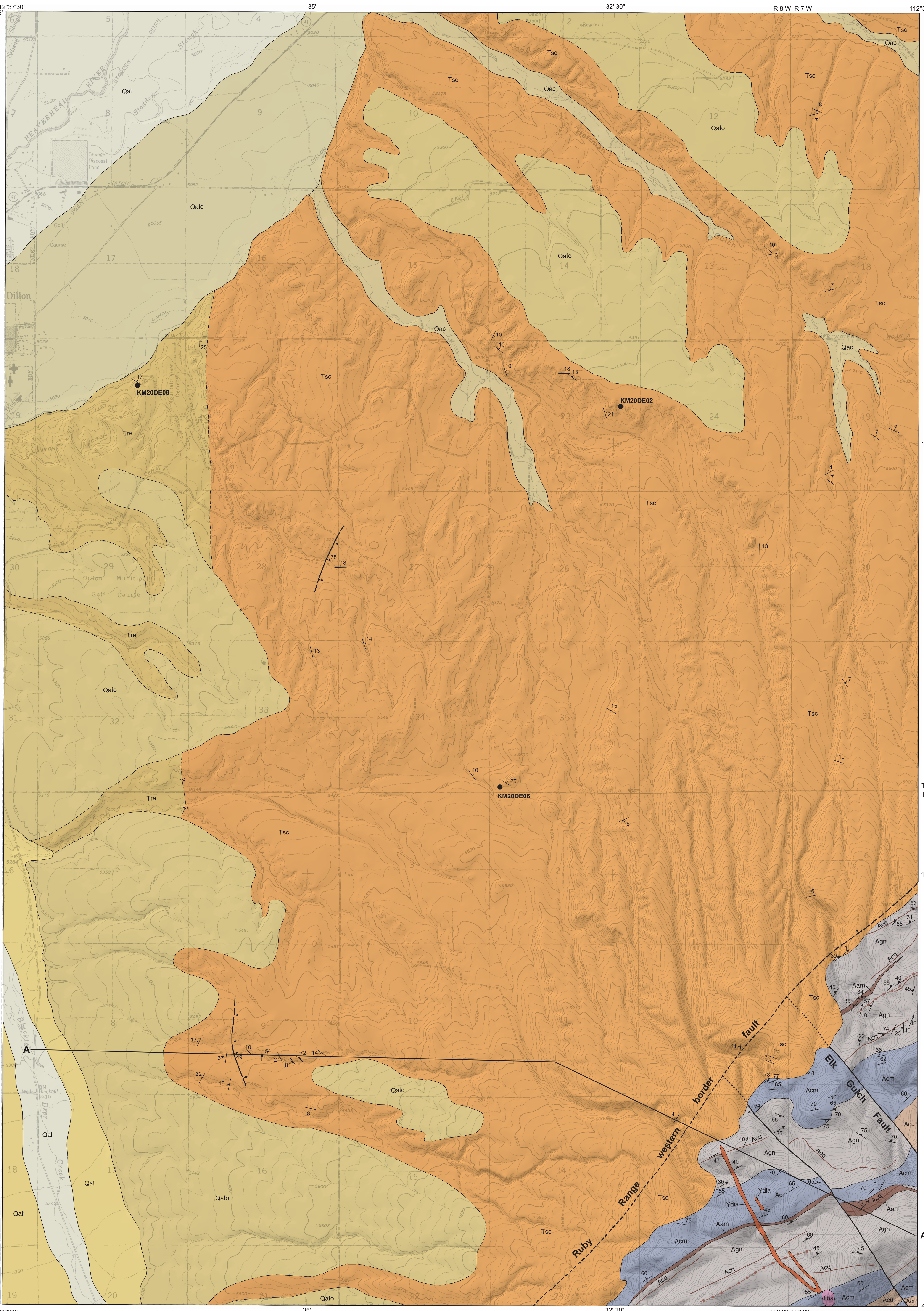


Dillon East 1:24,000-scale quadrangle map
Base map produced by the United States Geological Survey
Control by: USGS and USC&GS
Compiled from aerial photographs taken 1960
Field checked: 1962
Projection: Polyconic
Grid:1000 meter Universal Transverse Mercator Zone 12
Vertical Datum: National Geodetic Vertical Datum of 1929
Horizontal Datum: 1927 North American Datum

Shaded relief created from 10-meter digital elevation model from U.S. Geological Survey National Elevation Dataset.

