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Geologic Map of the Shoshone Quadrangle, Garfield County, Colorado

DESCRIPTION OF MAP UNITS

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DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

Surficial deposits shown on the map are generally more than about 5-ft thick, but may be thinner locally. Residual deposits and some artificial fills were not mapped. Contacts between surficial units may be gradation, and mapped occasionally include deposits of another type. Divisions of the Pleistocene correspond to those of Richmond and Fullerton (1986). Age assignments for surficial deposits are based primarily upon the degree of erosional modification of original surface morphology, height above stream level, and degree of soil development. Many of the surficial deposits are calcareous and contain varying amounts of both primary and secondary calcium carbonate.

HUMAN-MADE DEPOSITS

af **Artificial fill (latest Holocene)**—Fill placed by humans during construction projects. Mostly earthen materials used for dams of reservoirs and ponds, but also includes fill used beneath Interstate Highway 70. Composed mostly of silt, sand, and rock fragments. Maximum thickness about 30 ft. Poorly compacted fill may be subject to settlement when loaded.

ALLUVIAL DEPOSITS—**Silt, sand, and gravel deposited in stream channels, flood plains, terraces, debris fans, and sheet-wash areas along the Colorado River and tributary streams.**

Qa **Stream-channel, flood-plain, and low terrace deposits (Holocene and late Pleistocene)**—Includes modern alluvium and other deposits underlying the Colorado River, adjacent flood-plain deposits, and low terrace alluvium that is up to about 15 ft above modern stream level. May locally include organic-rich deposits and talus. May be interbedded with younger debris-flow deposits where the distal ends of fans extend into modern river channels. Mostly clast-supported, slightly bouldery, pebble and cobble gravel in a sand matrix occasionally interbedded and overlain by sandy silt and gravelly sand. Locally includes lacustrine deposits within Glenwood Canyon which were deposited when the river was blocked by rockfalls or debris flows (Bowen, 1988). Unit is poorly to moderately well sorted and poorly to well bedded. Clasts are subangular to round, and their varied lithology reflects the diverse types of bedrock within their provenance. Maximum thickness about 154 ft in Glenwood Canyon (Bowen, 1988), but generally much thinner. Low-lying areas within this mapped unit are subject to flooding. May be a source of aggregate.

Qdfy **Younger debris-flow deposits (Holocene)**—Sediments deposited in active debris-flow areas. Dominantly poorly sorted, clast- and matrix-supported, pebble and cobble gravel in a sandy silt or silty sand matrix; frequently very bouldery, particularly near fan heads. Distal part of many fans is characterized by mudflow and sheet-wash deposits and tends to be finer grained. Distal ends may be interfingered with modern alluvium adjacent to active stream channels. Unit locally grades to talus or colluvium. Clasts are mostly angular to subround sedimentary rock and basalt fragments up to about 6 ft in diameter. Original depositional character of the surface of the unit is preserved, except where disturbed by human activities. Maximum thickness probably about 80 ft. Subject to episodic debris-flow activity following intense rainstorms, except on distal ends, where mudflow and sheet-wash processes control sediment deposition. Distal parts may be prone to hydrocompaction. Subject to piping and sinkholes where underlain by evaporitic bedrock. May be corrosive if derived from evaporitic rocks. May be a source of aggregate where derived from Precambrian and lower Paleozoic rocks.

Qsw **Sheet-wash deposits (Holocene and late Pleistocene)**—Includes deposits derived from weathered bedrock and unconsolidated, surficial materials that are transported dominantly by sheet erosion and accumulate in very small intermittent stream valleys or in basin areas which may lack external drainage. Common on gentle to moderate slopes underlain by limestone, shale, basalt, red beds, and landslide deposits. Typically consists of pebbly, silty sand and sandy silt. Maximum thickness probably about 25 ft. Subject to sheet wash and occasionally prone to settlement when loaded. May be susceptible to hydrocompaction, settlement, and piping when derived from Maroon Formation or evaporitic rocks.

Qdfm **Intermediate debris-flow deposits (Holocene and late Pleistocene)**—Similar in texture and depositional environment to younger debris-flow deposits (Qdfy), but slightly older. Geomorphic character of original depositional surface commonly recognizable, but the surface is topographically about 20 to 40 ft above active debris-flow channels. Generally not susceptible to future debris-flow activity unless a major blockage develops in an adjacent, active, debris-flow channel or during unusually large debris-flow events. Hydrocompaction, piping, and settlement may occur where the deposits are fine-grained.

Qdfo **Old debris-flow deposits (late and middle? Pleistocene)**—Occur as remnants of formerly extensive debris fans at the mouth of Ike Creek and in Spring Valley. Deposits east of the mouth of Ike Creek include rounded basalt clasts, suggesting deposition in a fluvial environment associated with Ike Creek. Original geomorphic surfaces are generally preserved. May locally be mantled with loess. Elevation differences between original depositional surface and adjacent modern drainages range from 20 to 200 ft. Texturally similar to younger debris-flow deposits (Qdfy), although the deposit east of the mouth of Ike Creek includes well rounded basalt clasts and may in part be stream alluvium deposited by Ike Creek. Thickness generally about 30 to 60 ft, but may locally exceed 100 ft. Where fine-grained, unit may be prone to hydrocompaction, piping, and settlement. Corrosive when derived from evaporitic bedrock. May be a source of aggregate.

Qto **Older terrace alluvium (middle Pleistocene)**—Includes a single deposit of stream alluvium on the north side of the Colorado River at the western edge of the quadrangle. Upper surface of unit about 140 ft above modern stream level. Unit is generally a clast-supported, cobble or pebble gravel in a sand matrix with occasional small boulders, but may range to a matrix-supported, gravelly sand or gravelly silt. Clasts are chiefly subround to round, with varied lithologies that reflect the heterogeneous nature of the provenance area. Granitic clasts moderately weathered at shallow depths. Locally may include fine-grained overbank deposits. Unit is tentatively correlated with terrace T5 in the Carbondale-Glenwood Springs area of Piety (1981), with terrace C of Bryant (1979) in the Aspen-Woody Creek area, and with older terrace alluvium of Fairer and others (1993). Deposits are probably of Bull Lake age, which may be about 140–150 ka (Pierce and others, 1976; Pierce, 1979) or about 130–300 ka (Richmond, 1986). Thickness estimated at about 100 ft. May be a source of aggregate.

QTbg **High-level basaltic gravel (early Pleistocene or Pliocene)**—Includes several deposits of boulder gravel on hill and ridge crests on the south side of the Colorado River between 1,300 and 2,800 ft above modern river level. Consists of subangular to rounded boulders, cobbles, and pebbles of basalt, red sandstone, and red conglomerate in a clayey or sandy silt matrix. Locally includes pebbles derived from evaporitic bedrock. Percentage of basaltic clasts increases eastward across quadrangle. Well exposed in head scarp of landslide in SW 1/4SW 1/4 sec. 32, T. 5 S., R. 87 W. in a tributary to Devils Hole Creek. Probably deposited as debris flows, colluvium, or landslides on the south valley wall of the Colorado River. Maximum thickness probably about 80 ft. May be a source of aggregate.

