich, 1969). Has been used for crushed-rock aggregate for roads and has been quarried for use as building stone

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

TKda DAWSON AND ARAPAHOE FORMATIONS (PALEOCENE AND UPPER CRETACEOUS)—Arkosic sandstone, siltstone, claystone, and (or) minor amounts of conglomerate. Where unit underlies the Denver Formation, it is called the Arapahoe 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 Arapahoe Formation is an important aquifer in the Denver Area.

TKd 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

Ts SHOSHONITE (LOWER PALEOCENE)—Dark-gray porphyritic lava flows capping North and South Table Mountains and forming dikes near Ralston Reservoir (also includes Flagstaff Mountain sill near Boulder, dated at 64 m.y. by Hoblitt and Larson, 1975). Includes Table Mountain Shoshonite (Scott, 1972) and monzonite and latite of Van Horn (1972). Three 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 Ralston Reservoir intrusive is 62 m.y. (Hoblitt and Larson, 1975)

Kl 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, and refractory clay

Kf 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 along the mountain front that stand up between topographically lower areas of Pierre Shale and Laramie Formation. The Fox Hills Sandstone is an important aquifer.

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

Kn NIOBRARA 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, hard dense limestone beds, about 9 to 12.2 m thick. Has been used as a source of cement rock and smelter limestone

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

Kd DAKOTA GROUP (UPPER 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 the mountain front, the so-called "Dakota hogback." The South Platte Formation contains refractory clay

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

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

TRPl LYKINS FORMATION (LOWER TRIASSIC AND UPPER PERMIAN)—Interbedded reddish-brown silty shale and limestone. Wavy-lamination limestone about 4.5 to 6.1 m thick occurs in lower middle part of formation which is as much as 137 m thick

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

PIPfl LYONS SANDSTONE AND FOUNTAIN FORMATION, UNDIFFER-ENTIATED

PIPf FOUNTAIN FORMATION (LOWER PERMIAN TO MIDDLE PENNSYLVANIAN)—Reddish-brown arkosic conglomerate and pebbly sandstone containing thin layers of dark reddish-brown shales. Forms red spines and monuments at Red Rocks and Roxborough Parks and flatirons west and southwest of Boulder. Thickness 512 to 610 m

Cr 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). Unit appears south of Jarre Canyon (at the midpoint of the south edge of map)

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

YXp 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

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

Xqm 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

Xbc BOULDER CREEK GRANODIORITE (PRECAMBRIAN X)—Mottled black and white medium- to coarse-grained, foliated granodiorite, locally porphyritic and may include some quartz monzonite. Age about 1.72 billion years (Hedge and others, 1967, p. 555)

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

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

Xg 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

Xfg 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. Interlayered biotite-gneiss, hornblende gneiss, or amphibolite are locally abundant. Locally contains abundant sillimanite (20 to 30 percent of the rock)

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

CONTACT

FAULT OR FRACTURE—Dotted where concealed

THRUST FAULT—Dotted where concealed. Teeth on upper plate

FAULT ZONE—Zone of intense fault brecciation, usually associated with numerous en echelon faults

HORIZONTAL BEDDING

20 INCLINED BEDDING—Showing strike and dip

VERTICAL BEDDING—Showing strike

65 OVERTURNED BEDDING—Showing strike and dip

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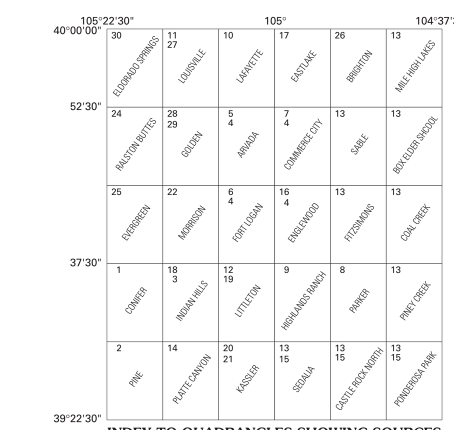

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