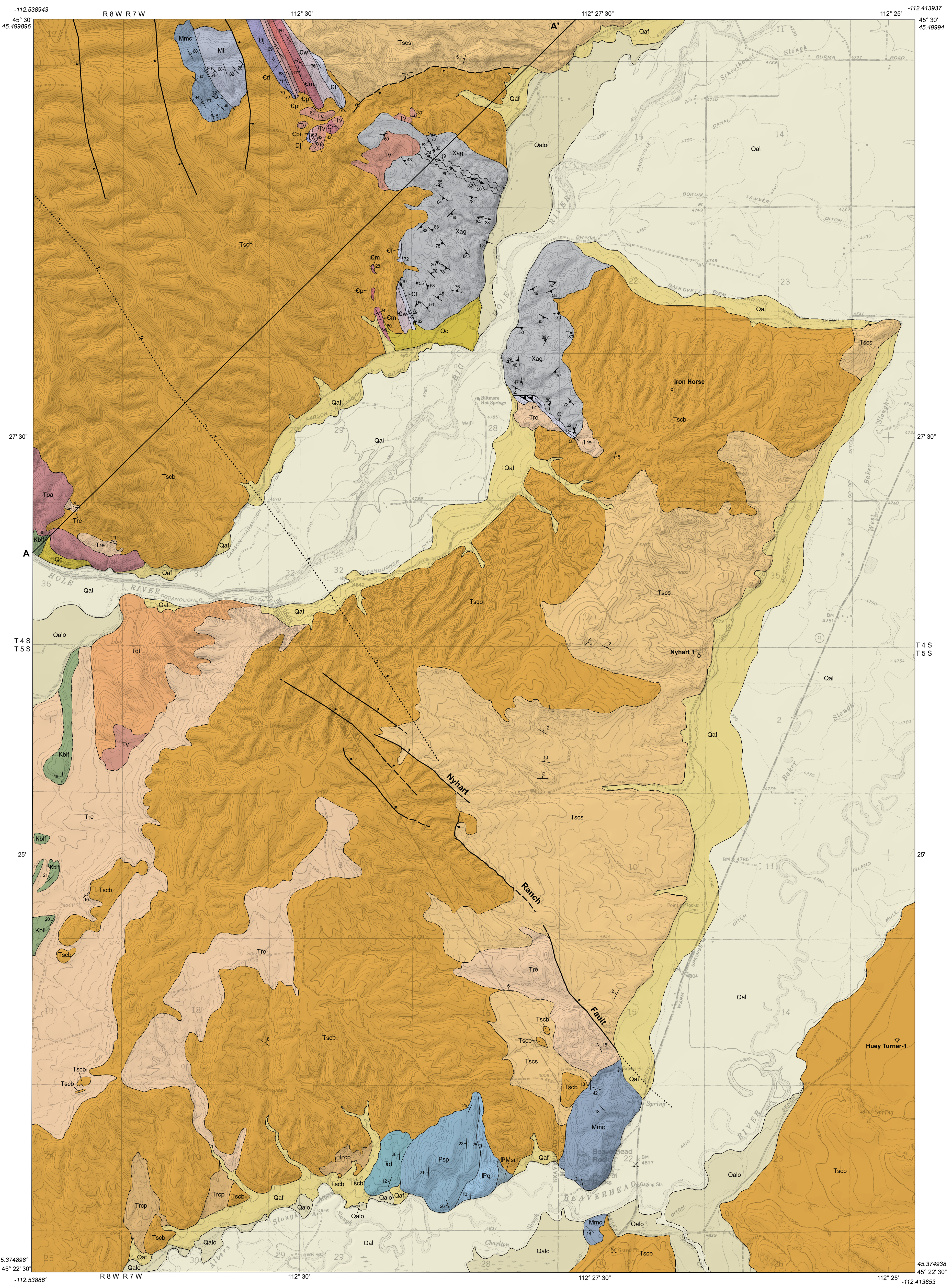


Block Mountain 1:24,000-scale quadrangle map
Base map produced by the United States Geological Survey
Control by: USGS and USC&GS
Topography by photogrammetric methods from aerial photographs taken 1959. Field checked 1960
Projection: polyconic
Grid:1000-meter Universal Transverse Mercator Zone 12
Vertical 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.