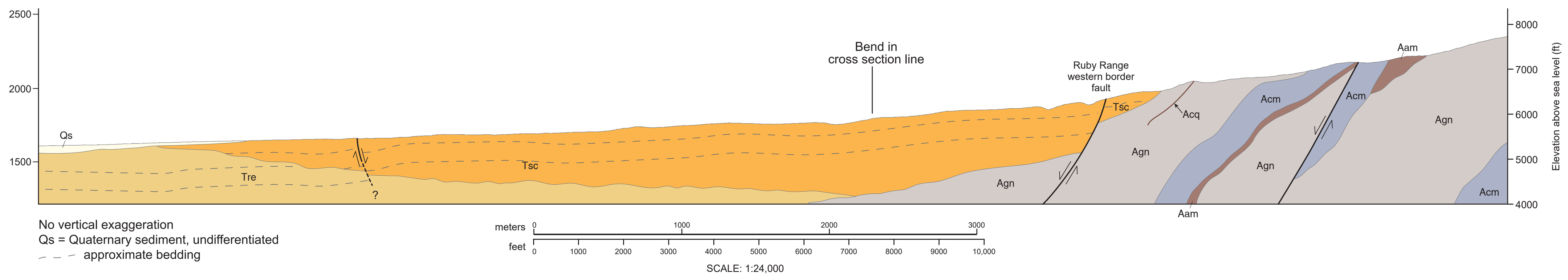
UTM GRID AND 2019 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24,000

CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

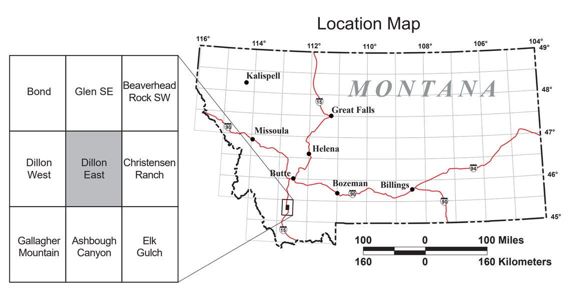
Maps may be obtained from:
Publications Office
Montana Bureau of Mines and Geology
1300 West Park Street
Butte, Montana 59701-8997
Phone: (406) 496-4174
http://mbmg.mtech.edu

Cross Section A–A'



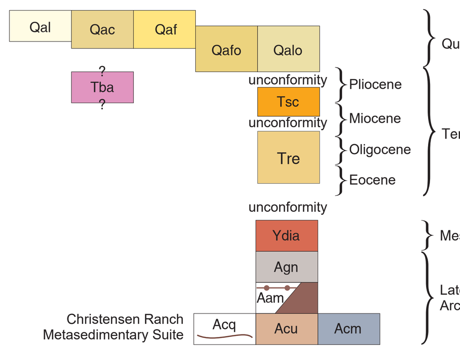
No vertical exaggeration
Qs = Quaternary sediment, undifferentiated
approximate bedding

SCALE: 1:24,000



Research supported by the U.S. Geological Survey, National Cooperative Geologic Mapping Program, under USGS award number G20AC00270.
GIS production: Yiwen Li and Paul Thale, MBMG. Map layout: Susan Smith, MBMG. Editing: Susan Barth, MBMG.

CORRELATION DIAGRAM



MAP SYMBOLS

Contact: long dash where approximately located; short dash where inferred, question mark where questionable

Fault: dotted where concealed

Normal fault: long dash where approximately located; short dash where inferred, bar and ball on downthrown side, arrow showing dip value and direction

Key bed

Small, minor inclined joint—Showing strike and dip

Inclined bedding or layering in metasedimentary rocks—Showing strike and dip

Inclined metamorphic or tectonic foliation—Showing strike and dip

Inclined generic lineation or linear structure—Showing bearing and plunge

Geocronology sample location

INTRODUCTION

The Dillon East quadrangle is located east of Dillon, Montana within the foothills of the Ruby Range (fig. 1). The Beaverhead River transects the northwest corner of the quadrangle; Blacktail Deer Creek crosses the southwest corner. The majority of land in the quadrangle is privately owned and used for agricultural purposes.

The Montana Bureau of Mines and Geology (MBMG), in conjunction with the STATEMAP advisory committee, selected the Dillon East 7.5′ quadrangle for detailed mapping as part of MBMG's ongoing effort to complete the Dillon 30′ x 60′ (1:100,000-scale) geologic map. A key goal was more detailed mapping of the Cenozoic valley deposits that underlie the majority of the quadrangle.