COLLUVIAL DEPOSITS—**Silt, sand, gravel, and clay on valley sides, valley floors, and hill slopes that were mobilized, transported, and deposited primarily by gravity, but frequently assisted by sheet erosion, freeze-thaw action, and water-saturated conditions that affect pore pressure.**

Qc **Colluvium (Holocene and late Pleistocene)**—Mostly clast-supported, pebble to boulder gravel in a sandy silt matrix that was derived from weathered bedrock and transported down gradient primarily by gravity, but aided by sheet erosion. Deposits usually coarser grained in upper reaches and finer grained in distal areas. Deposits derived from easily eroded formations tend to be finer grained and matrix supported. Clasts typically are angular to subangular. Commonly unsorted or poorly sorted with weak or no stratification. Clast lithology variable and dependent upon types of rocks occurring with the provenance area. Locally includes talus, landslide deposits, sheet-wash deposits, and debris-flow deposits that are too small or too indistinct on aerial photography to be mapped separately. Maximum thickness probably about 50 ft, but generally thinner. Areas mapped as colluvium are typically susceptible to active deposition and are frequently subject to sheet wash, rockfall, small debris flows, and minor landsliding. Fine-grained colluvium locally prone to hydrocompaction, piping, and settlement, particularly when derived from Maroon Formation or evaporitic rocks.

Qt

Talus (Holocene and late Pleistocene)—Angular, cobbly and bouldery rubble on steep slopes that is derived from bedrock outcrops and is transported down slope principally by gravity as rockfalls, rockslides, rock avalanches, and rock topples. Locally may be aided by water and freeze-thaw processes. Generally derived from well indurated Precambrian and lower Paleozoic rocks or basalt. Locally lacks matrix material. May include alluvium and colluvium (Qac), particularly on narrow valley floors where talus is mapped on both sides of the valley floor. Maximum thickness estimated at about 80 ft. Subject to severe rockfall, rockslide, rock avalanche, and rock topple hazards. May be a source of high quality riprap and aggregate.

Qlsr

Recent landslide deposits (latest Holocene)—Includes active and recently active rotational and translational landslides with fresh morphological features. Deposit is a heterogeneous unit consisting of unsorted, unstratified rock debris, gravel, sand, silt, and clay. Texture and clast lithology dependent upon source area. Thickness probably a maximum of about 50 ft. Prone to renewed or continued landsliding, and also suggestive of the type of environment which may produce landslides in the current climatic regime. May be susceptible to settlement when loaded and to hydrocompaction and subsidence when derived from evaporites or Maroon Formation.

Qls

Landslide deposits (Holocene and Pleistocene)—Highly variable deposits similar in texture and lithology to recent landslide deposits (Qlsr). Deposits range in age from historic to middle or perhaps even early Pleistocene. Includes rotational landslides, translational landslides, complex slump-earth flows, and extensive slope-failure complexes. Large landslide between Ike and Cimarron Creeks includes numerous small, recently active landslides suggesting that at least part of the large slide mass is presently active. Maximum thickness possibly 250 ft. Unit may be subject to renewed landslide activity, but deeply dissected deposits probably are stable. May be prone to settlement when loaded. Deposits derived from evaporitic rocks or Maroon Formation may be susceptible to hydrocompaction and subsidence.

Qco

Older colluvium (Pleistocene)—Includes various types of older deposits that were transported primarily by gravity and are preserved as erosional remnants of formerly more extensive deposits. Area not subject to significant continued depositional activity. Occurs on ridge line between Ike and Spruce Creeks and on a bench within Glenwood Canyon west of Blue Gulch. Texture and bedding similar to colluvium (Qc). Clast lithology dependant on provenance. Maximum thickness about 40 ft.

Qlso

Older landslide deposits (Pleistocene and late Pliocene?)—Landslide deposits dissected by erosion that lack distinctive landslide morphologic features. Similar in texture, bedding, sorting, and clast lithology to recent landslide deposits (Qlsr). Type of landslide movement not identifiable due to eroded character of deposits. Maximum thickness may exceed 120 ft in deposit southwest of Tie Gulch. Probably not prone to reactivation unless significantly disturbed by construction activities.

ALLUVIAL AND COLLUVIAL DEPOSITS— **Silt, sand, gravel, and clay in stream channels, floodplains, and adjacent hill slopes along tributary valleys. Depositional processes in stream channels and on flood plains primarily alluvial, while colluvial and sheet-wash processes commonly dominant on hill slopes and along the hill slope/valley floor boundary.**

Qac **Alluvium and colluvium, undivided (Holocene and late Pleistocene)**—Sediments in tributary valleys of small perennial and intermittent streams deposited by alluvial and colluvial processes. Chiefly stream-channel, low terrace, and flood-plain deposits along valley floors, with colluvium and sheet wash common on valley sides. Deposits of alluvium and colluvium probably are interfingered. Locally includes older alluvium and colluvium, younger debris-flow deposits, and also lacustrine deposits associated with man-made reservoirs and ponds. Alluvium typically composed of moderately well to well sorted, stratified, interbedded sand, pebbly sand, and sandy gravel, but colluvium may range to poorly sorted, unstratified or poorly stratified clayey, silty sand, bouldery sand, and sandy silt. Clast lithologies dependant upon type of rock within source area. Thickness commonly 5 to 20 ft, with maximum thickness estimated at about 40 ft. Low-lying areas are subject to flooding. Valley sides prone to sheet wash, rockfall, and small debris flows. Deposits derived from evaporitic rocks may be subject to settlement, piping, and hydrocompaction. May be a source of aggregate.

GLACIAL DEPOSITS—**Gravel, sand, silt, and clay deposited by ice in moraines.**

Qti **Till (late and middle Pleistocene)**—Heterogenous deposits of gravel, sand, silt, and minor clay deposited by ice in ground and lateral moraines between East and West Dead Horse Creeks. Only southerly ends of extensive morainal deposits extend into the mapped area. Moraine crests poorly preserved. Lower limit of glaciation at an altitude of about 9,200 ft. Unit is dominantly unsorted or poorly sorted, unstratified or poorly stratified, matrix-supported bouldery, pebble and cobble gravel with a matrix of silty sand. May locally be clast-supported where composed mostly of gravel. Clasts are typically angular to round pieces of Precambrian and lower Paleozoic bedrock that occasionally exceed 10 ft in length. Age of unit not known. Probably in part of Pinedale age (approximately 12–35 ka, Richmond, 1986), but may also in part be of Bull Lake age or perhaps even of pre-Bull Lake age. Maximum thickness estimated at about 100 ft. May be prone to landsliding. May be a source of aggregate.

LACUSTRINE DEPOSITS—**Organic-rich silty clay, silt, and sand deposited in a lacustrine environment within Spring Valley.**

Ql **Lacustrine deposits**—Well stratified deposits of medium to dark gray, organic-rich, well sorted silty clay and silt, and medium red brown, coarse sand deposited in a lacustrine environment within Spring Valley. Unit generally very poorly exposed. According to Calvin Cox (1994, oral communication), a lake existed in Spring Valley until near the end of the last century. His ancestors hand excavated a ditch at the northwest end of Spring Valley to drain the lake and then farmed the exposed lake bottom to demonstrate agricultural use of the land for homesteading purposes. Land ownership was transferred from the federal government to his ancestor in 1896, therefore dewatering of the lake occurred prior to that year. The lake in Spring Valley does not appear to have resulted from landsliding, glaciation, or faulting which blocked the outlet, but rather the valley floor apparently subsided, perhaps as a result of diapirism in the underlying evaporite-bearing formations. Minimum thickness as determined by a test hole hand augered in the excavated depression is 8.5 ft. Maximum thickness unknown. May be prone to settlement when loaded.

