U.S. DEPARTMENT OF THE INTERIOR

U. S. GEOLOGICAL SURVEY

PRELIMINARY GEOLOGIC MAP OF THE STORM KING MOUNTAIN QUADRANGLE, GARFIELD COUNTY, COLORADO

by

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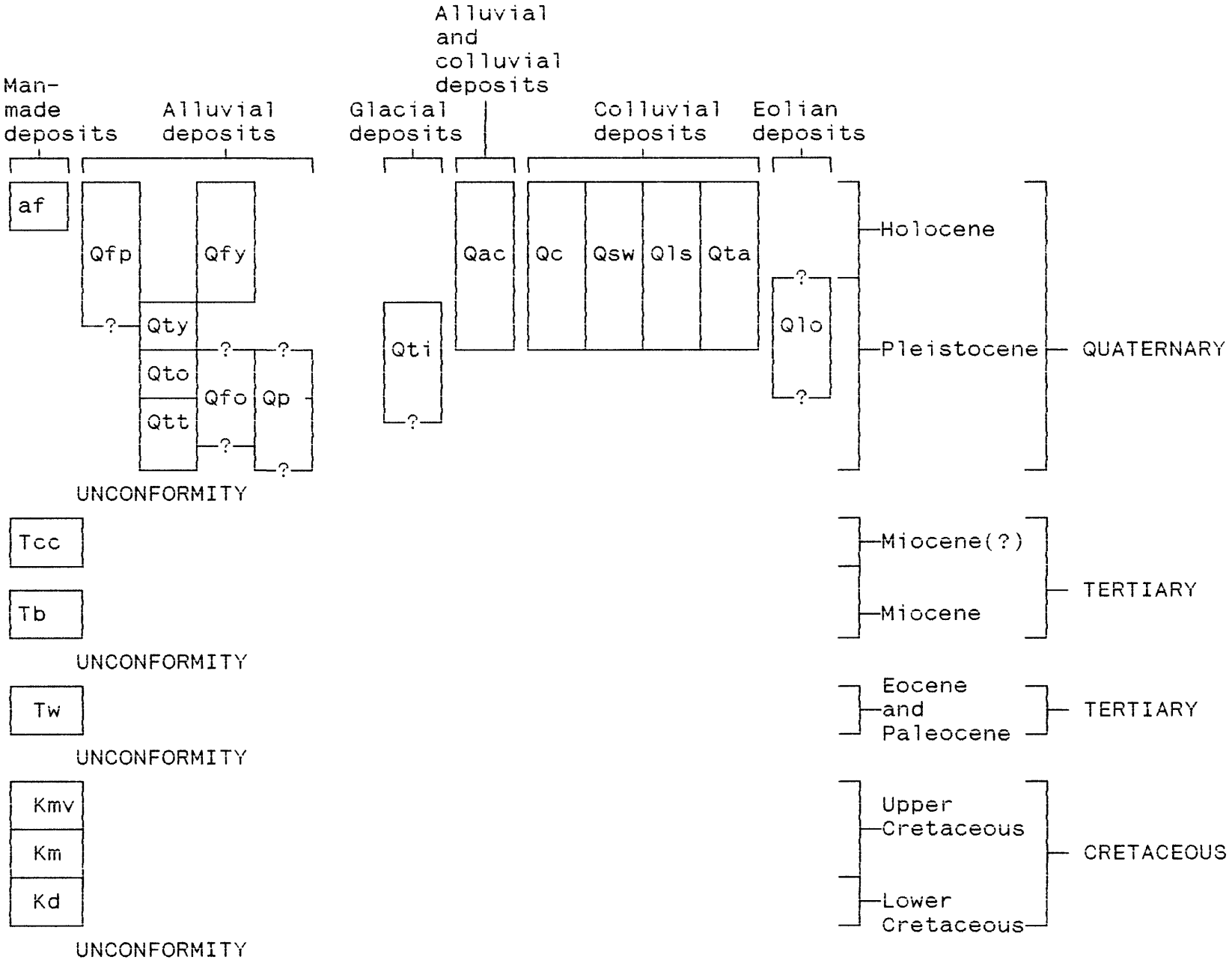
This map is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature

