U. S. DEPARTMENT OF THE INTERIOR

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PRELIMINARY GEOLOGIC MAP OF THE NEW CASTLE QUADRANGLE, GARFIELD COUNTY, COLORADO

by

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

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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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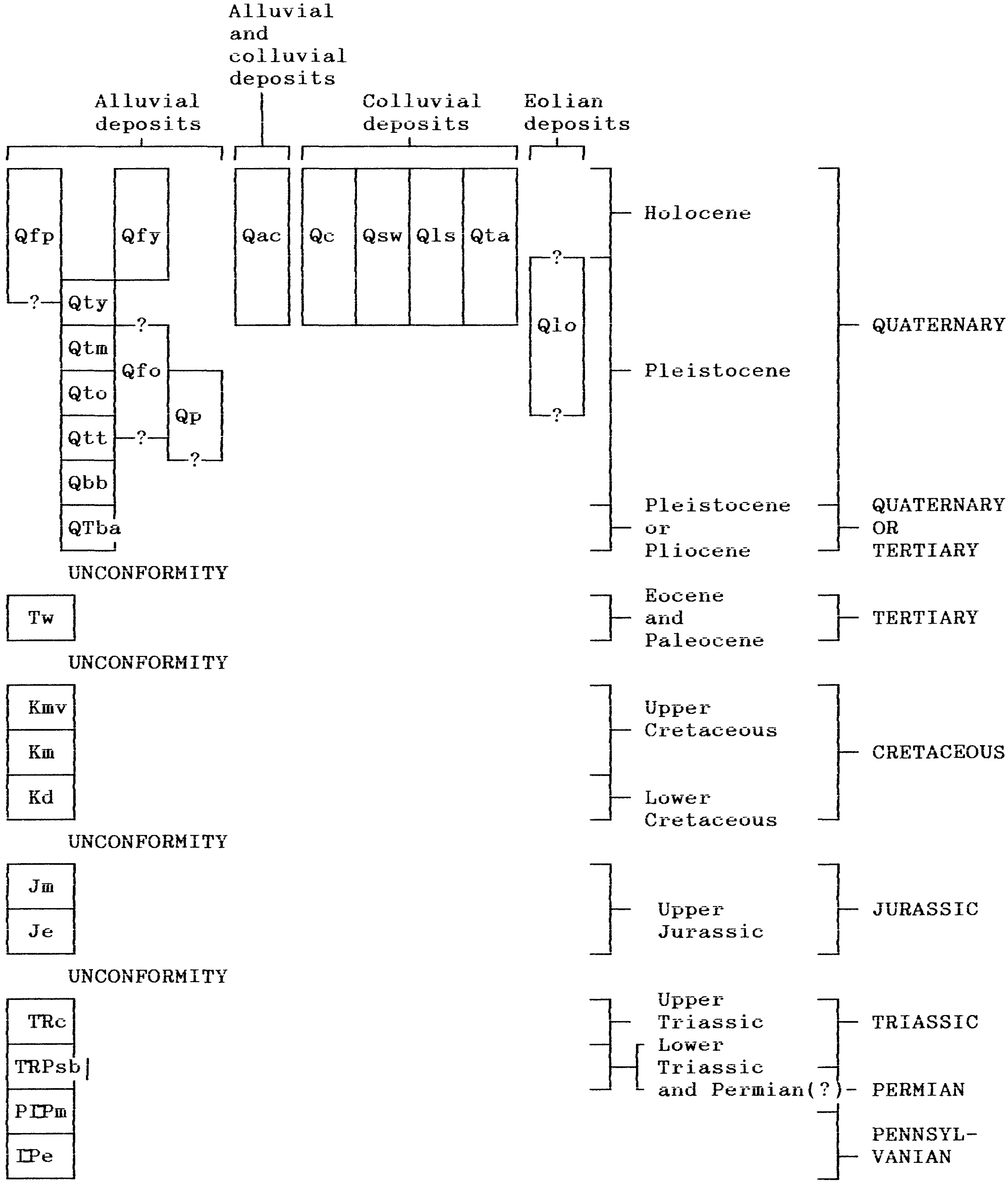
CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