SINTER DEPOSITS—**Chemical sediment deposited by a mineral spring.**

Qtu **Tufa (Holocene and Pleistocene?)**—Low density, porous chemical sedimentary rocks consisting of calcium carbonate precipitated from mineral-charged spring, ground, and surface water. Occurs as massive ledges and as a gravel-cementing material in Dead Horse Creek. Appears to have created the dam behind which Hanging Lake has formed. Maximum thickness probably 30 to 40 ft.

UNDIFFERENTIATED DEPOSITS

Q **Undifferentiated surficial deposits (Quaternary)**—Shown only on cross sections.

BEDROCK

Tta **Trachyandesite (Pliocene)**—Possible volcanic centers (domes), flows, and breccias of trachyandesite located near Mesa and West Coulter Creeks. Primarily an olivine basalt with large xenocrysts of quartz, sanidine, and plagioclase. Quartz xenocrysts are rounded, corroded anhedra with a rim of pigeonite and range in size from 0.4 to 8.0 mm. Sanidine crystals are fresh subhedra up to 8 mm in size with inclusions of plagioclase and quartz. Plagioclase (An_{58}) occurs as rounded, zoned, corroded anhedra and euhedra ranging in size from 0.2 to 4.0 mm. Olivine phenocrysts occur as fine euhedral and subhedral crystals generally altered to hematite and iddingsite. Groundmass consists of fine, fresh laths of plagioclase, olivine, and pyroxene. Accessory minerals include biotite, hematite, and magnetite. A sample of sanidine from this rock was dated using the $^{40}Ar/^{39}Ar$ method at 3.94 ± 0.02 Ma (L. Snee, personal communication, 1995). Potential source of high quality riprap and aggregate.

Tb **Basalt (Miocene)**—Multiple flows of basalt, olivine basalt, and andesitic basalt, interbedded with occasionally tuffaceous, commonly calcareous, fluvial siltstone and sandstone, lacustrine claystone, volcanic ash, and volcanic agglomerate. Interbedded sedimentary rocks may correlate with Browns Park Formation. Flow rocks range from massive to highly vesicular, with amygdules of calcite and iron-rich clay. Phenocrysts when present are euhedral and subhedral olivine altered to hematite and iddingsite and ranging in size from 0.4 to 3.0 mm. Plagioclase phenocrysts were observed in one sample. Groundmass is dominantly plagioclase and pyroxene with lesser but varying amounts of olivine, glass, pigeonite, augite, and magnetite. Trace minerals include apatite, iddingsite, and hematite. Estimated maximum thickness about 200 ft, but typically is much thinner. May be a source of rockfall debris where exposed in steep cliffs. May be susceptible to subsidence or sink holes where lava tubes occur near land surface. Potential source of high quality riprap and aggregate.

Larson and others (1975) included all basalt in this quadrangle except for that in the southwest corner of the quadrangle in their Group 2 rocks based primarily on whole rock K-Ar age dates of 10.1 ± 0.5 Ma on basalt from Lookout Mountain west of the map area and 11.1 ± 1.0 Ma on basalt from near Cottonwood Pass east of the mapped area. Group 2 rocks reportedly ranged from about 9 to 14 Ma (Larson and others, 1975). Basalt in the southwest corner of the quadrangle southwest of Spring Valley was described as Group 3 rocks, which should be around 8 Ma (Larson and others, 1975). The young date assigned to the trachy andesite of 3.94 ± 0.02 Ma is well outside the established chronology of Larson and others (1975). Also, in the Glenwood Springs quadrangle just to the west of this quadrangle Kirkham and others (1995) report a whole rock $^{40}Ar/^{39}Ar$ date of 22.4 ± 0.3 Ma from olivine basalt from a roadcut at the northwest end of Spring Valley, a much older date than the established chronology of Larson and others (1975).

PIPm **Maroon Formation and Weber Sandstone, undivided (Permian and Pennsylvanian)**—Mainly red beds of sandstone, conglomerate, mudstone, siltstone, and claystone with minor, thin beds of gray limestone. Includes Schoolhouse Tongue of Weber Sandstone at top of formation (Bass and Northrop, 1963; Stewart and others, 1972b). Conglomerate contains pebble- and cobble-sized clasts. Commonly arkosic and very micaceous. Weber Sandstone Member consists of light gray to greenish black, grayish red, and pale reddish brown, fine-grained, feldspathic sandstone and conglomeratic sandstone which contains locally abundant interstitial and grain-coatings of solid hydrocarbon. Nodules of pyrite occasionally present in middle of Weber Sandstone Member. Total thickness about 3,000 to 4,000 ft, including the 150- to 175-ft-thick Weber Sandstone Member. Generally poorly exposed in quadrangle. Deposition probably occurred in braided streams and on adjoining flood plains and distal sheet-wash areas in a large, coalescing alluvial fan complex on the margin of the Eagle Basin in an arid or semi-arid climate (Johnson, 1987; Fairer and others, 1993).

Formation is prone to slope instability. Large intact blocks of Maroon Formation have been rafted within the massive landslide complex on the northeast side of Spring Valley.

IPeu **Eagle Valley Formation and Eagle Valley Evaporite, undivided (Middle Pennsylvanian)**—Includes Eagle Valley Formation and Eagle Valley Evaporite on south wall of Glenwood Canyon where heavy forest cover and lack of outcrops obscures the contact between units. Eagle Valley Formation includes interbedded reddish brown, gray, reddish gray, and tan siltstone, shale, sandstone, gypsum, and carbonate rocks which represent a stratigraphic interval in which the red beds of the Maroon Formation intertongue with the dominantly evaporitic rocks of the Eagle Valley Evaporite. It includes rock types of both formations. Eagle Valley Evaporite is a sequence of evaporitic rocks consisting mainly of gypsum, anhydrite, halite, and traces of potash salts interbedded with light colored, fine-grained clastic rocks, thin carbonate beds, and conglomerate. Beds are commonly intensely folded, faulted, and plastically deformed by diapirism, flowage, load metamorphism, hydration of anhydrite, and Laramide tectonism (Mallory, 1971). Generally poorly exposed in quadrangle except in recent alluvial cuts, man-made exposures, and headscarps of landslides.

Contact with Maroon Formation placed at top of uppermost evaporite bed or light-colored clastic bed and below base of thick sequence of red beds. Eagle Valley Formation was deposited in Eagle Basin on the margin of an evaporite basin at the distal end of a coalescing alluvial fan complex and in submarine environment within the evaporite basin. Eagle Valley Evaporite was primarily deposited in evaporitic basin formed as the outlet for the sea within the Paleozoic Eagle Basin was restricted (Mallory, 1971). Most clastic sediments in formation likely resulted from transgressive and regressive fluvial and lacustrine deposition (Fairer and others, 1993), but Schenk (1987) reports subaerial deposition of eolian sandstone within the formation between Eagle and Wolcott. Thickness highly variable, but averages about 2,000 ft. May be prone to subsidence, sink holes, compaction, settlement, piping, and diapiric swelling where evaporitic rocks lie near land surface.