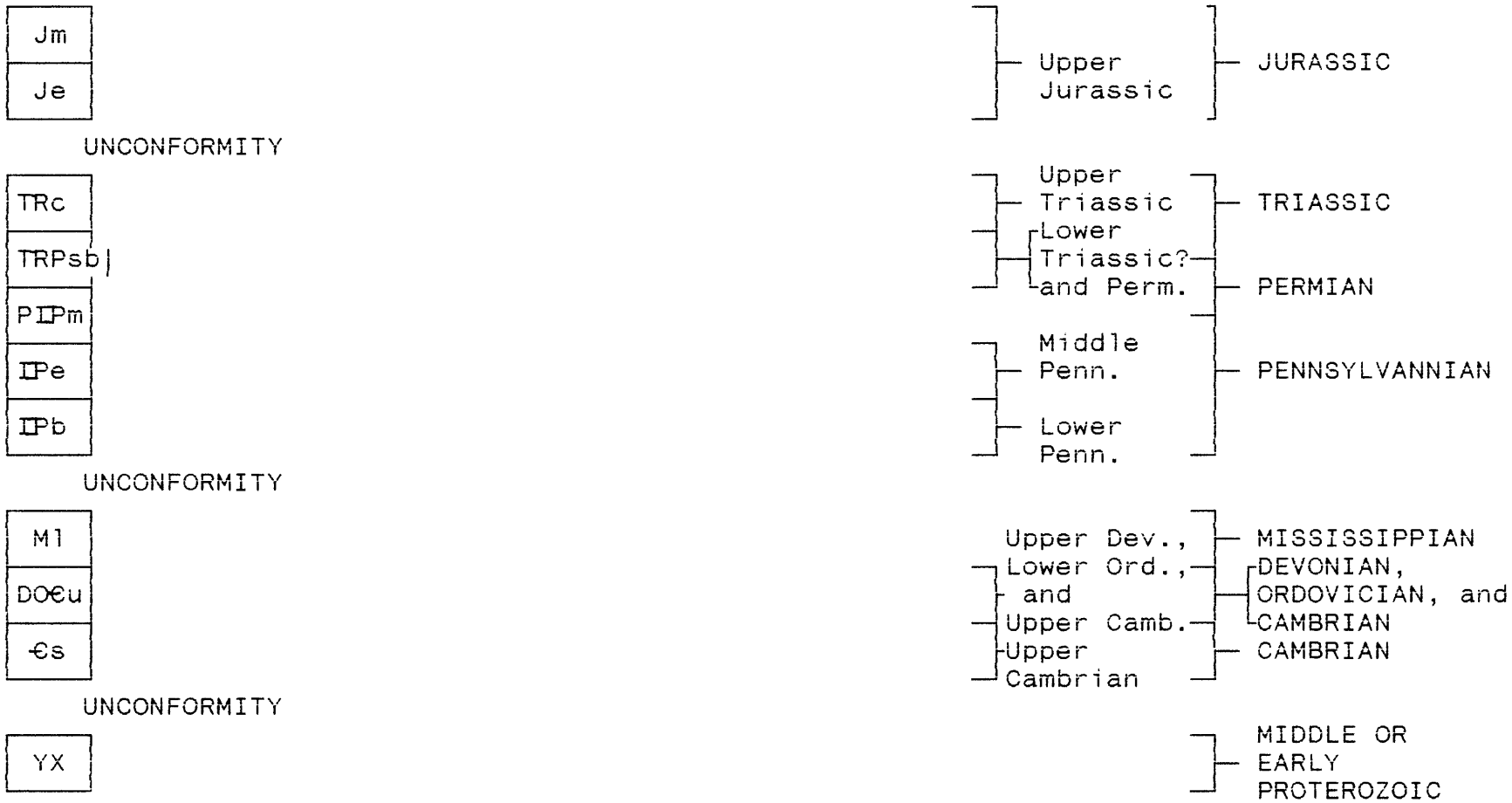
[1] Denver, Colorado

1993

Preliminary Geologic Map of the Storm King Mountain Quadrangle, Garfield County, Colorado
By George M. Fairer, Morris W. Green, and Ralph R. Shroba

CORRELATION OF MAP UNITS




Jm
Je
UNCONFORMITY
TRc
TRPsb
PIPm
IPe
IPb
UNCONFORMITY
Ml
DO€u
€s
UNCONFORMITY
YX
Upper Jurassic
JURASSIC
Upper Triassic
Lower Triassic? and Perm.
TRIASSIC
PERMIAN
Middle Penn.
Lower Penn.
PENNSYLVANNIAN
Upper Dev., Lower Ord., and Upper Camb.
MISSISSIPPIAN
DEVONIAN, ORDOVICIAN, and CAMBRIAN
Upper Cambrian
CAMBRIAN
MIDDLE OR EARLY PROTEROZOIC

DESCRIPTION OF MAP UNITS

[Surficial deposits shown on the map are estimated to be at least 3 ft thick. Fractional map symbols (for example, Qlo/Qto) are used where loess mantles older surficial deposits and the underlying deposits have been identified. Thin, discontinuous colluvial deposits, residual material on bedrock, and some of the artificial fills were not mapped. Also not mapped are four elongate areas above mined coal beds on the north side of the Grand Hogback, near Coal Ridge and Horse Mountain, where the ground surface is highly oxidized, fractured, and prone to subsidence (Stover and Soule, 1985). Divisions of Pleistocene time correspond to those of Richmond and Fullerton (1986). Age assignments for surficial deposits are based chiefly on the degree of modification of original surface morphology, height above stream level, and degree of soil development. Soil-horizon designations are those of the Soil Survey Staff (1975) and Guthrie and Whitney (1982). Most of the surficial deposits are calcareous and contain different amounts of primary and secondary calcium carbonate; stages of secondary calcium carbonate morphology are those of Gile and others (1966). Grain sizes given for surficial deposits are based on visual estimates and follow the modified Wentworth grade scale (American Geological Institute, 1982). In descriptions of surficial map units, the term clasts refers to the fraction greater than 0.08 in. (2 mm) in diameter, whereas the term matrix refers to the finer material. Dry matrix colors of the surficial deposits were determined by comparison with Munsell Soil Color Charts (Munsell Color, 1973). The colors of the surficial deposits correspond to those of the sediments and(or) bedrock from which they were derived. Surficial deposits derived from non-red sediments and bedrock are commonly light brownish gray (2.5Y 6/2), pale yellow (2.5Y 7/4), light gray (10YR 7/2), very pale brown (10YR 7/3, 8/3, 7/4, and 8/4), pale brown (10YR 6/3), light yellowish brown (10YR 6/4), light brown (7.5YR 6/4), and pink (7.5YR 7/4). Those derived from red sediments and bedrock are commonly light reddish brown (5YR 6/4 and 2.5YR 6/4), reddish brown (5YR 5/4 and 2.5YR 5/4), reddish yellow (5YR 6/6), light red (2.5YR 6/6), and red (2.5YR 5/6).]

MANMADE DEPOSITS—Earth and rock fragments placed in the former channel of the Colorado River

af **Artificial fill (latest Holocene)**--Compacted fill material composed mostly of silt, sand, and rock fragments. Mapped only in the former channel of the Colorado River beneath segments of Interstate 70 and beneath the nearby tracks of the Denver and Rio Grande Western Railroad. The unit locally includes small areas of flood plain and stream-channel deposits (Qfp), young fan alluvium (Qfy), young terrace alluvium (Qty), and colluvium (Qc). Thickness generally less than 30 ft

ALLUVIAL DEPOSITS—Silt, sand, and gravel in flood plains, stream channels, and terraces along the Colorado River and its major tributaries, in alluvial fans on flood plains and terraces, and in pediment deposits on gently sloping surfaces cut on bedrock

Qfp **Flood-plain and stream-channel deposits (Holocene and late Pleistocene)**--Chiefly clast-supported, slightly bouldery, pebble- and cobble-gravel in a sand matrix that is locally overlain by gravelly sand to sandy silt. Poorly to moderately well sorted and poorly to well bedded. Clasts are commonly subangular to rounded; their lithologies reflect those of the bedrock in the upstream areas. The unit occurs along the Colorado River and along Canyon Creek upstream of the terminal moraines (unit Qti). Low-lying areas are prone to periodic flooding. Deposits along Canyon Creek may contain more sand and silt than those along the Colorado River. The unit locally includes small alluvial-fan deposits (Qfy), low terrace deposits that are commonly less than 15 ft above modern stream level, and sheetwash deposits (Qsw), and locally may include some organic-rich deposits. The upper part of the unit may be a complex of cut-and-fill deposits of Holocene and late Pleistocene(?) age. The lower part of the unit is probably equivalent, at least in part, to the younger terrace alluvium (Qty). The unit is tentatively correlated with deposits in terrace T8 of Piety (1981) along the Roaring Fork River between Glenwood Springs and Carbondale, Colo. Thickness along the Colorado River greater than 45 ft near the western quadrangle boundary (Colorado Highway Department, unpublished data); maximum thickness along the Colorado River may be about 60 ft; maximum thickness along Canyon Creek may be 80 ft or more

