U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

PRELIMINARY GEOLOGIC MAP OF THE HORSE MOUNTAIN QUADRANGLE, GARFIELD COUNTY, COLORADO

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Open-File Report 93-699

[1] Denver, Colorado

1993

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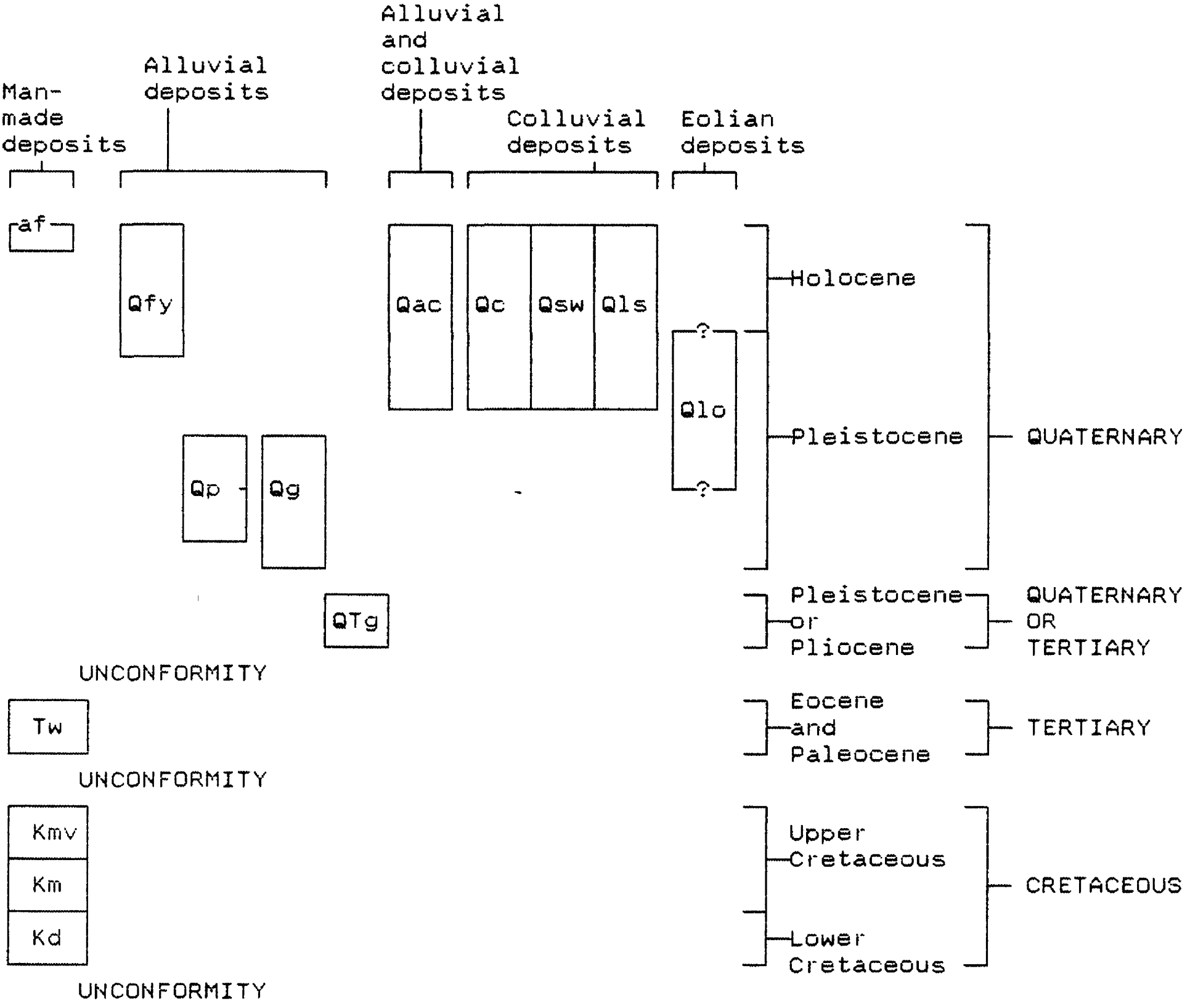
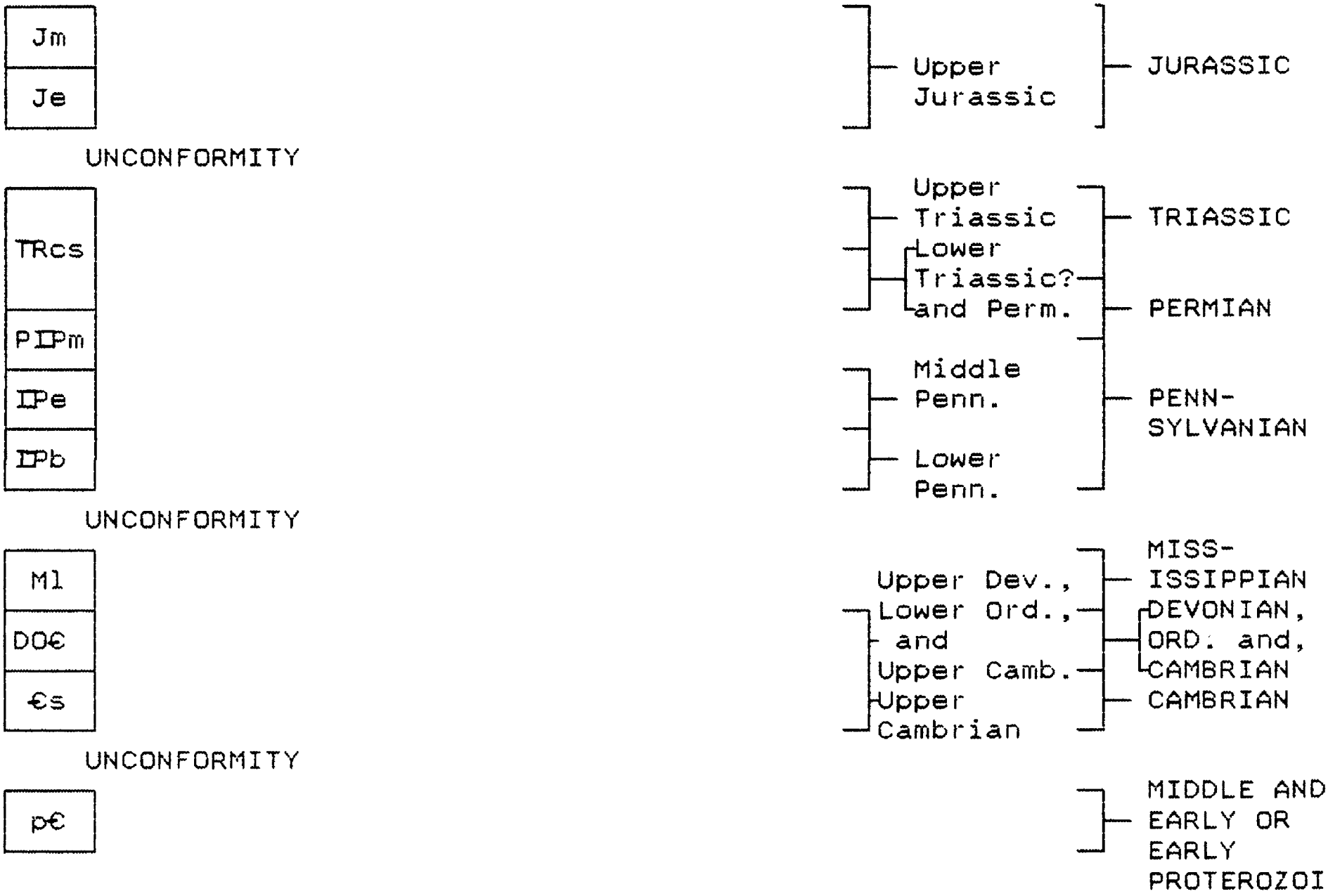
CORRELATION OF MAP UNITS




