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

PRELIMINARY GEOLOGIC MAP OF THE RIFLE FALLS QUADRANGLE, GARFIELD COUNTY, COLORADO

By

MORRIS W. GREEN[1], GEORGE M. FAIRER[1], AND RALPH R. SHROBA[1]

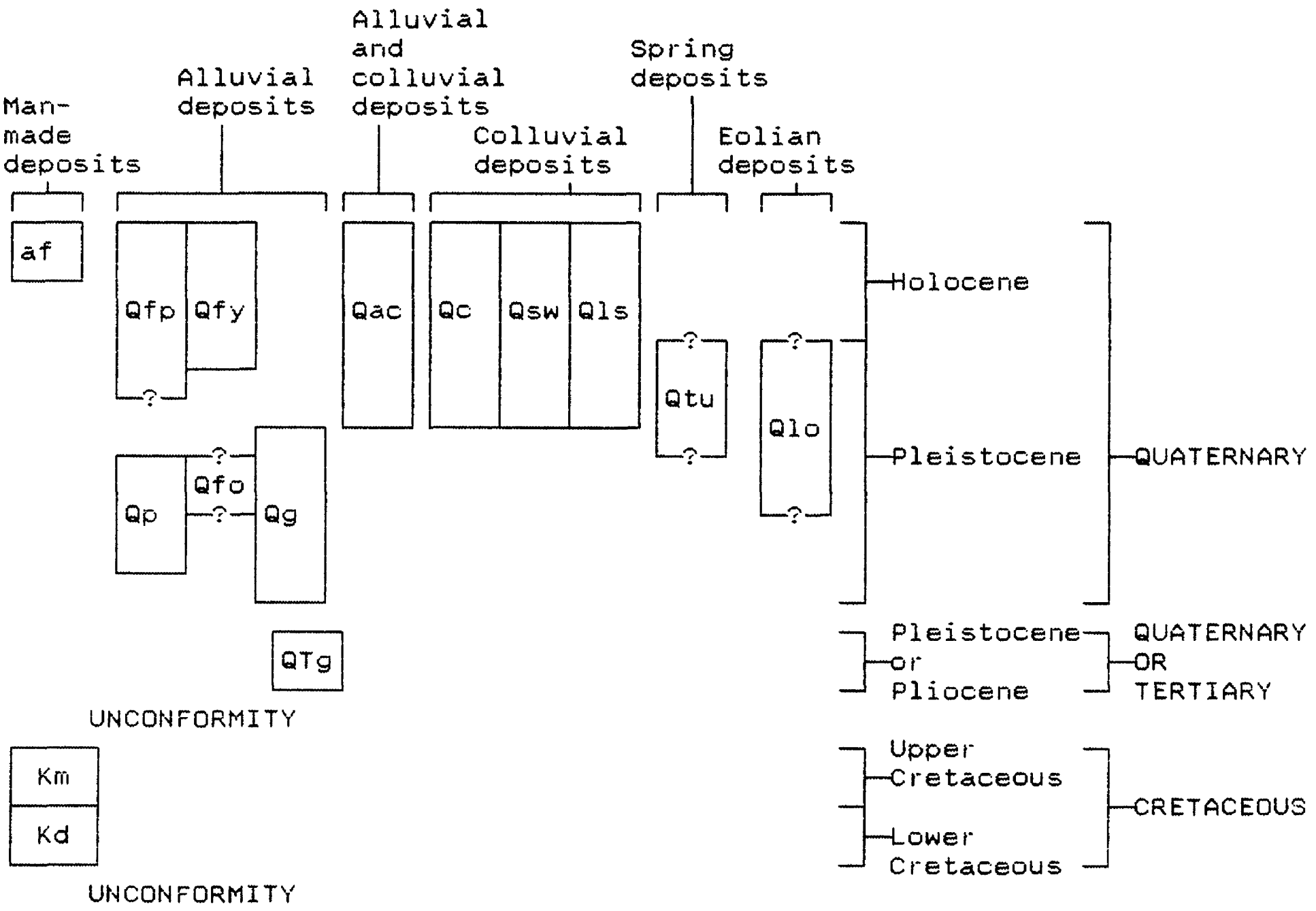
Open-File Report 93-700

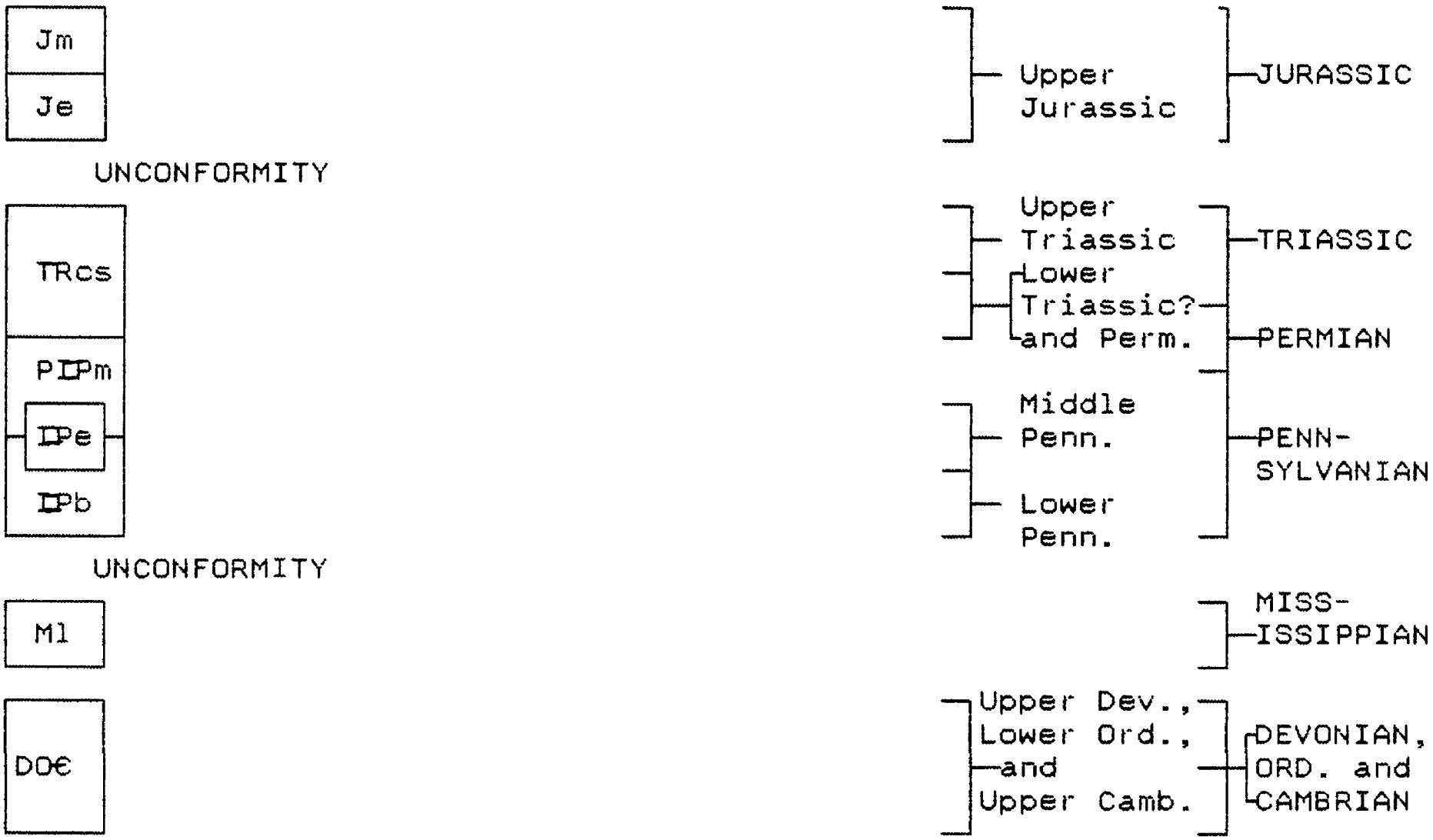
[1] Denver, Colorado

1993

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

CORRELATION OF MAP UNITS




Jm
Je
UNCONFORMITY
TRcs
PIPm
IPe
IPb
UNCONFORMITY
Ml
DO€
Upper Jurassic
JURASSIC
Upper Triassic
Lower Triassic? and Perm.
TRIASSIC
PERMIAN
Middle Penn.
Lower Penn.
PENN-SYLVANIAN
MISS-ISSIPPIAN
Upper Dev., Lower Ord., and Upper Camb.
DEVONIAN, ORD. and CAMBRIAN

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 small dam at West Elk Resevoir on West Elk Creek in the east-central part of the quadrangle

af **Artificial fill**--Compacted fill material composed mostly of silt-, sand-, and gravel-size material. Thickness about 20 ft

ALLUVIAL DEPOSITS-Silt, sand, and gravel in flood plains, stream channel, and alluvial fans on valley bottoms, in pediment deposits on gently sloping surfaces cut on bedrock, and in stream gravels on hillsides and hilltops along East Rifle Creek, Dry Rifle Creek, and unnamed intermittent streams