[Surficial deposits shown on the map are estimated to be at least 3 ft thick. Fractional map symbols (for example, Qlo/Qto) are used where loess mantles older surficial deposits and the underlying deposits have been identified. Artificial fills and thin, discontinuous colluvial deposits and residual material on bedrock were not mapped. Artificial fills consist mainly of compacted fill material beneath segments of U.S. Highway 6, Interstate 70, and the nearby tracks of the Denver and Rio Grande Western Railroad, and uncompacted fill in several small mine dumps. Also not mapped are several elongate areas above mined coal beds on the north side of the Grand Hogback, near Burning Mountain and Coal Ridge, where the ground surface is highly oxidized, fractured, and prone to subsidence (Stover and Soule, 1985). Divisions of Pleistocene time correspond to those of Richmond and Fullerton (1986). Age assignments for surficial deposits are based chiefly on the degree of modification of original surface morphology, height above stream level, and degree of soil development. Age assignments for units Qtt, Qbb, and QTba are based chiefly on a regional rate of stream incision of about 45 ft/100 ka and on a regional rate of tectonic uplift of about 600 ft/Ma. The incision rate is based on an average of three values for stream incision, since the deposition of the 620-ka Lava Creek B volcanic ash, of about 300 ft along the Colorado River near the east end of Glenwood Canyon (Izett and Wilcox, 1982), about 290 ft along the Roaring Fork River near Carbondale, Colorado (Piety, 1981), and about 260-280 ft along the White River near Meeker, Colorado (J.W. Whitney, oral commun., 1992; Whitney and others, 1983). The rate of tectonic uplift of about 6000 ft/10 Ma was determined for the Derby Peak fauna, in the Flat Tops area (Colman, 1985), which is about 30 mi northeast of the quadrangle. 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).]

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

Qfp **Flood plain and stream channel deposits (Holocene and late Pleistocene)**– Chiefly clast-supported, slightly bouldery, pebble- and cobble-gravel in a sand matrix that is locally overlain by gravelly sand to sandy silt. Along the Colorado River, the upper 3-4 ft of the flood plain deposits is commonly clean or humic and slightly silty, very fine to medium sand that locally contains a minor amount of pebbles and cobbles. Poorly to moderately well sorted and poorly to well bedded. Clasts are commonly subangular to rounded; their lithologies reflect those of the bedrock in the upstream areas. The unit occurs along the Colorado River and its major tributaries. Low-lying areas are prone to periodic flooding. Deposits along tributary streams may contain more sand and silt than those along the Colorado River. The unit locally includes small alluvial-fan deposits (Qfy), low terrace deposits that are commonly less than 15 ft above modern stream level, and sheetwash deposits (Qsw), and locally may include some organic-rich deposits. A thick (>45 ft) sequence of flood plain deposits, which is exposed in gullies along West Elk Creek (NW¼ sec. 16, T. 5 S., R. 91 W.), consists of interbedded sand and silt. This thick sequence of interbedded sand and silt may have been produced in part by damming of West Elk Creek by one or more former alluvial fans from intermittent tributary drainages downstream of the sequence. The upper part of the unit may be a complex of cut-and-fill deposits of Holocene and late Pleistocene(?) age. The lower part of the unit is probably equivalent, at least in part, to the younger terrace alluvium (Qty). The unit is tentatively correlated with deposits in terrace T8 of Piety (1981) along the Roaring Fork River between Glenwood Springs and Carbondale, Colo. Thickness along the Colorado River 15 ft and more near the western quadrangle boundary and greater than 45 ft near the eastern quadrangle boundary (Colorado Highway Department, unpublished data); maximum exposed thickness 45 ft along West Elk Creek; maximum thickness along the Colorado River may be about 60 ft

