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Geologic Map of the Dotsero Quadrangle, Eagle and Garfield Counties, Colorado

Description of Map Units, Economic Geology, Measured Sections, Whole-Rock Analyses, and References

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INTRODUCTION

Geologic mapping of the 7.5-minute Rules Hill quadrangle was undertaken by the Colorado Geological Survey as part of the National Cooperative Geologic Mapping Act-STATEMAP component program. The Rules Hill quadrangle was selected as the first quadrangle to be mapped in the Durango area because of the rapid population growth, geologic hazards such as methane seepage and natural gas resources found within it. The Colorado Geological Survey plans to map the geology of several other 7.5-minute quadrangles in this area in future years. Our understanding of the geology of this region will likely evolve as future mapping is completed.

DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

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

HUMAN-MADE DEPOSITS—Materials placed by humans

af — **Artificial fill (latest Holocene)**—Consists of fill and waste rock placed during construction of roads and small dams. Composed mostly of unsorted silt, sand, and rock fragments, but may include construction materials. Maximum thickness is about 40 ft. Artificial fill may be subject to settlement when loaded, if not adequately compacted

ALLUVIAL DEPOSITS—Silt, sand, and gravel deposited in stream channels, flood plains, outwash terraces, and sheetwash areas along Los Pinos and Florida Rivers and their tributaries

Qa — **Stream-channel, flood-plain, and low-terrace deposits (Holocene and late Pleistocene)**—Includes various alluvial deposits in the valleys of Los Pinos River and Florida River. Consists of unconsolidated silt, sand, gravel, and occasional boulders, deposited in main-stem river beds and flood plains. Clast lithologies include sedimentary, metamorphic, and igneous rocks eroded from the San Juan Mountains north of the map area and from local sedimentary bedrock sources within or near the map area. Boulders and cobbles derived from the Vallecito Conglomerate are found only along Los Pinos River. Alluvial deposits in this valley are extremely hard because of the dense rocks derived from the provenance area. Low-lying areas are subject to flooding. Unit is a good source of sand and gravel.

Qsw — **Sheetwash deposits (Holocene and late Pleistocene)**—Includes deposits derived from weathered bedrock and unconsolidated surficial materials transported predominantly by sheetwash and deposited in small intermittent stream valleys, on gentle hillslopes, or in basinal areas which lack

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. Residuum and artificial fills of limited extent were not mapped. Contacts between surficial units may be gradational, and mapped units 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 modern streams, relative degree of soil development, and stratigraphic relationships with the Lava Creek B volcanic ash. Correlation of terraces and interpretations of their ages is hindered by their discontinuous distribution and typical poor exposures. Morphological stages of secondary calcium carbonate used herein are those described by Gile and others (1966).

HUMAN-MADE DEPOSITS—Materials placed by humans

af — **Artificial fill (latest Holocene)**—Fill and waste rock deposited during construction of highways and railroads. Artificial fill is composed mostly of unsorted silt, sand, and rock fragments, but may include construction materials. Maximum thickness is about 40 ft. It may be subject to settlement when loaded, if not adequately compacted.

ALLUVIAL DEPOSITS—Silt, sand, and gravel deposited in stream channels, flood plains, terraces, and sheetwash areas along the Colorado and Eagle Rivers and their tributaries

Qa — **Stream-channel, flood-plain, and low-terrace deposits (Holocene and late Pleistocene)**—Includes modern alluvium and other deposits underlying the Colorado and Eagle Rivers, adjacent floodplain deposits, and low-terrace alluvium that is up to about 12 ft above modern stream level. Unit may be interbedded with younger debris-flow deposits where the distal ends of fans extend into modern river channels. Unit is mostly clast-supported, silty, sandy, occasionally bouldery, pebble and cobble gravel interbedded and often overlain by sandy silt and silty sand. It includes a thick sequence of organic-rich, gray, silty clay of probable lacustrine origin within and immediately above Glenwood Canyon (Bowen, 1988). This lacustrine sequence was encountered in test holes drilled by the Colorado Department of Transportation for Interstate Highway 70. It was probably deposited in a lake formed by a rockfall dam near the west end of Hanging Lake tunnel (Bowen, 1988; J. White and R. Pihl, 1996, oral commun.). Radiocarbon dates on wood contained within the lacustrine sequence ranged from 9,800 to 3,890 years B.P. (J.B. Gilmore, 1996, written commun.). Unit is poorly to moderately well sorted and poorly to well bedded. Clasts are subangular to well rounded, and their varied lithology reflects the diverse types of bedrock within their provenance. The lacustrine deposits are well sorted and well bedded. Unit also includes fine-grained, silt and clay of possible lacustrine or deltaic origin upstream of Dotsero lava flow. Maximum thickness may exceed 100 ft (Bowen, 1988). Low-lying areas within this mapped unit are subject to flooding. It is frequently a good source of aggregate.

Qsw — **Sheetwash deposits (Holocene and late Pleistocene)**—Includes deposits locally derived from weathered bedrock and surficial materials which are transported predominantly by sheetwash and accumulate in ephemeral stream valleys, on gentle hillslopes, or in basinal areas. Common on gentle to moderate slopes underlain by shale, basalt, red beds, and landslide deposits. Sheetwash deposits typically consist of pebbly, silty sand and sandy silt. Locally they are gradational and interfingered with colluvium on steeper hillslopes and with lacustrine or ponded basinal deposits in closed depressions. Maximum thickness is probably about 20 ft. Area is subject to future sheetwash deposition. Unit may be susceptible to hydrocompaction, settlement, and piping where fine grained and low in density.

Qty — **Younger terrace alluvium (late Pleistocene)**—Chiefly stream alluvium underlying terraces that range from about 20 to 80 ft above modern stream level. Stream alluvium is mostly poorly sorted, clast-supported, occasionally bouldery, pebble and cobble gravel in a sand matrix, but unit may include fine-grained overbank deposits or organic-rich deposits. Clasts are mainly subround to round and are comprised of a variety of lithologies reflecting the diverse types of bedrock found in the provenance. Clasts generally are unweathered or only slightly weathered. Unit ranges from about 10 to 40 ft thick, but may be thinner locally. West of the quadrangle at the rest area on Highway I-70 in West Glenwood Springs, peat interbedded with tufa that overlies a terrace deposit 19 ft above the Colorado River yielded a ^{14}C date of 12,410 ± 60 years B.P. (Kirkham and others, 1995a; 1996). Younger terrace alluvium in the Dotsero quadrangle probably correlates in part with the dated terrace at West Glenwood Springs. Unit may also correlate with younger terrace alluvium (Qty) of Fairer and others (1993) in the Storm King Mountain quadrangle. Unit is probably in part equivalent to outwash of the Pinedale glaciation, which Richmond and Fullerton (1986) estimated to be about 12 to 35 ka. Younger terrace alluvium is a good source of sand and gravel.

Qtm **Intermediate terrace alluvium (late Pleistocene)**—Composed of stream alluvium underlying terraces about 90 to 120 ft above modern stream level. It consists of poorly sorted, clast-supported, occasionally bouldery, pebble and cobble gravel in a sand matrix. Fine-grained overbank deposits are locally present. Clasts are chiefly subround to round and consist of various lithologies that reflect the types of bedrock found in their provenance. Micaceous clasts generally are slightly to moderately weathered, but other types of clasts are unweathered or only very slightly weathered. Stage I and occasionally weakly developed Stage II carbonate development is present in the unit. Thickness ranges up to about 77 ft, but intermediate terrace alluvium typically is only 20 to 40 ft thick. Unit is a good source of sand and gravel.

Qto **Older terrace alluvium (middle Pleistocene)**—Includes deposits of stream alluvium in terraces along the Colorado River and Sweetwater and Deep Creeks and in a fan at the mouth of Deep Creek. Upper surface of unit ranges from about 160 to 180 ft above stream level. Unit is generally a clast-supported, sometimes bouldery, cobble or pebble gravel in a sand matrix, but may range to a matrix-supported gravelly sand or silt. Locally it is capped by 1 to 3 ft of gravelly sandy silt. Clasts are chiefly subround to round and have varied lithologies that reflect the rock types found in the provenance. Micaceous clasts are moderately to highly weathered, but other types of clasts are only slightly weathered or unweathered. Thickness ranges from about 20 to 85 ft. Unit may be a source of sand and gravel.

Qtt **Oldest terrace alluvium (middle Pleistocene)**—Consists of stream alluvium in terraces that range from about 160 to 460 ft above adjacent rivers. Unit is poorly to moderately well-sorted, clast-supported, slightly bouldery, cobble and pebble gravel with a sand matrix. Locally it includes thin lenses and beds of sandy silt and silty sand. Micaceous gravel clasts are commonly moderately to strongly weathered. Thickness ranges up to about 30 ft. Unit occurs on two hills north of the Colorado River at the east end of Glenwood Canyon and on a mesa between Sweetwater and Irrawaddy Creeks. At both locations at the east end of Glenwood Canyon the unit is in part overlain by volcanic ash (Qva). At the westerly location the unit is about 280 ft above the river and is capped by volcanic ash identified by Izett and Wilcox (1982) as the 0.62 Ma Lava Creek B ash. The easterly deposit, which also is capped by volcanic ash, is about 80 to 100 ft lower in elevation than the deposit to the west. G.A. Izett has identified the easterly ash as one of the Pearlette-type of ashes, but additional work is needed to further correlate this ash. The deposit between Sweetwater and Irrawaddy Creeks lies about 460 ft above Sweetwater Creek and 240 ft above Irrawaddy Creek and is likely older than those at the east end of Glenwood Canyon. Oldest terrace alluvium may be a source of sand and gravel.