Qfy **Younger fan alluvium (Holocene and latest Pleistocene)**--Mostly poorly sorted, clast- and matrix-supported, slightly bouldery, pebble- and cobble-gravel in a silty sand matrix, and locally pebbly and cobbly silty sand that contains thin (5-20 in.) lenses of sand, pebble gravel, and cobbly pebble gravel. Deposits derived from the Mancos Shale (Km) have a clayey silt matrix that is sticky when it is wet and has prominent shrinkage cracks when dry. Some of these deposits may contain expansive clays and have high shrink-swell potential. The unit locally contains boulders as long as 6 ft; some of the larger boulders were probably deposited by debris flows. Nonbedded to poorly bedded; beds are commonly less than 3 ft thick. Clasts are commonly angular to subangular sandstone north of the Colorado River and angular to subangular sandstone, angular to subrounded basalt, and locally angular to subangular shale and siltstone south of the Colorado River. The unit is undissected and was deposited chiefly by small intermittent streams graded to the flood plains of modern streams (Qfp) and to the tops of terraces that are underlain by younger terrace alluvium (Qty). Locally includes valley-fill deposits of intermittent streams, debris-flow deposits, sheetwash deposits (Qsw), and colluvium (Qc). Exposed thickness 10-60 ft; maximum thickness probably about 80 ft

Qty **Younger terrace alluvium (late Pleistocene)**--Stream alluvium that underlies terrace remnants that are about 40 ft above the Colorado River. The unit consists mostly of a poorly sorted, clast-supported, slightly bouldery, pebble- and cobble-gravel in a sand matrix. Where deposited by minor tributary streams, the upper part of the unit commonly consists of poorly sorted, clast-supported, bouldery, pebble- and cobble-gravel in a sand matrix that is overlain by about 3 ft of pebbly sand. Clasts in the lower part of the unit are commonly subrounded to rounded and are derived from a variety of sedimentary, igneous, and metamorphic rocks in the upstream areas. Near the mouth of South Canyon Creek, clasts in the upper part of the unit are mostly sandstone and a minor amount of siltstone and basalt. The unit is commonly overlain by about 3-10 ft of loess (Qlo) and by younger fan alluvium (Qfy). Unit Qty is probably equivalent in part to outwash of the Pinedale glaciation, which is about 12-35 ka (Richmond, 1986, chart 1A). Much of the glacial outwash along Canyon Creek and East Canyon Creek is buried by younger fan alluvium (Qfy) and is probably of Pinedale age. Unit Qty is tentatively correlated with deposits in terraces T7 and T6 of Piety (1981) along the Roaring Fork River between Glenwood Springs and Carbondale, Colo., and with deposits in terraces A and B of Bryant (1979) farther upstream between Woody Creek and Aspen, Colo. Exposed thickness 40 ft; maximum thickness possibly about 130 ft

Qto **Older terrace alluvium (middle Pleistocene)**--Stream alluvium that underlies terrace remnants about 130 ft above the Colorado River. The unit mostly is a poorly to moderately well-sorted, clast-supported, bouldery, pebble- and cobble-gravel and cobbly pebble gravel in a sand matrix that is overlain by about 15-30 ft of sand and pebbly sand. Locally thin beds of sandy pebble gravel near the base of the unit are cemented by fine-grained calcium carbonate. Clasts are chiefly subrounded to rounded sandstone, gneiss, quartzite, basalt, granodiorite(?), limestone, and dolomite deposited by the Colorado River and by Canyon Creek near its confluence with the Colorado. Alluvium along the Colorado upstream of the confluence of Canyon Creek contains abundant basalt boulders, some of which are as long as 6 ft The unit is locally mantled by 8-12 ft of loess (Qlo) and by older fan alluvium (Qfo). The morphologic development of the soil that is formed in the top of the unit and locally in the lower of two loess sheets that locally mantle the unit in the adjacent New Castle 7½-minute quadrangle (Green and others, 1993) suggests that unit Qto is of Bull Lake age (Shroba, 1989) and may be about 140-150 ka (Pierce and others, 1976; Pierce, 1979) or about 130-300 ka (late middle Pleistocene; Richmond, 1986, chart 1A). The unit is tentatively correlated with deposits in terraces T5 and T4 of Piety (1981) along the Roaring Fork River between Glenwood Springs and Carbondale and with deposits in terrace C of Bryant (1979) farther upstream between Woody Creek and Aspen. Exposed thickness 60 ft, maximum thickness possibly about 130 ft

Qtt **Oldest terrace alluvium (middle Pleistocene)**--Stream alluvium that underlies small terrace remnants that are about 220 and 300 ft above the Colorado River downstream of its confluence with Canyon Creek. The unit is mostly a poorly sorted, clast-supported, slightly bouldery, pebble- and cobble-gravel in a sand matrix. It locally consists of thin (5-15 in.) lenses and beds of sandy silt, silty sand, and sandy pebble gravel. The unit locally grades upward into about 20 in. of moderately well-sorted, clast-supported, pebble gravel in a sand matrix that is overlain by about 20-40 in. of slightly pebbly sand. Clasts are mostly subrounded to rounded and are derived from a variety of sedimentary, igneous, and metamorphic rocks in the upstream areas. Many pebbles and cobbles of biotite-bearing rocks in the upper part of the unit are weathered to gruss. A stage III K soil horizon is locally present in the top of the unit. The unit is mantled by 6-13 ft of loess (Qlo) and locally by about 15-30 ft of sandstone-rich older fan alluvium (Qfo), which is overlain by loess. The loess mantle locally consists of two or more sheets. The unit may be correlative in part with other terrace deposits within 30 mi of the quadrangle that contain or are overlain by the 620 ka Lava Creek B volcanic ash. The ash is about 300 ft above the Colorado River near the east end of Glenwood Canyon (Izett and Wilcox, 1983), about 290 ft above the Crystal River near Carbondale, (Piety, 1981) and about 260-280 ft above the White River near Meeker, Colo. (J.W. Whitney, U.S. Geological Survey oral commun., 1992; Whitney and others, 1983). The unit is tentatively correlated with deposits in terraces T3 and T2 of Piety (1981) along the Roaring Fork River between Glenwood Springs and Carbondale, and with deposits in terrace D of Bryant (1979) farther upstream between Woody Creek and Aspen. Exposed thickness 20-30 ft; maximum thickness possibly about 80 ft