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 (4-16 in.) lenses of sand, pebble gravel, and cobbly pebble gravel. At the mouth of Alkali Creek, the unit is mostly very thin-bedded (0.2-0.8 in.) sandy silt. The unit locally contains boulders as long as 12 ft. Some of the larger boulders were probably deposited by debris flows. Nonbedded to poorly bedded; beds are commonly less than 3 ft thick. Clasts are commonly angular to subangular sandstone north of the Colorado River and are angular to subangular sandstone and angular to subrounded basalt south of the Colorado River. The unit is undissected and was deposited chiefly by small intermittent streams graded to the flood plains of modern streams (Qfp) and locally to the tops of terraces that are underlain by younger terrace alluvium (Qty). Locally includes valley-fill deposits of intermittent streams, debris-flow deposits, sheetwash deposits (Qsw), and colluvium (Qc). Exposed thickness 10-55 ft; maximum thickness probably about 80 ft

Qty **Younger terrace alluvium (late Pleistocene)**–Stream alluvium that underlies terrace remnants that are about 40 ft above the Colorado River, Divide Creek, and Elk Creek. Along the Colorado River, the lower part of the unit consists mostly of a poorly sorted, clast-supported, pebble- and cobble-gravel in a sand matrix. Where deposited by minor tributary streams, the upper part of the unit commonly consists of 2-23 ft of silty sand that contains lenses and thin (as much as 20 in.) beds of cobbly pebble gravel and pebbly sand. Clasts in the lower part of the unit are commonly subrounded to rounded and are derived from a variety of sedimentary, igneous, and metamorphic rocks in the upstream areas. Where deposited by minor tributary streams, the clasts in the upper part of the unit are basalt and sandstone on the south side of the Colorado River and are almost entirely sandstone on the north side of the river. Along Divide Creek, the unit is mostly a poorly sorted, clast-supported, bouldery, cobble and pebble gravel in a sand matrix. Near the mouth of Divide Creek, the unit is a gravelly silty sand that contains lenses of cobbly pebble gravel. Clasts are chiefly subrounded to rounded basalt. Along Elk Creek, the unit is poorly exposed, but it appears to consist mostly of poorly sorted, clast-supported, cobble and pebble gravel in a sand matrix. The unit along the Colorado and its major tributaries is overlain by about 6-10 ft of loess (Qlo) and by younger fan alluvium (Qfy). Unit Qty is probably equivalent in part to outwash of the Pinedale glaciation, which is about 12-35 ka (Richmond, 1986, chart 1A). Unit Qty is tentatively correlated with deposits in terraces T7 and T6 of Piety (1981) along the Roaring Fork River between Glenwood Springs and Carbondale, Colo., and with deposits in terraces A and B of Bryant (1979) farther upstream between Woody Creek and Aspen, Colo. Exposed thickness 50 ft along the Colorado River and 15 ft along Divide Creek; maximum thickness along the Colorado River possibly about 100 ft

Qtm **Intermediate terrace alluvium (late Pleistocene)**--Alluvium that underlies small terrace remnants about 70-80 ft above West Elk and Elk Creeks. The unit is poorly exposed, but it appears to consist of poorly sorted, clast-supported, slightly bouldery, pebble- and cobble-gravel in a sand matrix. Clasts are mostly subangular to rounded sandstone, quartzite, granite (or gneiss), limestone, conglomerate, and siltstone. The unit is locally weakly cemented by fine-grained calcium carbonate and is locally overlain by loess (Qlo) and by thin, unmapped deposits of slopewash (Qsw) or colluvium (Qc). The unit is inferred to be intermediate in age between the younger and older terrace alluviums (Qty and Qto) and may be of middle or early Wisconsin age (about 35-65 or 65-80 ka; Richmond and Fullerton, 1986, fig. 2). Thickness probably about 15-30 ft