QTg **High-level gravel (early Pleistocene or late Tertiary)**—Occurs on two hilltops between Lyons Gulch and Irawaddy Creek about 600 to 680 ft above the Colorado River as eroded remnants of formerly extensive fluvial deposits. Unit probably was deposited by an ancestral Colorado River. High-level gravel is poorly exposed, but appears to consist of clast-supported, sandy and silty cobble, pebble, and boulder gravel. Smaller clasts are subround to well rounded and composed chiefly of various types of coarse-grained intrusive rocks, quartz, quartzite, and limestone. Larger clasts are subangular to subround and are nearly entirely composed of basalt. Micaceous clasts are moderately to highly weathered. Thickness may be as much as about 60 feet. Unit is a possible source of sand and gravel.

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

Qc **Colluvium (Holocene and late Pleistocene)**—Ranges from clast-supported, pebble to boulder gravel in a sandy silt matrix to matrix-supported gravelly, clayey, sandy silt. Colluvium is derived from weathered bedrock and surficial deposits and is transported downslope primarily by gravity. Locally it grades to sheetwash on some flatter slopes. Deposits are usually coarser grained in the upper reaches of a colluvial slope and finer grained in distal areas. Deposits derived from clay-rich formations such as the Belden Formation are finer grained and often matrix supported. Clasts typically are angular to subangular. Colluvium commonly is unsorted or poorly sorted with weak or no stratification, but it may be bedded in some deposits. Clast lithology is variable and dependent upon types of rocks occurring with the provenance. Locally the unit includes talus, landslides, sheetwash, and debris flows that are too small or too indistinct on aerial photography to be mapped separately. Maximum thickness is probably about 50 ft. Colluvial deposits may locally be dissected by erosion where small drainages are advancing headward into bluffs at the toes of colluvial slopes. Areas mapped as colluvium are susceptible to future colluvial deposition and locally subject to sheetwash, rockfall, small debris flows, mudflows, and landslides. Fine-grained, low-density colluvium may be prone to hydrocompaction, piping, and settlement, particularly when derived from the Maroon Formation or Eagle Valley Evaporite.

Qls **Landslide deposits (Holocene and Pleistocene)**—Highly variable deposits consisting of unsorted, unstratified rock debris, silt, sand, clay, and gravel. Texture and clast lithology are dependent upon source area. They range in age from active, slowly creeping landslides to long-inactive middle or early Pleistocene landslides. Unit includes rotational landslides, translational landslides, complex slump-earthflows, and extensive slope-failure complexes. Maximum thickness is probably around 150 ft. Area may be subject to future landslide activity; however, deeply dissected landslide deposits may be stable. Deposits may be prone to settlement when loaded. Low-density, fine-grained deposits may be susceptible to hydrocompaction. Local areas within this unit may have shallow groundwater.

Qco **Older colluvium (Pleistocene)**—Occurs on ridge lines, drainage divides, and hillslopes on valley walls as erosional remnants of formerly more extensive deposits that were transported primarily by gravity and aided by sheetwash. Texture, bedding, and clast lithology are similar to colluvium (Qc). Unit typically is 10 to 25 ft thick. Generally is not subject to significant future colluvial deposition, except where adjacent to eroding hillslopes. Unit may be subject to hydrocompaction, piping, and settlement where fine grained and low in density.

ALLUVIAL AND COLLUVIAL DEPOSITS—Silt, sand, gravel, and clay in debris fans, stream channels, flood plains, and adjacent hillslopes along tributary valleys. Depositional processes in stream channels and on flood plains are primarily alluvial, whereas colluvial and sheetwash processes are commonly predominant on debris fans, hillslopes, and along the hillslope/valley floor boundary.

Qdfy **Younger debris-flow deposits (Holocene)**—Sediments deposited by debris flows, hyperconcentrated flows, mudflows, sheetwash, and alluvial processes on active debris fans and in stream channels. Unit ranges from poorly sorted, matrix-supported, gravelly, sandy, clayey silt to clast-supported, pebble and cobble gravel in a sandy, clayey silt or silty sand matrix. Frequently it is very bouldery, particularly near fan heads. Distal parts of some fans are characterized by mudflow and sheetwash and tend to be finer grained. Younger debris-flow deposits are locally interfingered or interbedded with modern alluvium adjacent to perennial stream channels. Clasts are mostly angular to subround sedimentary rock and basalt fragments up to about 6 ft in diameter. Maximum thickness is estimated at about 50 ft. Original depositional surfaces are usually preserved, except where they have been disturbed by human activities. Area is subject to future debris-flow, hyperconcentrated-flow, and alluvial deposition following intense rainstorms, except on distal parts of some fans, where mudflow and sheetwash processes are predominant. Deposits are prone to settlement, piping, and hydrocompaction where fine grained and low in density, subject to sinkhole development by piping where underlain by cavernous evaporitic rocks, and corrosive if derived from evaporitic rocks.

Qac **Alluvium and colluvium, undivided (Holocene and late Pleistocene?)**—Unit is chiefly stream-channel, low-terrace, and flood-plain deposits along the valley floors of intermittent, ephemeral, and small perennial streams, with colluvium and sheetwash common on valley sides. Deposits of alluvium and colluvium probably are interfingered. Locally includes younger debris-flow deposits (Qdfy). Alluvium is typically composed of poorly to well-sorted, stratified, interbedded pebbly sand, sandy silt, and sandy gravel, but colluvium may range to unsorted, unstratified or poorly stratified, clayey, silty sand, bouldery sand, and sandy silt. Clast lithologies are dependant upon type of rock within source area. Thickness is commonly 5 to 20 ft. Low-lying areas are subject to flooding. Valley sides are prone to sheetwash, rockfall, and small debris flows. Fine-grained, low-density deposits may be subject to settlement, piping, and hydrocompaction. Unit is a potential source of sand and gravel.

Qdfm **Intermediate debris-flow deposits (Holocene and late Pleistocene?)**—Similar in texture and depositional environment to younger debris-flow deposits (Qdfy). Geomorphic character of original depositional surfaces are preserved, but the surfaces are topographically about 10 to 30 ft above active debris-flow channels. Area is generally not susceptible to future debris-flow activity unless a channel becomes blocked or an unusually large debris flow occurs. Hydrocompaction, piping, and settlement may occur where the deposits are fine grained and have low density.

Qaco **Older alluvium and colluvium, undivided (Holocene? and Pleistocene)**—Deposits of alluvium and colluvium ranging from about 10 to 40 ft above adjacent intermittent, ephemeral, and small perennial streams. Texture, bedding, clast lithology, and sorting are similar to alluvium and colluvium (Qac). Unit locally includes debris-flow and sheetwash deposits. Thickness averages 10 to 20 ft. Unit is locally overlain by volcanic deposits from Dotsero volcano. Area is subject to active colluvial and sheetwash deposition only where adjacent to hillslopes. Unit may be a source of sand and gravel.

Qdfo **Older debris-flow deposits (Holocene? and Pleistocene)**—Occur as locally extensive, erosional remnants of former debris fans. Unit is texturally similar to younger debris-flow deposits (Qdfy). Boulders within older debris-flow deposits (Qdfo) commonly are 1 to 2 ft in diameter and occasionally are larger. Clasts range from unweathered to moderately weathered. Elevation differences between original depositional surfaces and adjacent modern drainages range from about 80 to 240 ft. Thickness is generally about 20 to 60 ft, but locally exceeds 100 ft. Older debris-flow deposits north of Dotsero overlie younger terrace alluvium (Qty). In the northeast corner of the quadrangle they overlie intermediate terrace alluvium (Qtm). Where fine grained and low in density, unit may be prone to hydrocompaction, piping, and settlement. It is corrosive when derived from evaporitic bedrock and may be a source of sand and gravel.

EOLIAN DEPOSITS—Volcanic ash deposited by wind

Qva **Volcanic ash (middle Pleistocene)**—White to light-gray, bedded, slightly indurated volcanic ash found at two locations north of the Colorado River upstream of Glenwood Canyon. The westerly outcrop of ash lies against a hillside. Here a lenticular deposit of ash in part overlies oldest terrace alluvium (Qtt). The contact between the ash and gravel deposits is about 280 ft above the Colorado River. The ash has an apparent maximum thickness of about 25 ft, appears to have undergone minor reworking, and has an apparent strike of N38°E and dip of 12°SE. It has been identified by Izett and Wilcox (1982) as the 0.62 Ma Lava Creek B ash. The easterly outcrop of ash caps part of a hilltop. It also in part overlies oldest terrace alluvium (Qtt) and is in turn partly overlain by older colluvium (Qco). The gravel-ash contact is around 80 to 100 ft lower in elevation in the eastern outcrop. G.A. Izett (1996, personal communication) has identified the eastern ash as one of the Pearlette-type of ashes, on the basis of the character of the glass shards and phenocryst assemblages. Further studies are needed to positively identify the eastern ash and to interpret the significance of the elevation differences between the two outcrops.