Jm
Je
UNCONFORMITY
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Upper Jurassic
JURASSIC
Upper Triassic
Lower Triassic? and Perm.
TRIASSIC
PERMIAN
Middle Penn.
Lower Penn.
PENN-SYLVANIAN
Upper Dev., Lower Ord., and Upper Camb.
Upper Cambrian
MISS-ISSIPPIAN
DEVONIAN, ORD. and, CAMBRIAN
CAMBRIAN
MIDDLE AND EARLY 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/Qp) 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. 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 Whitty (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 in the dam at Rifle Gap Reservoir near the southeastern corner of the quadrangle

af **Artificial fill**--Compacted fill material composed mostly of silt-, sand-, and granule- to boulder-sized material. The unit locally includes small areas of young fan alluvium (Qfy) and colluvium (Qc). Thickness about 120 ft

ALLUVIAL DEPOSITS-Silt, sand, and gravel in alluvial fans on valley bottoms, in pediment deposits on gently sloping surfaces cut on bedrock, and in stream gravels on hillsides and hilltops along West Rifle Creek

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 (5-25 in.) lenses of sand, pebble gravel, and cobbly pebble gravel. Deposits derived from the Mancos Shale (Km) commonly 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. The unit is undissected and was deposited chiefly by small intermittent streams graded to the valley bottoms of modern streams. Locally includes valley-fill deposits of intermittent streams, debris-flow deposits, and minor sheetwash deposits (Qsw) and colluvium (Qc). Exposed thickness 3-10 ft; maximum thickness possibly about 100 ft

Qp **Pediment deposits (middle Pleistocene)**--Gravelly alluvium and debris-flow deposits at three levels that overlie some of the gently sloping surfaces cut on the Wasatch Formation (Tw) near the southwestern corner of the quadrangle, on the Mesaverde Group rocks (Kmv) at the southern boundary of the quadrangle, and on Mancos Shale (Km) north of Rifle Gap Reservoir. The lower limits of the pediment deposits are about 120, 220, and 300 ft above stream level. 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 is locally overlain by 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 are as long as 6 ft. A stage III K soil horizon is locally formed in the top of the unit. The unit is dissected and is mantled by about 3-6 ft of loess (Qlo). Exposed thickness commonly 6-15 ft; maximum thickness possibly about 50 ft

Qg **Gravelly alluvium (middle and early Pleistocene)**--Small deposits of alluvium on hillsides and hilltops about 80, 160, 240, 300, 380, and 540 ft above West Rifle Creek near Rifle Gap Reservoir. The unit is poorly exposed, but it appears to consist mostly of poorly sorted, clast-supported, slightly bouldery pebble- and cobble-gravel in a sand matrix. The gravel probably contains lenses and thin beds of pebbly sand and slightly silty sand. Clasts are mostly subangular and subrounded sandstone along with minor amounts of limestone and chert and rare quartzite. Some of the sandstone boulders are as long as 4 ft. The unit is locally mantled by about 3 ft of loess (Qlo). Exposed thickness 8-15 ft; maximum thickness possibly 30 ft

QTg **High-level gravelly alluvium (early Pleistocene or late Pliocene)**-- Valley-fill or pediment(?) deposits that underlie a gently sloping surface about 750 ft above Butler Creek, in the northeastern corner of the quadrangle. The unit is poorly exposed, but it appears to consist of beds and lenses of poorly sorted, clast-supported, slightly bouldery, cobble- and pebble-gravel, sandy pebble gravel, and pebbly sand. The clasts are mostly angular to subrounded limestone along with minor amounts of chert and sandstone and rare quartzite. Some of the sandstone clasts are as long as 4 ft. The unit is mantled by a thin (probably less than 5 ft) layer of pebbly silty sand, which is probably loess (Qlo) that has been mixed with the underlying alluvium. Thickness possibly about 40 ft

ALLUVIAL AND COLLUVIAL DEPOSITS--Clay, silt, sand, and minor gravel in valley bottoms and sheets of pebbly, silty sand that locally mantle valley bottoms and the adjacent valley sides

Qac **Undivided alluvium and colluvium (Holocene and late Pleistocene)**--Chiefly undifferentiated alluvial flood-plain and stream-channel deposits and young fan alluvium (Qfy), and colluvial debris-flow (Qc) and sheetwash (Qsw) deposits that grade laterally into each other. The alluvial deposits typically consists of interbedded clay, sandy silty clay, sandy clayey silt, silty sand, and lenses of pebbly sand, sandy pebble gravel, and pebble- and cobble-gravel in a sand matrix. Sheetwash deposits are typically pebbly silty sand. Alluvial and colluvial deposits derived from Mancos Shale (Km) commonly contain more silt and clay than those derived from the other bedrock units. Some of the alluvial deposits derived from the Mancos contains numerous thin, buried, soil A horizons in the upper half of the unit and may contain expansive clays and have high shrink-swell potential. These deposits are prone to gullying and piping. Alluvial deposits form flood plains, low terraces, and small alluvial fans along the perennial streams and some of the larger intermittent streams. Sheetwash deposits locally mantle the valley bottoms and the adjacent valley sides. Exposed thickness of the alluvium 3-35 ft; maximum thickness probably about 50 ft. Exposed thickness of the colluvium 3-5 ft; maximum thickness probably about 15 ft