Qto **Older terrace alluvium (middle Pleistocene)**--Stream alluvium that underlies terrace remnants about 130-150 ft above the Colorado River, about 130 ft above Divide, Garfield, and Elk Creeks, and about 150 ft above West Elk Creek. Along the Colorado River, the unit mostly is a poorly to moderately well sorted, clast-supported, bouldery pebble- and cobble-gravel in a sand matrix that (1) is overlain by about 23-50 ft of thin-bedded (0.5-6 in.), slightly silty sand and thin (2-10 in.) lenses of pebbly sand and sandy pebble gravel, or (2) grades upward into slightly cobbly pebble gravel and pebbly sand in the upper 6-10 ft. Locally the unit is a pebble gravel that is overlain by about 10 ft of thin bedded, sandy silt that contains thin (2-14 in.) lenses of sand and sandy pebble gravel. Locally the lower 3 ft of the unit is cemented by fine-grained calcium carbonate. Clasts are chiefly subrounded to rounded sandstone, gneiss, quartzite, basalt, granodiorite(?), limestone, and dolomite deposited by the Colorado River. Locally, the clasts in the upper part of the unit were deposited by streams tributary to the Colorado. They are basalt and a minor amount of sandstone near the mouths of Divide Creek and Garfield Creek and are sandstone near the mouths of intermittent tributary streams that head on the south flank of the Grand Hogback. Along Garfield Creek, the unit is mostly a poorly sorted, clast-supported, bouldery, pebble- and cobble-gravel in a sand matrix. Clasts are chiefly subrounded to rounded basalt. Some of the clasts are as long as 3.5 ft. Along Divide Creek the unit is mostly a poorly sorted, clast-supported, bouldery, pebble- and cobble-gravel in a sand matrix. The unit locally contains a few thin (10-14 in.) lenses of sand and sandy pebble gravel. Clasts are chiefly subrounded to rounded basalt and a minor amount of sandstone. Locally the clasts in the upper part of the unit are chiefly subangular to subrounded sandstone and a minor amount of basalt. Some of the basalt clasts in the lower part of the unit are as long as 5 ft. Along Elk and West Elk Creeks, the unit is mostly a poorly to moderately well sorted, clast-supported, cobbly pebble gravel in a sand matrix. The unit locally contains lenses and beds of pebbly sand and sandy silt that are about 2-40 in. thick and rare sandstone boulders, some as long as 5.5 ft. Locally some of the beds are weakly cemented by fine-grained calcium carbonate and form small ledges that are as much as 3 ft thick. Clasts are chiefly subrounded to rounded sandstone, quartzite, granite (or gneiss), limestone, conglomerate, and siltstone. The unit along the Colorado and its major tributaries is locally mantled by 8-12 ft of loess (Qlo) and by older fan alluvium (Qfo) and slopewash deposits (Qsw). Locally there is a buried soil that is formed in the upper part of the unit. The soil has an argillic B horizon, 24 in. thick, that is formed in silty alluvium or in the overlying loess. It overlies a stage III K horizon, 48 in. thick, that is formed in the upper part of the underlying gravel. The morphologic development of the soil suggests that the unit is of Bull Lake age (Shroba, 1989) and may be about 140-150 ka (Pierce and others, 1976; Pierce, 1979) or about 130-300 ka (late middle Pleistocene; Richmond, 1986, chart 1A). Locally the buried soil is formed in the lower of two loess sheets that locally mantle the unit. The unit is tentatively correlated with deposits in terraces T5 and T4 of Piety (1981) along the Roaring Fork River between Glenwood Springs and Carbondale, and with deposits in terrace C of Bryant (1979) farther upstream between Woody Creek and Aspen. Exposed thickness along the Colorado River 35-120 ft, maximum thickness probably about 130 ft. Exposed thickness 10 ft along Garfield Creek, 60 ft along Divide Creek, 12-20 ft along Elk Creek, and 50 ft along West Elk Creek. Maximum thickness along these creeks possibly about 100 ft