UNDIFFERENTIATED DEPOSITS

Q — **Surficial deposits, undifferentiated (Quaternary)**—Shown only on cross section

BEDROCK

VOLCANIC AND VOLCANICLASTIC DEPOSITS OF DOTSERO AND WILLOW PEAK VOLCANOES

Qltu — **Unconsolidated lapilli tuff (Holocene)**—Black to gray, rounded to subrounded, holocrystalline to partially glassy, lapilli-sized fragments of scoriaceous trachybasalt with very minor amounts of fragmented country rock. Deposit contains volcanic bombs up to 4 inches in diameter, especially in the vicinity of Dotsero volcano. Composition is basaltic to trachybasaltic. Unit is unconsolidated and, in fresh exposures where commercially quarried near the crater rim, displays distinct planar bedding that ranges from 2 inches up to 20 inches in thickness. Unconsolidated lapilli tuff forms a continuous blanket on hillslopes around and east of Dotsero crater, which suggests airfall deposition controlled by prevailing westerly winds. Deposits are of variable thickness ranging from 50 ft at or near the crater rim to less than 4 ft in more distal areas. Unconsolidated lapilli tuff has been dated at 4,150 years ± 300 yrs. by radiocarbon analysis of a carbonized tree trunk recovered from the unit near the southeast rim of the crater (Geigengack, 1962). Unit has been locally reworked by alluvial and colluvial processes which has caused thinning of the deposit on ridges and thickening of the deposit in areas of lower relief. Reworked material is weakly crossbedded and contains nonvolcanic colluvial detritus. Unit is exploited commercially from quarry excavations immediately east and southeast of the crater rim for use in the manufacture of cinder blocks and as lightweight aggregate. Unit may be prone to mobilization by debris flow and/or landslide processes where exposed in steep cuts and where subjected to intense rainstorm activity.

Qltc — **Consolidated lapilli tuff (Holocene)**—Black to gray, rounded to subrounded, holocrystalline to partly glassy, lapilli-sized fragments of scoriaceous cinder. Composition is basaltic to trachybasaltic. Unit is identical to Qltu except in degree of induration. Deposits may have been partially welded at time of deposition or have been partially cemented by shallow diagenesis. Unit occurs only as two small outcrops within Dotsero Crater and in one isolated deposit south of the crater immediately above Dotsero trailer park. Unit may be suitable for lightweight aggregate, but has not been exploited commercially.

Qca — **Agglutinated cinders (Holocene)**—Red to reddish-brown, brown, and black, partly to completely welded, brecciated, scoriaceous cinder beds, reddish-brown to brown volcanic bombs from 8 inches to 24 inches in length with resorbed quartz xenocrysts and sandstone xenoliths, and interbedded black, dense lava flows. Unit includes all layered and interbedded deposits comprising Dotsero cinder cone complex that could not be mapped separately. Agglutinated cinder deposits occur only in the vicinity of Dotsero Crater and are the result of pyroclastic accumulation of originally molten ejecta. Cementation occurred by fusing of the glassy skin at points of contact as the deposit cooled. Beds of welded scoria and bombs are very porous and do not contain an ash or tuff matrix. Unit includes a 3 to 6-foot-thick dense flow of trachybasaltic lava occurring between beds of agglutinated cinders. This is interpreted as a "fire-fountain-fed" flow resulting from a rhythmic eruption of gas-charged lava, forming a fountain of molten rock, which coalesced into a liquid flow upon contact with the ground surface. Both the dense lava flow and cinder beds drape over and were controlled by preexisting topography. The relationship between agglutinated cinder beds and interbedded trachybasaltic lava, as well as the paleotopographic control which influenced their deposition, can be observed in the abandoned quarry immediately south of Dotsero Crater. Cinder-cone-complex deposits preserved in the north wall of Dotsero Crater contain discontinuous lenses of dense trachybasalt in a matrix of agglutinated cinders, representing a less vigorous "fire-fountain-fed" eruption.

Unit is very unstable and is susceptible to rockfall and rock topple, especially on steep slopes where competent trachybasalt flows overlie less competent scoria beds. Unit is a source of good quality, lightweight aggregate.

Qtb

Trachybasalt (Holocene and upper Pleistocene?)—Dark-gray to black, dense to vesicular, trachybasaltic lava flows associated with Dotsero and Willow Peak volcanoes. Flow at Dotsero contains clear, partly resorbed quartz xenocrysts and white sandstone xenoliths. Phenocrysts are 80 percent euhedral olivine, without appreciable iddingsite along fractures, and 20 percent euhedral to subhedral, fairly fresh, augite. Groundmass is predominantly plagioclase microlites (trachytic texture) with lesser amounts of very fine-grained amphibole, olivine, and pyroxene between feldspar laths.

The flow at Dotsero occurs as a body of lava which occupies approximately one-third of a square mile of the Eagle River Valley floor directly below Dotsero Crater and as scattered, unmapped, small erosional remnants. The flow is from 20 to 40 ft thick. It has a well developed aa carapace which accounts for at least half of the thickness of the flow. The flow is fan-shaped and appears to have flowed out from two drainages located behind Dotsero trailer park immediately below Dotsero Crater. Both drainages contain remnants of agglutinated cinder deposits. The westernmost of the two gullies contains a 3-foot-thick remnant of a "fire-fountain-fed" lava flow enclosed between two agglutinated cinder beds. The trachybasalt flow on the floor of the Eagle River Valley more than likely originated in the vicinity of Dotsero Crater as a "fire-fountain-fed" flow. The strongly developed aa texture of this flow suggests that lava rushed out of the vent and down into the valley below. Trachybasalt preserved in the south wall of Dotsero Crater consists of an upper and lower flow also associated with agglutinated cinders. These flows are shown on the map as agglutinated cinders because they are interbedded with cinder deposits and could not be mapped separately. This package of trachybasalt flows and cinder beds dips 13 to 17 degrees west-southwest, reflecting the effect of paleotopography.

The trachybasalt flow at Dotsero extends to the north bank of the modern Eagle River, and younger debris-flow deposits form the south bank of the river. Although no fluvial or lacustrine sediments were observed to overlie the lava flow, arguable evidence suggests the flow may have damned or at least decreased the velocity of the Eagle River. Fine-grained sediments, possibly of lacustrine or deltaic origin, are exposed along the banks of the Eagle River for nearly three miles upstream of where the river encounters the lava flow, suggesting ponded water may have existed in this reach of the river during the Holocene. An abrupt change in the sinuousity of the river occurs about two miles upstream of the flow and is possibly related to the presence of a former lake.

Willow Peak flow issued from the Willow Peak cinder cone located on the White River Uplift, west of the quadrangle, and flowed eastward down an unnamed tributary. The flow contains sparse xenocrysts of pyroxene and partially resorbed quartz. Phenocrysts are 90 percent euhedral, slightly altered olivine and 10 percent euhedral to subhedral pyroxene. Groundmass is very fine grained and includes plagioclase microlites with weak trachytic texture. In an exposure on Coffee Pot Road in Sec. 36, T. 4 S., R. 87 W. (sample DT-R3), the flow consists of 10 ft of dense trachybasalt that is slightly vesicular at the top. Because the Willow Peak trachybasalt flow is restricted to the lower valley walls of a modern valley and its cinder cone is only partly eroded, it likely is of Quaternary age, perhaps even late Quaternary age. Preliminary $^{40}Ar/^{39}Ar$ analyses of a whole-rock sample of trachybasalt from this outcrop was dated as less than 0.5 Ma.

OTHER BEDROCK

Tb

Basalt (Miocene)—Gray to black, dense to vesicular, olivine basalt. Phenocrysts are euhedral olivine with strong reaction rims altered to pyroxene (?). Groundmass consists of abundant plagioclase microlites with a felty to weakly trachytic texture. Unit is also sub-ophitic with laths of plagioclase encased by pyroxene.

Basalt that caps the large mesa 1 mile northeast of Dotsero Crater consists of two distinct flows with a combined thickness of 60 ft. Larson and others (1975) report a whole-rock K-Ar age of 22.1 ± 1.0 Ma for a basalt probably collected from this mesa. Preliminary whole-rock $^{40}Ar/^{39}Ar$ analyses of sample DT-R2, collected from this mesa in the NW 1/4 Sec. 35, T. 4 S., R. 86 W., suggests an age greater then 20 Ma (M. Kunk, 1997, written commun.). The basalt flow which caps this mesa has been tilted and faulted since deposition and now dips 12 to 16 degrees to the north-northeast. This tilting is occurring along the north flank of the Eagle River anticline, most likely due to salt tectonism centered on the Eagle River Valley. The whole-rock chemistry of sample DT-R4, collected from the NE 1/4 of Sec. 22, T. 4 S., R. 86 W., at an elevation of 8,060 ft, is similiar to that of sample DT-R2 which was collected from an elevation of 8,180 ft at the south edge of the basalt-capped mesa, suggesting the basalt remnants that lie north of the tilted, basalt-capped mesa may have once been part of a continuous basalt cap. Unit may be a source of rockfall debris where exposed in steep cliffs. Basalt flows are a potential source of high quality riprap.

PPm **Maroon Formation (Permian and Upper Pennsylvanian)**—Red beds of sandstone, conglomerate, mudstone, siltstone, and claystone with a few thin beds of gray limestone. Unit is arkosic and very micaceous. Unit is exposed on two erosional remnant mesas which have been isolated from the White River Uplift to the west by downcutting of the Colorado and Eagle Rivers. These mesas are cored by evaporite and evaporitic clastic rocks of the Eagle Valley Evaporite and Eagle Formations. Flowage, diapirism, and dissolution-related subsidence of the underlying evaporitic rocks have caused brittle deformation of the overlying Maroon Formation and late Tertiary basalts. Contact with overlying basalts is unconformable and sharp. Unit is 3,000 to 5,000 ft thick in adjacent areas, however only the bottom one third of the formation is present in the map area. Unit may generate rockfall hazards where exposed in steep cliffs.