Beaverhead Rock 1:24,000-scale quadrangle map
Base map produced by the United States Geological Survey
Control by: USGS and USC&GS
Topography by photogrammetric methods 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

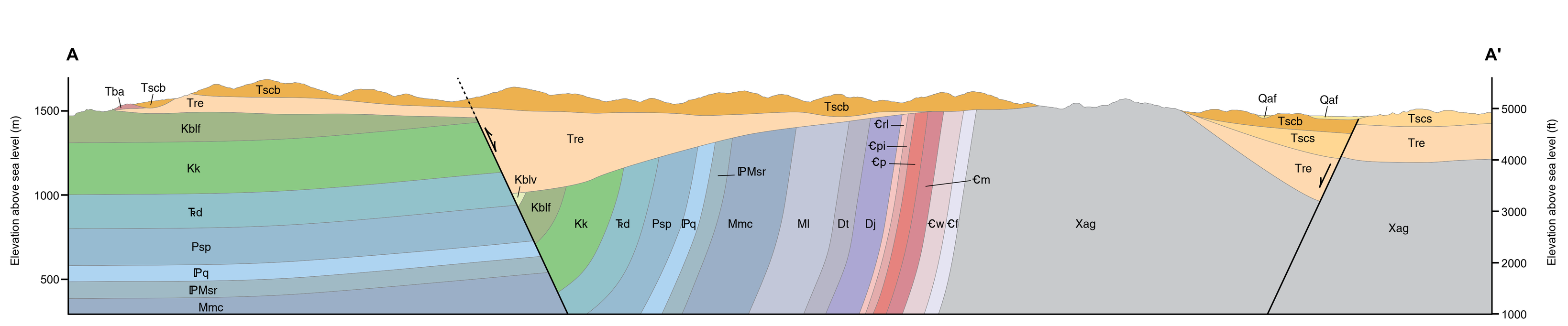
Shaded relief created from 10-meter digital elevation model from U.S. Geological Survey National Elevation Dataset.

UTM GRID AND 2017 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24,000

CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

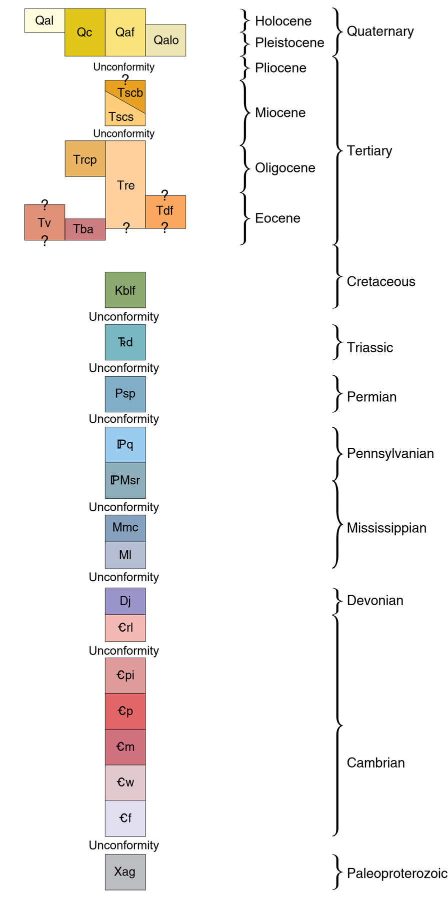
Maps may be obtained from:
Publications Office
Montana Bureau of Mines and Geology
1300 West Park Street
Butte, Montana 59701-8997
Phone: (406) 496-4174
http://mbmg.mtech.edu



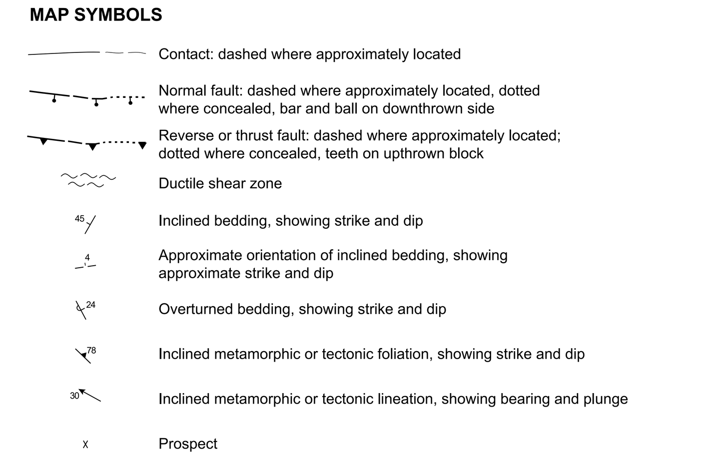
Units not exposed in map area, but shown in cross-section:
- Kblv Blackleaf Fm., Vaughn Member
- Kk Kootenai Fm.
- Dt Three Forks Fm.
- Reactivated fault (see text for discussion).