Qfp **Flood-plain and stream channel deposits (Holocene and late Pleistocene)**--Chiefly interstratified sandy silt, silty sand, and locally, lenses of pebbly sand, and poorly sorted, clast-supported pebble and cobble gravel in the lower part of the unit. The unit locally may include some organic-rich deposits, such as organic muds. Clasts are commonly subangular to subrounded sandstone, limestone, quartzite, and granite (or gneiss). The unit is prone to gullying and low-lying areas are prone to flooding. The unit was deposited by minor streams near the southeastern corner of the quadrangle. Maximum exposed thickness 45 ft along West Elk Creek in the northwest corner of the adjacent New Castle quadrangle

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 3-5 ft; maximum thickness possibly about 100 ft

Qfo **Older fan alluvium (middle Pleistocene)**--Fan-shaped deposit on the north side of West Elk Creek in the east-central part of the quadrangle. The unit is poorly exposed, but it probably consist mostly of poorly sorted, clast- and matrix-supported, slightly bouldery, pebble- and cobble-gravel, sandy pebble gravel, and pebbly sand. Clasts are chiefly subangular to subrounded sandstone and conglomerate from the Maroon Formation (PIPm). Probably poorly bedded and probably contains discontinuous beds and lenses. The unit underlies a slightly dissected surface that is mantled by about 3-6 ft of loess (Qlo). Deposited by a small intermittent stream tributary to West Elk Creek. Locally includes debris-flow deposits, sheetwash deposits (Qsw), and colluvium (Qc). Maximum thickness possibly about 80 ft

Qp **Pediment deposits (middle Pleistocene)**--Gravelly alluvium and debris-flow deposits at three levels that overlie gently sloping surfaces cut on Mancos Shale (Km) in the southern part of the quadrangle. The lower limits of the pediment deposits are about 80, 120, and 180 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 and a minor amount of limestone. 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 4-6 ft; maximum thickness possibly about 50 ft

Qg **Gravelly alluvium (middle to early? Pleistocene)**-- Small deposits of alluvium on hillsides and hilltops about 40, 100, 120, 160, 200, 240, and 320 ft above East Rifle Creek, Dry Elk Creek, and unnamed intermittent streams in the southeastern part of the quadrangle. Much of 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, slightly silty sand, and silty clay. 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 5 ft. The unit is commonly mantled by about 3-6 ft of loess (Qlo). The highest deposit may be of early Pleistocene age and the lowest deposits, about 40 ft above stream level, may be of late Pleistocene age. Exposed thickness 5-70 ft; maximum thickness possibly about 100 ft