Pe **Eagle Valley Formation (Middle Pennsylvanian)**—Interbedded reddish-brown, gray, reddish-gray, and tan siltstone, shale, sandstone, gypsum, gypsiferous siltstone and sandstone, and carbonate rocks. Unit is somewhat micaceous. It is transitional between predominantly evaporitic rocks of the underlying Eagle Valley Evaporite and overlying red beds of the Maroon Formation, possessing characteristics of both. Contact with overlying Maroon Formation is gradational, occasionally intertonguing, and conformable. It is placed where light-colored clastics transition into a predominantly red bed sequence. The Eagle Valley Formation is well exposed in the quadrangle, especially in the cliffs on the east side of the Colorado River. A striking intertongue of Eagle Valley Evaporite within the Eagle Valley Formation is well exposed in these cliffs. We interpret the intertongue as being an original depositional feature; it is plausible but less likely due to intrusive flowage of evaporite. Schenk (1989) mapped the entire exposure of evaporites and transitional clastics as Eagle Valley Formation which he subdivided into clastic and evaporitic members. Contact with overlying Maroon Formation is gradational and conformable. Original thickness of this unit is difficult to estimate due to deformation caused by interbedded and underlying evaporite beds, but it probably does not exceed 1,000 ft in the quadrangle.

Unit may be susceptible to corrosion problems and dissolution-induced subsidence and sinkholes. Surficial deposits derived from this formation may be prone to compaction, piping, and corrosion problems.

Pee **Eagle Valley Evaporite (Middle Pennsylvanian)**—Sequence of evaporitic rocks consisting mainly of gypsum, anhydrite, and halite, interbedded with light-colored, fine-grained clastic rocks and thin carbonate beds. Locally contains 2- to 6-inch-long selenite crystals. Commonly is intensely deformed by flowage, diapirism, dissolution-induced subsidence, load metamorphism, and regional tectonism. Formation is very well exposed in quadrangle, especially on the east side of the Colorado River where two prominent evaporite beds are traceable for 3.5 miles along the west side of Blowout Hill. These two evaporite beds merge into the thick bed of evaporite which crops out in the northeast corner of the quadrangle. This zone of intertonguing is characterized by post-depositional deformation of primary bedding contacts by salt tectonism. Evaporite is also exposed in the apparent axial trough of a syncline on the west side of the Colorado River just south of Sweetwater

Creek. It is not clear whether this is an intertongue of evaporite occurring at the contact with the underlying Minturn/Belden combined unit or if this evaporitic remnant is related to Laramide folding. In the northeast corner of the quadrangle in Sec. 35, T. 3 S., R. 86 W., two lenses of Eagle Valley Formation clastic rocks about 500 ft long by 100 ft high crop out in evaporite. These exotic blocks may have collapsed into large solution cavities or sinkholes developed in the underlying evaporite or they may be lenses within the evporitic sequences. Contact with overlying Eagle Valley Formation is conformable and intertonguing. Upper contact is defined as the base of the predominant reddish to reddish-brown clastic sequence.

Unit is prone to development of dissolution cavities into which overlying bedrock and surficial deposits may subside and fine-grained surficial deposits may be piped. Evaporitic rock is corrosive, and surficial deposits derived from it may be subject to compaction, settlement, and corrosion problems. Formation may be prone to diapiric or hydration swelling. Gypsum within the Eagle Valley Evaporite is a valuable industrial mineral that is mined and processed into wallboard near the town of Gypsum.

IPm

Minturn Formation (Middle Pennsylvanian)—Tan to brown lithic wacke, tan to reddish-brown, lithic subarkose, tan to brown, medium- to coarse-grained sandstone and lithic sandstone, silty sandstone, and a few beds of siltstone. Subarkoses and wackes are very coarse grained, conglomeratic, poorly sorted, and weakly crossbedded. Clasts are pebble- to cobble-sized, angular to subangular fragments of quartz, feldspar, and lithics. Matrix is predominantly coarse- to medium-grained quartz, feldspar, and lithics. These rocks occur in massive individual beds up to 16 ft in thickness. Sandstones are coarse grained, weakly crossbedded and contain angular quartz clasts with minor feldspar and lithic fragments up to 0.5 inch in length. Siltstone beds are thin and micaceous. The coarse clastic beds in this sequence are persistent but thin considerably to the south and southeast into the Cottonwood Pass quadrangle, where they intertongue with marine shales of the Belden Formation (Streufert and others, 1997) Contact with the overlying Eagle Valley Evaporite is conformable and usually sharp. A section measured through the Minturn and Belden Formations north of Sweetwater Creek is reported in Table 1. The Minturn Formation is 287 ft thick in this measured section.

These rocks resemble time-equivalent, coarse clastics occurring on the flanks of the Central Colorado Trough. On the east side of the trough these types of rocks are included in the Minturn Formation (Tweto and Lovering, 1977), whereas on the west side of the trough they are mapped as Gothic Formation (Langenheim, 1954). We have correlated these deposits in the Dotsero quadrangle with the Minturn Formation because they occur closer to the east side of the trough. The near-source, immature nature of these sedimentary rocks, coupled with their south-thinning, wedge-shaped depositional pattern, suggests a previously unrecognized, probably localized, Middle Pennsylvanian highland which occurred to the north of the quadrangle. This uplift could have been a small fault block or other type of small uplift event in the middle of the Central Colorado Trough. These tectonic sediments most likely accumulated in a series of broad, coalescing alluvial fans. A suggestion that these rocks represent a turbidite sequence is less defensible due to the lack of a recognizable Bouma cycle. Unit may be a source of rockfall debris where exposed in steep slopes.

IPb

Belden Formation (Lower Pennsylvanian)—Predominantly gray to black, calcareous shale and fossiliferous gray limestone with minor beds of fine- to medium-grained, micaceous sandstone, micaceous siltstone, and a few beds of faintly crossbedded arkose. Contains thin beds of gray to brown and black chert in very lowermost part of unit and discontinuous and localized beds of evaporite which can occur anywhere in the formation, as seen in Sec. 6, T. 5 S., R. 87 W. just north of the footbridge across the Colorado River. South of the Colorado River the unit includes intertonguing beds of coarse-grained clastic rocks which are Minturn Formation equivalent. Intertonguing beds of Minturn Formation rocks occurring near the top of the Belden Formation extend well into the Cottonwood Pass quadrangle to the south (Streufert and others, 1997). Rocks of the Belden Formation were deposited in a low-energy marine environment at a distance from their source over a widespread area in the Central Colorado Trough between the Ancestral Uncompahgre and Front Range Highlands. Minturn

Formation equivalent rocks were most likely deposited in a series of coalescing alluvial fans, the distal ends of which intertongue with rocks of the Belden Formation. Unit is approximately 500 to 750 ft thick across map area but may be thickened or thinned by bedding-plane faulting. A measured section in the Belden and Minturn Formations north of Sweetwater Creek is described in Table 1. Unit is highly prone to landsliding, especially on north-facing slopes.

IPmb **Minturn and Belden Formations, undivided (Lower and Middle Pennsylvanain)**—Includes the Minturn and Belden Formations where it is not practical to map them separately due to poor outcrop exposures. Thickness of combined unit is approximately 800 to 900 ft. Unit is mapped in the low hills west and north of the Colorado River. Unit is prone to rockfall hazards where upper coarse clastic beds are exposed in steep cliffs, and to landsliding.

Ml **Leadville Limestone (Mississippian)**—Light- to medium-gray, bluish-gray, massive, coarsely to finely crystalline, micritic, fossiliferous limestone and dolomite. Contains lenses and nodules of dark-gray to black chert, especially in lower third of formation. Upper half of formation contains coarse-grained oolites. Top of unit contains collapse breccia, filled solution cavities, and locally a red to reddish-purple claystone regolith (Molas Formation), all of which formed on and below a paleokarst surface. Entire unit is well exposed in upper Deep Creek canyon on the west edge of the quadrangle. Spectacular paleo-towers of Leadville Limestone, which have been exhumed by the downcutting of Deep Creek and to a lesser extent by Sweetwater Creek on the north end of the quadrangle, provide a glimpse of what the middle to late Carboniferous karst landscape may have looked like. At the east end of Glenwood Canyon on the south side of the Colorado River a thermal spring (33°C) emerges from an outcrop of Leadville Limestone. The unit also crops out along Coffee Pot Road near the west boundary of the quadrangle, where it is exposed along the axis and south limb of an anticline. Formed in a marine environment in the sublittoral zone. Unit is unconformable with the overlying Belden Formation. The Leadville Limestone is 180 to 200 ft thick.

Unit can be chemically pure and has been mined as a metallurgical grade limestone near Glenwood Springs. Also it is a potential source of riprap. Unit is susceptible to sinkholes and subsidence where karst features occur near the land surface. May be a source of rockfall debris where exposed in steep cliffs.

Dc **Chaffee Group (Upper Devonian)**—Sequence composed of green shale, quartzite, dolomite, limestone, and dolomitic sandstone. Consists of three named formations which from top to bottom are the Gilman Sandstone, Dyer Dolomite, and Parting Formation. The Chaffee Group crops out near the west edge of the quadrangle where exposed in Deep Creek and in Glenwood Canyon at the southwest corner of the quadrangle. Contact with overlying Leadville Limestone is unconformable and sharp. Unit formed under fluctuating conditions in shallow marine and tidal flat environments. Total thickness of the Chaffee Group is approximately 250 ft. Unit may create rockfall hazards where exposed in steep cliffs.

MDr **Mississippian and Upper Devonian rocks, undivided**—Includes rocks of the Leadville Limestone and Chaffee Group where it is not practical to map them separately due to poor exposures. Thickness of combined unit is about 450 ft.