PREVIOUS MAPPING AND METHODS

The Dillon East 7.5′ quadrangle is included in small-scale mapping by Ruppel and others (1993, scale 1:250,000). Detailed 1:24,000-scale bedrock mapping of Precambrian basement rocks was published by James (1990) in the far southeast corner of the quadrangle. The James (1990) mapping was partly compiled for this map. New field mapping, focused primarily on the Tertiary valley-fill deposits, was completed during 2020, using a USGS topographic base map, 2009 orthoimagery from the National Agricultural Imagery Program (NAIP), and a handheld Trimble Juno GPS for locating sample and field observation point data. Rock samples collected for U-Pb geochronology were processed at the MBMG mineral separation laboratory. Zircon was isolated from selected samples by standard density and magnetic separation techniques. Zircon separates were analyzed by Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) by Jesse Mosolf, MBMG, at the University of California, Santa Barbara.

GEOLOGIC SUMMARY

The oldest bedrock in the quadrangle is deformed and metamorphosed Archean metasedimentary and metaigneous rocks exposed along the west flank of the Ruby Range. The metasedimentary rocks are part of the Christensen Range Metasedimentary Suite (CRMS) defined by James (1990) for sequences originally mapped by Heinrich (1960) in the central Ruby Range. The major lithologies are marble, gneiss, schist, amphibolite, and quartzite that form northeast-trending, generally northwest-dipping lithologic belts. Marble is the most prominent lithology and hosts significant talc deposits. The CRMS assemblage has been metamorphosed to upper amphibolite facies during at least two regional tectonothermal events known as the ~2,450 Ma Tendoy Orogeny (Kellogg and others, 2003; Jones, 2008; Cramer, 2015) and the ~1,780–1,720 Ma Big Sky Orogeny (O'Neill, 1998; Harmes and others, 2004; Crawford and Pearson, 2018).

Unmetamorphosed, northwest-trending, Mesoproterozoic diabase dikes crosscut the CRMS and other Archean rocks and appear to be associated with formation of the talc deposits (Wooden and others, 1978; Anderson and others, 1990; Brady and others, 1998). The youngest bedrock is a localized Tertiary basalt flow that overlies the CRMS along the southern map border.

The majority of the Dillon East quadrangle is underlain by Tertiary sedimentary deposits of the Renova and Sixmile Creek Formations. These deposits extend from the Beaverhead River to the western foothills of the Ruby Range, where they unconformably overlie Precambrian basement rocks. The deposits accumulated in the Beaverhead Graben (fig. 1), one of several Cenozoic extensional intermontane basins in southwest Montana. In the central part of the graben, data from a petroleum well log (Ruppel, 1993) suggest the Tertiary sediments are up to 517 m (1,700 ft) thick.

The Renova and Sixmile Creek Formations can be difficult to distinguish in the Dillon East quadrangle because of similar lithologies. Sandy, tuffaceous deposits exposed just east of the Beaverhead River (fig. 2A) yielded zircon grains with U-Pb age dates as young as 22.1 ± 1.0 Ma (sample KM20DE08), indicating they are likely Miocene age and within the upper part of the Renova Formation. The Sixmile Creek Formation unconformably overlies the Renova and has been subdivided into three, interfingering members in the Dillon area—the Sweetwater Creek, Anderson Ranch, and Beaverhead River members (Kuenzi and Fields, 1971; Fritz and Sears, 1993). The individual members were not distinguished for this map, primarily due to lack of exposure or access. However, coarse breccias and conglomerates that extend for several miles to the west of the Ruby Range likely correlate with the Sweetwater Creek Member (fig. 2B). Finer-grained tuffaceous deposits (fig. 2C) exposed in the central part of the map likely correlate with the Anderson Ranch Member based on preliminary U-Pb age dates that yielded grains as young as 9.8 ± 0.5 Ma (sample KM20DE02) and 14.9 ± 0.3 Ma (KM20DE06), similar to ages reported for the Anderson Ranch by Fritz and Sears (1993).