IPb **Belden Formation (Lower Pennsylvanian)**—Medium gray to black and dark brown, calcareous and locally micaceous shale and coarse-grained gray fossiliferous limestone. Contains interbeds and lenses of fine-grained, micaceous, greenish-tan sandstone; gritstone (quartz arenite); coaly shale; and gypsum. Very fossiliferous. Bass and Northrop (1963) describe 258 fossil species including algae, foraminifera, anthozoans, bryozoans, brachiopods, pelecypods, gastropods, scaphopods, cephalopods, annelids, trilobites, ostracods, blastoids, crinoids, echinoderms, and vertebrate remains. Unit is 700- to 900-ft thick across study area. Rarely forms discernable outcrop except where subjected to rapid erosion. Normally forms a vegetated slope above the prominent cliffs of the underlying Leadville Limestone. Conformably overlain by a massive bed of gypsum which is the basal marker horizon of the overlying Eagle Valley Evaporite (Mallory, 1971).

Deposited in the Eagle Basin which formed in the northwestern portion of the Central Colorado Trough between the Uncompahgre and Front Range elements of the Ancestral Rocky Mountains. Formed in a relatively low energy environment at a distance from source areas.

Ml **Leadville Limestone (Mississippian)**—Light to medium gray, bluish gray, massive, coarse to finely crystalline, fossiliferous micritic, limestone and dolomite. Contains lenses and nodules of dark gray to black chert as much as 0.3-ft thick in the lower one-third of the formation. Upper half of the formation contains coarse-grained oölites. Carbonate veins with disseminated silt-sized quartz grains are common. Top of unit contains collapse breccias, filled solution cavities, and a red to reddish purple claystone regolith (Molas Formation), all of which formed on a paleokarst surface. Very fossiliferous, including abundant crinoid and brachiopod fragments. Forms a prominent cliff and is frequently the cap rock of outcrops within Glenwood and tributary canyons. Upper contact is irregular and unconformable with overlying Belden Formation. Unit is 200-ft thick across study area. Formed in a marine environment in the sub-littoral zone by chemical precipitation and through the accumulation of biogenic and oölitic sediment.

Unit can be chemically pure and has been investigated as a source of metallurgical grade limestone in an area north of the quadrangle. Also a source of riprap and aggregate. Modern solution features including caves and solution pockets are common in these rocks. Unit may be susceptible to sink holes and subsidence where karst features occur near land surface. May be a source of rockfall debris where exposed in cliffs.

Dc

Chaffee Group (Upper Devonian)—Sequence composed of green shale, quartzite, dolomite, limestone, and dolomitic sandstone. Consists of three named formations, from top to bottom: Gilman Sandstone, Dyer Dolomite, and Parting Formation. Total thickness of the Chaffee Group in Glenwood Canyon as measured by Soule (1992) is 252.5 ft.

Gilman Sandstone consists of tan to yellow, laminated, fine to very fine-grained quartz arenite and dedolomitic limestone. Highly variable in lithology and thickness across study area. Predominantly a 16-ft thick calcareous sandstone on the southeast flank of the White River Uplift. Unit thins to the west of the quadrangle. Sandstone phase consists of rounded to sub-rounded quartz grains which are well sorted. Laminae are generally less than 1 inch in thickness consisting of zones of fine sand which locally display weak planar-tabular cross-bedding and minor load structures. Some laminae contain discontinuous lenses of quartz arenite with visible relict casts of carbonate rhombohedron. Limestone beds consist of a greater than 99 percent pure calcite-bearing dedolomitic limestone with minor hematite and quartz. Upper contact with the overlying Mississippian Leadville Limestone is unconformable. Tweto and Lovering (1977) suggest a water reworked, eolian origin for the Gilman Sandstone near Gilman. Most likely deposited in a changing environment of very shallow water and periodic subaerial exposure in the supratidal (tidal flat) zone.

Dyer Dolomite is divided into two members on the White River Plateau. Upper Coffee Pot Member consists of crystalline, micritic dolomite, dolomitic gray shale, and micritic limestone. Somewhat sandy, especially near the top. Fossiliferous in places. Member is characterized by abundant rip-up clasts, intraformational breccia, and bioturbated bedding (Soule, 1992). Together with the Gilman Sandstone forms blocky slopes beneath the prominent cliff of overlying Leadville Limestone in canyon outcrops. Deposited predominantly in the uppermost intertidal to supratidal (tidal flat) zones in a changing environment of periodic subaerial exposure with influxes of shallow marine conditions. Lower Broken Rib Member consists of gray nodular crystalline limestone. Dyer Dolomite is abundantly fossiliferous with brachiopods dominant (34 species) (Bass and Northrop, 1963). Forms a very distinctive "knobbly-weathering" gray ledge above blocky slopes of the underlying Parting Formation in canyon outcrops. Formed in a shallow marine environment in the sub-littoral zone.

Parting Formation is variable in lithology across study area. In Glenwood Canyon it consists of white to buff, well-cemented, orthoquartzite with minor feldspar and rock fragments, micaceous green shale with discontinuous lenses of orthoquartzite, and sandy micritic dolomite. Thicknesses of orthoquartzite beds are consistent across study area ranging from 0.5 to 1.0 ft. Other beds show much greater variation in thickness. Forms a blocky slope with distinct ledges above prominent cliffs of underlying Manitou Formation. Bass and Northrop (1963) report fish remains collected from the Parting in Glenwood Canyon. Formed in a shallow marine environment.

MDr

Mississippian and Devonian rocks, undivided (Mississippian and Upper Devonian)—Includes rocks of the Leadville Limestone and Chaffee Group where it is not practicable to separate formations due to poor outcrop exposure, inaccessibility, or poorly defined marker horizons. These rocks occur between the Ordovician Manitou Formation below and the Pennsylvanian Belden Formation above. Thickness of combined unit is 450 ft. Combined unit may be susceptible to sink holes and subsidence where karst features occur near land surface.

Om

Manitou Formation (Lower Ordovician)—Formation consists predominantly of medium-bedded brown dolomite at the top with thin beds of gray flat-pebble limestone interbedded with greenish gray calcareous shale, sandstone, and brown-weathering limestone and dolomite in the lower portions. In Glenwood Canyon the unit is 155.8 ft thick according to Bass and Northrop (1963) and 167.3-ft thick as measured by Soule (1992).

Upper Tie Gulch Member consists of massive, micritic, brown and orange-weathering, crystalline, somewhat siliceous, dolomite and minor limestone. Member becomes somewhat sandy near the top. Member forms a consistent 50- to 90-ft thick, brown to orange colored cliff in Glenwood Canyon rising distinctly above a gentler slope produced on the lower Manitou and Dotsero Formations. Some beds are glauconitic although considerably less so than the underlying beds of the Dead Horse Conglomerate Member. No fossils are known to occur in the member. Upper contact with the overlying Devonian Chaffee Group is unconformable, occurring at a thin shale bed which may be the remains of a paleosol (Soule, 1992). Strong dolomitization and lack of marine fossils suggests that sediments of the Tie Gulch Member accumulated in the upper intertidal and/or lowermost supratidal (tidal flat) environments.

Lower Dead Horse Conglomerate Member consists mostly of thin-bedded, gray, flat-pebble limestone conglomerate, thin-bedded limestone, shaly limestone, and two beds of massive dolomitic orthoquartzite. Member is somewhat glauconitic, especially in the bottom portion. A diverse Lower Ordovician fossil fauna has been described from the member by Bass and Northrop (1963) collected from outcrops in Glenwood Canyon. Base of member generally forms a continuous slope with underlying rocks of the Dotsero Formation. Upper portions of member frequently form an unbroken cliff with overlying rocks of the Tie Gulch Member in Glenwood Canyon, rendering close inspection of upper contact difficult. Member most likely was deposited under fluctuating conditions and varying water depths in the intertidal and shallow marine environments. May be a source of rockfall debris.