Om **Manitou Formation (Lower Ordovician)**—Consists predominantly of medium-bedded, brown dolomite at the top of the formation, 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. It is divided into two members: the upper Tie Gulch Member and the lower Dead Horse Conglomerate Member. Unit crops out only in upper Deep Creek and in Glenwood Canyon. Formed under changing conditions in shallow marine to supratidal environments. Unit is approximately 150 to 160 ft thick. The Manitou Formation may cause rockfall hazards where exposed in steep cliffs.

Ꞓd **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. Formation consists of two members: the upper Clinetop

Member and the lower Glenwood Canyon Member. Despite the name of the formation, the type localities for the included members are not in the quadrangle. The type locality for the Glenwood Canyon Member is in Glenwood Canyon in the SE 1/4 Sec. 16, T. 5 S., R. 87 W., to the west in the Shoshone quadrangle. The type locality for the Clinetop Member is located approximately 17.6 miles northwest of the Dotsero quadrangle, on the White River Uplift in the SW1/4 Sec. 23, T. 3 S., R. 90 W., near Sixmile Lake (Bass and Northrop, 1953). The Dotsero Formation crops out only at the bottom of Deep Creek canyon on the west edge of the quadrangle. Unit formed in the supratidal environment. Total thickness is 90 ft.

€s **Sawatch Quartzite and unnamed overlying rocks, undivided (Upper Cambrian)**—White and buff to gray-orange brown-weathering, vitreous orthoquartzite in beds from 1 to 3 ft-thick. Unit includes unnamed beds of massive, brown, sandy dolomite and white quartzite. Shown only on cross-section.

p€ **Precambrian rocks, undivided (Proterozoic)**—Shown only on cross-section

ECONOMIC GEOLOGY

Scoriaceous lapilli tuff (Qltu) mined from thick, unconsolidated deposits in the vicinity of Dotsero Crater is mixed with other lightweight fillers and cement to produce cinder blocks by the Mayne Block Company in Dotsero. This scoriaceous material is also marketed as landscaping aggregate, road cinders, and as other lightweight construction products.

In 1995 Eagle Gypsum Company produced 400,000 tons of gypsum from an open pit developed in the Eagle Valley Evaporite at their Eagle Gypsum Mine, located 2.5 miles east of the quadrangle. The gypsum was manufactured into wallboard and other products at a calcining and production facility located in the town of Gypsum (J. Cappa, 1996, oral commun.). Similiar gypsum resources may exist in Dotsero quadrangle.

Other potential mineral resources in the quadrangle include high-grade limestone, sand, gravel, and crushed rock.

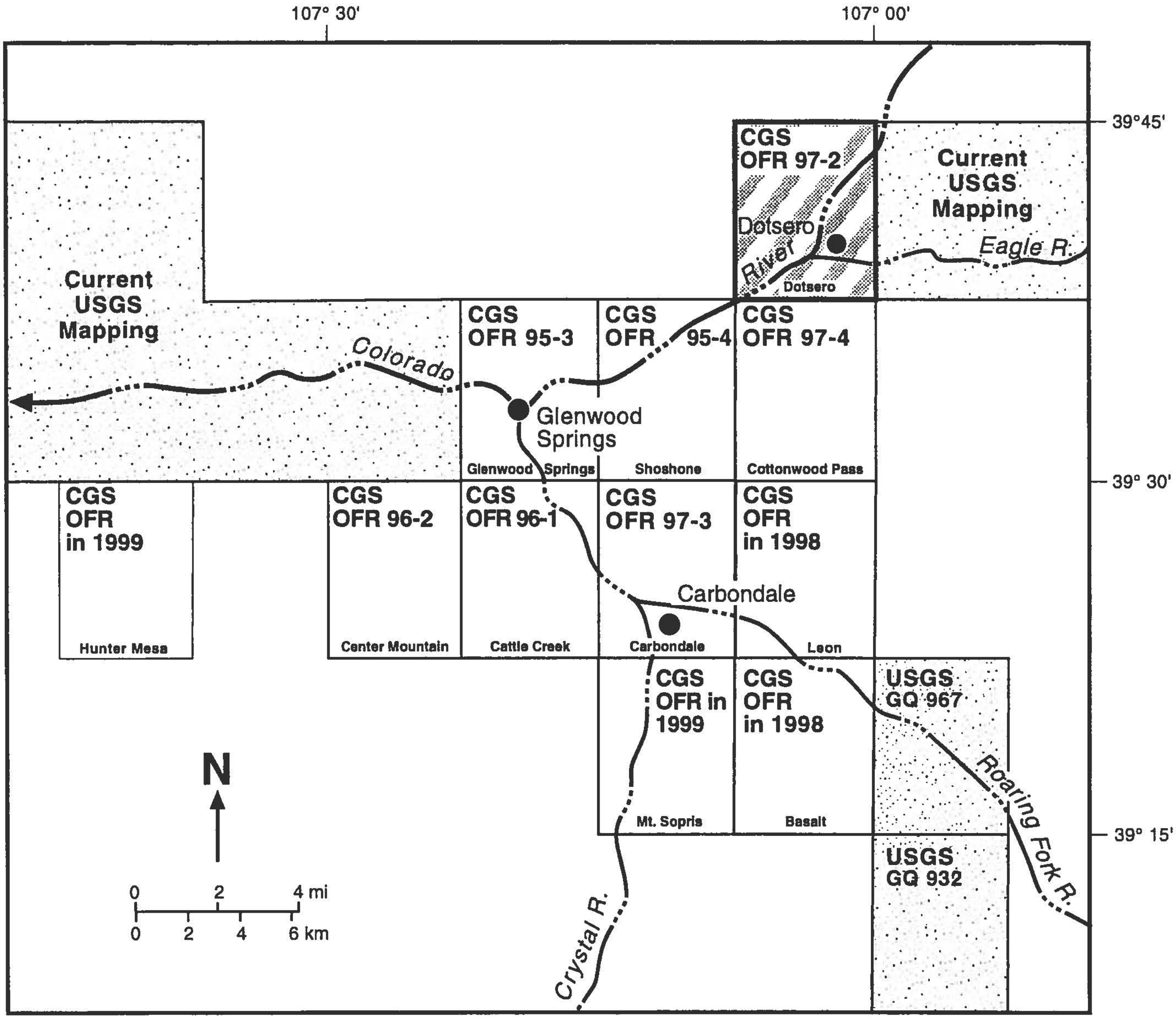

Figure 1. Status of geologic mapping of 7.5-minute quadrangles in the vicinity of Dotsero quadrangle.

TABLES

Table 1. Measured Section: Minturn and Belden Formations

North of Sweetwater Creek: E½SW¼ Sec. 31, T. 3 S., R. 86 W.

Eagle Valley Evaporite (Middle Pennsylvanian): ....(not measured)

Sequence of evaporitic rocks consisting mainly of gypsum, anhydrite, halite, interbedded fine-grained clastic rocks and thin carbonate bedsrocks beds

	Minturn Formation (Middle Pennsylvanian):	**Thickness**
*	Lithic wacke, tan to brown, crossbedded, very coarse-grained, with 0.5–2 in. angular to subangular quartz, feldspar, and lithic clasts	7.0
*	Covered interval	3.0
*	Lithic wacke, tan to brown, crossbedded, very coarse-grained, with 0.5–2 in. angular to subangular quartz, feldspar, and lithic clasts, poorly sorted	32.0
*	Covered interval	6.0
*	Lithic wacke, tan to brown, coarse- to very coarse-grained with up to 0.5 in. angular to subangular quartz, feldspar, and lithic clasts	12.0
*	Covered interval	1.0
*	Quartz wacke, tan to yellowish-tan, coarse- to very coarse-grained; clasts are angular to sub-angular quartz with feldspar in matrix	14.0
*	Sandstone, tan, thinly bedded, fine-grained, micaceous	4.0
*	Covered interval, mostly sandstone float	20.0
*	Sandstone, gray, medium-grained	1.0
*	Sandstone, tan to greenish-tan, thinly bedded, micaceous	5.0
*	Covered interval	3.0
*	Sandstone, white, crossbedded, medium-grained	2.0
*	Covered interval	18.0
*	Sandstone, tan, fine- to coarse-grained, silty	4.0
*	Covered interval	11.0
*	Sandstone, tan, medium- to coarse-grained, with angular to subangular quartz clasts (0.125 in.)	6.0
*	Sandstone, tan to brown, fine- to medium-grained; clasts are quartz and feldspar	3.5
*	Covered interval	6.0
*	Sandstone, tan, thinly bedded, fine- to medium-grained	1.0
*	Covered interval	3.5
*	Lithic subarkose, white and tan, very coarse-grained, over 70% quartz; contains 0.5–1 in. feldspar and 0.5–2 in. quartz clasts; also contains 2 in. lithic clasts	2.0
*	Covered interval, sandstone float	22.0
*	Lithic subarkose, very angular clasts	3.0
*	Quartz sandstone, somewhat feldspathic	1.0
*	Covered interval	3.0
*	Lithic subarkose, buff to tan, faintly cross-bedded, very coarse-grained, poorly sorted; clasts are angular to subangular; contains feldspar and lithic clasts	15.0
*	Siltstone, tan	1.5
*	Sandstone, tan, medium-grained	1.5

Table 1. Continued

*	Siltstone, gray, very fine-grained, micaceous	2.0
*	Lithic subarkose, white to buff, coarse-grained, angular to subrounded; some feldspar clasts	7.0
*	Covered interval	4.0
*	Sandstone, white to buff, medium-grained, angular to subangular with some feldspar clasts	5.0
*	Covered interval	10.0
**	Lithic subarkose, tan, massive, coarse-grained; some feldspar clasts; angular to sub-angular clasts	5.0
*	Covered interval	24.0
*	Sandstone, tan to gray, medium-grained	2.0
*	Sandstone, fine- to medium-grained	8.0
*	Sandstone, white to buff, medium-to coarse-grained, angular	8.0
	Total thickness of Minturn Formation is	287.0