Qfo **Older fan alluvium (late and middle Pleistocene)**--Mostly poorly sorted, clast- and matrix-supported, slightly bouldery, pebble- and cobble-gravel in a silty sand matrix, sandy pebble gravel, and pebbly sand. Clasts are chiefly angular to subangular sandstone and locally shale and siltstone. Poorly bedded; commonly contains discontinuous beds and lenses. Unit underlies slightly dissected surfaces along the Colorado River that are mantled by about 3-10 ft of loess (Qlo). Deposited by Baldy Creek and small intermittent streams graded to the tops of terrace remnants composed of old terrace alluvium (Qto and Qtt). Locally includes valley-fill deposits of intermittent streams, debris-flow deposits, sheetwash deposits (Qsw), and colluvium (Qc). Exposed thickness 3-25 ft; maximum thickness possibly about 80 ft

Qp **Pediment deposits (middle Pleistocene)**--Gravelly alluvium and debris-flow deposits at two levels that overlie gently sloping surfaces cut on Mancos Shale (Km) north of the Colorado River, near the western quadrangle boundary. Mostly poorly sorted, clast-supported, bouldery, pebble- and cobble-gravel in a sandy silt matrix and poorly sorted, cobbly sandy pebble gravel to pebbly silty sand. Clasts are chiefly angular to subrounded sandstone. The unit probably consists of alluvium, debris-flow deposits, sheetwash deposits (Qsw), and colluvium (Qc). Nonsorted, bouldery, debris-flow(?) deposits are common in the upper part of the unit. Some of the sandstone boulders in the unit are as long as 6 ft. A stage III K soil horizon is locally formed in the top of the unit. The bedrock beneath the unit is locally slightly oxidized to a depth of 10 ft or more. The unit is dissected and is mantled by about 6-13 ft of loess (Qlo), which locally consists of two or more sheets. A reddish-yellow (5YR 6/6) argillic B horizon is locally present in the top of the basal loess sheet. The lower limits of the pediment deposits are about 280 and 360 ft above the Colorado River. The lower pediment deposit appears to be graded to a terrace remnant of the oldest terrace alluvium (Qtt) in the adjacent New Castle 7½-minute quadrangle. Exposed thickness commonly 6-10 ft; maximum thickness possibly about 50 ft

GLACIAL DEPOSITS--Ice-deposited silt, sand, and gravel in moraines near the junction of Canyon Creek and East Canyon Creek

Qti **Till (late and middle Pleistocene)**--Gravelly deposits that typically form steep-sided, bouldery, hummocky lateral and end moraines and ground moraine near the junction of Canyon Creek and East Canyon Creek. The unit is mostly an unstratified, unsorted, matrix- and locally clast-supported, slightly bouldery, pebble- and cobble-gravel in a matrix of slightly silty, poorly sorted sand. Clasts are mostly angular to rounded and include gneiss, schist, fine-grained metasedimentary rocks (greenstone (?) of Bass and Northrop, 1963), dolomite, limestone, quartzite, sandstone, and basalt. A few dolomite clasts are soled and striated. Boulders of Precambrian rocks on the moraines are as long as 24 ft. Closed depressions surrounded by low ridges are common on the terminal moraines. The closed depressions are probably partly filled by unmapped loess (Qlo) or loess-derived sheetwash deposits (Qsw). The map unit is locally overlain by young fan alluvium (Qfy), loess (Qlo), sheetwash deposits (Qsw), landslide deposits (Qls), and talus deposits (Qta); and it may locally include deposits of stratified drift. Terminal moraines in the valley of Canyon Creek are well preserved and are narrowly breached by stream erosion, whereas those in the valley of East Canyon Creek were modified or were removed by stream erosion and landsliding. The lower limit of glaciation is at an altitude of about 5900 ft along Canyon Creek. Much of the unit is probably of Pinedale age (about 12-35 ka, Richmond, 1986, chart 1A); although some of the outermost glacial deposits near the junctions of Canyon and Bearwallow Creeks and East Canyon and Possum Creeks, are probably of Bull Lake age (about 140-150 ka; Pierce and others, 1976 and Pierce, 1979 or about 130-300 ka; Richmond, 1986, chart 1A)and some of them may be of pre-Bull Lake age. Exposed thickness 3-30 ft, maximum thickness possibly about 500 ft in the large lateral moraine on the west side of Canyon Creek

ALLUVIAL AND COLLUVIAL DEPOSITS—Sand and gravel in flood plains and small alluvial fans along minor tributary streams, and sheets of pebbly sand that locally overlie alluvial deposits in valley bottoms and mantle the adjacent valley sides and hill slopes

Qac **Undivided alluvium and colluvium (Holocene and late Pleistocene)**--Chiefly undifferentiated flood plain and stream-channel deposits (Qfp), young fan alluvium (Qfy), and colluvial debris-flow (Qc) and sheetwash (Qsw) deposits. The alluvium typically consists of interbedded sand, pebbly sand, and pebble gravel and ranges from thin-bedded (0.2-6 in.) clayey, silty sand to thick-bedded (>3 ft), poorly sorted, clast- and matrix-supported, slightly bouldery, pebble- and cobble-gravel in a sand matrix. Sheetwash deposits are typically pebbly silty sand. Deposits derived from Mancos Shale (Km) commonly contain more silt and clay than those derived from the other bedrock units. Some of the deposits derived from the Mancos may contain expansive clays and have high shrink-swell potential. Alluvial deposits form flood plains, low terraces, and small alluvial fans along small perennial streams and some of the larger intermittent streams that are tributary to the Colorado River. Sheetwash deposits locally mantle the valley bottoms and the adjacent valley sides and hill slopes. Exposed thickness of the alluvium 3-30 ft; maximum thickness probably about 40 ft. Exposed thickness of the colluvium 3-6 ft; maximum thickness probably about 15 ft. The post-glacial sediments, which accumulated above the lateral moraine that dams the south end of the valley of Bearwallow Creek, may be as much as about 300 ft thick and may include some lacustrine deposits

COLLUVIAL DEPOSITS—Silt, sand, and gravel on valley sides and hill slopes that were mobilized, transported, and deposited by gravity and sheet erosion