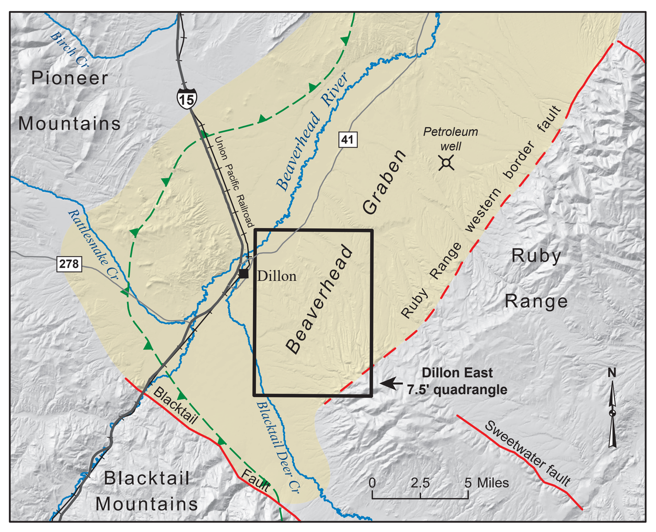


Figure 1. Location and simplified tectonic map for the Dillon East quadrangle. Tectonic features shown are the Beaverhead Graben (yellow shaded area), the leading edge of the fold-thrust belt (green line with triangles), and identified Quaternary faults (red lines). Quaternary faults from the U.S. Geological Survey and MBMG fault and fold database (accessed 6/11/2020).

The youngest deposits in the quadrangle are Quaternary alluvial deposits exposed along the floodplains of the Beaverhead River and Blacktail Deer Creek and thin (generally less than 3 m) older alluvial fan deposits that overlie the Tertiary sediments.

STRUCTURE

The major structures in the Dillon East quadrangle are high-angle, northeast- and northwest-trending faults that offset Tertiary and Archean deposits. The northeast-trending Ruby Range western border fault is a steeply dipping, west-side-down normal fault with recurrent movement during the Tertiary and Quaternary (Tysdal, 1976; Ruppel, 1982, 1993; James, 1990). The fault marks the eastern edge of the Beaverhead Graben and is one several major faults bordering the Ruby Range that are associated with regional Cenozoic extension in southwest Montana (Ruppel, 1982, 1993; Sears and Fritz, 1998).The high-angle northwest-trending faults, including the Elk Gulch Fault, are part of a regional fault system that was active in the Precambrian, followed by renewed movement during uplift of the Ruby Range in the late Mesozoic and Cenozoic (Ruppel, 1982; James, 1990). Precambrian left-lateral displacement of hundreds of meters occurred prior to emplacement of the Middle Proterozoic, northwest-trending diabase dikes and was followed by younger reverse and normal fault movement (James, 1990).

Two minor, east-dipping faults were mapped in the Sixmile Creek Formation in the western part of the map. These faults, along with tilting of the Tertiary deposits (generally to the northeast in northern exposures and southwest in southern exposures), suggest a more complex structural history than is shown on the map and that is difficult to resolve due to generally poor exposures.

MAP UNITS

QUATERNARY DEPOSITS

Qal **Alluvium (Holocene)**—Unconsolidated gravel, sand, silt, clay, and cobbles deposited primarily by the Beaverhead River and Blacktail Deer Creek. Cobbles predominantly subrounded to well-rounded quartzite. Thickness as much as 10 m (33 ft).

Qac **Alluvium and colluvium (Holocene and Pleistocene?)**—Unconsolidated sand, silt, clay, and subordinate gravel, deposited on gentle slopes and along small drainages by intermittent streams and sheetwash. Variable thickness, generally less than 10 m (33 ft).

Qaf **Alluvial-fan deposit (Holocene and Pleistocene?)**—Unconsolidated, poorly sorted, cobbles, gravel, sand, and silt forming fan-shaped deposits along Blacktail Deer Creek. Thickness probably less than 15 m (50 ft).

Qafo **Alluvial-fan deposit, older (Holocene and Pleistocene?)**—Poorly sorted gravel, sand, and silt with angular to well-rounded cobbles that are predominantly Archean crystalline rock and Mesoproterozoic through Cenozoic sedimentary and volcanic rock. Occurs primarily along northwest-facing, gently sloping surfaces in north part of map, interpreted as alluvial fan deposits, older than map unit Qaf. Thickness up to 10 m (30 ft).

Qalo **Alluvium, older (Holocene and Pleistocene?)**—Unconsolidated, stratified to unstratified gravel, sand, silt, and clay deposited along Beaverhead River and Blacktail Deer Creek prior to deposition of Qal. Adjacent to but at elevations higher than Qal. Estimated thickness up to 30 m (100 ft).