Belden Formation (Lower Pennsylvanian):

*	Sandstone and shale; 1-2 ft thick sandstone beds and gray to black shale	26.0
*	Shale, black and gray, with thin sandstone beds	40.0
*	Covered interval	9.0
*	Sandstone, tan to buff, crossbedded, fine-to medium-grained, micaceous	4.0
*	Shale and sandstone; thinly bedded tan sandstone and gray shale	8.0
*	Shale, black	5.0
*	Covered interval	8.0
*	Sandstone, tan to reddish-tan	1.5
*	Covered interval	5.5
*	Sandstone, tan, thinly bedded, very fine-grained	1.0
*	Sandstone and shale	8.0
*	Sandstone, tan, medium- to fine-grained; some feldspar	1.5
*	Shale and sandstone, micaceous, fine-grained	21.0
*	Sandstone, tan	0.5
*	Covered interval	2.0
*	Sandstone, tan, crossbedded, medium- to coarse-grained, micaceous	4.0
*	Covered interval	3.0
*	Sandstone, brown, micaceous	1.0
*	Covered interval	4.0
*	Sandstone, tan to greenish-tan, micaceous	1.0
*	Shale, sandy, glauconitic	6.0
*	Limestone, gray, crystalline	1.0
*	Shale, sandy, green to greenish-gray, glauconitic and micaceous	3.0
*	Sandstone, tan, medium-grained, micaceous	4.0
*	Shale, gray to reddish-gray	1.5
*	Limestone, gray, sandy	1.0
*	Shale, gray to greenish-gray, micaceous, sandy	3.5
*	Sandstone, tan to brown, medium-grained	2.5
*	Shale, gray	1.5
*	Sandstone, tan	3.5

Table 1. Continued

*	Shale, gray to green	3.0
*	Limestone, gray to tan, sandy	1.0
*	Shale, gray, sandy with a few sandstone beds	6.0
*	Sandstone, tan, crossbedded, micaceous	1.0
*	Shale, gray to dark-gray	6.5
*	Limestone, gray	2.0
*	Shale, greenish-gray, with sandstone interbeds	13.0
*	Sandstone, tan, fine-grained, silty	1.5
*	Covered interval	3.5
*	Arkosic sandstone, reddish-brown	1.0
*	Sandstone, light-greenish-gray, silty	1.0
*	Lithic wacke, tan to buff, very coarse-grained; clasts are angular to subrounded quartz and lithics	11.5
*	Arkosic sandstone, reddish-brown, faintly-crossbedded, coarse-grained; numerous angular quartz clasts	10.0
*	Shale, glauconitic	2.5
*	Shale, reddish-brown	2.0
*	Arkosic sandstone, reddish-brown; contains angular quartz clasts	5.0
*	Covered interval	6.5
*	Sandstone, brown to gray, micaceous	2.0
*	Shale, gray to black	11.0
*	Limestone, gray	0.5
*	Shale, gray to black, glauconitic	15.5
*	Limestone, gray, sandy	2.0
*	Shale, gray, glauconitic	5.5
*	Sandstone, reddish-brown, micaceous, limy	3.0
*	Shale, grenish-gray	1.8
*	Shale, reddish-brown	1.0
*	Shale, gray	3.5
*	Limestone, gray, sandy	1.0
*	Shale, micaceous	0.8
*	Limestone, gray	0.8
*	Shale, micaceous	1.0
*	Limestone, gray, sandy	1.5
*	Shale, greenish-gray, micaceous	4.5
*	Limestone, gray to tan, crystalline, fossiliferous	2.5
*	Shale, black	1.5
*	Limestone, gray to tan, crystalline, fossiliferous	7.0
*	Covered interval	3.5
*	Shale, black	3.0
*	Limestone, black, micritic	1.0
*	Limestone, gray	2.0
*	Shale, gray to black	2.5
*	Limestone, light-gray, fossiliferous	2.0
*	Covered interval	1.5
*	Limestone, gray	0.5

Table 1. Continued

*	Covered interval	1.0
*	Shale, micaceous, limy	1.0
*	Limestone, black	1.0
*	Covered interval	2.5
*	Limestone, sandy, fossiliferous	2.0
*	Covered interval	15.5
*	Limestone, gray	4.0
*	Covered interval	2.5
*	Limestone, tan, crystalline, with shaly partings	1.0
*	Shale, gray	2.0
*	Covered interval	4.5
*	Shale, gray	3.5
*	Limestone, gray to black	2.0
*	Covered interval	5.5
*	Limestone, black, fossiliferous	7.0
*	Shale, sandy, limy	3.5
*	Shale, black	4.0
*	Covered interval	5.0
*	Limestone, gray, micritic	1.0
*	Covered interval	6.5
*	Limestone, gray, micaceous, with sandy interbeds	5.0
*	Limestone, fossiliferous	0.7
*	Limestone, black, micritic	4.0
*	Shale and limestone, gray to black	4.0
*	Limestone, grey, micritic	1.5
*	Shale and limestone, gray to black	17.5
*	Limestone, gray, fossiliferous	1.5
*	Covered interval	4.5
*	Limestone, gray, micritic	3.0
*	Covered interval, most likely shale and limestone	80.0
	Total thickness of Belden Shale is	537.6
	TOTAL:	824.6

Leadville Limestone (Mississippian): (not measured)

Sequence of gray to blue-gray, micritic to crystalline, oolitic, fossiliferous, chert-bearing marine limestone

Table 2. Whole-Rock Aanalyses of the Dotsero Quadrangle

Samples DT-39 and SWV-1 were analyzed by the U.S. Geological Survey, Denver, CO. All other analyses by Chemex Labs, Inc., Sparks, NV
[LOI=loss on ignition; ppm=parts per million]

Sample	Al_2O_3 %	CaO %	Cr_2O_3 %	Fe_2O_3 %	K_2O %	MgO %	MnO %	Na_2O %	P2O5 %	SiO2 %	TiO_2 %	LOI %	Total %	Ba ppm	Rb ppm	Sr ppm	Nb ppm	Zr ppm	Y ppm
DT-R1	15.82	8.56	—	11.12	2.44	7.15	0.18	3.44	0.64	47.95	1.47	0.76	99.23	—	—	—	—	—	—
DT-R2	14.36	9.00	<0.01	12.53	1.21	6.00	0.15	2.90	0.67	48.62	2.49	0.28	98.21	920	86	466	8	243	18
DT-R3	16.05	8.22	<0.01	11.24	2.43	6.54	0.18	3.09	0.58	49.39	1.58	0.11	99.41	635	86	464	8	210	20
DT-R4	14.39	8.99	<0.01	12.50	1.32	6.12	0.15	3.05	0.70	48.27	2.52	0.24	98.25	565	78	618	6	132	14
DTV-1	15.59	8.55	<0.01	11.99	2.92	7.03	0.19	3.18	0.69	47.74	1.58	0.01	99.47	555	84	610	6	138	14
DTV-2	15.66	8.49	<0.01	11.87	2.98	7.07	0.19	3.10	0.69	47.79	1.58	0.01	99.43	1580	132	460	8	225	18
DTV-3	15.61	8.54	<0.01	11.73	2.84	7.01	0.19	3.13	0.68	47.76	1.58	0.01	99.08	1205	118	460	8	258	20
DT-39	16.20	8.57	—	11.87	2.72	7.12	0.20	3.17	0.73	47.66	1.58	-0.40	99.42	—	—	—	—	—	—
SWV-1	14.66	12.1	—	11.42	0.95	4.41	0.14	3.03	0.52	46.70	1.57	4.32	99.82	—	—	—	—	—	—

Sample descriptions:

DT-R1: Lapilli tuff (Qltu), collected from 0.75 miles northeast of Dotsero Crater. Latitude 39.66342/Longitude 107.02111.

DT-R2 Basalt (Tb) from edge of tilted mesa, 1.5 miles northeast of Dotsero Crater. Latitude 39.66434/Longitude 107.00754.

DT-R3 Trachybasalt (Qtb) from Willow Peak flow exposed on Coffee Pot Road. Latitude 39.65951/Longitude 107.12470.

DT-R4 Basalt (Tb) from erosional remnant on north ridge of Blowout Hill. Latitude 39.69682/Longitude 107.01465.

DTV-1 Trachybasalt (Qtb) from Dotsero lava flow in Eagle River Valley. Latitude 39.64375/Longitude 107.03827.

DTV-2 Trachybasalt (Qca) exposed in south wall of Dotsero Crater, lower flow. Latitude 39.65930/Longitude 107.03592.

DTV-3 Trachybasalt (Qca) exposed in south wall of Dotsero Crater, upper flow. Latitude 39.65898/Longitude 107.03617.

DT-39 Trachybasalt (Qtb) from Dotsero lava flow in Eagle River Valley (same sample location as DTV-1). Latitude 39.64368/Longitude 107.03816.

SWV-1 Basalt (Tb) from an erosional remnant on ridge between Irrawaddy and Sweetwater Creeks. Latitude 39.72789/Longitude 107.06421.