Qtt **Oldest terrace alluvium (middle Pleistocene)**--Stream alluvium that underlies small terrace remnants that are about 220, 250, and 320 ft above the Colorado River, about 320 ft above Elk Creek near its confluence with East Elk Creek, and about 320 ft above Garfield Creek near its confluence with the Colorado River. Along the Colorado River and Elk Creek, the unit is mostly a poorly sorted, clast-supported, slightly bouldery, pebble- and cobble-gravel in a sand matrix. It locally consists of thin (0.2-14 in.) lenses and beds of silt, sandy silt, silty sand, and sandy pebble gravel. The unit locally grades upward into about 12-20 in. of moderately well sorted, clast-supported, pebble gravel in a sand matrix that is overlain by about 20-30 in. of non-pebbly to slightly pebbly, slightly silty sand. Clasts are mostly subrounded to rounded and are derived from a variety of sedimentary, igneous, and metamorphic rocks in the upstream areas. Locally along the Colorado River, the upper part of the unit was deposited by tributary streams and is composed of angular to subrounded sandstone or basalt clasts in a sand matrix. A stage III K soil horizon, 24-36 in. thick, is locally present in the top of the unit and the lower 3-6 ft of the unit is locally cemented by fine-grained calcium carbonate. Along Garfield Creek, the unit is mostly a poorly sorted, clast-supported, bouldery, basalt-rich gravel that contains a minor amount of sandstone and quartzite clasts. The basalt clasts are subrounded to rounded and are as long as 6 ft. The unit along the Colorado River and its major tributaries is locally mantled by 6-13 ft of loess (Qlo) and locally by about 15-30 ft of sandstone-rich older fan alluvium (Qfo), which is overlain by loess. The loess mantle locally consists of two or more sheets. The unit may be correlative in part with other terrace deposits within 30 mi of the quadrangle that contain or are overlain by the 620 ka Lava Creek B volcanic ash. The unit is tentatively correlated with deposits in terraces T3 and T2 of Piety (1981) along the Roaring Fork River between Glenwood Springs and Carbondale and with deposits in terrace D of Bryant (1979) farther upstream between Woody Creek and Aspen. Exposed thickness commonly 6-30 ft and locally 70 ft along the Colorado River, 30 ft along East Elk Creek, and 13 ft along Garfield Creek; maximum thickness along the Colorado possibly about 80 ft

Qfo **Older fan alluvium (late and middle Pleistocene)**--Mostly poorly sorted, clast- and matrix-supported, slightly bouldery, pebble- and cobble-gravel in a silty sand matrix, sandy pebble gravel, and pebbly sand. Clasts are chiefly angular to subrounded basalt and a minor amount of angular to subrounded sandstone in deposits on the south side of the Colorado River, and angular to subrounded sandstone in deposits on the north side of the river. Poorly bedded; commonly contains discontinuous beds and lenses. The unit underlies slightly dissected surfaces that are mantled by about 3-10 ft of loess (Qlo). Deposited by Baldy Creek and small intermittent streams that were graded to the tops of terrace remnants composed of old terrace alluvium (Qto and Qtt). Locally includes valley-fill deposits of intermittent streams, debris-flow deposits, sheetwash deposits (Qsw), and colluvium (Qc). Exposed thickness 6-35 ft; maximum thickness possibly about 80 ft

Qp **Pediment deposits (middle Pleistocene)**--Gravelly alluvium and debris-flow deposits at four or more levels that overlie gently sloping surfaces cut on Mancos Shale (Km) and Wasatch Formation (Tw). Locally as much as 20 ft of relief on the pediment (bedrock surface) where it is incised by stream channels. 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 locally minor amounts of siltstone, limestone, and quartzite. The quartzite clasts are subrounded to rounded and were probably derived from older fluvial surficial deposits. The unit probably consists of alluvium, debris-flow deposits, sheetwash deposits (Qsw), and colluvium (Qc). Nonsorted, bouldery, debris-flow(?) deposits are common in the upper part of the unit. Some of the sandstone boulders in the unit near the Grand Hogback are as long as 10 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 are disintegrated and weathered to sand-size particles. The bedrock beneath the unit is locally slightly oxidized to a depth of 10 ft or more. The unit is dissected and is mantled by about 6-13 ft of loess (Qlo), which locally consists of two or more sheets. A reddish-yellow (5YR 6/6) argillic B horizon, 25 in. thick, is locally present in the top of the basal loess sheet. The lower limits of the pediment deposits are about 130-330 ft above Elk and West Elk Creeks and about 130-620 ft above the Colorado River. The three lower pediment deposits along the Colorado River east of New Castle appear to be graded to terrace remnants composed of old terrace alluvium (Qto and Qtt) that are about 130-150, 220, and 250 ft above the river. Some of the loess (Qlo) on gently sloping surfaces along the Colorado River and on the east side of Garfield Creek may overlie pediment deposits. Exposed thickness commonly 6-15 ft; maximum observed thickness 30 ft; maximum thickness possibly about 50 ft