TERTIARY DEPOSITS

Tsc **Sixmile Creek Formation (Miocene to Pliocene?)**—Pale orange to gray, unconsolidated to consolidated, tuffaceous to quartz-rich, silt, sand, gravel, breccia, conglomerate, and volcanic ash and tuff. Lithologies are interbedded but show a clear westward-fining trend. The coarsest deposits are breccia and conglomerate beds that are typically trough cross-bedded, poorly sorted, with angular to subrounded pebbles, cobbles, and boulders in a coarse, sandy matrix; in exposures near the western Ruby Range front, clasts are locally derived, with angular Archean igneous and metamorphic clasts and Eocene volcanic clasts; in more western exposures, clasts are overall smaller (pebbles and cobbles), more rounded, and polymictic with predominantly quartzite clasts. The finer-grained deposits dominate exposures in the central part of the map and include very thin- to thick-bedded, massive to cross-stratified silt, sand, and gravel with lenses and beds of conglomerate, along with intervals of gray volcanic ash and very pale orange to tan, massive tuffs. The ash generally forms tabular, brown-weathered beds less than 0.6 m (2 ft) thick with fresh glass shards. The tuff intervals are thick-bedded, massive, and contain scattered pumice and ripped-up tuff clasts. Tuff intervals are at least 30 m (100 ft) thick where best exposed (sections 34 and 35, T. 7 S., R. 8 W.). U-Pb zircon age dates for samples KM20DE02 and KM20DE06, collected from an ash and tuff, respectively, yielded grains as young as 10.1 ± 0.4 Ma to 14.9 ± 0.3 Ma. In some places, poorly sorted beds with burrows, nodules, and caliche-cemented intervals containing abundant rhizoliths are interpreted as paleosols. Base not exposed, but up to 305 m (1,000 ft) thick west of the Ruby Range western border fault and much thinner east of the fault, where Sixmile Creek unconformably overlies crystalline basement rocks.

Tre **Renova Formation, undivided (early Miocene to late Eocene)**—Poorly sorted, light yellowish-brown to light gray, immature, tuffaceous sandstone, siltstone, and shale. Dominantly thick, irregular beds with matrix-supported granules, pebbles, and sparse cobbles. Locally contains burrows or root casts, bone fragments, and pumice clasts. Forms low, rounded bluffs. Shale is very poorly exposed and weathers into thin, laminated pieces. The youngest grain from a detrital zircon sample (KM20DE08) yielded a preliminary age of 22.1 ± 1.0 Ma. Exposed thickness up to 30 m (100 ft).

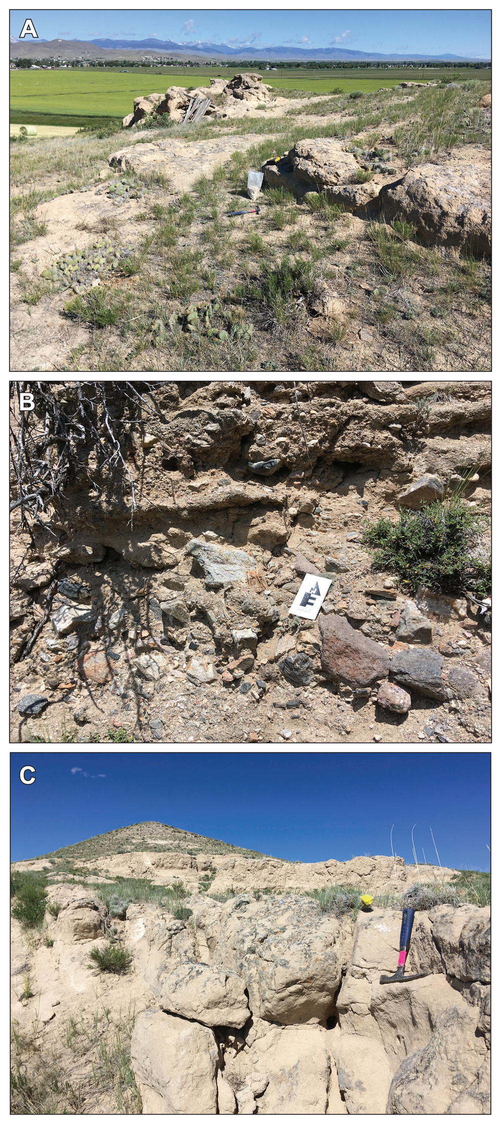


Figure 2. Photographs of typical lithologies of the Renova and Sixmile Creek Formations. (A) Lithified tuffaceous sandstones within the Renova Formation, (B) cemented conglomerate beds correlated with the Sweetwater Creek Member of Sixmile Creek Formation consisting of locally derived, mostly angular Archean basement clasts, and (C) massive tuffaceous beds in the Anderson Ranch Member of the Sixmile Creek Formation.