QTg **High-level gravelly alluvium (early Pleistocene or late Pliocene)**-- Valley-fill or pediment(?) deposits that underlie one or more gently sloping surfaces that are about 800 ft above George Creek, 1,000 ft above Mansfield Creek, and 1,700 ft above East Rifle Creek, in the northern part 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 6 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 (Qfp) 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 part 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 3-25 ft; maximum thickness possibly about 50 ft. Exposed thickness of the colluvium 3-5 ft; maximum thickness possibly 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) 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 near the southern boundary of the quadrangle. Exposed thickness 3-5 ft; maximum thickness probably about 15 ft

Qsw **Sheetwash deposits (Holocene and late Pleistocene)**--Mostly pebbly, silty sand that is derived chiefly from Mancos Shale (Km) and 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), and Mancos Shale (Km). 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 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 3-10 ft; maximum thickness possibly 500 ft

SPRING DEPOSITS-Spring deposited calcium carbonate that forms rapids and falls along East Rifle Creek at the Rifle Falls Fish Hatchery

Qtu **(late Pleistocene?)**--Porous, weakly indurated calcium carbonate deposited by evaporation of calcium carbonate-rich water near the mouthes of hot(?) or warm(?) springs that may be associated with faults. Some of vertically oriented tubes in the tufa may have been produced by deposition of calcium carbonate on plant stems. One or both of the deposits may be dome-shaped and have alluvium deposited against their upstream sides. One tufa sample, collected along East Rifle Creek in NE¼ sec. 22, T. 4 S., R. 92 W., is composed of 95 percent calcium carbonate and 5 percent very fine to coarse sand. Unit may locally include dense, well-indurate travertine and tufa-cemented sand and gravel. Maximum exposed thickness about 50 ft

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 the loess lacks distinct topographic expression. The unit commonly mantles gently sloping deposits. Exposed thickness 3-6 ft

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 siliceous silty sandstone; rocks 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 of the Mancos Shale 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 a lower coastal plain by high-energy transgressive 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 by silica. North of the Rifle Gap Resevoir 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 hummocky surfaces downslope on 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 of the Dakota Sandstone 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. Silt and carbonaceous material were deposited in shallow-water embayment and estuary environments as well as farther seaward and 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 of the Morrison Formation occurred in a lacustrine-dominated fluvio-lacustrine environment. In the map area, the formation represents the distal 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. Locally the Entrada Sandstone crops out as two ledges, the lower of which is well-cemented and forms a prominant 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 in the Entrada Sandstone 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 Entrada Sandstone 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)--Thin 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 of the Chinle Formation occurred in relatively shallow, seasonally dry, lacustrine depositional settings within large interfluvial areas (flood plains) or in broad shallow lakes. 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 relatively 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).

IPe **Eagle Valley Evaporite (Middle Pennsylvanian)**--
Principally gypsum and anhydrite and lesser amounts of halite; contains traces of potash salts. Evaporites contain interbeds of locally carbonaceous conglomerate, sandstone, siltstone, shale, and limestone. Beds range from a few feet to about 150 ft in thickness and tend to thin in a northwesterly direction in the map area. 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). Regionally, the evaporite sequence intertongues with Belden Formation below and the Maroon Formation above. Formation incompletely exposed in the map area. Thickness in the quadrangle ranges from 0 to about 500 ft.

Evaporites are the products of sea water evaporation in a restricted seaway that was present in the central part of the landlocked 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 of algae, foraminifera, anthozoans, bryozoans, brachiopods, pelecypods, gastropods, scaphopods, cephalopods, annelids, trilobites, ostracods, blastoids, crinoids, echinoderms, and vertebrate remains. About 900 ft thick

The Belden Formation is the oldest in a series of superimposed formations deposited in the Eagle 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 of the Belden Formation 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, the Belden Formation 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, the upper part of the formation consists of up to about 50 ft of red to reddish-purple claystone. 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 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 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.

