U.S. DEPARTMENT OF THE INTERIOR

U. S. GEOLOGICAL SURVEY

PRELIMINARY GEOLOGIC MAP OF THE RIFLE 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

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Preliminary Geologic Map of the Rifle Quadrangle, Garfield County, Colorado
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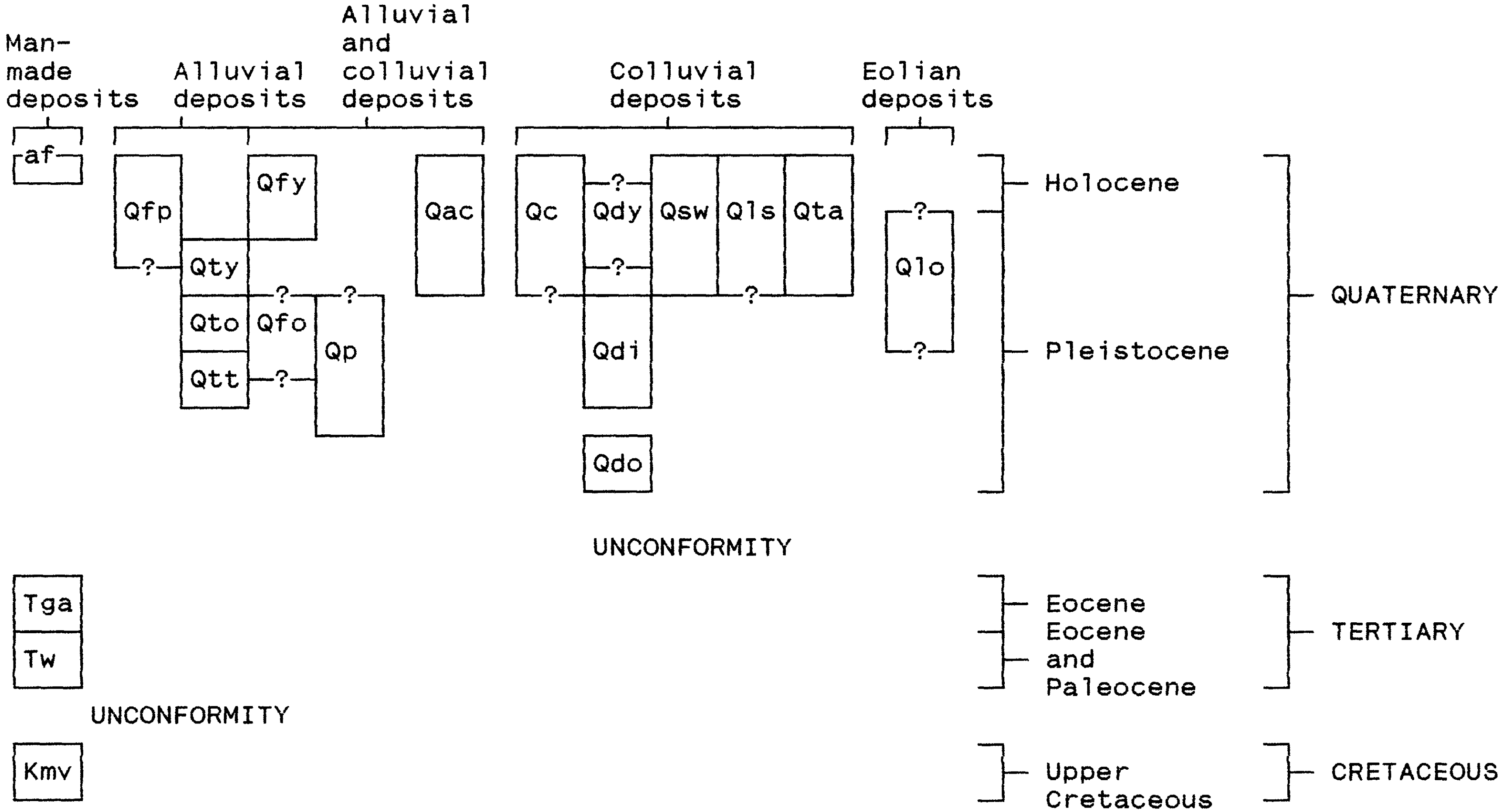
CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