Qc **Colluvium, undivided (Holocene and late Pleistocene)**--Mostly clast-supported, pebble-, cobble-, and boulder-gravel in a silty sand matrix, and gravelly, silty sand, sandy silt, and clayey silt. Deposits derived from the Mancos Shale (Km) commonly contain more silt and clay than those derived from the other bedrock units. Some of the deposits derived from the Mancos Shale and shale in the Morrison Formation (Jm) and Mesaverde Group (Kmv) may contain expansive clays and have high shrink-swell potential. Typically unsorted to poorly sorted and unstratified to poorly stratified. Clasts are typically angular to subrounded; their lithologic composition reflects that of the bedrock and(or) the surficial deposits from which the colluvium was derived. The unit locally includes sheetwash (Qsw) creep, debris-flow, and landslide (Qls) deposits that are too small to map separately or that lack distinctive surface morphology and could not be distinguished in the field or on aerial photographs. The map unit also locally includes thin loess (Qlo) mantles on older gently sloping colluvial deposits, small deposits of alluvium and colluvium (Qac) in and along minor drainageways, and probably small pediment deposits (Qp) on the north side of the Grand Hogback. Exposed thickness 6-13 ft; maximum thickness probably about 15 ft

Qsw **Sheetwash deposits (Holocene and late Pleistocene)**--Mostly pebbly, silty sand and sandy silt that are derived chiefly from weathered bedrock and loess (Qlo) by sheet erosion. Common on gentle to moderate slopes in areas underlain by the Wasatch Formation (Tw). The unit locally includes small deposits of loess (Qlo) and undivided alluvium and colluvium (Qac) in and along minor drainageways; may locally include creep (colluvium, Qc) and alluvial-fan (Qfy) deposits. Exposed thickness 6-15 ft; maximum thickness probably about 30 ft

Qls **Landslide deposits (Holocene and late Pleistocene)**--Chiefly unsorted and unstratified rock debris characterized by hummocky topography. Many of the landslides were complex (Varnes, 1978) and commonly formed on unstable slopes that are underlain by the Eagle Valley Evaporite (IPe), Maroon Formation (PIPm), Mancos Shale (Km), and Wasatch Formation (Tw). The younger deposits are commonly bounded upslope by crescentic headwall scarps and downslope by lobate toes. The unit includes debris-slide, rock-slide, debris-slump, slump-earth-flow, earth-flow, and debris-flow deposits (Varnes, 1978). The sizes and lithologies of the clasts and the grain-size distributions of the matrices of these deposits reflect those of the bedrock units and surficial deposits that were displaced by sliding. Deposits derived from the Mancos may contain expansive clays and have high shrink-swell potential. Deposits derived from the Eagle Valley Evaporite are prone to hydrocompaction and subsidence owing to the dissolution of gypsum, anhydrite, and halite. The unit locally includes sheetwash (Qsw), creep, and debris-flow (colluvium, Qc) deposits. Exposed thickness 6-15 ft; maximum thickness possibly 150 ft

Qta **Talus deposits (Holocene and late Pleistocene)**--Chiefly unsorted, crudely stratified, angular, cobbly and bouldery rubble on steep slopes below bedrock outcrops in the northern part of the quadrangle. The matrix is mostly sand and silt; some of the matrix in the older deposits may be of eolian origin. The upper part of the unit locally lacks matrix. The unit probably includes minor deposits of colluvium (Qc). Small talus deposits in the valleys of Canyon, East Canyon, and Possum Creeks were not mapped. Maximum thickness probably about 50 ft

EOLIAN DEPOSITS—Wind-deposited sand, silt, and clay that mantles level to gently sloping surfaces

Qlo **Loess (late and middle ? Pleistocene)**--Wind-deposited, nonstratified, friable, slightly plastic to plastic, slightly clayey, sandy silt and silty sand. The unit may locally include minor deposits of clayey silt. The grain-size distribution of slightly weathered loess in and near the quadrangle is about 23 percent sand, 55 percent silt, and 17 percent clay (Harmon and Murray, 1985, tables 13 and 14). Most of the sand-size particles are very fine and fine. The unit is prone to sheet erosion, gullying, and compaction when wet. Locally includes some loess-derived sheetwash (Qsw) and creep (colluvium, Qc) deposits. Deposited during two or more episodes of eolian activity. Deposition may have continued into Holocene time. Probably derived chiefly from flood plain sediments of the Colorado River and its major tributaries and possibly in part from (1) outcrops of Tertiary siltstone and mudstone in the Piceance Basin west of the quadrangle (Tweto, 1979) and (2) large areas of exposed sandstone in the Canyonlands region in southeastern Utah (Whitney and Andrews, 1983). The mapped distribution of loess is approximate, because it lacks distinct topographic expression. The unit commonly mantles level to gently sloping surficial deposits that are older than the younger fan alluvium (Qfy). Younger terrace alluvium (Qty) is mantled by one loess sheet, older terrace alluvium (Qto) is locally mantled by two loess sheets, and pediment deposits (Qp) and the oldest terrace alluvium (Qtt) are locally mantled by two or more loess sheets. The soil that is formed in the upper loess sheet on the older terrace alluvium commonly consists of the following sequence of horizons: A/Bw/Bt/Bk. The soil that is formed in the lower loess sheet on the older terrace alluvium contains more clay and calcium carbonate than the soil in the upper loess sheet and commonly consists of the following sequence of horizons: Bw/Btk/K/Bk. Where the upper loess sheet is composed of silty sand, the soils have weakly developed, non-prismatic argillic B horizons. Exposed thickness 6-13 ft

Tcc **Conglomerate on Canyon Creek (Miocene ?)**--Mostly poorly sorted, clast- and locally matrix-supported, cobbly pebble gravel in a sand matrix that is locally cemented by fine-grained calcium carbonate. Contains subangular to subrounded clasts derived from the Maroon Formation (PIPm) and older bedrock units. Lithologies include red sandstone, quartzite, limestone, and chert as well as red siltstone and igneous and metamorphic rocks reported by Bass and Northrop (1963). Much of the unit may be fan alluvium deposited by former streams flowing from the south flank of the White River Plateau. The conglomerate on the north flank of Storm King Mountain is slightly better sorted and contains fewer cobbles than the conglomerate near Canyon Creek. Because the conglomerate on Storm King Mountain lacks clasts younger than the Maroon Formation, it is mapped with the conglomerate on Canyon Creek rather than as a high-level deposit of the ancestral Colorado River. Near Canyon Creek, the unit is steeply folded in a west-northwest-trending syncline that may have formed as a result of the dissolution and subsidence of the underlying Eagle Valley Evaporites (IPe) (Bass and Northrop, 1963) or possibly late Cenozoic (post 10 Ma) differential movement associated with the renewed uplift of the White River Plateau (Larson and others, 1975). The western limit of the unit may extend as much as 3 mi beyond the western limit shown on the map. The unit was named by Bass and Northrop (1963) for outcrops along Canyon Creek in the Storm King Mountain quadrangle and was subsequently mapped as Browns Park Formation (Miocene) by Tweto and others (1978). Estimated thickness about 200 ft (Bass and Northrop, 1963)