€d

Dotsero Formation (Upper Cambrian)—Thinly-bedded, tan to gray silty and sandy dolomite, dolomitic sandstone, green dolomitic shale, limestone and dolomite conglomerate, limestone, and pinkish-light gray to very light gray and white to lavender-weathering algal limestone.

Upper Clinetop Member is a 5-ft-thick sequence of matrix-supported limestone pebble conglomerates with abundant rip-up clasts which occurs below a bed of stromatilitic limestone with well preserved algal-head crinkle structure. Upper contact of the Dotsero Formation in Glenwood Canyon is defined by an identified upper Cambrian fossil assemblage collected from the Clinetop Member as distinguished from a lower Ordovician fossil assemblage collected 3 ft above in conformably overlying limestone pebble conglomerates of the Manitou Formation (Bass and Northrop, 1953). The Clinetop algal biostrome and bounding limestone pebble conglomerates occur throughout a 400-square-mile area across the White River Plateau suggesting periods of high energy characteristic of the intertidal environment separated by a period of remarkable, wide-spread quiescence at the close of Cambrian time indicative of the uppermost intertidal to supratidal environment.

Glenwood Canyon Member consists of thinly-bedded dolomite, dolomitic sandstone, conglomeratic limestone, coarse-grained fossiliferous limestone, and dolomitic shale. Dolomitic beds contain abundant glauconite giving a greenish hue to float rocks and locally, sericite. Worm tracks and worm burrows (fucoids) are common, especially in the middle third of the member. Desiccation cracks are less common. These rocks generally form a vegetated slope above the prominent cliffs of the Sawatch Quartzite, however, they can be a cliff-former, especially in the deeper portions of Glenwood Canyon. Member is 90-ft thick. Variation in lithologies and sedimentary structures in the member indicate a period of widely fluctuating depositional patterns ranging from near-shore shallow marine through intertidal to supratidal (tidal flat) environments.

€s

Sawatch Quartzite (Upper Cambrian)—White and buff to gray-orange, brown-weathering, vitreous orthoquartzite in beds from 1- to 3-ft thick. Locally contains beds of arkosic quartz-pebble conglomerate at base of unit resting unconformably on highly weathered Precambrian rocks. Basal hematite-stained, planar to tabular cross-bedded sandstone interbedded with quartzite is also observable in the map area. Map unit includes beds of massive, brown, sandy dolomite, which are a suggested equivalent of the Peerless Formation described by Tweto and Lovering (1977) and Bryant (1979) at Minturn and Aspen, respectively, and overlying beds of unnamed sandy dolomite and white dedolomitic quartzite. These upper beds are possibly disconformable with sediments of the Sawatch Quartzite below and the overlying Dotsero Formation. These sediments form a continuous cliff with the Sawatch Quartzite in Glenwood Canyon and cannot be mapped separately. Fossils are extremely rare to nonexistent in these rocks. Total thickness of this combined unit is 500 ft. Primary sedimentary structure is poorly preserved in the Sawatch Quartzite which most likely originated as beach deposits or in shallow water of the littoral zone from sediment eroding off a highland in the vicinity of the Front Range (Tweto and Lovering, 1977). Peerless Formation equivalent rocks and unnamed overlying dolomitized sediments possibly formed in the intertidal or lowermost supratidal (tidal-flat) environment characterized by fluctuating water depth. Formation prone to rockfalls, rockslides, and rock avalanches. May be a source of aggregate.

PRECAMBRIAN ROCKS

Xg

Biotite granite (Proterozoic)—Generally dark gray and white speckled, medium to coarse-grained, equigranular granite and granodiorite. Primary constituents are soda-rich anhedra of plagioclase, anhedra of microcline and perthite, and severely strained anhedra of quartz. Small blebs of quartz also occur within the feldspar crystals. Accessory minerals include interstitial anhedra of biotite and hornblende. Trace minerals are magnetite, apatite, sphene, epidote, chlorite, and zircon. Mafic xenoliths averaging about a foot in diameter are common in the granite. Samples of the granite examined under the petrographic microscope have a weak gneissic foliation defined by the alignment of the biotite and hornblende crystals.

Unit forms spectacular, well-jointed outcrops in Glenwood Canyon. The granite contains numerous dikes and sills of white to pink pegmatite and aplite. Dikes and sills range from an inch to 10-ft wide and have lengths as much as a few hundred feet.

Lithological similarity of the biotite granite to granites exposed in the Aspen area (Bryant, 1979) and Sawatch Range (Wetherill and Bickford, 1965) indicate that the biotite granite (and other foliated igneous rocks) are of 1.6 to 1.7 Ga (Precambrian X age). Presence of foliation in these rocks indicates a syn- or post metamorphic origin for the intrusive rocks.

Unit is subject to rockslides and rockfalls in the canyons where it is exposed. May be a source of aggregate and riprap.

Xmgn

Biotite-muscovite gneiss (Proterozoic)—Dark gray to black, well to poorly foliated, biotite-muscovite gneiss composed primarily of fine-grained quartz, orthoclase, plagioclase, and as much as 35 percent biotite and muscovite. Biotite is commonly partially replaced by chlorite. In some localities the gneiss is coarse grained and contains distinct one inch diameter aggregates of white muscovite.

Quartz and feldspar podiform segregations that range from a few inches to 3-ft long and from less than an inch to 0.5-ft wide are common throughout the gneiss. Migmatitic layers of granite gneiss in bands ranging from approximately 1 in.- to 3-ft thick are locally abundant.

White and pink pegmatite and aplite zones are common within the gneiss and can locally comprise most of the mapped gneiss unit. Pegmatite units within the biotite-muscovite gneiss are generally composed of large, white, euhedral feldspars, muscovite, anhedral to euhedral, red garnets, dendritic aggregates and solitary crystals of black tourmaline, and oxidized specular hematite.

Several studies of the Precambrian in Colorado have established an accepted chronology (Bryant, 1979). Sedimentary rocks, most likely shales and graywackes, were deposited in this area from about 2.0 to 1.7 Ga. The sediments were metamorphosed and, during the waning stages of metamorphism, intruded by granitic rocks of variable composition and texture about 1.6 to 1.7 Ga. May be subject to rockfalls and rockslides. May be acceptable for use as aggregate and riprap.

ECONOMIC GEOLOGY

Mineral commodities with possible economic potential in the quadrangle include high-calcium limestone, and to a lesser degree, base metals. A small lead-zinc occurrence known as the Fort Defiance prospect is located approximately one mile north of the Colorado River on the divide between the Wagon Gulch and Dry Gulch canyons. The Fort Defiance prospect was described by Heyl (1964) as a weak stockwork in limestone controlled by easterly and northerly striking vertical fractures. The porous silicified breccia contains masses of cerrussite surrounding galena, chalcocite, malachite, limonite boxworks, and minor amounts of smithsonite. Petrographic examination of a mineralized sample from the Fort Defiance prospect collected during this mapping program indicates that the breccia fragments consist of sparry calcite from limestone, and lesser amounts of chert and dolomite. The breccia matrix consists primarily of quartz, with lesser amounts of calcite and hematite. The ore minerals in the sample are cerrussite and galena with trace amounts of chalcopyrite, covellite, and pyrite. One mineralized sample collected during this mapping program was analyzed by Xral Laboratories of Golden, Colorado for its metal content. The results are: 6 parts per billion (ppb) gold, 15.6 parts per million (ppm) silver, 44 ppm arsenic, 35 ppm antimony, 44 ppb mercury, 2080 ppm copper, 75.3 ppm zinc; <1 ppm cadmium; and 2 ppm cobalt. Samples collected by the U. S. Bureau of Mines at the Fort Defiance prospect (Gese and Scott, 1993) contained as much as 36.4 ppm silver, 6760 ppm lead, and 1500 ppm zinc.