Partial support has been provided by the STATEMAP component of the National Cooperative Geologic Mapping Program of the U.S. Geological Survey under Contract Number G19AS00006.
GIS production: Yiwen Li and Paul Thale, MBMG. Map layout: Susan Smith, MBMG. Editing: Susan Barth, MBMG.

CORRELATION DIAGRAM



MAP SYMBOLS



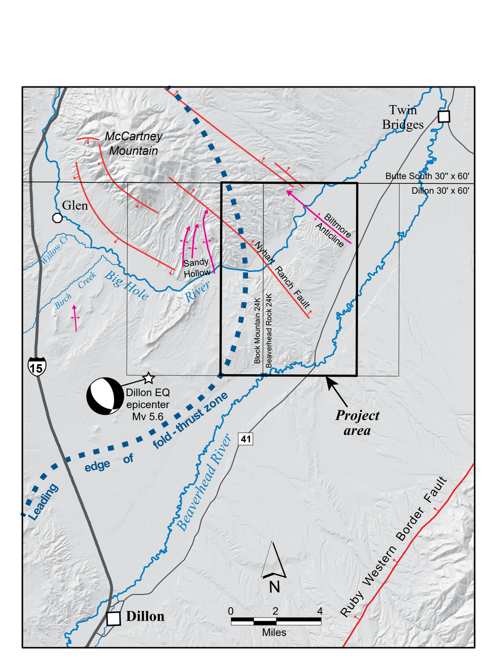
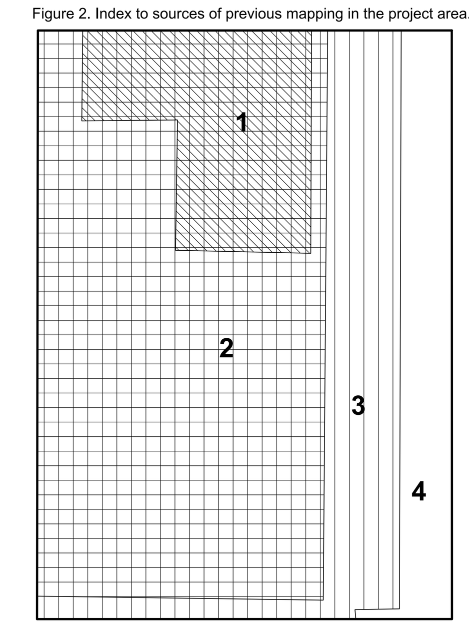


Figure 1. Simplified tectonic map of the area around the project quadrangles. Prominent folds shown as pink arrows. Potential Quaternary normal faults shown as red lines.

Figure 2. Index to sources of previous mapping in the project area.



1. Schmidt, C.J., Genovese, P.W., and Chase, R.B., 1993 (1:46,000)
2. Schmidt, C.J., O'Neill, J.M., and Brandon, W.C., 1988 (1:100,000)
3. Brandon, W.C., 1984 (1:63,360)
4. Hoffman, D.S., 1971 (1:48,000)

Table 1. Summary of depths and stratigraphic interpretations from Nyhart 1 petroleum well log. Lithology descriptions are directly from well log.

From (ft)	To (ft)	From (m)	To (m)	Formation	Description
0	21	0.0	6.4	Tsc	Sandy soil
21	110	6.4	33.5	Tsc	Sand and gravel
110	130	33.5	39.6	Tsc	Coarse gravel and boulders
130	400	39.6	121.9	Tsc/Tre	Clay with hard streaks of conglomerate
400	450	121.9	137.2	Tsc/Tre	Sand and gravel
450	850	137.2	259.1	Tre	Bentonite clay with layers of conglomerate
850	1,100	259.1	335.3	Tre	Sticky clay with lime or calcium stratas at intervals
1,100	1,350	335.3	411.5	Tre	Sticky clay with bentonite stratas
1,350	1,625	411.5	495.3	Tre	Sandy clay
1,625	2,088	495.3	636.4	Tre	Hard conglomerate with quartz boulders
2,088	2,175	636.4	662.9	Tre	Soft gray clay
2,175	2,240	662.9	682.7	Kk (middle)	Shale
2,240	2,322	682.7	707.7	Kk (middle)	Shale and sandy shale
2,322	2,545	707.7	775.7	Kk (middle)	Blue shale, sticky
2,545	2,570	775.7	783.3	Kk (middle)	Lime shell and red shale
2,570	2,608	783.3	794.9	Kk (middle)	Shale and lime
2,608	2,633	794.9	802.5	Kk (lower)	Chert