Tb **Basalt (Miocene)**--Multiple(?) flows of alkali basalt and basaltic andesite (Larson and others, 1975). Unit may locally include interbedded siltstone and sandstone of the Browns Park Formation(?) (Larson and others, 1975). Cut by northwest-trending faults in the southeastern part of the quadrangle and caps Horse Mountain in the south-central part of the quadrangle. The top of the unit is as much as 2,900 ft about the Colorado River, and 2,700 ft above the Roaring Fork River in the adjacent Glenwood Springs 7½-minute quadrangle. Mapped as unit Tv2 by Larson and others (1975), who report whole-rock K-Ar ages of 9-14 Ma for the unit. The uppermost flow of a three(?)-flow sequence of unit Tv2 on Lookout Mountain, about 6 mi east of the eastern quadrangle boundary, yielded a whole-rock K-Ar age of 10.1±0.5 Ma (Larson and others, 1975). Unit thickens southward toward its possible source near Sunlight Peak (Bass and Northrop, 1963; Larson and others, 1975, fig. 6), about 5 mi south of the southern quadrangle boundary. Estimated maximum thickness in the Storm King Mountain quadrangle about 160 ft

Tw **Wasatch Formation (Eocene to Paleocene)**--Interbedded, variegated reddish-brown, reddish-purple, yellowish-brown, tan, and white conglomerate, conglomeratic sandstone, sandstone, siltstone, mudstone, and claystone unconformably overlying Mesaverde Group rocks. Sediment is first cycle, poorly sorted, and contains an abundance of metamorphic and granitic rock fragments; locally includes a basal cobble conglomerate as much as about 50 ft thick, designated the Ohio Creek Conglomerate by Bass and Northrop (1963, p.J58). Coarse clastic beds are trough crossbedded and vary in thickness, whereas fine-grained clastic beds are commonly thin. All beds are laterally discontinuous and, in general, are lenticular; overall, the sequence fines upward. About 5000 ft thick

Deposition of sediments occurred in a high-energy stream-dominated fluvio-lacustrine depositional setting during the initial phase of sedimentary infill of the Piceance basin as it formed during the Laramide orogeny. Sediments were derived form multiple source areas within the present Rocky Mountains as they were uplifted during the orogeny. Braided-stream and flood plain deposition dominated as the primary means of sediment transport and deposition. Differentiation of sediment into more discrete lithofacies within alluvial complexes was hindered by the relatively short distances from sediment source to depocenters in the basin and the apparent large volume of sediment.

Kmv **Mesaverde Group rocks undivided (Upper Cretaceous)**--Thin and thick beds of yellowish-brown and olive-gray carbonaceous mudstone interbedded with fine- to medium-grained silty sandstone, siltstone, and claystone; contains thin beds and pockets of silty and sandy pebble- and cobble-conglomerate; beds are generally massive. Locally interbedded with thin beds (seams) and laminations of coal; clinker is common. Contains several beds of white, well-sorted, short forset-crossbedded, quartzose sandstone in the lower part which contrasts strongly in appearance and physical character with surrounding silty carbonaceous beds. Except for white sandstone beds, in clastic sediments are generally poorly sorted, subangular, quartzose, and occur with an appreciable quantity of particulated coaly carbonaceous material; some beds are silica cemented; beds form prominent ridges and cliffs. About 5000 ft thick

Deposition occurred during the first major Cretaceous regressive marine cycle in the Rocky Mountain seaway following the Dakota transgressive cycle. Mesaverde deposition occurred dominantly in backshore areas and on deltas of the lower coastal plain where sediment-laden streams meandered between coal swamps, marshes, and mudflats behind a seaward-migrating shoreline. White sandstone beds preserved in the lower part of the sequence are the product of shoreline processes at the beach where surf- and wave-zone fluvial activity winnowed, sorted, and otherwise concentrated sand-sized particles.

Mineable coal beds (not mapped) in the Mesaverde occur in three zones in the map area; the lower zone consists of the Wheeler, D, and Allen coal beds located approximately at 900, 985, and 1500 ft, respectively, above the base of the unit. The middle zone consists of the C, B, and A coal beds located approximately at 2200, 2245, and 2330 ft, respectively, above the base of the unit. The upper zone consists of a single bed, the Keystone coal bed, located at about 3900 ft above the base of the unit (Gale, 1910; Bass and Northrop, 1963, p.J57).

Km **Mancos Shale (Upper Cretaceous)**--Dominantly light- to dark-gray carbonaceous shale locally containing thin lenticular beds of dark-gray and black fossiliferous (mainly fragmented) limestone and thin-bedded, very fine grained silicious silty sandstone; sediments of the Mancos Shale are generally limy. The formation contains white to yellowish-brown bentonite horizons (altered volcanic ash) a few inches thick. The upper and lower formation contacts of the Mancos are conformable. Unit about 5,500 ft thick. Generally underlies floors of valleys where it commonly is poorly exposed beneath Quaternary surficial deposits.

Deposition occurred primarily on the continental slope in transgressive (lower part of the sequence) and regressive (upper part of the sequence) submarine environments. Clastic deposition occurred by sediment settling and turbidity flow, whereas limestone formed by chemical precipitation. The dark-gray and black color of the rocks is attributed largely to the content of black coaly detrital organic matter apparently derived from the destruction of pre-Dakota coaly carbonaceous swamp deposits on the lower coastal plain by high-energy transgressive shoreline processes.

Kd **Dakota Sandstone (Lower Cretaceous)**--Yellowish-brown, medium- to coarse-grained, massive to crossbedded, quartzose sandstone containing pockets and lenses of gray chert-pebble and chert-cobble conglomerate; interbedded with dark-gray to black carbonaceous sandy siltstone and mudstone. Sandstone is commonly well sorted, angular, and well cemented with silica; forms prominent cliffs. Contact with underlying Morrison Formation is unconformable; contact with overlying Mancos Formation is conformable and locally intertongueing. About 175 ft thick

Deposition occurred on a lower coastal plain, at or near the shoreline, and in shallow marine embayments in a transgressive coastal setting. Sandstone and conglomerate were deposited in broad, distributary fluvial channels in which fluvial currents and, locally, offshore currents, influenced the structure and distribution of sand bodies. Intervening carbonaceous siltstone was deposited in mudflats, bays, and estuaries adjacent to the shoreline and in interfluvial areas adjacent to distributary channels in backshore areas. Much silt and carbonaceous material deposited in shallow water embayments and estuarie environments as well as farther seaward, may have been derived from the destruction of backshore swamp and marsh deposits as the high-energy shoreline environment migrated landward during the Dakota transgressive cycle.