Qbb **Basaltic boulder gravel (middle or early Pleistocene)**-Bouldery pediment(?) deposits consisting mainly of alluvium and debris-flow deposits and possibly minor fan alluvium at two levels that overlie gently sloping surfaces cut on Wasatch Formation (Tw) in the southern part of the quadrangle. These surfaces are about 640-1,080 ft above Divide Creek and are about 320-560 ft below the adjacent geomorphic surface that is underlain by high-level basaltic alluvium (QTba). The unit is poorly exposed, but it appears to consist of very poorly sorted, clast-supported, very bouldery cobble gravel in a sand matrix. Clasts are subangular to subround basalt that are commonly greater than 3 ft in length and are as long as 6 ft. The gravel is locally mantled by about 3-5 ft of non-pebbly to pebbly, slightly silty sand. A stage III K soil horizon, 25 in. thick, is formed in the top of the unit. The K horizon is mantled by loess (Qlo) that is at least 1.5 ft thick. The unit probably locally includes sheetwash deposits (Qsw). Exposed thickness 13-20 ft; maximum thickness possibly about 60 ft

QTba **High-level basaltic alluvium (early Pleistocene or late Pliocene)**--Fan alluvium and valley-fill or pediment(?) deposits that underlie gently sloping geomorphic surfaces in the southern part of the quadrangle that are more than 900 ft above the Colorado River and about 960 ft above Garfield Creek. The northern part of the unit underlies a gentle, west-sloping geomorphic surface. It is a thick (150 ft) sequence of alluvial-fan deposits that consist of basaltic stream alluvium and debris-flow deposits. These deposits are well exposed in a steep landslide scarp (NE1/4SE1/4 sec. 7, T. 6 S., R. 91 W.) where they consist of alternating lenticular beds and lenses (about 0.3-6 ft thick) of mostly poorly bedded, poorly sorted, clast-support, very bouldery, cobble- and pebble-gravel and cobbly pebble gravel in a matrix of slightly silty sand. The sequence also includes minor amounts of poorly sorted, sandy pebble gravel, pebbly sand, and sand. The clasts are mostly subangular to rounded basalt and a minor amount of sandstone and intrusive igneous rocks. Basalt clasts are commonly 6 ft in length and are as long as 15 ft. A soil K horizon, 48 in. thick, is formed in pebbly, sandy alluvium at the top of the sequence. The K horizon has stage IV carbonate morphology in the upper 25 in. and stage III morphology in the lower 23 in. The K horizon is overlain by at least 18 ft of loess (Qlo), which consists of at least five separate loess sheets, about 3-4 ft thick. Where exposed, the sequence of alluvial-fan deposits overlies Wasatch Formation (Tw), but these deposits may locally overlie or be interstratified with unexposed gravelly alluvium deposited by the Colorado River. The presence of underlying or interstratified Colorado River alluvium is suggested by the lithologic composition of the colluvial deposits derived from the alluvial-fan deposits. These colluvial deposits locally contain a minor amount of rounded and well rounded pebbles and cobbles that are identical to those in nearby, but younger and topographically lower, terrace deposits that were laid down by the Colorado River. The southern part of the unit underlies a gentle, north-sloping geomorphic surface and is poorly exposed. It appears to be either valley-fill or pediment(?) deposits that consist of bouldery alluvium and colluvium that accumulated on a former valley floor or on a pediment(?) surface cut on the Wasatch Formation. The deposits are probably mostly poorly sorted, clast-supported, bouldery, cobble- and pebble-gravel in a sand matrix. The clasts are mostly subangular to rounded basalt that are as long as 6 ft. The gravelly deposits are overlain by one or more loess sheets (Qlo). The unit may have been deposited by ancestral Garfield Creek and(or) Baldy Creek. Exposed thickness of fan alluvium in the northern part of the unit 150 ft; thickness of valley-fill or pediment(?) deposits in the southern part of the unit possibly as much as 80 ft