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 that is derived chiefly from landslide deposits (Qls) by sheet erosion. Common on gentle to moderate slopes and in depressions caused by sliding. The unit may locally include landslide (Qls) and creep (colluvium, Qc) deposits. Exposed thickness 3-5 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 Belden Formation (IPb), Maroon Formation (PIPm), Chinle Formation and State Bridge Formations, undivided (TRcs), Morrison Formation (Jm), Dakota Sandstone (Kd), Mancos Shale (Km), and Mesaverde Group rocks, undivided (Kmv). The younger landslide 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 and shale in the Morrison and Mesaverde may contain expansive clays and have high shrink-swell potential. The unit locally includes sheetwash (Qsw), creep, and debris-flow (colluvium, Qc) deposits. Exposed thickness 3-15 ft; maximum thickness possibly 300 ft. Some of the fault-bounded blocks of Leadville Limestone (Ml) in the northeastern part of the quadrangle were displaced in part by gravity sliding into the deeply incised valley of Middle Rifle Creek

EOLIAN DEPOSITS–Wind-deposited clay, silt, and sand that mantles gently sloping surfaces

Qlo **Loess (late and middle? Pleistocene)**--Wind-deposited, nonstratified, friable, slightly plastic to plastic when wet, slightly clayey, sandy silt. The unit may locally include minor deposits of clayey silt. The grain-size distribution of slightly weathered loess in the vicinity of 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 may include some loess-derived sheetwash (Qsw). Deposited during one 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 gently sloping pediment deposits (Qp). Exposed thickness 3-6 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 abundant metamorphic and granitic rock fragments. 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. Base of the formation not exposed.

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 40 to 80 Ma and before post-Laramide tectonism which formed the White River uplift. Sediments were derived from multiple source areas within the present Rocky Mountains as they were uplifted during the orogeny. The sediment was deposited in braided-streams and on flood plains. Differentiation of sediment into 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 and 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 contains thin beds and laminations of coal; clinker is common. Contains several beds of white, well-sorted, short forset-crossbedded, quartz sandstone in the lower part which contrast strongly in appearance and physical character with surrounding silty carbonaceous beds. Except for white sandstone beds, clastic sediments are generally poorly sorted, subangular, quartz, and contain an appreciable quantity of coaly carbonaceous particles; some beds are silica cemented; beds form prominent ridges and cliffs. About 4500 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 in which surf- and wave-zone activity winnowed, sorted, and otherwise concentrated sand-sized particles.

Five mineable coal beds and numerous thin beds and seams (not mapped because of poor exposure) occur in the Mesaverde in the vicinity of Rifle Gap (sec. 7 T. 5 S. R. 92 W.). Mineable coal beds range from 4 to as much as 30 ft in thickness. Correlation of area coal beds with those present in the New Castle area is uncertain (Gale, 1910; p. 120).

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 formational contacts of the Mancos are conformable. Unit about 5,000 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 formation) 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 backshore and shoreline processes.

Kd **Dakota Sandstone (Lower Cretaceous)**--Yellowish-brown, medium- to coarse-grained, massive to crossbedded, quartz sandstone containing pockets and lenses of gray chert-pebble and chert-cobble conglomerate and dark-gray to black carbonaceous sandy siltstone, mudstone, and shale. Sandstone is commonly well sorted, angular, and well cemented with silica. North of the Rifle Gap Reservoir and West Rifle Creek in the vicinity of sec. 20-28 and 35-36 in T. 4 S. R. 93 W., the formation consists dominantly of black carbonaceous shale; sandstone beds are a minor constituent, are relatively thin, and do not form a caprock as is characteristic elsewhere in the Dakota interval. As a result, the formation forms an extensive area underlain by large landslides which characteristically form a hummocky topographic surface overlying the Morrison Formation. Contact with underlying Morrison Formation is unconformable; contact with overlying Mancos Formation is conformable and locally intertongueing. 150-200 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 estuaries 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. 450-500 ft thick