Jm **Morrison Formation (Upper Jurassic)**--Medium- to light-green and maroon shale and mudstone and thin beds of silty sandstone (mainly in lower part) and dark-gray limestone. Sand fraction is mainly clear, gray, and white quartz grains; but, green, gray, and brown chert grains are common. Beds are thin and lenticular. About 500 ft thick

Deposition occurred in a lacustrine-dominated fluvio-lacustrine depositional setting. In the map area, the formation is a single lithofacies of a large fluvio-lacustrine system present throughout much of the Colorado Plateau and western interior of the United States.

Je **Entrada Sandstone (Upper Jurassic)**--Light-orange, medium- to very fine grained, well-sorted, crossbedded sandstone; sand grains are subrounded to well rounded and consist mainly of quartz. Contact with overlying Morrison Formation is sharp and conformable; contact with underlying Chinle Formation is unconformable. About 90 ft thick

Crossbed sets are large scale and apparently were formed by eolian activity in large, laterally extensive, dune fields. The basal few inches of the formation commonly consists of a layer of coarse-grained sand- and pebble-sized clasts of variegated chert and quartz. This layer apparently formed as a lag concentrate by wind deflation on the erosion surface developed on top of the underlying Chinle Formation. The formation is present throughout much of the Colorado Plateau and western interior of the United States.

TRc **Chinle Formation (Upper Triassic)**--Thinly and even-bedded red beds composed of shale and siltstone and thin beds of limestone and limestone-pebble conglomerate. Shale and siltstone are dark reddish brown to reddish orange; limestone and limestone-pebble conglomerate are light purplish red and gray. Shale and siltstone locally exhibit ripple marks and mudcracks. Contact with the State Bridge Formation below is gradational; contact with the Entrada Sandstone above is unconformable. About 300 ft thick

Grain-size of clastic units, primary sedimentary structures, and the presence of limestone-pebble conglomerate, suggest that deposition occurred in relatively shallow, seasonally dry, lacustrine depositional settings within large interfluvial areas (flood plains) or in broad shallow lakes which occupied the central part of the sediment-filled Eagle basin. The lack of coarse-grained, bed-load clastic sediment in association with the formation is characteristic. The formation is present throughout the southwestern United States and is represented in the map area by only a part of the distal, fine-grained lithofacies of the formation.

TRPsb **State Bridge Formation--(Lower Triassic? and Permiam)** Thin uniform beds of brick-red, reddish-brown, light-gray, and green and greenish-gray micaceous siltstone and shale interbedded locally with medium- to fine-grained crossbedded sandstone and thin beds of gypsum/anhydrite. Unit grades vertically into underlying and overlying formations. About 150-200 ft thick

The unit represents a seasonally active lacustrine-dominated fluvio-lacustrine sequence, deposited in the latter stage of Eagle basin sedimentary infill, at a time when lakes and ponds were numerous and streams feeding them were shallow, sluggish, and near base level within the basin.

PIPm **Maroon Formation (Permian and Pennsylvanian)**--
Principally red beds of conglomerate, conglomeratic sandstone, arkosic sandstone, siltstone, mudstone, claystone, and shale and minor thin beds of limestone. Conglomerate contains pebble- and cobble-sized material in a matrix of poorly sorted, fine- to medium- and very coarse grained angular sand. Sediments are first cycle; they contain appreciable mica; colors are dominantly bright reddish orange and reddish brown; limestone beds are dark gray. Beds are generally trough crossbedded and uniform in thickness; they range from a few inches to several tens of feet in thickness and rarely exhibit scoured bases. Fine-grained beds locally exhibit current and oscillation ripple marks and mudcracks. About 3,000 ft thick

Deposition occurred dominantly in braided streams and adjacent flood plains in the mid-fan area of a large coalescing, arid to semi-arid, alluvial-fan complex present in marginal areas of the Paleozoic Eagle basin.

The upper part of the formation in the map area includes possible stratigraphic equivalents of the Weber Sandstone of northeast Utah and northwest Colorado (Bass and Northrop, 1963, p.J47). Overlying the Weber, ranging from about 50 to 100 ft below the top of the formation is a 6 foot interval of fossiliferous dolomite and dolomitic limestone differentiated by past workers and named the South Canyon Creek Member of the Maroon Formation (Bass and Northrop, 1963, p J48).

IPe **Eagle Valley Evaporite (Middle Pennsylvanian)**--Principally gypsum and anhydrite and lesser amounts of halite; contains traces of potash salts. Evaporites contain interbeds of conglomerate, sandstone, siltstone, shale, and limestone. Beds range from a few feet to about 150 ft in thickness. Colors are grayish white, yellowish gray, black, dark gray; beds are intensely folded, faulted, and ductilely deformed by load metamorphism, diapiric upwelling, and flowage and hydration of anhydrite (Mallory, 1971). Intertongues with Belden Formation below and the Maroon Formation above; intertongues laterally with the Minturn Formation east of the map area. Formation incompletely exposed in the map area. Estimated total thickness 1000-1500 ft

Evaporites are the products of sea water evaporation in a restricted seaway that was present in the central part of the landlocked Paleozoic Eagle basin which formed between the Uncompaghre and Front Range uplifts (Mallory, 1971). The formation is a distal lithofacies of a large fluvio-lacustrine and marine depositional system present in the basin from early Pennsylvanian through early Triassic time. Associated fluvial and lacustrine clastic sediments in the Eagle Valley Evaporite sequence are products of transgressive and regressive fluvial and lacustrine deposition under arid to semi-arid climatic conditions adjacent to the seaway.

IPb **Belden Formation (Lower Pennsylvanian)**--Dark-gray to black and dark-brown micaceous and locally coaly shale; contains beds and lenses of dark-gray to black argillaceous limestone, claystone, mudstone, sandstone, conglomerate, and thin coal seams and partings; abundantly carbonaceous and fossiliferous; Bass and Northrop (1963, p.J36-J39) identify 258 fossil species, including algae, foraminifera, anthozoans, bryozoans, brachiopods, pelecypods, gastropods, scaphopods, cephalopods, annelids, trilobites, ostracods, blastoids, crinoids, echinoderms, and vertebrate remains. About 900 ft thick

The oldest in series of superimposed and formations deposited in the Eagle sedimentary basin which formed in the northwestern part of the Central Colorado Trough which lay between the Uncompaghre and Front Range elements of the Ancestral Rocky Mountains.