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

Qac **Undivided alluvium and colluvium (Holocene and late Pleistocene)**--Chiefly undifferentiated flood plain and stream channel deposits (Qfp), young fan alluvium (Qfy), and colluvial debris-flow (Qc) and sheetwash (Qsw) deposits. The alluvium typically consists of interbedded sand, pebbly sand, and pebble gravel and ranges from thin-bedded (0.2-6 in.) silty sand to thick-bedded (>3 ft), poorly sorted, clast- and matrix-supported, slightly bouldery, pebble- and cobble-gravel in a sand matrix. The sheetwash is typically pebbly silty sand. Alluvial deposits form flood plains, stream channels, and small alluvial fans along Alkali Creek and the lower reaches of some of the larger intermittent streams. Sheetwash deposits locally mantle the valley bottoms and the adjacent valley sides and hill slopes. Exposed thickness of the alluvium 3-26 ft; maximum thickness probably about 40 ft. Exposed thickness of the colluvium 3-6 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. Deposits derived from the Mancos Shale and shale in the Mesaverde Group (Kmv) may contain expansive clays and have high shrink-swell potential. Deposits derived from the Eagle Valley Evaporite (IPe) are prone to hydrocompaction and subsidence owing to the dissolution of gypsum, anhydrite, and halite. Typically unsorted to poorly sorted and unstratified to poorly stratified. Clasts are typically angular to subrounded; their lithologic composition reflects that of the bedrock and(or) the surficial deposits from which the colluvium was derived. The unit locally includes sheetwash (Qsw) creep, debris-flow, and landslide (Qls) deposits that are too small to map separately or that lack distinctive surface morphology and could not be distinguished in the field or on aerial photographs. The map unit also locally includes thin loess (Qlo) mantles on older gently sloping colluvial deposits, small deposits of alluvium and colluvium (Qac) in and along minor drainageways, and probably small pediment deposits (Qp) on the north side of the Grand Hogback. Exposed thickness 6-13 ft; maximum thickness probably about 15 ft

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

Qls **Landslide deposits (Holocene and late Pleistocene)**--Chiefly unsorted and unstratified rock debris characterized by hummocky topography. Many of the landslide deposits are complex (Varnes, 1978). The younger deposits are commonly bounded upslope by crescentic headwall scarps and downslope by lobate toes. The unit includes small debris-slide, 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. Rock and evaporite deposits of the Eagle Valley Evaporite (IPe) were mobilized and incorporated in debris-slide deposits near the northeast corner of the quadrangle. Earth-slump and earth-flow deposits are common near the southern quadrangle boundary where they were derived from the Wasatch Formation (Tw) and the overlying high-level basaltic alluvium (QTba). The deposits derived from the Eagle Valley Evaporite are prone to hydro-compaction and subsidence owing to the dissolution of gypsum, anhydrite, and halite. The unit locally includes sheetwash (Qsw), creep, and debris-flow (Colluvium, Qc) deposits. Exposed thickness 6-15 ft; maximum thickness possibly 150 ft

Qta **Talus deposits (Holocene and late Pleistocene)**--Chiefly unsorted, crudely stratified, angular, cobbly and bouldery rubble on steep slopes below outcrops of Dakota Sandstone (Kd). The matrix is mostly sand and silt; some of it may be of eolian origin. The upper part of the unit locally lacks matrix. The unit probably includes minor deposits of colluvium (Qc). Only one large deposit is mapped in the northeast part of the quadrangle. Small talus deposits in the valleys of Elk Creek and Main Elk Creek were not mapped. Maximum thickness probably about 50 ft