Deposition occurred in a lacustrine-dominated fluvio-lacustrine environment. In the map area, the formation represents a part of the distal lithofacies of a large fluvio-lacustrine system which is 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. Locally is divisible into two ledges; lower is well-cemented and forms a prominent cliff. Upper is less well cemented and forms a rounded slope. Contact with overlying Morrison Formation is sharp and conformable; contact with underlying Chinle Formation is unconformable. About 100 ft thick

Crossbed sets are large scale and apparently were formed by eolian deposition 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.

TRcs **Chinle Formation and State Bridge Formation (Upper Triassic, Lower Triassic (?), and Permian)**

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 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 environments within large flood plains. The lack of coarse-grained, bed-load clastic sediment in 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.

State Bridge Formation--(Lower Triassic? and Permian) Thin uniform beds of reddish-brown, light-gray, and green and greenish-gray micaceous siltstone and shale and local medium- to fine-grained crossbedded sandstone and thin beds of gypsum and anhydrite. Unit grades vertically into underlying and overlying formations. Siltstone and shale beds locally exhibit ripple marks and mudcracks. 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 consists of pebbles and cobbles 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 on 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). Stratigraphically above the Weber equivalent, ranging from about 50 to 100 ft below the top of the formation, is a 10-15 ft 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).

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 beds and laminations; abundantly carbonaceous and fossiliferous; Bass and Northrop (1963, p.J36-J39) identify 258 fossil species of algae, foraminifera, anthozoans, bryozoans, brachiopods, pelecypods, gastropods, scaphopods, cephalopods, annelids, trilobites, ostracods, blastoids, crinoids, echinoderms, and vertebrate remains. About 900 ft thick

Forms basal unit in series of superimposed formations deposited in the Eagle sedimentary basin which formed in the northwestern part of the Central Colorado Trough 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, reefs, 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 at considerable distance from the basin margins and sediment-source areas. East of the map area, in 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, overlying the Leadville and mapped with it is a unit of red to reddish-purple claystone which ranges from 0 to as much as 50 ft in thickness. The claystone unit contains nodules of weathered Leadville Limestone but is composed dominantly of clay-sized resistate sediment. This unit was designated the Molas Formation by Bass and Northrop (1963).

The Leadville 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 marine depositional environment, whereas the claystone at the top of the formation probably formed as a weathered mantle 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.

DOC **Devonian, Ordovician, and Cambrian rocks undivided** -- Rocks in the vicinity of Parker Lake along Middle Rifle Creek in sections 12 and 13, T. 4 S., R. 93 W. 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, pale-yellowish-orange 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 yellowish-gray 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 pale-yellowish-orange glauconite-bearing dolomite, greenish-gray limy shale, and thin beds of limestone and dolomite-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 flooding, modified by oscillatory current action to form 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)**--Pale-orange-white, light-brown, and pink, fine- to very coarse 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.

pC **Precambrian rocks (Middle and Early or 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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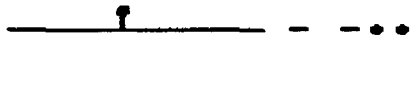
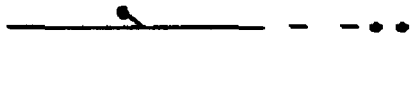
CONVERSION FACTORS

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

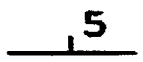
CONTACT--Dashed where approximately located; dotted where concealed.



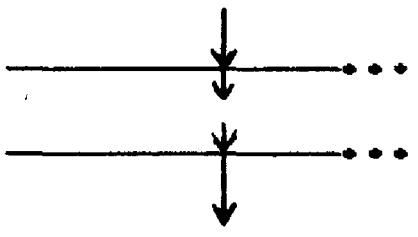
NORMAL FAULT--Dashed where approximately located; dotted where concealed. Bar and ball on downthrown side



SCISSOR FAULT--Dashed where approximately located; dotted where concealed. Bar and ball on downthrown side. Angle of bar and ball indicates direction of increased throw



STRIKE AND DIP OF BEDS



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