Note: Kk, Kootenai Formation (shown only in cross section).

INTRODUCTION

The Montana Bureau of Mines and Geology (MBMG), in conjunction with the STATEMAP advisory committee, selected the Beaverhead Rock area, comprised of the east 1/3 of the Block Mountain 7.5′ quadrangle and the west 2/3 of the Beaverhead Rock 7.5′ quadrangle, for detailed mapping as part of the MBMG's on-going effort to complete the Dillon 30' x 60' (1:100,000 scale) geologic map. The Beaverhead area is located north of Dillon, Montana, and includes Tertiary deposits on the eastern flank of McCartney Mountain (fig. 1). A key goal of the mapping was to identify potential Quaternary normal faults for inclusion in the USGS Quaternary Fault and Fold database. An additional goal was to extend Tertiary stratigraphy into the quadrangle using new interpretations developed by the MBMG in the process of drafting the Butte North and Butte South 30′ x 60′ quadrangles to the north (Scarberry and others, 2019; McDonald and others, 2012) and the Glen 7.5′ quadrangle to the west (Yakovlev, 2019).

PREVIOUS MAPPING

The map area includes the less extensively mapped portions of the Block Mountain and Beaverhead Rock 7.5′ quadrangles. Previous mapping includes small-scale mapping by Ruppel and others (1993, scale 1:250,000). The Block Mountain quadrangle was mapped by Hoffman (1971, scale 1:48,000), is partially covered by a FY2017 EDMAP project (Dolan and others, unpublished, scale 1:24,000), as well as smaller unpublished field maps completed during instruction of geology field courses at the University of Montana Western (Thomas, R., oral commun.). Existing maps focus on deformed Pennsylvanian through Cretaceous strata in the western 2/3 of the Block Mountain quadrangle, and do not adequately describe Tertiary deposits in the eastern 1/3. The Beaverhead Rock quadrangle was partially mapped by Hoffman (1971, scale 1:48,000) and Petkewitch (1972, scale 1:42,240), and is dominated by Quaternary deposits of the Beaverhead River in its eastern 1/3. The extent of previous mapping is shown on figure 2.

GEOLOGIC SUMMARY

The Beaverhead Rock area is dominated by Miocene to Pliocene deposits of the Sixmile Creek Formation. Cambrian through Cretaceous strata primarily crop out as monadnocks (inselbergs) above Tertiary deposits. These older strata are better exposed in the western 1/3 of the Block Mountain quadrangle, and the Ruby Range to the southeast.

The oldest rocks exposed in the quadrangle are Paleoproterozoic amphibolites to biotite–quartzofeldspathic orthogniess. These basement rocks outcrop near the Big Hole River in the northern third of the map area. Discordant U-Pb zircon ages from a biotite–quartzofeldspathic orthogneiss indicate a crystallization age of 1.89 ± 0.02 Ga (Foster and others, 2006). Foster and others (2006) use this and other 2.4–1.8 Ga crystallization ages in the region to define the Selway Terrane, a region of arc-like crust accreted to the western edge of the > 2.5 Ga Wyoming Craton in late Paleoproterozoic time.

Basement rocks are unconformably overlain by the Cambrian Flathead Formation. Cambrian rocks younger than the Flathead are in turn overlain by the Devonian Jefferson Formation and the Mississippian Lodgepole through the Early Triassic Dinwoody Formations. The Late Jurassic Morrison Formation is not exposed in the map area. Rocks of Middle Triassic through early Late Jurassic age are not present in southwest Montana. Their absence reflects a shift in the tectonic setting of western North America from a continental shelf to an actively subsiding foreland basin (Gibson, 2007). Cretaceous strata of the Kootenai, Blackleaf, and Frontier Formations are well exposed in nearby quadrangles, but only the Blackleaf is exposed in the map area. The Kootenai Formation (shown only in the cross section) is broadly associated with terrestrial deposition, while the overlying Blackleaf and Frontier Formations mark a return to marine sedimentation.