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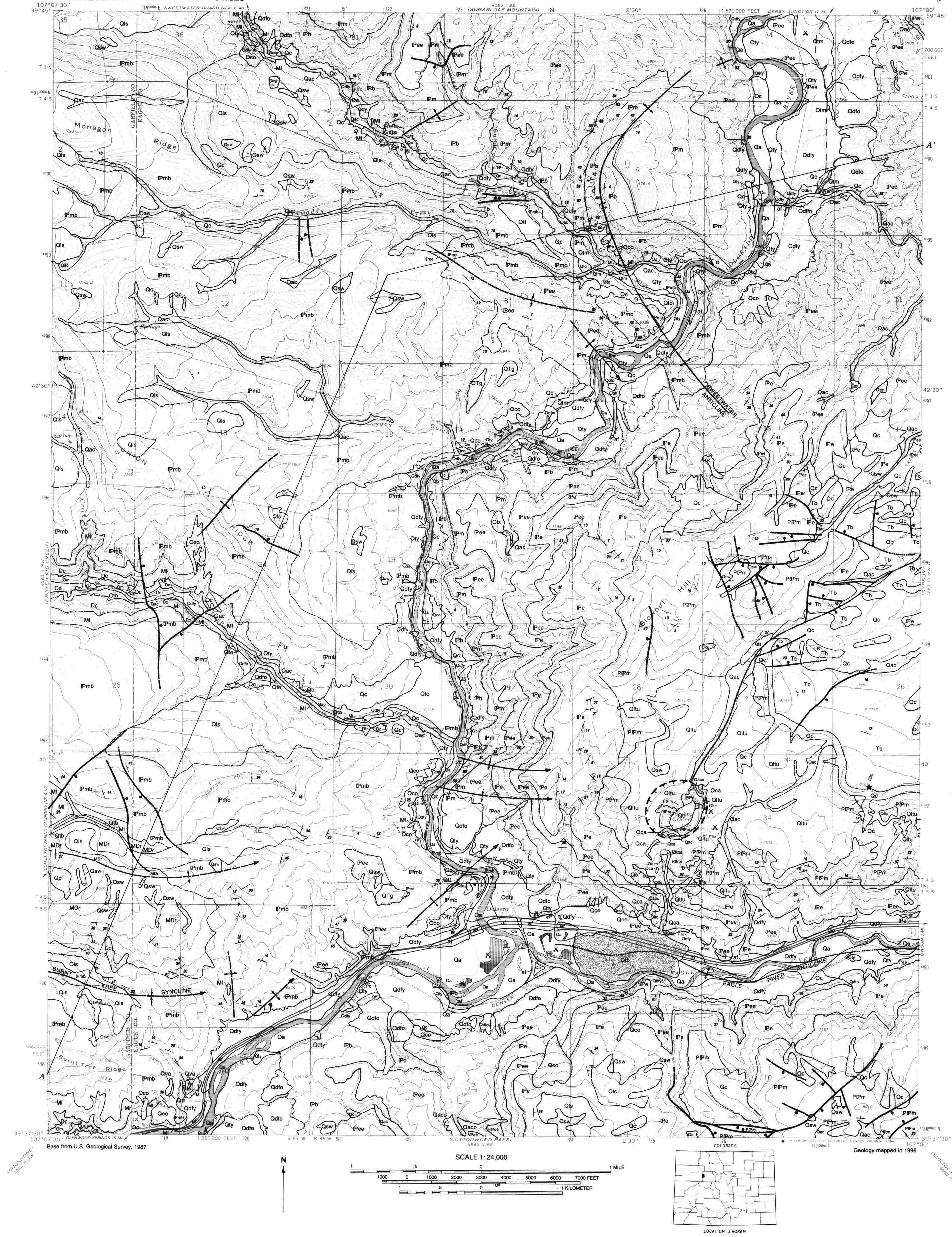
COLORADO GEOLOGICAL SURVEY
DIVISION OF MINERALS AND GEOLOGY
DEPARTMENT OF NATURAL RESOURCES

OPEN FILE MAP 97-2
GEOLOGIC MAP OF THE DOTSERO QUADRANGLE,
EAGLE AND GARFIELD COUNTIES, COLORADO
Booklet accompanies map



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)—Material placed by humans

ALLUVIAL DEPOSITS—Sediments deposited in stream channels, flood plains, terraces, and sheetwash areas

Qa — **Stream-channel, flood-plain, and low-terrace deposits (Holocene and late Pleistocene)**—Mostly poorly sorted, clast-supported gravel in a sandy or silty matrix. Includes terraces up to about 12 ft above modern river level

Qsw — **Sheetwash deposits (Holocene and late Pleistocene)**—Gravelly sand, sandy silt, and clayey silt deposited in ephemeral and intermittent stream valleys, on gentle hillslopes, and in basinal areas

Qty — **Younger terrace alluvium (late Pleistocene)**—Mostly poorly sorted, clast-supported, occasionally bouldery, pebble and cobble gravel in a sand and silt matrix. Deposited as glacial outwash. Underlies terraces 20–80 ft above modern stream level. May include fine-grained overbank deposits

Qtm — **Intermediate terrace alluvium (late Pleistocene)**—Deposits texturally and depositionally similar to younger terrace alluvium (Qty). Underlies terraces 90–120 ft above modern stream level

Qto — **Older terrace alluvium (middle Pleistocene)**—Deposits texturally similar to younger terrace alluvium (Qty). Micaceous clasts moderately weathered. Underlies terraces 160–180 ft above modern streams

Qtt — **Oldest terrace alluvium (middle Pleistocene)**—Deposits texturally similar to younger terrace alluvium (Qty). Micaceous clasts moderately to highly weathered. Underlies terraces about 160–460 ft above rivers

QTg — **High-level gravel (early Pleistocene or late Tertiary)**—Chiefly clast-supported, sandy, silty, cobble and pebble gravel occuring on hills 600–680 ft above the Colorado River. Micaceous clasts are very highly weathered

COLLUVIAL DEPOSITS—Sediments on valley sides, valley floors, and hillslopes transported and deposited primarily by gravity

Qc — **Colluvium (Holocene and late Pleistocene)**—Ranges from clast-supported, pebble to boulder gravel in a sandy silt matrix to matrix-supported gravelly, clayey sandy, silt. Usually coarser grained in upper reaches of colluvial slope and finer grained in distal areas

Qls — **Landslide deposits (Holocene and Pleistocene)**—Includes various types of landslide deposits consisting of unsorted, unstratified rock debris, gravel, sand, silt, and clay. Ranges from active, slowly creeping slides to long-inactive Pleistocene landslides

Qco — **Older colluvium (Pleistocene)**—Texturally similar to colluvium (Qc), but generally not subject to active deposition

ALLUVIAL AND COLLUVIAL DEPOSITS—Sediments in debris fans, stream channels, flood plains, and hillslopes along tributary valleys

Qdfy — **Younger debris-flow deposits (Holocene)**—Poorly sorted, matrix- and clast-supported deposits ranging from gravelly clayey silt to sandy, silty, cobbly, pebbly, and bouldery gravel. Fan heads tend to be bouldery, while distal fan areas are finer grained. Deposited on active fans and drainage channels. Includes stream alluvium and debris-flow, hyperconcentrated-flow, and sheetwash deposits

Qac — **Alluvium and colluvium, undivided (Holocene)**—Moderately well-sorted 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

Qdfm — **Intermediate debris-flow deposits (Holocene and late Pleistocene)**—Poorly sorted gravelly deposits found 10-30 ft above adjacent streams. Similar in texture and genesis to younger debris-flow deposits (Qdfy). Generally not subject to active deposition except during large events or when drainage channels plug with debris and are overtopped

Qaco — **Older alluvium and colluvium, undivided (Holocene? and Pleistocene)**—Deposits texturally and depositionally similar to alluvium and colluvium (Qac) that underlie the floor and hillslopes of tributary valleys. Locally covered by volcanic deposits from Dotsero volcano

Qdfo — **Old debris flow-deposits (Holocene? and Pleistocene)**—Remnants of inactive debris fans found on low-lying mesas and ridgelines 80–240 ft above adjacent drainages. Similar in texture and genesis to younger debris-flow deposits (Qdfy)

EOLIAN DEPOSITS

Qva — **Volcanic ash (middle Pleistocene)**—White to light-gray, bedded, volcanic ash. Slightly to moderately indurated

UNDIFFERENTIATED DEPOSITS

Q — **Surficial deposits, undifferentiated (Quaternary)**—Shown only on cross section

BEDROCK

VOLCANICLASTIC AND VOLCANIC ROCKS OF DOTSERO AND WILLOW PEAK VOLCANOES

Qltu — **Unconsolidated lapilli tuff (Quaternary)**—Black to gray, holocrystalline to partly glassy, unconsolidated, lapilli-sized fragments of scoriaceous trachybasalt with very minor amounts of country rock. Unit was deposited as fallout on hillslopes in vicinity of Dotsero Crater. Locally reworked post-depositionally by alluvial and colluvial processes

Qltc — **Consolidated lapilli tuff (Quaternary)**—Black to gray, holocrystalline to partly glassy, lapilli-sized fragments of scoriaceous trachybasalt with very minor amounts of country rock. Deposits are partially to fully cemented by primary welding or later diagenetic processes. Unit is very localized, occurring as two small outcrops within, and as one small outcrop south of, Dotsero Crater

Qca — **Agglutinated cinders (Quaternary)**—Red to reddish-brown, brown, and black, partly to completely welded, brecciated, scoriaceous cinder beds; reddish-brown, to brown volcanic bombs; and interbedded, black, dense, lava flows. Unit includes rocks formed by pyroclastic accumulation of molten ejecta from the Dotsero volcano

Qtb — **Trachybasalt (Quaternary)**—Dark-gray to black, dense to vesicular, trachybasaltic lava erupted from Dotsero and Willow Peak volcanoes

OTHER BEDROCK

Tb — **Basalt (Miocene)**—Gray to black, dense to vesicular, olivine basalt. Unit caps large mesa 1 mile northeast of Dotsero crater. Also occurs as erosional remnants north of Blowout Hill.