The Mississippian Leadville Limestone crops out extensively on the White River Plateau and has been suggested as a source of high-calcium limestone. There are quarries near the city of Glenwood Springs on the adjacent Glenwood Springs quadrangle where the Leadville Limestone has been produced for aggregate and high-calcium limestone. CF&I Steel Corporation, Pueblo, identified an area about 2.5 mi north of the Shoshone quadrangle near Willow Peak that has been proven by core drilling to contain a sizeable resource of metallurgical limestone (Wark, 1980). Specific quality parameters pertaining to limestone feedstock for steel making applications (high calcium content—over 97 percent $CaCO_3$ and low silica content—less than 1 percent SiO_2) are frequently attainable in the Leadville Limestone, particularly in its upper part where dolomitization is less prevalent and away from the chert-bearing lower zones.

It is possible that zones of high-calcium limestone exist in the Devonian age Chaffee Group, but this is less likely. Any area within the quadrangle where the Leadville Limestone or other high-calcium rocks occur without appreciable overburden may be a target area for limestone development.

Whole-Rock Analyses of the Shoshone Quadrangle

Sample ID	Percent											
	SiO_2	Al_2O_3	CaO	MgO	Na_2O	K_2O	Fe_2O_3	MnO	Cr_2O_3	P_2O_5	TiO_2	LOI*
SCR1	61.60	15.10	4.34	3.44	2.96	3.20	6.69	0.10	<0.01	0.25	0.649	0.75
SHL5	69.30	13.80	1.13	1.83	1.99	3.03	6.49	0.05	<0.01	0.07	0.828	0.80
SHL2	73.20	14.30	1.18	0.57	3.34	4.33	2.38	0.03	<0.01	0.10	0.218	0.70
SH267	54.50	15.10	7.31	4.12	3.17	3.20	7.76	0.15	0.01	0.57	1.290	3.20
SH268	54.40	15.10	6.23	5.27	3.34	3.48	8.36	0.14	0.02	0.59	1.320	0.45
SH300	54.00	15.10	6.00	5.07	3.39	3.65	8.09	0.13	0.02	0.54	1.310	0.70
SH301B	54.80	15.10	6.47	4.70	3.33	3.45	8.13	0.13	0.02	0.53	1.290	1.75
SH303	50.40	15.20	7.08	6.36	3.20	2.47	11.20	0.15	0.03	0.69	1.800	0.60

* Loss On Ignition

SAMPLE DESCRIPTIONS

SCR1: Proterozoic coarse grained granite from Glenwood Canyon approximately 1.1 mi upstream (northeast) from Shoshone Powerplant.

SHL5: Proterozoic mafic gneiss from Glenwood Canyon near Dead Horse Creek, SW1/4SW1/4 Sec. 20, T. 5 S., R. 87 W.

SHL2: Aplite dike from pegmatite in Proterozoic mafic gneiss, Dead Horse Creek, SE1/4SE1/4 Sec. 19, T. 5 S., R. 87 W.

SH267: Trachyandesite, Little Buck Point, CSW1/4NW1/4SW1/4 Sec. 20, T. 6 S., R. 87 W.

SH268: Trachyandesite, Little Buck Point, CNW1/4SW1/4 Sec. 20, T. 6 S., R. 87 W.

SH300: Trachyandesite, south of Little Buck Point, SW1/4SE1/4SW1/4 Sec. 20, T. 6 S., R. 87 W.

SH301B: Trachyandesite, south of Little Buck Point, CSW1/4NW1/4NW1/4 Sec. 29, T. 6 S., R. 87 W.

SH303: Olivine basalt from knoll south of Dock Flats, SW1/4NE1/4NW1/4 Sec. 17, T. 6 S., R. 87 W.

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COLORADO GEOLOGICAL SURVEY
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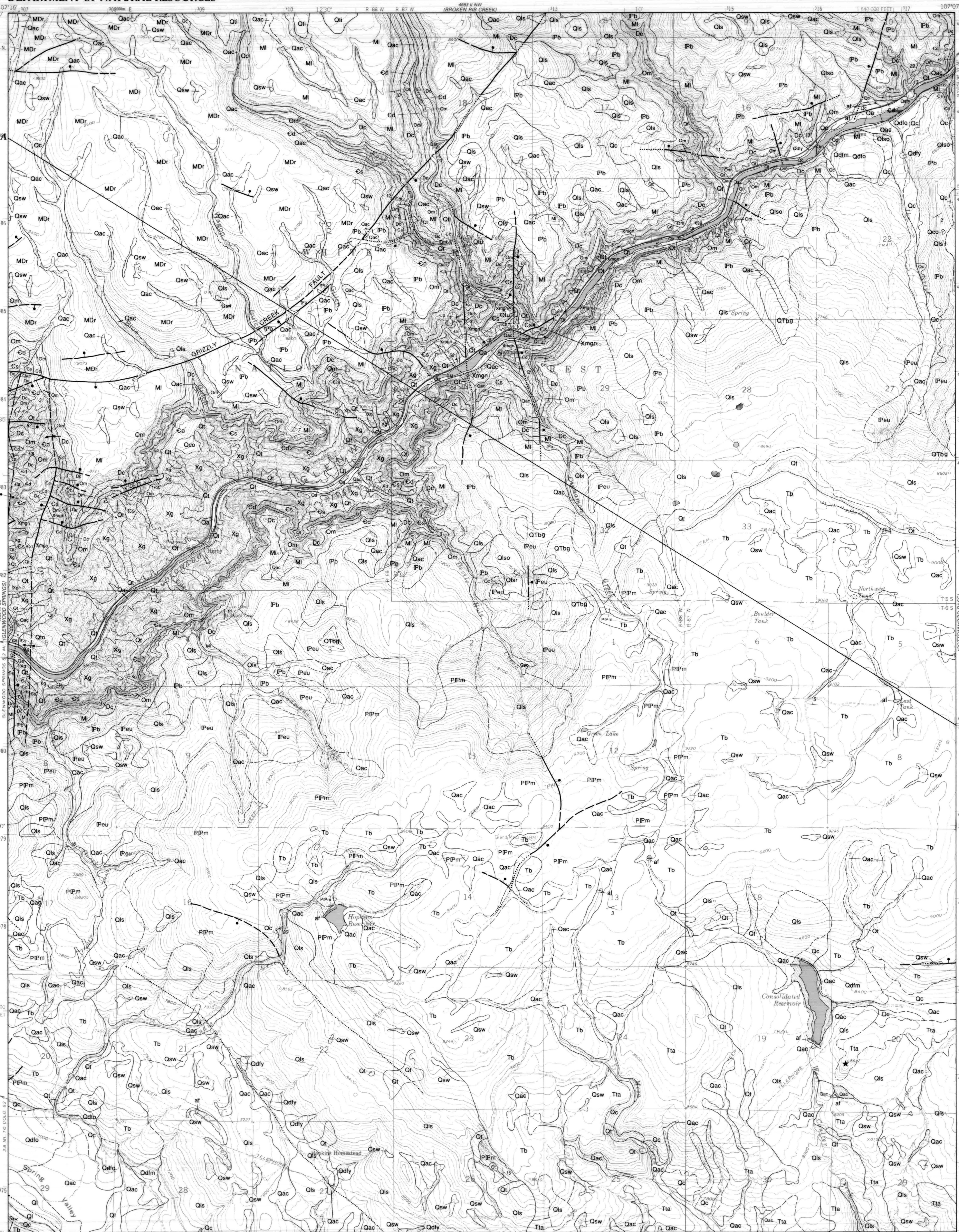
DEPARTMENT OF NATURAL RESOURCES

OPEN FILE MAP 95-4
GEOLOGIC MAP OF THE SHOSHONE QUADRANGLE, GARFIELD COUNTY, COLORADO
Booklet accompanies map



Base from U.S. Geological Survey, 1987
10,000-foot grid based on Colorado coordinate system, central zone
1000-meter Universal Transverse Mercator grid ticks, zone 13

UTM GRID AND 1987 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

QUADRANGLE LOCATION

Geology mapped in 1994; assisted by Peter L. Stelling.