Deposition was dominantly in littoral and sublittoral marine and lower deltaic environments under moderately humid climatic conditions. Subenvironments included interfluvial, poorly and well-drained fresh- and salt-water swamps, marshes, lakes, ponds, bays, estuaries, and shallow distributary fluvial channels and channel complexes.

Based on the dominance of fine-grained sediment and apparent low depositional energies, sediment apparently accumulated near base level in the subsiding central part of the Eagle basin a relatively long distance from the basin margins and sediment source areas. East of the map area, in close proximity to the former basin margin, the Belden grades laterally into coarse-grained fluvial rocks of the Minturn and Maroon Formations; it conformably grades upward into evaporite sequence of the overlying Eagle Valley Evaporite (Mallory, 1971) called the Paradox Formation by Bass and Northrop,(1963)

Ml **Leadville Limestone (Mississippian)**--Light- to medium-gray, massive, fossiliferous, oolitic limestone, containing thin beds of sandy and crystalline dolomite in the lower part; limestone contains stringers of dark-gray chert. Locally, the upper part of the formation consists of as much as about 50 ft of red to reddish-purple claystone containing nodules of weathered limestone that was designated the Molas Formation by Bass and Northrop (1963). The limestone forms prominent cliffs and lies unconformably below the Belden Formation. About 250 ft thick

Limestone and dolomite beds apparently formed by chemical precipitation and limestone diagenesis in a deep marine depositional environment, whereas the claystone in the upper part of the formation probably formed as saprolite on a karst surface under moderately humid terrestrial conditions subsequent to lithification and uplift of the marine sequence in either late Mississippian or early Pennsylvanian time.

DO€u **Devonian, Ordovician, and Cambrian rocks undivided** -- Rocks containing abundant invertebrate marine fossils whose ages and stratigraphic occurrence allow recognition of the formations and members described below (see Bass and Northrop, 1963); sequence mapped as single unit. Includes, in descending order, the Chaffee Formation (Upper Devonian), Manitou Formation (Lower Ordovician), and Dotsero Formation (Upper Cambrian). Total thickness about 450 ft

Chaffee Formation (Upper Devonian) consists of the Dyer and Parting Members. Total thickness about 250 ft **Dyer Member**: Alternating limestone and dolomite locally containing stringers of chert; some beds are sandy. Grades upward into the Leadville Limestone. Lower part of member consists mostly of gray nodular limestone. 140-180 ft thick. **Parting Member**: Interbedded light-green and black shale, tan quartzite, and sandy dolomite; shale is micaceous; quartzite is medium to coarse grained and locally conglomeratic. Unconformably overlies the Manitou Formation. 60-95 ft thick

Manitou Formation (Lower Ordovician) consists of the Tie Gulch Dolomite and Dead Horse Conglomerate Members. Total thickness 120-150 ft **Tie Gulch Dolomite Member**: Cliff-forming unit consisting of light- to medium-brown, fine- to medium-grained, dolomite in thin, even beds; locally contains yellow chert stringers and thin beds of flat-pebble conglomerate. About 50 ft thick **Dead Horse Conglomerate Member**: Dominantly thin beds of gray flat-pebble limestone conglomerate similar to pebble- conglomerate beds in the underlying Glenwood Canyon Member of the Dotsero Formation; conglomerate beds alternate locally with thin beds and laminae of shale. Glauconite present in the lower part of the sequence but almost absent in the upper part. About 90 ft thick

Dotsero Formation (Upper Cambrian) consists of the Clinetop Algal Limestone and Glenwood Canyon Members. Total thickness about 100 ft
Clinetop Algal Limestone Member: Light-gray to lavender-white, flat-pebble limestone conglomerate and crystalline to dense algal limestone. Forms 3-5 ft thick caprock on the Dotsero Formation.
Glenwood Canyon Member: Light-gray to tan glauconite-bearing dolomite, greenish-gray limy shale, and thin beds of limestone and dolomite flat-pebble conglomerate. About 80-90 ft thick

Sediment composition and primary sedimentary structures indicate deposition of the sequence in shallow marine water through chemical precipitation of limestone, dolomite, and subaqueous clastic deposition of sand and silt. The abundance of limestone and dolomite flat-pebble conglomerate suggests periodic subaerial exposure of mudflats on which desiccation polygons formed that were, during later aqueous inundation, modified by oscillation to rounded pebble- and cobble-sized mudballs. Some units in the sequence also contain beds and laminations marked by oscillation ripples and hummocky crossbeds formed by agitation of relatively shallow water.

Cs **Sawatch Formation (Upper Cambrian)** Buff-white, light-brown, and pink, fine- to very course grained quartzite, sandstone (locally arkosic and conglomeratic), and dolomite; commonly in uniform beds 2-4 ft thick; contains thin beds and laminae of gray, green, and purple micaceous shale. Quartzite and sandstone are locally crossbedded and laterally continuous. Quartzite forms conspicuous cliffs. Dolomite in upper part of the formation locally contains glauconite. Upper and lower contacts covered or obscured by faulting. About 500 ft thick

Sediment apparently deposited under current-dominated shallow-marine conditions in the littoral and sublittoral zones.

YX **Precambrian rocks (Middle to Early Proterozoic)**--Dark-greenish-gray, reddish-black, and black quartz-biotite schist intruded locally by granite and pegmatite dikes. Contact with overlying rocks unconformable and poorly exposed.

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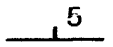
CONVERSION FACTORS

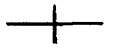
Multiply	By	To obtain
inches (in.)	2.540	centimeters(cm)
feet (ft)	0.3048	meters (m)
miles (mi)	1.609	kilometers (km)

CONTACT--Dashed where approximately located; dotted where concealed.

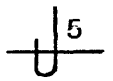
NORMAL FAULT--Dashed where approximately located; dotted where concealed. Bar and ball on downthrown side



STRIKE AND DIP OF BEDS



STRIKE OF VERTICAL BEDS



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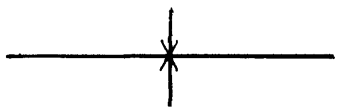
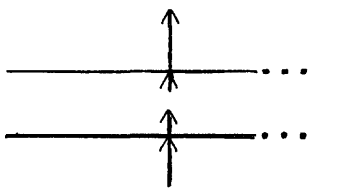
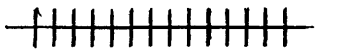


SYNCLINE--Showing trace of troughline.



MONOCLINE--Showing upper and lower fold axes. Arrows indicate direction of dip. Longer arrow indicates flatter dip. Dotted where concealed.



MORAINE CREST--Crest of prominent lateral and terminal moraines in map unit Qti on the west side of Canyon Creek