DO€ **Devonian, Ordovician, and Cambrian rocks undivided** -- Rocks in the vicinity of Parker Lake along Middle Rifle Creek in secs. 12 and 13, T. 4 S., R. 93 W., contain 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-pebble conglomerate. About 80-90 ft thick

Sediment composition and primary sedimentary structures in these formations indicate deposition 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.

REFERENCES CITED

American Geological Institute, 1982, Grain-size scales used by American geologists, modified Wentworth scale, *in* Data sheets (2nd ed.): Falls Church, Va., American Geological Institute, sheet 17.1.

Bass, N.W., and Northrop, S.A., 1963, Geology of Glenwood Springs quadrangle and vicinity, northwestern Colorado: U.S. Geological Survey Bulletin 1142-J, 74 p.

Gile, L.H., Peterson, F.F., and Grossman, R.B., 1966, Morphological and genetic sequences of carbonate accumulation in desert soils: Soil Science, v. 101, p. 347-360.

Guthrie, R.L., and Whitty J.E., 1982, New designations for soil horizons and layers and the new Soil Survey Manual: Soil Science Society of America Journal, v. 46, p. 443-444.

Harmon, J.B., and Murray, D.J., 1985, Soil survey of Rifle area Colorado--parts of Garfield and Mesa Counties: U.S. Department of Agriculture, Soil Conservation Service, 149 p.

Mallory, W.M., 1971, The Eagle Valley Evaporite, northwest Colorado--a regional synthesis: U.S. Geological Survey Bulletin 1311-E, 37 p.

Munsell Color, 1973, Munsell soil color charts: Baltimore, Md., Kollmorgen Corp., Macbeth Division.

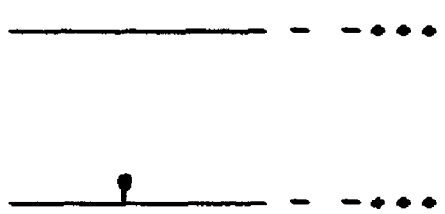
Richmond, G.M., and Fullerton, D.S., 1986, Introduction to Quaternary glaciations in the United States of America, *in* Sibrava, V., Bowen, D.Q., and Richmond, G.M., eds., Quaternary glaciations in the northern hemisphere: Quaternary Science Reviews, v. 5, p. 3-10.

Soil Survey Staff, 1975, Soil taxonomy: U.S. Department of Agriculture Handbook 436, 754 p.

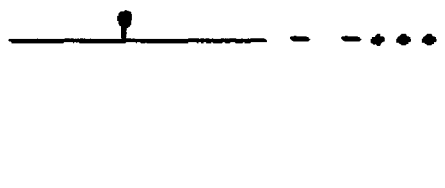
Tweto, Ogden, 1979, Geologic map of Colorado: U.S. Geological Survey, scale 1:500,000.

Varnes, D.J., 1978, Slope movement types and process, *in* Schuster, R.L., and Krizek, R.J., eds., Landslides, analysis, and control: National Academy of Sciences, Transportation Research Board Special Report 176, p. 11-33.

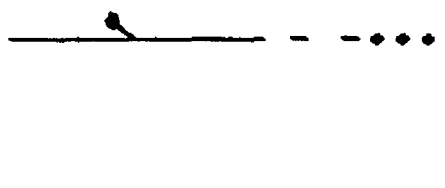
Whitney, J.W., and Andrews, E.D., 1983, Past and present geomorphic activity in the Piceance Creek drainage basin, northwestern Colorado, *in* Gary, J.H., ed., Sixteenth oil shale symposium proceedings: Golden, Colorado School of Mines Press, p. 566-577.



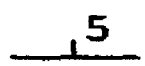
CONTACT--Dashed where approximately located; dotted where concealed.



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

MONOCLINAL AXIS--Upper fold axis. Lower axis not present in the map area Arrows indicate direction of dip. Longer arrow indicates flatter dip.

CONVERSION FACTORS

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