CONDENSED DESCRIPTION OF MAP UNITS

The complete description of map units and references is in the accompanying booklet.

SURFICIAL DEPOSITS

HUMAN-MADE DEPOSITS

af — **Artificial fill (latest Holocene)**

ALLUVIAL DEPOSITS—Sediments deposited in stream channels, floodplains, terraces, debris fans, and sheet-wash areas

Qa — **Stream-channel, floodplain, and low terrace deposits (Holocene and late Pleistocene)**—Mostly poorly sorted, clast-supported gravel in a sandy or silty matrix up to about 15 ft above modern stream level

Qdfy — **Younger debris-flow deposits (Holocene)**—Poorly sorted, clast- and matrix-supported, pebble and cobble gravel in a sandy silt or silty sand matrix. Distal fan areas are finer grained. Deposited on active fans

Qsw — **Sheet-wash deposits (Holocene and late Pleistocene)**—Bedded deposits of gravelly sand, sandy silt, and clayey silt

Qdfm — **Intermediate debris-flow deposits (Holocene and late Pleistocene)**—Poorly sorted gravels found 20–40 ft above adjacent streams. Similar in texture to younger debris-flow deposits

Qdfo — **Old debris-flow deposits (late and middle? Pleistocene)**—Remnants of inactive debris fans 20-200 ft above adjacent streams. Similar in texture to younger debris-flow deposits

Qto — **Older terrace alluvium (middle Pleistocene)**—Deposits texturally similar to younger terrace alluvium. Underlies a terrace about 140 ft above modern stream level at western edge of quadrangle

QTbg — **High-level basaltic gravel (early Pleistocene or Pliocene)**—Poorly sorted boulder and cobble gravel on hill and ridge crests about 1,300 to 2,800 ft above modern river level. Probably deposited as debris flows, alluvium, colluvium, or landslides

COLLUVIAL DEPOSITS—Sediments on valley sides, valley floors, and hill slopes mobilized, transported, and deposited primarily by gravity

Qc — **Colluvium (Holocene and late Pleistocene)**—Matrix- and clast-supported, pebble to boulder gravel in a sandy silt matrix. Locally fine grained

Qt — **Talus (Holocene and late Pleistocene)**—Angular, cobbly and bouldery rubble derived from bedrock outcrops and transported as rockfalls, rockslides, rock avalanches, and rock topples

Qlsr — **Recent landslide deposits (latest Holocene)**—Includes active and recently active landslides with fresh morphological features. Heterogeneous unit consisting of unsorted, unstratified rock debris, gravel, sand, silt, and clay

Qls — **Landslide deposits (Holocene and Pleistocene)**—Similar in texture and lithology to recent landslide deposits but generally older

Qco — **Older colluvium (Pleistocene)**—Highly variable deposits texturally similar to colluvium, but not presently active

Qlso — **Older landslide deposits (Pleistocene and late Pliocene?)**—Landslide deposits dissected by erosion that lack distinctive landslide morphology. Similar in texture to recent landslide deposits

ALLUVIAL AND COLLUVIAL DEPOSITS—Sediments in stream channels, floodplains, and hill slopes along tributary valleys

Qac — **Alluvium and colluvium, undivided (Holocene and late Pleistocene)**—Moderately well to well sorted, stratified, interbedded sand, pebbly sand, and sandy gravel to poorly sorted, unstratified or poorly stratified clayey, silty sand, bouldery sand, and sandy silt

GLACIAL DEPOSITS

Qti — **Till (late and middle Pleistocene)**—Heterogenous deposits of gravel, sand, silt, and minor clay deposited in lateral, end, and ground moraines

LACUSTRINE DEPOSITS

Ql — **Lacustrine deposits**—Well stratified deposits of medium to dark gray, organic-rich, silty clay and silt, and medium red brown, well sorted, coarse sand deposited in Spring Valley

SINTER DEPOSITS

Qtu — **Tufa (Holocene and Pleistocene?)**—Low density, porous calcium carbonate deposits precipitated from mineral-charged spring water

UNDIFFERENTIATED DEPOSITS

Q — **Undifferentiated surficial deposits (Quaternary)**—Shown only on cross section

BEDROCK

Tta — **Trachyandesite (Pliocene)**—Possible volcanic domes, flows, and breccias consisting of trachyandesite. Xenocrysts consist of quartz, sanidine and plagioclase. A sanidine crystal in the trachyandesite from Little Buck Point in sec. 20, T. 6 S., R. 87 W. was age dated at 3.94 ± .02 Ma using the $^{40}Ar/^{39}Ar$ method (L. Snee, personal communication, 1995)

Tb — **Basalt (Miocene)**—Multiple flows of basalt, olivine basalt, and andesitic basalt, interbedded with tuffaceous, fluvial siltstone and sandstone, lacustrine claystone, volcanic ash, and volcanic agglomerate.

PIPm — **Maroon Formation (Permian and Pennsylvanian)**—Mainly reddish brown sandstone, conglomerate, mudstone, siltstone, and claystone with minor, thin beds of gray limestone. Includes Schoolhouse Tongue of Weber Sandstone at top of formation

IPeu — **Eagle Valley Formation and Eagle Valley Evaporite, undivided (Middle Pennsylvanian)**—Includes the Eagle Valley Evaporite, which is a sequence of gypsum, anhydrite, and halite interbedded with light colored, fine-grained clastic rocks, limestone, and conglomerate; and the Eagle Valley Formation, which is an intertonguing sequence of Maroon Formation and Eagle Valley Evaporite. Commonly intensely folded, faulted, and deformed

IPb — **Belden Formation (Lower Pennsylvanian)**—Medium gray to black, calcareous shale and fossiliferous limestone with interbeds of fine-grained micaceous sandstone, gritstone, coaly shale, and gypsum

Ml — **Leadville Limestone (Mississippian)**—Gray to bluish gray, coarse to finely crystalline limestone and dolomite. Abundant chert nodules in lower part of formation

Dc — **Chaffee Group (Upper Devonian)**—Includes in ascending order: Parting Formation, white to buff orthoquartzite, green shale, and gray dolomite; Dyer Dolomite, limestone and dolomite; and Gilman Sandstone, a tan to yellow, fine-grained dolomitic sandstone

MDr — **Mississippian and Devonian rocks—undivided (Mississippian and Upper Devonian)**

Om — **Manitou Formation (Lower Ordovician)**—Flat-pebble, limestone conglomerate, brown and tan crystalline dolomite, and greenish gray calcareous shale