PIPm — **Maroon Formation (Permian and Pennsylvanian)**—Red beds of sandstone, conglomerate, mudstone, siltstone, and claystone with a few beds of gray limestone. Only bottom one third of formation occurs in quadrangle

IPe — **Eagle Valley Formation (Middle Pennsylvanian)**—Interbedded reddish-brown, gray, reddish-gray, and tan siltstone, shale, sandstone, gypsum, gypsiferous siltstone, sandstone, and carbonate rocks. Unit is transitional between evaporitic rocks of underlying Eagle Valley Evaporite and overlying red beds of the Maroon Formation

IPee — **Eagle Valley Evaporite (Middle Pennsylvanian)**—Sequence of evaporitic rocks consisting mainly of gypsum, anhydrite, halite, and fine-grained clastic rocks. Unit is commonly intensely deformed by dissolution, flowage, diapirism, and load metamorphism

IPm — **Minturn Formation (Middle Pennsylvanian)**—Tan to reddish-brown lithic subarkose, tan to brown lithic wacke, tan to brown, medium- to very-coarse-grained sandstone and lithic sandstone, silty sandstone, and a few beds of siltstone. Unit is mapped north of Sweetwater Creek and along east side of Colorado River Canyon

IPb — **Belden Formation (Lower Pennsylvanian)**—Gray to black, calcareous shale, and fossiliferous gray limestone with a few beds of fine-grained, micaceous sandstone and siltstone. Contains abundant, bedded, gray chert in lower portion of formation

IPmb — **Minturn and Belden Formations, undivided (Lower and Middle Pennsylvanian)**—Includes rocks of the Belden and Minturn Formations where it is not practical to map them separately due to poor exposure

Ml — **Leadville Limestone (Mississippian)**—Light- to medium-gray, bluish-gray, massive, coarsely to finely crystalline, fossiliferous, marine limestone and dolomite. Contains nodules and lenses of dark-gray to black chert in lower portions of formation

Dc — **Chaffee Group (Upper Devonian)**—Sequence composed of green shale, quartzite, dolomite, limestone, and dolomitic sandstone. Consists of three named formations which from top to bottom are the Gilman Sandstone, Dyer Dolomite, and Parting Formation

MDr — **Mississippian and Devonian rocks-undivided (Mississippian and Upper Devonian)**—Includes rocks of the Leadville Limestone and Chaffee Group where it is not practical to map them separately due to poor exposures

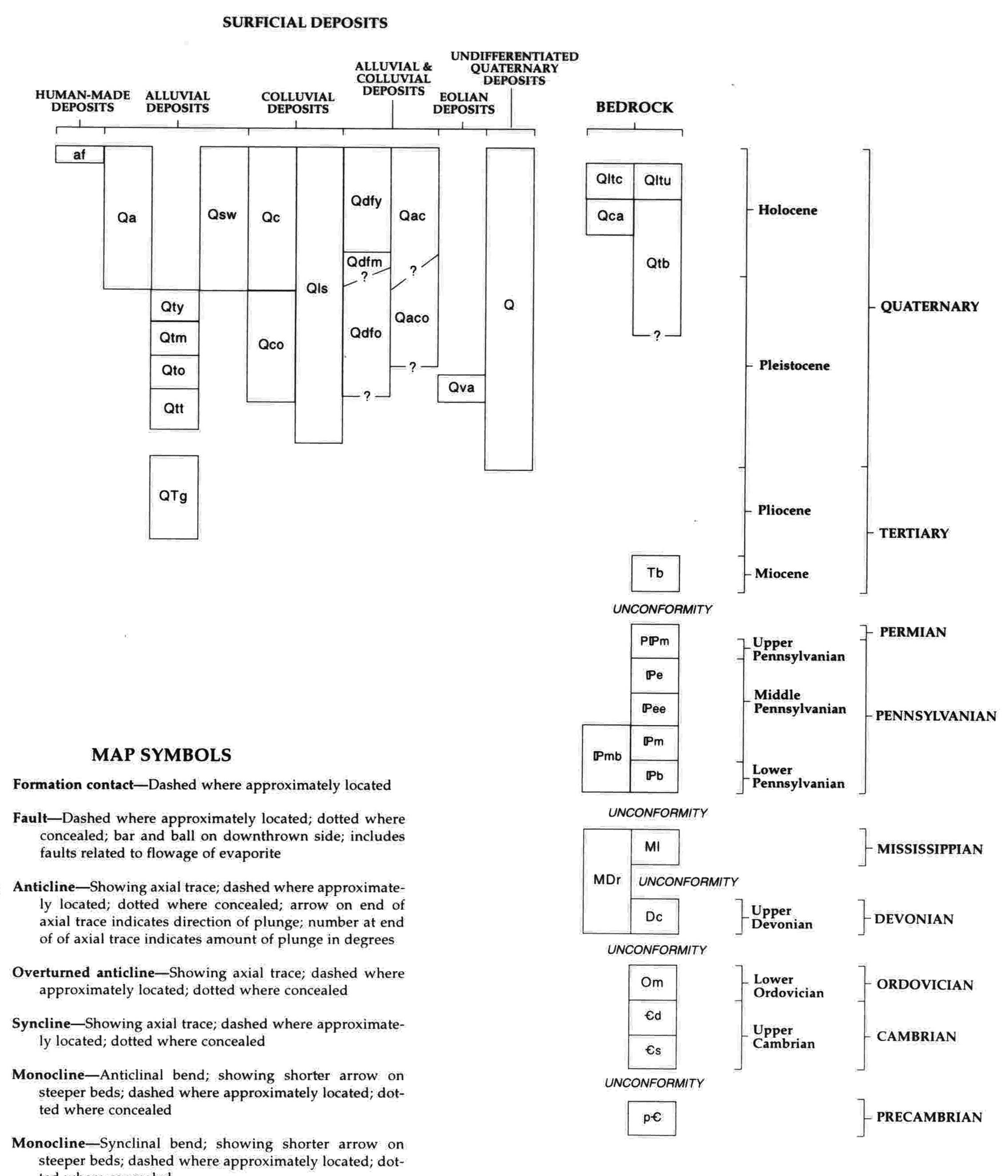
Om — **Manitou Formation (Lower Ordovician)**—Brown-weathering limestone and dolomite, greenish-gray calcareous shale, and thin beds of gray, flat-pebble limestone. Unit is divided into two members: the upper Tie Gulch Member and lower Dead Horse Conglomerate Member

Ꞓd — **Dotsero Formation (Upper Cambrian)**—Tan to gray, silty and sandy dolomite, dolomitic sandstone, green dolomitic shale, limestone and dolomite conglomerate, and algal limestone. Consists of two members: the upper Clinetop Member and lower Glenwood Canyon Member

Ꞓs — **Sawatch Quartzite and unnamed overlying rocks, undivided (Upper Cambrian)**—White and buff to gray-orange brown-weathering, vitreous orthoquartzite in beds from 1 to 3 ft-thick. Unit includes unnamed beds of massive, brown, sandy dolomite and white quartzite. Shown only on cross-section

pꞒ — **Precambrian rocks, undivided (Proterozoic)**—Shown only on cross-section

CORRELATION OF MAP UNITS



MAP SYMBOLS

Formation contact—Dashed where approximately located

Fault—Dashed where approximately located; dotted where concealed; bar and ball on downthrown side; includes faults related to flowage of evaporite

Anticline—Showing axial trace; dashed where approximately located; dotted where concealed; arrow on end of axial trace indicates direction of plunge; number at end of of axial trace indicates amount of plunge in degrees

Overturned anticline—Showing axial trace; dashed where approximately located; dotted where concealed

Syncline—Showing axial trace; dashed where approximately located; dotted where concealed

Monocline—Anticlinal bend; showing shorter arrow on steeper beds; dashed where approximately located; dotted where concealed

Monocline—Synclinal bend; showing shorter arrow on steeper beds; dashed where approximately located; dotted where concealed

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

Overturned beds

Perimeter of Dotsero Crater

Gravel pit or cinder pit

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

Thermal spring

A——A′ **Alignment of cross section**

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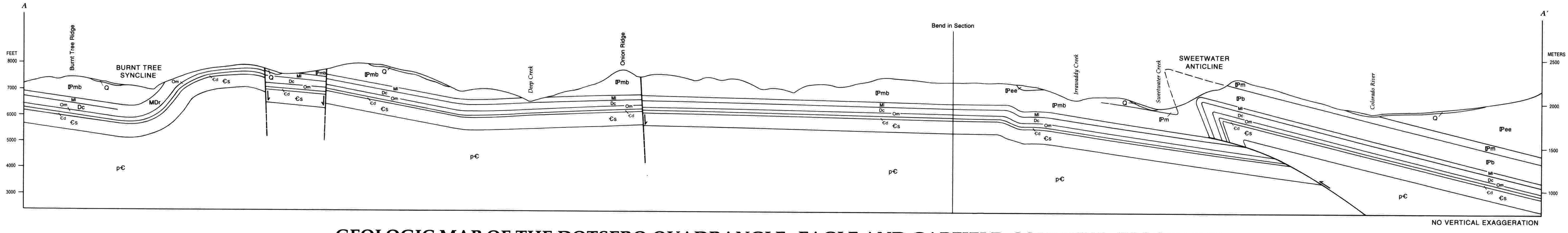

GEOLOGIC MAP OF THE DOTSERO QUADRANGLE, EAGLE AND GARFIELD COUNTIES, COLORADO

By
Randall K. Streufert, Robert M. Kirkham, Timothy J. Schroeder II, and Beth L. Widmann
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