Exposed Tertiary sediments in the map area date from late Eocene to Pliocene time. The stratigraphically lowest exposed unit is the upper Eocene Bone Basin Member of the Renova Formation. Multiple paleontologic investigations in this area have yielded an upper Eocene (Chadronian) fossil assemblage and depositional age of this unit (Riel, 1961; Hoffman, 1971; McHugh, 2003). Overlying fluvial and debris flow deposits of the Cabbage Patch Member of the Renova Formation are coeval with an early phase of Oligocene to early Miocene extension (e.g., Sears and Fritz, 1998). The Renova Formation is overlain by the Sixmile Creek Formation, which includes both proximally sourced debris flow deposits of the Sweetwater Creek Member and distal fluvial deposits of the Big Hole Member. The tuffaceous Anderson Ranch Member of the Sixmile Creek Formation is missing in the Beaverhead Rock area. Deposition of the Sixmile Creek Formation is coeval with the initiation of rapid Basin and Range style extension beginning in Miocene time (e.g., Sears and Fritz, 1998).

Subsurface data from an abandoned petroleum well (Nyhart 1 on map) indicates the Tertiary deposits are at least 663 m (2,175 ft) thick. Depths and lithologic descriptions from the well log are summarized in table 1, along with two interpretations of where the contact between the Renova Formation (map unit Tre) and the overlying Sixmile Creek Formation (unit Tsc) may occur. Based on the two interpretations, the contact in the subsurface appears to lie between 40 and 137 m (130 and 450 ft) deep.

The youngest mapped units are Quaternary deposits associated with modern or abandoned stream beds and flood plains, colluvium, and modern alluvial fans. The largest area of Quaternary fluvial deposits is associated with the Beaverhead River. Additional alluvium was deposited by the Big Hole River and by ephemeral streams in minor drainages.

STRUCTURE

The Beaverhead Rock area lies within the leading edge of the McCartney Mountain Salient fold-thrust belt (fig. 1). Shortening and thickening within the fold-thrust belt is evidenced by folding and faulting that is broadly synchronous with Late Cretaceous igneous activity (Kalakay and others, 2001). Cretaceous deformation exhumed Paleozoic through Mesozoic sedimentary rocks and Proterozoic basement rocks, which may record earlier phases of deformation (Foster and others, 2006; Schmidt and others, 1988). Tertiary Basin and Range style extension likely initiated in Miocene time and produced normal faults that both reactivated and crosscut older compressional structures (e.g., Schmidt and others, 1988; Pardee, 1950; Ruppel, 1982).

Basin and Range style extension in the Beaverhead Rock area continues into modern time, and generates earthquakes as part of the Intermountain Seismic Belt (Stickney, 2007). The 2005 Mw 5.6 Dillon earthquake occurred 4 km (2 mi) southwest of the Beaverhead Rock area at a depth of 10.5 km (6.5 mi; fig. 1). Moment tensor solutions indicated oblique normal faulting with an ENE–WSW-directed extension direction. Aftershocks suggested a north-trending, east-dipping fault at depth (Stickney, 2007). In the Beaverhead Rock area, surface morphologies are consistent with active faulting on a northwest–southeast-trending fault—herein referred to as the Nyhart Ranch fault.

Basement exposures in the Beaverhead Rock area include a prominent shear zone that trends ~289° and has a sinistral sense of motion. The orientation of this shear zone is oblique to the generally north- to northwest-striking faults associated with Sevier–Laramide deformation of Paleozoic strata in the Sandy Hollow area to the west. Parallel structural trends are present ~13 km to the north, within Archean rocks located in the Butte South 30′ x 60′ quadrangle (McDonald and others, 2012). I infer that this ductile shear zone predated the north- to northwest-trending brittle faults associated with Sevier–Laramide deformation. To the southwest of this shear zone, the strike of foliations in the basement rocks makes a prominent clockwise turn from northwest–southeast to north–south and become subparallel to bedding of Cretaceous rocks. However, to the east of the Big Hole River, foliations in basement rocks are highly scattered and orthogonal to bedding of Cretaceous strata, suggesting that basement structures predate the Sevier–Laramide Orogeny and are more complex than can be mapped at a 1:24,000 scale.