[Surficial deposits shown on the map are estimated to be at least 3 ft thick. Thinner deposits are not shown. Fractional map symbols (for example, Qlo/Qty) are used where loess mantles older surficial deposits and these underlying deposits have been identified. Thin, discontinuous colluvial deposits and residual material on bedrock 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. Age assignments for units Qtt and Qdo are inferred chiefly on the basis of regional rates of stream incision of about 45 ft/100 k.y. (k.y., thousand years) and 530 ft/m.y. (m.y., million years) and on a regional rate of tectonic uplift of about 600 ft/m.y. The first incision rate is based on an average of three values for stream incision since the deposition of the 620-ka (ka, thousand years) Lava Creek B volcanic ash: (1) about 300 ft along the Colorado River near the east end of Glenwood Canyon (Izett and Wilcox, 1982), (2) about 290 ft along the Roaring Fork River near Carbondale, Colo. (Piety, 1981), and (3) about 260-280 ft along the White River near Meeker, Colo. (J.W. Whitney, oral commun., 1992; Whitney and others, 1983). The second incision rate is based on about 4,000 ft of down cutting by the Colorado River since the deposition of the 7.5-Ma (Ma, million years) basalt on Battlement Mesa (Stover, 1984, 1988), about 6 mi south of the map area. The rate of tectonic uplift of about 6,000 ft/10 m.y. was determined for the Derby Peak fauna, in the Flat Tops area (Colman, 1985), about 40 mi northeast of the map area. 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-size terminology for the surficial deposits is based on visual estimates and follow the modified Wentworth grade scale (American Geological Institute, 1982). In descriptions of surficial deposits, the term clasts refers to the fraction greater than 0.08 in. (2 mm) in diameter, whereas the term matrix refers to particles less than 2 mm in size. Dry matrix colors of the surficial deposits in the map area were determined by comparison with Munsell Soil Color Charts (Munsell Color, 1973). These deposits 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).]

MANMADE DEPOSITS—Sand and finer material and rock fragments in fills along the Colorado River, Rifle Creek, Government Creek, and Estes Gulch

af **Artificial fill (latest Holocene)**--Compacted and uncompacted fill material composed mostly of varying amounts of silt, sand, and rock fragments. The unit includes major fills along Estes Gulch near the northern boundary of the map area, in the town of Rifle, and beneath segments of Interstate 70; minor fills beneath segments of Colorado Highway 13 and the tracks of the Denver and Rio Grande Western Railroad; and two large dump fills composed of uranium and vanadium mill tailings along the Colorado River (NE¼ sec. 16 and SE¼ sec. 18, T. 6 S., R. 93 W.) near Rifle. Uranium is a source of potentially hazardous gamma radiation and radon gas (Duval, 1991). Uranium and its decay products in the mill tailings may pose a hazard to the ground water in the underlying flood-plain and stream-channel deposits (Qfp). The mill tailings are susceptible to wind erosion and have contaminated the ground surface within about several hundred yards of the tailings piles (Stover, 1984). These mill tailings are being transported to and buried at the Department of Energy disposal site in the Wasatch Formation (Tw) along Estes Gulch. The mapped distribution of the fill at this site corresponds to the distribution shown on the final site plans. Piles of fill material at the Estes Gulch site that will be used to cover the mill tailings were not mapped. After the mill tailings and some of the underlying sediment have been removed from the two sites along the Colorado River in 1995, the excavations at these sites will be filled with suitable material (Scott Bunney, M.K. Ferguson Co., oral commun., 1994). Thickness generally less than 40 ft; maximum thickness about 70 ft

ALLUVIAL DEPOSITS--Silt, sand, and gravel beneath flood plains, in stream channels, and beneath terraces along the Colorado River, Rifle Creek, Government Creek, and the unnamed stream in Hubbard Gulch; 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)**--Along the Colorado River, the upper 3-15 ft of the unit is commonly slightly silty to silty, very fine to medium sand that locally contains a minor amount of pebbles and cobbles and thin lenses of silt and clayey silt. The lower 4-23 ft of the unit is chiefly clast-supported, cobbly pebble gravel with a sand matrix. Deposits along Rifle Creek and the lower part of Government Creek commonly contain more sand and silt than those along the Colorado River. Poorly to moderately well sorted and poorly to well stratified. Clasts are commonly subangular to rounded; those along the Colorado River are derived from a variety of sedimentary, igneous, and metamorphic rocks exposed upstream, whereas clasts along Rifle Creek and the lower part of Government Creek are mostly sandstone. Low-lying areas of unit Qfp are prone to periodic flooding. Locally includes unmapped alluvial-fan deposits (Qfy), low terrace deposits that are commonly less than 15 ft above stream level, and sheetwash deposits (Qsw) that are too small to map separately. The upper part of the unit may be a complex of alluvial cut-and-fill deposits of Holocene and late Pleistocene age. The lower part of the unit probably consists of older alluvial deposits that are equivalent, at least in part, to the younger terrace alluvium (Qty). Unit Qfp is tentatively correlated with deposits of terrace T8 along the Roaring Fork River between Glenwood Springs and Carbondale, Colo. (Piety, 1981). Thickness along the Colorado River is about 10-30 ft and about 15-20 ft along Rifle Creek (Colorado Highway Department, unpublished data). Maximum thickness probably about 40 ft along the Colorado River and possibly about 30 ft along Rifle Creek and the lower part of Government Creek