Ꞓd — **Dotsero Formation (Upper Cambrian)**—Thin bedded, brown to tan sandy dolomite and dolomitic sandstone with abundant glauconite and pinkish light gray to light gray algal limestone and conglomerate

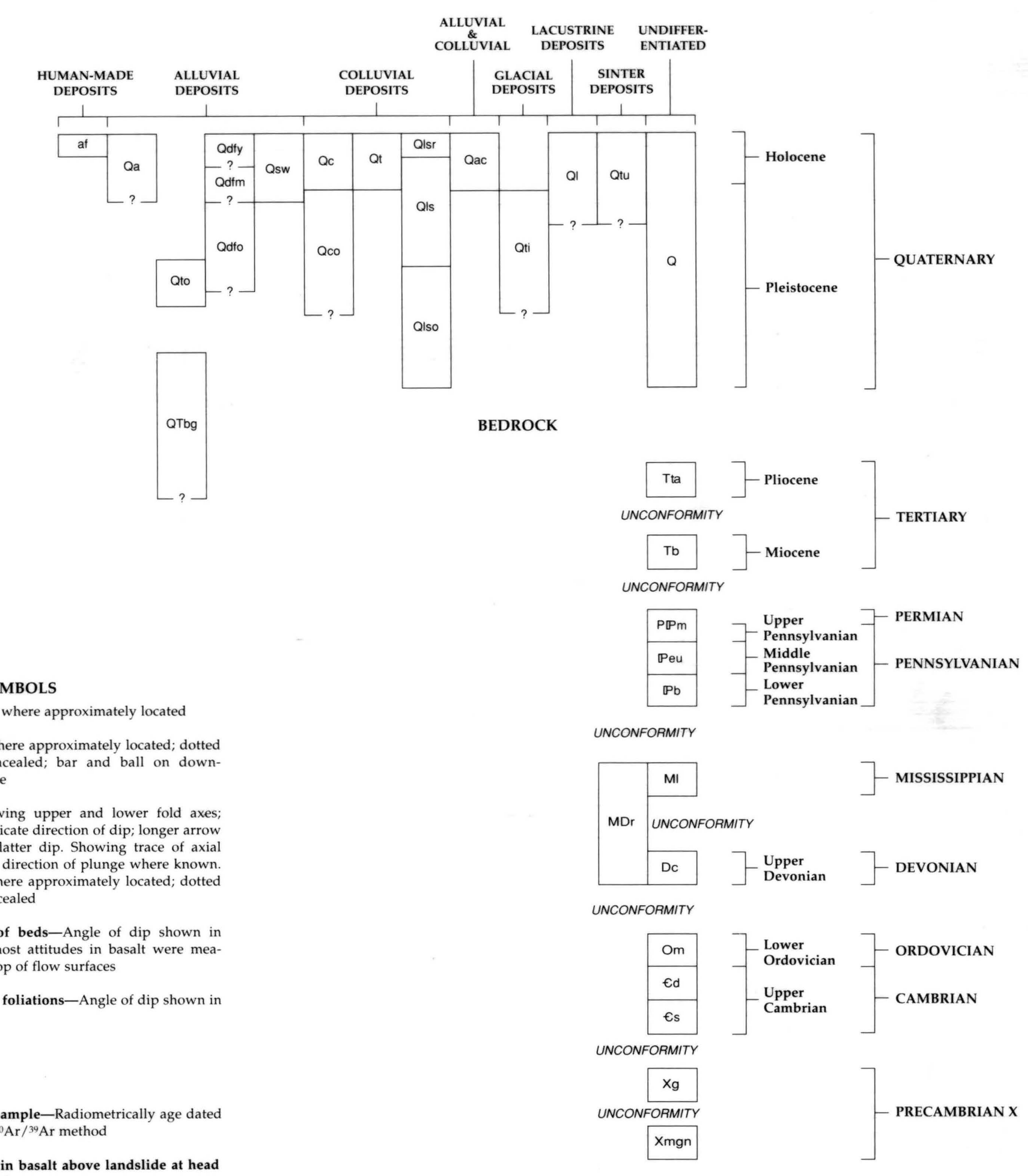
Ꞓs — **Sawatch Quartzite (Upper Cambrian)**—White to buff, massive, medium-grained orthoquartzite and arkosic quartz-pebble conglomerate. Unit includes Peerless Formation equivalent sandy dolomites, white quartzites, and quartzose sandstones

PRECAMBRIAN ROCKS

Xg — **Biotite granite (Proterozoic)**—Dark gray and white speckled, fine- to coarse-grained, equigranular granite and granodiorite

Xmgn — **Biotite-muscovite gneiss (Proterozoic)**—Well to poorly foliated biotite-muscovite gneiss, locally pegmatitic

CORRELATION OF MAP UNITS



MAP SYMBOLS

Contact—Dashed where approximately located

Fault—Dashed where approximately located; dotted where concealed; bar and ball on downthrown side

Monocline—Showing upper and lower fold axes; arrows indicate direction of dip; longer arrow indicates flatter dip. Showing trace of axial plane, and direction of plunge where known. Dashed where approximately located; dotted where concealed

62 **Strike and dip of beds**—Angle of dip shown in degrees; most attitudes in basalt were measured on top of flow surfaces

Strike and dip of foliations—Angle of dip shown in degrees

14 **Inclined**

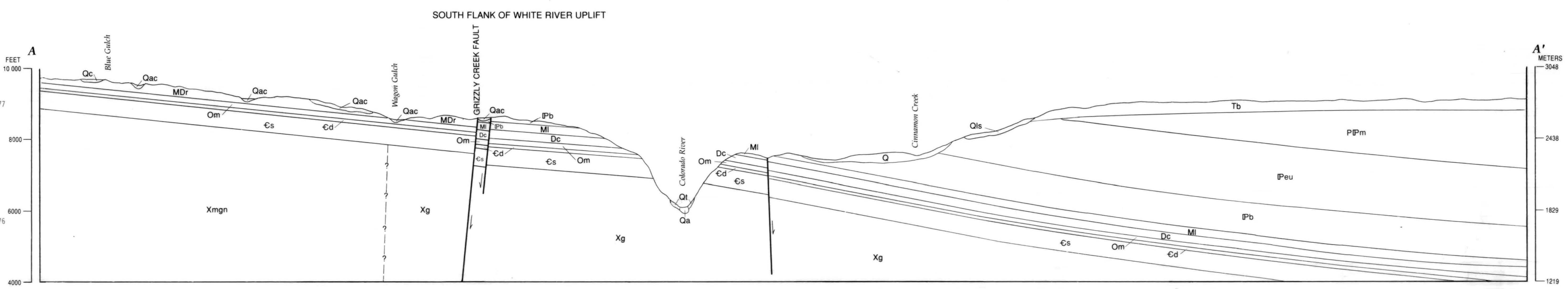
Vertical

Locality of rock sample—Radiometrically age dated using the $^{40}Ar/^{39}Ar$ method

Tension fracture in basalt above landslide at head of Ike Creek

ACKNOWLEDGEMENT

This map was funded jointly by the Colorado Geological Survey and the U.S. Geological Survey STATEMAP Program of the National Geologic Mapping Act of 1992.



GEOLOGIC MAP OF THE SHOSHONE QUADRANGLE, GARFIELD COUNTY, COLORADO

By
Robert M. Kirkham, Randall K. Streufert, and James A. Cappa
1995