The contact between basement rocks and overlying strata is correlated with a strong contrast in seismic wave velocities by Lopez and Schmidt (1985). Lopez and Schmidt (1985) interpret a seismic profile across the map area as showing a broad basement uplift they refer to as the Biltmore Anticline (fig. 1). Schmidt and others (1993) suggest that foliations in basement rocks are parallel to the axial surface of the anticline, implying that foliations developed during Sevier–Laramide deformation. However, the scattered foliations orientations of basement rocks east of the Big Hole River, and ductile deformation in an observed foliation-parallel shear zone, preclude this interpretation. Geologic cross-sections based on Schmidt and others (1988) interpretations of seismic reflection data show the Biltmore Anticline as a southwest-verging structure, with associated northeast-dipping faults in the subsurface. Schmidt and others (1988) interpret that the Biltmore Anticline has subsequently been dissected and rotated by extensional faults, some of which cut Tertiary strata and are exposed at the surface.

Previous mapping (Schmidt and others, 1988; Brandon, 1984) places a northeast-dipping normal fault (Nyhart Ranch fault on this map) to the west of the Biltmore Anticline. Structural orientations and known thicknesses of strata exposed in the Biltmore Anticline and in Sandy Hollow, as well as the seismic interpretations of Lopez and Schmidt (1985), indicate that the Nyhart Ranch fault was an east-dipping thrust fault during Sevier compression. Schmidt and others (1988) infer that this fault has subsequently been reactivated as a normal fault based on a normal sense offset of Mesozoic strata interpreted from the nearby seismic reflection profile. However, the inferred trace of the Nyhart Ranch fault does not appear to offset the Sixmile Creek Formation north of the Big Hole River, but offsets the Sixmile deposits south of the river. This suggests that extension on the Nyhart Ranch fault was first active after Sevier compression and was subsequently reactivated along part of its trace since deposition of the Sixmile Creek Formation.

Geomorphic analysis of the Nyhart Ranch fault suggests that it may be an active Quaternary fault. Just south of the Big Hole River, the fault is highly segmented and offsets the Sixmile Creek Formation 3–6 m (10–20 ft), while further to the southeast it has a single clearly defined fault strand that likely offsets strata by as much as 100 ft (30 m). In the southeastern portion of the map area, younger strata of the Big Hole Member of the Sixmile Creek Formation have been eroded, exposing older strata of the Sweetwater Creek Member at lower elevations in the hanging wall of the fault. As erosion is locally greater than fault offset, this leads to an apparent inversion of the expected stratigraphic relationship in map view. I infer that the Nyhart Ranch fault is currently propagating from the southeast, where it offsets the Sixmile Creek Formation, to northwest, where it does not. An alternative interpretation is that normal displacement on the fault dies out near the Big Hole River, and extension is localized elsewhere. The northwest trend of the Nyhart Ranch fault is consistent with northeast–southwest-directed extension observed in local seismicity, including the 2005 Mw 5.6 Dillon earthquake (Stickney, 2007), suggesting that it may pose a potential seismic hazard.

ECONOMIC GEOLOGY

The Beaverhead Rock area includes portions of the Nogo, Ruby Range, and McCartney Mountain mining districts (Albright, 2004), but has seen limited mining activity. An unnamed phosphate prospect is present in exposures of the Lodgepole Formation in the northern portion of the map area, but was not developed. Tertiary deposits in the Beaverhead Rock area have been targets for gravel pits, and a single bentonite clay pit near the Beaverhead River. The Iron Horse prospect is located within Tertiary deposits in the northern half of the map area, and is reported to have yielded trace iron (Montana Department of Environmental Quality Abandoned Mines Historical Narratives website: https://deq.mt.gov/cleanupandrec/Programs/aml, accessed 10/09/2018).