Qty **Younger terrace alluvium (late Pleistocene)**--Stream alluvium that underlies terrace remnants that are about 30-50 ft above the stream in Hubbard Gulch and about 60 ft above Rifle Creek and Government Creek. The unit consists mostly of poorly sorted, clast-supported, non-bouldery to slightly bouldery, cobbly pebble gravel with a sand matrix, and moderately well sorted, clast-supported, cobbly pebble gravel with a slightly silty sand matrix. The clasts are mostly subangular to subrounded sandstone. The unit is well exposed in roadcuts in Hubbard Gulch and along Rifle Creek, but is only mapped in the lower part of Hubbard Gulch in the central part of the map area. It is locally overlain by one loess sheet (Qlo) about 3-5 ft thick. Widespread deposits of younger fan alluvium (Qfy) along the Colorado River probably overlie deposits of younger terrace alluvium. Unit Qty is probably equivalent in part to outwash of the Pinedale glaciation, which is about 12-35 ka (Richmond, 1986, chart 1A). The unit is tentatively correlated with deposits of terraces

T7 and T6 along the Roaring Fork River between Glenwood Springs and Carbondale (Piety, 1981), and with deposits of terraces A and B farther upstream between Woody Creek and Aspen (Bryant, 1979). Exposed thickness 6-13 ft along the stream in Hubbard Gulch, 3-10 ft along Rifle Creek, and 9 ft along Government Creek. Maximum thickness along these drainages probably about 25 ft

Qto **Older terrace alluvium (middle Pleistocene)**--Stream alluvium that underlies terrace remnants about 120-160 ft above the Colorado River, Rifle Creek, and Government Creek. Along the Colorado River, the upper part of the unit was deposited by tributary streams and the lower part was deposited by the Colorado River. The upper 25-50 ft of the unit commonly consists of slightly silty to silty sand that is locally slightly pebbly and locally contains thin, discontinuous beds and lenses of poorly to moderately well sorted, clast-supported, non-bouldery to bouldery, cobbly pebble gravel and pebble gravel with a sand matrix. The lower 10-40 ft of the unit is mostly poorly to moderately well sorted, clast-supported, cobbly pebble gravel with a sand matrix. Thin beds and lenses of non-silty, medium to very coarse sand and non-silty to silty, fine to very fine sand are locally present. Some of the beds have climbing ripples and involute bedding. The base of the unit is locally cemented by fine-grained calcium carbonate. The clasts in the upper part of the unit are mostly subangular to subrounded sandstone. The clasts in the lower part of the unit are chiefly subrounded to well rounded sandstone, granite, granodiorite(?), gneiss, limestone, quartzite, and minor to trace amounts of basalt, dolomite, chert, siltstone, vein quartz, and schist. Along Rifle Creek and Government Creek, the unit commonly consists of poorly sorted to moderately well sorted, clast-support, non-bouldery to bouldery, cobbly pebble gravel with a sand matrix, and locally thin beds and lenses of pebble gravel, pebbly sand, silty sand, and silt. The clasts in these deposits are mostly subangular to subrounded sandstone. The unit is mantled by about 5-19 ft of loess (Qlo) that commonly consists of two sheets, and locally by intermediate debris-flow deposits (Qdi) near the mouth of Beaver Creek (SW¼ sec. 23, T. 6 S., R. 94 W) and by sheetwash deposits (Qsw). The loess-mantled deposit of older terrace alluvium on Graham Mesa northeast of Rifle marks a former course or former courses of Rifle Creek. The presence of a well developed soil that is locally observed in the top unit

(Green and others, 1993a; Shroba and others, 1994) and the presence of the two overlying loess sheets suggest that unit Qto is of Bull Lake age (Shroba, 1989; Pierce and others, 1982) 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 of terraces T5 and T4 along the Roaring Fork River between Glenwood Springs and Carbondale (Piety, 1981), and with deposits of terrace C farther upstream between Woody Creek and Aspen (Bryant, 1979). Exposed thickness 45-70 ft along the Colorado River, 10-20 ft along Rifle Creek, and 30-40 ft along Government Creek. Maximum thickness along the Colorado River probably about 80 ft and possibly about 50 ft along Rifle Creek and Government Creek