Tba **Basalt flow (Pliocene?)**—Dark gray to black, porphyritic basalt that forms iron-stained weathered outcrop; overlies crystalline basement rock. Mapped using orthoimagery (NAIP, 2009) and data from the south adjacent Ashbough Canyon 7.5′ geologic map (Crawford and Pearson, 2018). James (1990) describes similar basalts elsewhere in the southern Ruby Range.

PRECAMBRIAN BEDROCK

Ydia **Diabase (Middle Proterozoic)**—Black to reddish brown, medium-grained diabase with augite, plagioclase, minor quartz, and accessory magnetite and ilmenite; occurs as poorly exposed dike whose trend can be recognized in topographic sags and by the presence of speroidally weathered boulders. The diabase dikes in the Ruby Range generally transect the northeasterly trend of the crystalline basement rock, are unmetamorphosed, and related to the northwest-trending fault system (James, 1990). Outcrop widths are as much as 150 m (500 ft) but most are less than 30 m (100 ft). Whole-rock Rb-Sr ages of 1,455 Ma and 1,100 Ma are reported for the diabase dikes in the southern Ruby Range (Wooden, 1975; Wooden and others, 1978).

Agn **Gneiss (Late Archean or Early Proterozoic)**—Gray to brown, medium-grained, moderately well-foliated, locally mylonitic, gneiss of granitic composition. Occurs as sheet-like outcrops developed in or engulfing quartzite-bearing strata along the range-front of the southern Ruby Range (James, 1990). Can be difficult to distinguish from older quartzofeldspathic gneiss ("Dillon Granite Gneiss" of Heinrich, 1960) exposed to the south and west of the map area (James, 1990).

Aam **Amphibolite (Late Archean or Early Proterozoic)**—Black, medium- to coarse-grained, massive to well-foliated amphibolite composed of mostly hornblende and plagioclase; some garnetiferous; forms thin layers/dikes and lenses and sheet-like outcrops. As much as 915 m (3,000 ft) in width (James, 1990).

Christensen Ranch Metamorphic Suite (CRMS)

Acq **Quartzite (Late Archean or Early Proterozoic)**—White to yellow brown, fine- to medium-grained, vitreous to sugary quartzite with around 90 percent quartz and minor feldspar, muscovite, and chloritized biotite (James, 1990). Occurs throughout the CRMS in layers that range from a few centimeters thick to resistant beds as much as 30 m (100 ft) thick. Where surrounded by dolomite, can occur as thick lenses and boudins formed by deformation of unknown age.

Acu **Undifferentiated metasedimentary rocks (Late Archean or Early Proterozoic)**—Complex interbedded unit of the more prominent lithologies of the CRMS. Includes poorly exposed, well-foliated quartz–mica schist and quartzose gneiss, including sillimanitic, garentiferous, and corundum-bearing varieties; resistant calc–silicate gneiss and schist ranging from greenish gray diopside gneiss to fissile, brown weathered, green or gray schist; minor anthophyllite schist forming small isolated outcrops of strongly foliated, light brown to reddish brown anthopholite; and small bodies of amphibolite and granitic gneiss.

Acm **Marble (Late Archean or Early Proterozoic)**—White, gray or buff, fine- to medium-grained, locally very coarse-grained, calcitic and dolomitic marble. Typically contains small to moderate amounts of light-colored diopside, less abundant tremolite, and scarce graphite flakes (James, 1990). Outcrops are massive to well-bedded, with characteristic bright-orange lichen on exposed surfaces. Occurs as steeply dipping belts as much as 670 m (2,200 ft) in outcrop width. Host rock for several economic talc deposits in the western part of Ruby Range.

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Montana Bureau of Mines and Geology

Geologic Map 89

Geologic Map of the Dillon East 7.5′ Quadrangle, Beaverhead County, Montana

Mapped and compiled by
Catherine McDonald

2022

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