Oil exploration in the Beaverhead Rock area was carried out sporadically between the 1950's and early 1980's. According to the Montana Board of Oil and Gas Conservation website (http://www.bogc.dnrc.mt.gov/webapps/dataminer/Wells/Wells.aspx), four wildcat oil wells were drilled in and near the map area, all producing dry holes. The Huey Turner 1 well (Montana Board of Oil & Gas Conservation # 25057210020000) was drilled in 1973, in order to test the Madison Group at an estimated depth of 762 m (2,500 ft). However, drilling ended at 140 m (460 ft) and did not penetrate through the base of sands and gravels interpreted to be Tertiary in age. The Nyhart 1 well (Montana Board of Oil & Gas Conservation #25057070000000) was drilled in 1953 to a depth of 803 m (2,633 ft). Well logs include lithologic descriptions, but do not correlate lithologies with known stratigraphic units. The well was subsequently reentered in 1970 to collect samples between depths of 335 to 366 m (1,100 to 1,200 ft), but the attempt was unsuccessful and the well was abandoned. A seismic profile that crossed the southern part of the map area, and included information from the nearby petroleum wells, has been interpreted and published by Lopez and Schmidt (1985).

DESCRIPTION OF MAP UNITS

Qal **Alluvium (Holocene)**—Unconsolidated, poorly sorted deposits of gravel, sand, silt, and clay deposited by modern streams and rivers. Cobbles and boulders are generally angular in tributary streams in the western portion of the quadrangle, and well rounded in the Big Hole River in the northeastern portion of the quadrangle. Clasts are predominantly locally sourced bedrock, including shale, sandstone, limestone, quartzite, and granodiorite. Thickness as much as 12 m (40 ft), based on logs for household groundwater wells.

Qc **Colluvium (Holocene and Pleistocene?)**—Unconsolidated, locally derived slope deposits that contain angular, poorly sorted clasts, pebble size and larger. Thickness generally less than 10 m (33 ft).

Qaf **Alluvial fan deposits (Holocene and Pleistocene)**—Clay to cobble-sized, angular clasts forming broad conical deposits at outlets of mountain streams. Qaf deposits across the map area likely do not correlate with one another. Up to 10 m (33 ft) thick.

Qalo **Alluvium, older than Qal (Holocene and Pleistocene?)**—Unconsolidated, poorly sorted deposits of gravel, sand, silt, and clay deposited by streams in Holocene time. Likely represent ancient channels and flood plains of modern streams. Cobbles and boulders generally angular to rounded and are locally sourced from bedrock, including shale, sandstone, limestone, quartzite, and granodiorite. Thickness as much as 12 m (40 ft).

Tscb **Sixmile Creek Formation, Big Hole Member? (Pliocene and Miocene)**—Sand and gravel, tan to tan gray, well to moderately sorted, clast- to matrix-supported, coarse sand to boulder gravel with silty to sandy matrix. Clasts are subrounded to rounded. Contains tan weathering white, gray, tan, purple, and pink cobbles sourced from Belt Supergroup quartzites and the Flathead Formation. Contains subordinate clasts of granite, as well as sandstone, and shale from local Mesozoic to Paleozoic strata. Distinguished from other Tertiary sediments by the presence of abundant tan weathering subrounded cobbles. Likely correlates with the Big Hole River Member of the Sixmile Creek Formation as described by Fritz and Sears (2009) and Sears and others (2009). Exposures are up to 110 m (360 ft) high. Thickness up to more than 120 m (395 ft). Locally missing due to erosion or non-deposition.

Tscs **Sixmile Creek Formation, Sweetwater Creek Member? (Pliocene and Miocene)**—Tan to light gray, unlithified to weakly consolidated silt, sand, and gravel. Clasts are granule to pebble sized, angular to subangular, and are primarily derived from quartzite, shale, and sandstone with rare granodiorite and basalt. Locally contains clasts of amphibolite, reflecting local sourcing from basement rocks. Locally contains paleosols with calcic horizons up to 1 m (3 ft) thick. Distinguished from overlying Big Hole Member based on higher angularity of clasts, finer overall grain size, higher degree of weathering, and clasts being predominantly matrix rather than clast supported. Exposures are up to 50 m (164 ft) high. At least 60 m (200 ft) thick based on domestic ground water well logs in the nearby Glen quadrangle. May be a finer-grained facies of the Sweetwater Creek Member as described by Fritz and Sears (2009) and Sears and others (2009). Locally missing due to erosion or non-deposition.

Trcp **Renova Formation, Cabbage Patch Member? (early Miocene–Oligocene)**—Gray, gray tan, and white sand, clay, and bentonitic clay to micaceous tuff with rare matrix-supported granules. Commonly has distinctive "popcorn" weathering on exposed surfaces. May correlate with the Cabbage Patch Member of the Renova Formation. Thickness is at least 10 m (33 ft) based on exposures in the southern portion of the map area. Locally missing due to erosion or non-deposition.