Qtt **Oldest terrace alluvium (middle Pleistocene)**--Stream alluvium that underlies terrace remnants that are about 240 and 300 ft above the Colorado River, about 240, 300, and 360 ft above Rifle Creek, and about 180, 240, and 360 ft above Government Creek. Terrace alluvium about 600 ft above the Colorado River at the north end of Grass Mesa in the southeastern part of the map area is buried by older debris-flow deposits (Qdo) and is not mapped. Along the Colorado River, the unit is mostly a poorly to moderately well sorted, clast-supported, cobbly pebble gravel with a sand matrix. The unit locally consists of thin beds and lenses of pebble gravel, pebbly sand, and silty sand. Clasts are mostly rounded to well rounded and consist of sandstone, granodiorite(?), quartzite, gneiss, limestone, and minor to trace amounts of basalt, granite, metasiltstone(?), chert, conglomerate, siltstone, and dolomite that were deposited by the Colorado River. Biotite-bearing granitic clasts near the top of the unit are extensively weathered and are easily disintegrated. Locally on the north side of the Colorado River, the clasts in the upper part of the unit are mostly subangular to subrounded sandstone that were deposited by south-flowing tributary streams. Deposits along Rifle Creek and Government Creek are mostly poorly sorted, clast-support, slightly bouldery to bouldery, cobbly pebble gravel with a non-silty to silty sand matrix and thin beds and lenses of pebble gravel, pebbly sand, and sand. The clasts in the deposits along Rifle Creek are mostly of subangular to subrounded sandstone along with a minor amount of limestone and a trace amount of quartzite. The clasts in the deposits along Government Creek are mostly subangular to subrounded sandstone, siltstone, and marlstone. A stage III K soil horizon, 12-30 in. thick, is locally present in the top of the unit. The base of the unit is locally cemented by fine-grained calcium carbonate. The unit is locally mantled by 3-16 ft of loess (Qlo) that commonly consists of two or more sheets. Small deposits of oldest terrace alluvium near the eastern boundary of the map area, north of the Colorado River, mark former courses of Rifle Creek. Unit Qtt may be correlative in part with other terrace deposits within about 35 mi of the map area that contain or are overlain by the 620-ka Lava Creek B volcanic ash. The unit is tentatively correlated with deposits of terraces T3 and T2 along the Roaring Fork River between Glenwood Springs and Carbondale (Piety, 1981) and with deposits of terrace D farther upstream between Woody Creek and Aspen (Bryant, 1979). Exposed thickness 5-22 ft along the Colorado River, 3-31 ft along Rifle Creek, and 8-45 ft along Government Creek. Maximum thickness along the Colorado River possibly about 60 ft and possibly about 50 ft along Rifle Creek and Government Creek

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

Qfy **Younger fan alluvium (Holocene and latest Pleistocene)**--Mostly poorly sorted, poorly stratified, clast- and matrix-supported, slightly bouldery, cobbly pebble gravel with a silty sand matrix, and locally silty sand that contains thin, discontinuous beds and lenses of cobbly pebble gravel, pebble gravel, and sand. The unit locally contains boulders as long as 3 ft. Some of the larger boulders were probably deposited by debris flows. Clasts are commonly angular to subangular sandstone north of the Colorado River and angular to subrounded sandstone and basalt south of the Colorado River. Low-lying areas of unit Qfy are prone to periodic flooding. Thick beds of silty sand are prone to piping and gullying primarily along desiccation fractures. The unit is undissected to slightly dissected and was deposited chiefly by small intermittent streams graded to the flood plains of modern streams (Qfp) and locally to the tops of terraces that are underlain by younger terrace alluvium (Qty). Locally includes unmapped deposits of intermittent streams and colluvium (Qac), younger debris-flow deposits (Qdy), and sheetwash deposits (Qsw) that are too small to map separately. The unit may contain hyperconcentrated-flow deposits, which have characteristics that are intermediate between those of stream-flow and debris-flow deposits. Exposed thickness 10-40 ft; maximum thickness probably about 80 ft