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

Qlo **Loess (late and middle? Pleistocene)**--Wind-deposited, nonstratified, friable, slightly plastic to plastic, slightly clayey, sandy silt and silty sand. The unit may locally include minor deposits of clayey silt. The grain-size distribution of slightly weathered loess in and near the quadrangle is about 23 percent sand, 55 percent silt, and 17 percent clay (Harmon and Murray, 1985, tables 13 and 14). Most of the sand-size particles are very fine and fine. The unit is prone to sheet erosion, gullying, and compaction when wet. Locally includes some loess-derived sheetwash (Qsw) and creep (Colluvium, Qc) deposits. Deposited during five or more episodes of eolian activity. Deposition may have continued into Holocene time. Probably derived chiefly from flood plain sediments of the Colorado River and its major tributaries and possibly in part from (1) outcrops of Tertiary siltstone and mudstone in the Piceance Basin west of the quadrangle (Tweto, 1979) and (2) large areas of exposed sandstone in the Canyonlands region in southeastern Utah (Whitney and Andrews, 1983). The mapped distribution of loess is approximate, because it lacks distinct topographic expression. The unit commonly mantles level to gently sloping surficial deposits that are older than the younger fan alluvium (Qfy). Younger terrace alluvium (Qty) is mantled by one loess sheet, older terrace alluvium (Qto) is locally mantled by two loess sheets, pediment deposits (Qp) and the oldest terrace alluvium (Qtt) are locally mantled by two or more loess sheets, and the high-level basaltic alluvium (QTba) is mantled by five 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 12 in. thick; a cambic B horizon about 4 in. thick; a weak to moderate prismatic, argillic B horizon about 16 in. thick; and a stage I Bk horizon greater than 30 in. thick. The soil that is formed in the lower loess sheet on the older terrace alluvium contains more clay and calcium carbonate than the soil in the upper loess sheet and commonly consists of the following horizons: a cambic B horizon about 8 in. thick; a strong prismatic, argillic B horizon about 16 in. thick that contains weak stage II calcium carbonate; a weak stage III K horizon about 20 in. thick; and a stage I-II Bk horizon about 12 in. thick. Where the upper loess sheet is composed of silty sand, the soils have weakly developed, non-prismatic argillic B horizons that are about 14 in. thick. The upper two loess sheets on the high-level basaltic alluvium have 10YR-hue colors and cambic and(or) incipient argillic B horizons, whereas the lower three loess sheets have 7.5YR-hue colors and the lowest two loess sheets have strong prismatic argillic B horizons, 20-35 in. thick, that have stage I-II calcium carbonate morphology. The degree of soil development in these loess sheets suggests that the upper two sheets are probably late Pleistocene and one or more of the lower three sheets may be middle Pleistocene. Exposed thickness 5-18 ft; commonly 6-13 ft thick

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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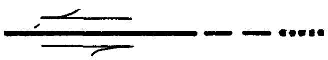
CONVERSION FACTORS

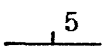
Multiply	By	To obtain
inches (in)	2.540	centimeters(cm)
feet (ft)	0.3048	meters (m)
miles (mi)	1.609	kilometers (km)

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

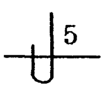
NORMAL FAULT--Dashed where approximately located; dotted where concealed. Bar and ball on downthrown side



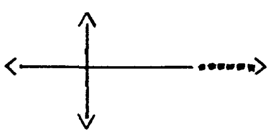
STRIKE-SLIP FAULT--Dashed where approximately located; dotted where concealed. Arrows show direction of relative movement



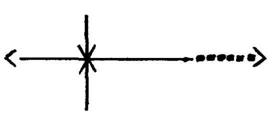
STRIKE AND DIP OF BEDS



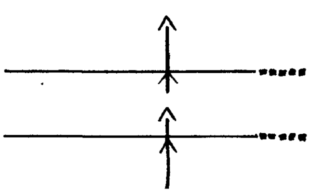
STRIKE AND DIP OF OVERTURNED BEDS



ANTICLINE--Showing trace of crestline and direction of plunge. Dashed where approximately located; dotted where concealed.



SYNCLINE--Showing trace of troughline and direction of plunge. Dashed where approximately located; dotted where concealed.



MONOCLINE--Showing upper (not present on this map) and lower fold axes. Arrows indicate direction of dip. Longer arrow indicates flatter dip. Dotted where concealed.