Qac **Undivided alluvium and colluvium (Holocene and late Pleistocene)**--Chiefly undifferentiated alluvial flood-plain and stream-channel deposits (Qfp) and younger fan alluvium (Qfy), and colluvial younger debris-flow (Qdy), sheetwash (Qsw), and possibly hyperconcentrated-flow deposits. Some of these deposits probably grade laterally and vertically into each other. The alluvial deposits commonly consist of interstratified silty sand, sandy clayey silt, and thin beds and lenses of cobbly pebble gravel, pebble gravel, and pebbly sand. Sheetwash deposits are typically pebbly, silty sand and sandy silt. Low-lying areas of unit Qac are prone to periodic flooding. Some of the alluvial deposits are prone to extensive gullying and piping. Alluvial deposits form flood plains, low terraces, and small alluvial fans along intermittent streams and the upper part of Government Creek. Sheetwash deposits locally mantle the valley bottoms and the adjacent valley sides. Exposed thickness of the alluvium 3-22 ft; maximum thickness possibly about 50 ft. Exposed thickness of the colluvium 3-5 ft; maximum thickness possibly about 20 ft

Qfo **Older fan alluvium (middle Pleistocene)**--One deposit near the northeastern corner of the map area that was deposited by an intermittent stream that was graded to a surface about 160-180 ft above Rifle Creek. Mostly poorly sorted, poorly stratified, clast-supported, slightly bouldery, cobbly pebble gravel with a silty sand matrix, and discontinuous beds and lenses of pebble gravel and pebbly, silty sand. Clasts are chiefly angular to subrounded sandstone. The deposit may contain minor, unmapped intermediate debris-flow deposits (Qdi) and hyperconcentrated-flow deposits. It is deeply dissected and is mantled by loess (Qlo). Exposed thickness 15 ft; maximum thickness possibly about 100 ft

Qp **Pediment deposits (middle Pleistocene)**--Gravelly alluvium and debris-flow deposits at four or more levels that overlie gently sloping surfaces cut on Wasatch Formation (Tw). Locally there is as much as 20 ft of relief on the underlying bedrock. Mostly poorly sorted, clast-supported, non-bouldery to bouldery, cobbly pebble gravel with a non-silty to silty sand matrix, and thin beds and lenses of poorly sorted, clast- and matrix-supported, pebble gravel to pebbly, silty sand. Clasts are chiefly angular to subrounded sandstone and locally minor amounts of limestone, siltstone, and marlstone. The unit probably locally includes minor, unmapped sheetwash deposits (Qsw) and colluvium (Qc), and possibly hyperconcentrated-flow deposits. Bouldery, debris-flow deposits are locally common in the upper part of the unit. Some of the sandstone boulders in the upper part of the unit are as long as 5 ft. A stage III K soil horizon is locally formed in the upper 20-30 in. of the unit and some of the sandstone cobbles in the upper 6 ft have weathered to sand-size particles. The unit is locally mantled by about 6-9 ft of loess (Qlo) that locally consists of two or more sheets. The lower limits of the unit are about 160, 200, and 400 ft above the Colorado River, about 200 and 280 ft above Rifle Creek, and about 180 and 300 ft above Government Creek. The lowest pediment deposits along the Colorado River appear to be graded to terrace remnants underlain by older terrace alluvium (Qto) that are about 120-160 ft above the Colorado River. Exposed thickness commonly 5-38 ft; maximum observed thickness 48 ft; maximum thickness possibly about 60 ft

COLLUVIAL DEPOSITS—Clay, silt, sand, gravel, and angular rock fragments 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, pebbly, cobbly, and bouldery gravel with a silty sand matrix, and gravelly, silty sand to clayey silt. 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 the surficial deposits from which the colluvium was derived. The unit locally includes creep, younger debris-flow (Qdy), sheetwash (Qsw), landslide (Qls), and possibly hyperconcentrated-flow deposits, talus (Qta), and deposits of alluvium and colluvium (Qac) in and along minor drainageways that are too small to map separately or lack distinctive surface morphology and could not be distinguished in the field or on aerial photographs. Exposed thickness 3-50 ft; maximum thickness possibly about 100 ft

Qdy **Younger debris-flow deposits (Holocene and late Pleistocene)**--Small, lobate and fan-shaped masses of debris and bouldery levees with well preserved surface morphology that were deposited by sediment-charged flows in Yellow Slide Gulch and near the mouth of Beaver Creek in the southwestern part of the map area. Much of the unit is poorly exposed, but it appears to consist mostly of very poorly sorted and very poorly stratified boulders to granules supported in a matrix of silty sand, and locally includes poorly sorted, clast-supported, bouldery, cobbly pebble gravel with a silty sand matrix in levees and lenticular beds. The clasts in the deposit in Yellow Slide Gulch are mostly subangular to subrounded sandstone, siltstone, and marlstone and those in the deposit near the mouth of Beaver Creek are mostly subangular to subrounded basalt and minor amounts of sandstone, siltstone, and marlstone. Some of the clasts are as long as 4 ft. The top of the unit is less than 50 ft above stream level, irregular, and locally mantled by loess (Qlo). The unit may locally include minor stream-flow and hyperconcentrated-flow deposits. Exposed thickness 2-10 ft; maximum thickness possibly 50 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 Wasatch Formation (Tw) and loess. Low-lying areas of unit Qsw are prone to periodic sheet flooding. The unit locally includes deposits of loess, undivided alluvium and colluvium (Qac) in and along minor drainageways, and outcrops of Wasatch that are too small to map separately. Exposed thickness 6-15 ft; maximum thickness probably about 30 ft

Qls **Landslide deposits (Holocene and late Pleistocene)**--Chiefly unsorted and unstratified rock debris that is commonly characterized by its lobate form and hummocky topography. Many of the landslides are complex (Varnes, 1978) and commonly formed on steep, unstable slopes that are underlain by the Mesaverde Group rocks (Kmv) on the south side of the Grand Hogback near the northern boundary of the map area; the Anvil Points Member of the Green River Formation (Tga) near the western boundary of the map area; and the Wasatch Formation (Tw) in the northern and southern parts of the map area. 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, earth-slump, slump-earth-flow, earth-flow, debris-flow deposits (Varnes, 1978) and possibly hyperconcentrated-flow deposits. 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, slumping, and flowing. The unit locally includes unmapped sheetwash (Qsw) and creep (colluvium, Qc) deposits that are too small to map separately. Exposed thickness 3-10 ft; maximum thickness possibly 400 ft

Qta **Talus deposits (Holocene and late Pleistocene)**--Mostly crudely sorted and stratified, angular, bouldery to pebbly rubble on steep slopes produced chiefly by rock fall from outcrops of Mesaverde Group rocks (Kmv) north of Rifle Gap near the northeastern corner of the map area. The matrix is mostly sand and silt; some of it may be of eolian origin. The upper part of the unit locally lacks matrix. Maximum thickness possibly about 100 ft

Qdi **Intermediate debris-flow deposits (middle Pleistocene)**--Mostly debris-flow deposits and a minor amount of stream alluvium that underlie three gently sloping, fan-shaped, geomorphic surfaces near the southwestern corner of the map area. The lower limits of these surfaces are about 180, 340, and 400 ft above the Colorado River. The debris-flow deposits are chiefly very poorly sorted and very poorly stratified boulders to granules supported in a matrix of slightly clayey, silty sand to clayey, sandy silt, and locally includes lenticular beds of poorly sorted, clast-supported, bouldery, cobbly pebble gravel with a silty sand matrix. Clasts are commonly randomly oriented and are mostly subangular to subrounded basalt, minor amounts of sandstone, siltstone, marlstone, and claystone, and locally trace amounts of rounded to well rounded igneous, sedimentary, and metamorphic pebbles and cobbles derived from Colorado River terrace deposits. Basalt clasts are as long as 9 ft. Stream alluvium commonly consists of poorly sorted, poorly stratified, clast-supported, slightly bouldery, cobbly pebble gravel with a slightly silty sand matrix, and lenses of cobbly pebble gravel and pebble gravel. The unit may locally include hyperconcentrated-flow deposits. The soil formed in the top of the unit in the eastern part of Taughenbaugh Mesa consists of a stage III K horizon 44 in. thick that overlies a stage II BK horizon 6 in. thick and a stage I Bk horizon greater than 8 in. thick. The unit overlies the Wasatch Formation (Tw), but near its lower limits it overlies unmapped terrace alluvium that is about 130, 240, and 300 ft above the Colorado River. The unit is mantled by greater than 6 ft of loess (Qlo), although large basalt boulders locally protrude through the loess mantle. Broad debris-flow levees locally flank both sides of Beaver Creek. Much of the material in the unit was probably mobilized by mass-wasting processes on the steep north flank of Battlement Mesa, about 6 miles south of the map area, and transported by sediment-charged flows down the valley of Beaver Creek. With time, deposition generally shifted from east to west. Deposits in the eastern part of Taughenbaugh Mesa are higher and older than those in the western part of the mesa, and deposits in the western part of the mesa are higher and older than those near the mouth of Beaver Creek. Debris-flow deposits near the base of the unit on Taughenbaugh Mesa are locally interbedded with the uppermost part of the underlying, unmapped terrace alluvium. Exposed thickness 15-100 ft; maximum thickness possibly about 150 ft

Qdo **Older debris-flow deposits (early? Pleistocene)**--Mostly debris-flow deposits and a minor amount of stream alluvium that underlie Grass Mesa, a gently sloping, fan-shaped, geomorphic surface near the southeastern corner of the map area. The lower limit of the surface is about 800-850 ft above the Colorado River. The debris-flow deposits are chiefly very poorly sorted and very poorly stratified boulders to granules supported in a matrix of slightly clayey, silty sand to sandy, clayey silt, and locally includes lenticular beds of poorly sorted, clast-supported, bouldery, cobbly pebble gravel with a silty sand matrix. The deposits are commonly about 3-8 ft thick and are locally overlain by layers of slightly silty sand 2-15 in. thick. Clasts are commonly randomly oriented and are angular to rounded basalt, sandstone, siltstone, and marlstone. Basalt clasts are as long as 5 ft. Stream alluvium is locally present near the top of the unit and commonly consists of poorly sorted, poorly stratified, clast-supported, slightly bouldery to bouldery, cobbly pebble gravel with a sand matrix, and lenses of cobbly pebble gravel and pebble gravel. The alluvium is mostly stream-channel deposits that are about 6-12 ft thick. The unit may locally include hyperconcentrated-flow deposits. The soil formed in the top of the unit consists of a stage IV K horizon 35 in. thick that overlies a stage III K horizon 4 in. thick and a stage II Bk horizon 20 in. thick. No buried soils were noted in the unit. The unit overlies the Wasatch Formation (Tw), but near its lower limit it overlies unmapped terrace alluvium that is about 600 ft above the Colorado River. The unit is mantled by greater than 3 ft of loess (Qlo) and may be similar in age to the high-level basaltic alluvium (QTba) in the nearby New Castle quadrangle (Green and others, 1993a). Exposed thickness 110-220 ft in the map area and about 70 ft in the adjacent North Mamm Peak quadrangle, about 4,000 ft south of the map area. Maximum thickness possibly 250 ft

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

Qlo **Loess (late and middle Pleistocene)**--Wind-deposited, nonstratified, friable when dry, slightly plastic to plastic when wet, calcareous (6-18 percent calcium carbonate), slightly clayey, sandy silt. The grain-size distribution of the carbonate-free fraction of unweathered loess in and near the map area commonly consists of 22-46 percent sand (2-0.05 mm), 43-62 percent silt (0.05-0.002 mm), and 15-18 percent clay (<0.002 mm). About 55-75 percent of the unweathered loess is composed of very fine sand (0.01-0.05 mm) plus coarse silt (0.05-0.02 mm). Median grain size ranges from 0.03 to 0.05 mm. The unit is prone to sheet erosion, gullying, and compaction when wet, due in part to its low dry bulk density of about 90 lbs/ft^3. Locally includes loess-derived sheetwash (Qsw) and creep (colluvium, Qc) deposits that are too small to map separately. Deposited during five episodes of eolian activity (Shroba, 1994). Deposition may have continued into Holocene time. Possible sources of the loess include flood-plain deposits of the Colorado River and its major tributaries; sparsely vegetated outcrops of Tertiary siltstone and mudstone in the Piceance Basin west of the map area (Tweto, 1979); and large areas of exposed sandstone in the Canyonlands region in southeastern Utah (Whitney and Andrews, 1983). However, the relatively high content of very fine sand plus coarse silt and the relatively high coarse silt/total silt ratios (about 0.7) of the unweathered loess suggest: (1) a relatively short distance of eolian transport and (2) the flood plain of the Colorado River, which aggraded primarily during glacial times in response to glacial and periglacial activity farther upstream, is the likely source of much of the loess (Shroba, 1994). 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 as old or older than the younger terrace alluvium (Qty). Younger terrace alluvium is locally 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 horizons: an organic-enriched A horizon about 8 in. thick; a cambic B horizon about 4-8 in. thick; a weak to moderate prismatic, argillic B horizon about 8-16 in. thick; and a stage I Bk horizon greater than 30 in. thick. The buried 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 horizons: a cambic B horizon about 8 in. thick; a moderate to strong prismatic, argillic B horizon about 22-28 in. thick that contains weak stage I-II calcium carbonate; a weak stage III K horizon about 16 in. thick; and a stage I-II Bk horizon about 12 to greater than 24 in. thick. Where the upper loess sheet is composed of very sandy silt, the soil formed in it has a weakly developed, non-prismatic argillic B horizons that is about 14 in. thick. If the upper and lower loess sheets on the older terrace alluvium correlate with loess units A and B, respectively, that are on and adjacent to the eastern Snake River Plain in eastern Idaho, then (1) the upper loess sheet in the map area accumulated between about 10-70 ka and is of late Pleistocene age and (2) the lower loess sheet accumulated during an interval that ended shortly after 140-150 ka and is partly or entirely of latest middle Pleistocene age (Pierce and others, 1982) Exposed thickness 2-20 ft; commonly 3-15 ft thick; maximum thickness possibly about 25 ft

Tga **Green River Formation, Anvil Points Member (Eocene)**--Interbedded light gray, light tan, yellowish-brown, and dark-brown sandstone, siltstone, and shale. Unit contains thin intervals of limestone and is conglomeratic in the lower part of the section. Contains beds of marlstone in upper part of the member in the adjacent Anvil Points quadrangle. Dominantly of low-energy fluvial and lacustrine origin. Contact with underlying Wasatch is indistinct. The member is about 780 ft thick within the map area, but is 1,530 ft thick at the type locality in the adjacent Anvil Points quadrangle (O'Sullivan, 1986). Upper part of the member is not present in the map area

Tw **Wasatch Formation (Eocene and 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 (Kmv). Sediment is first cycle, poorly sorted, and contains abundant metamorphic and granitic rock fragments; locally includes a basal cobble conglomerate as much as 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; generally, the sequence fines upward. About 5,000 ft thick

Sediments were transported and deposited in braided stream, flood-plain lacustrine, and lacustrine environments. Differentiation of sediments into more discrete lithofacies within fluvial and lacustrine complexes was hindered by the relatively short distances from sediment sources to depocenters in the basin.

Kmv **Mesaverde Group rocks, undivided (Upper Cretaceous)**--Thin to thick beds of yellowish-brown and olive-gray, carbonaceous mudstone and fine- to medium-grained, silty sandstone, siltstone, and claystone; contains thin beds and lenses of silty and sandy pebble and cobble conglomerate; beds are generally massive. Locally contains thin beds and laminae of coal; clinker, produced by combustion of coal *in situ*, is common. Contains several beds of white, well-sorted, short forset-crossbedded, quartz sandstone in the lower part of the unit. These beds contrast strongly in appearance and physical character with surrounding silty, carbonaceous beds. These white sandstone beds are equivalent to similar beds in the Trout Creek Sandstone Member of the Isles Formation as mapped by O'Sullivan (1985) in the nearby Rio Blanco quadrangle. These beds thin and pinch out due to non-deposition and erosion in a southeasterly direction along the Grand Hogback east and southeast of the map area. Except for the white sandstone beds, clastic sediments are generally poorly sorted, subangular, and contain abundant coaly, carbonaceous particles derived from rip-up of well- to poorly-drained swamp sediments in backshore areas. Some beds are silica cemented and form prominent ridges and cliffs. The upper part of this unit is equivalent to the Williams Fork Formation as mapped by O'Sullivan (1985). About 4,500 ft thick

Mesaverde deposition occurred during the first major Cretaceous regressive marine cycle in the Rocky Mountain seaway following the Dakota transgressive cycle. Deposition occurred primarily in backshore areas and on deltas of the lower coastal plain where sediment-laden streams meandered among coal swamps, marshes, and mudflats behind a seaward-migrating shoreline. White sandstone beds in the lower part of the unit are the product of high-energy shoreline processes in which surf- and wave-zone activity winnowed, sorted, and otherwise concentrated sand along an upper shoreface.

The extent and thickness of minable coal beds in the unit are unknown because most of them are covered. Correlation of coal beds in the map area with those in the nearby New Castle area is uncertain (Gale, 1910; p. 120)

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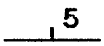
CONVERSION FACTORS

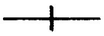
Multiply	By	To obtain
inches (in.)	2.540	centimeters (cm)
feet (ft)	0.3048	meters (m)
miles (mi)	1.609	kilometers (km)

CONTACT--Dotted where concealed; queried where inferred

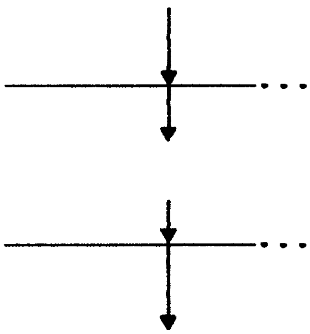
STRIKE AND DIP OF BEDS



Inclined



Vertical



MONOCLINE--Showing lower fold axis. The upper fold axis is in the adjacent Horse Mountain quadrangle (Fairer and others, 1993) and nearby Rifle Falls quadrangle (Green and others, 1993b) about 3 miles and 7 miles, respectively, northeast of the map area. Arrows indicate direction of dip. Longer arrow indicates direction of lower dip. Dotted where concealed

STREAM-TERRACE AND DEBRIS-FLOW SCARPS MANTLED BY LOESS--separates contiguous terrace alluvium and debris-flow deposits of the same map unit, but at different elevations and of different ages; tick marks are on the side of the lower (younger) deposit