Tre **Renova Formation, undivided (early Miocene–late Eocene)**—Tannish white to gray, fine-grained tuffaceous sand to tuff, locally containing muscovite, biotite- and/or feldspar grains. Locally includes calcic soil horizons (paleosols) and clast to matrix supported conglomerates with rounded pebbles of quartzite in a sandy matrix. Conglomeratic beds are moderately to well cemented with pebble- to cobble-sized, subrounded to rounded clasts. Lower part may correlate with the Bone Basin Member of the Renova Formation. Distinguished from overlying Sixmile Creek Formation by higher degree of induration, predominance of fine-grained beds, lighter color, and presence of micaceous beds. May be up to 541 m (1,775 ft) thick based on total thickness of Renova in the Nyhart 1 petroleum well.

Tdf **Debris flow deposit (Eocene?)**—Boulder and cobble lag deposit with boulders up to 3–4 m (10–13 ft) in diameter. Clasts are angular to sub-rounded, locally derived quartz arenite, quartzite conglomerate, porphyritic andesite, granodiorite, hornfels, gneiss, and petrified wood. Possibly interbedded with ashy gravels of the Renova Formation south of the Big Hole River. Differentiated from the Sixmile Creek and Renova Formations by its lack of well-rounded quartzite cobbles. Thickness approximately 30 m (100 ft).

Tv **Tertiary volcanic and volcanoclastic deposits (Eocene?)**—Massive to thin-bedded, white to pinkish white tuff with common volcanic glass, rare pumice fragments, and locally angular plagioclase crystals. Locally contains laminations and crossbedding, suggesting reworking of material after eruption. North of the Big Hole River, commonly altered to pink or brick red color and interbedded with shards, blocks, and flows of black to gray to red andesite and volcanic glass. Lavas are locally vesicular and contain 1–3 mm plagioclase phenocrysts. May be coeval with the Basalt of Block Mountain and related to the Eocene Dillon Volcanics. Exposures in the north half of the map area suggest a minimal thickness of 10 m (33 ft).

Tba **Basalt of Block Mountain (early Eocene)**—Black basalt, locally containing olivine phenocrysts and volcanic glass. Forms small mesas with prominent columnar jointing extending to flow margins. Locally contains red oxidized layers at flow margins, likely indicative of paleosol formation between eruptions. At Block Mountain, Chadwick (1981) obtained a whole-rock K-Ar age of 44.8 ± 1.6 Ma, while Fritz and others (2007) report a K-Ar age of 47.1 ± 0.6 Ma.

Kblf **Blackleaf Formation, Flood Member (Early Cretaceous)**—Pale brown to brownish gray, green, red, and gray fine- to medium-grained and locally coarse-grained to conglomeratic, quartz- and chert-rich lithic sandstone, shale, calcareous siltstone, siltstone, and conglomerate. Trough crossbedding common in sandstone (Tysdal and others, 1994; Dyman and Nichols, 1988). Thickness about 213 m (700 ft).

Ћd **Dinwoody Formation (Early Triassic)**—Interbedded shale, limestone, and calcareous sandstone characterized by platy, thinly laminated beds that weather a distinctive pale to light grayish brown. Upper part has massive calcareous, rippled sandstone beds as much as 1 m (3 ft) thick with shaley interbeds and massive, gray, pinkish gray weathering, limestone as much as 1 m (3 ft) thick. Phosphatic pelecypod Lingula and fish bone fossils are locally abundant. Lower part is predominantly olive drab, chippy-weathering, hard fissile shale with interbedded dark brown weathering, silty limestone beds 10 cm (4 in) or thinner. Thickness about 260–275 m (650 ft).

Psp **Shedhorn and Phosphoria Formations, undivided (Permian)**—Shedhorn Formation is grayish brown, fine-grained, thin- to thick-bedded quartz sandstone, and cherty sandstone with chert and quartz cement. Vertical and horizontal burrows are common. Phosphoria Formation is dark gray to black, carbonaceous and phosphatic mudstone with scarce phosphate beds, grayish and gray-brown cherty quartz sandstone, cherty or sandy dolomite, fine-grained dolomitic sandstone, and yellowish tan sandy siltstone with subordinate beds of vitreous quartz sandstone. Poorly exposed, typically covered by colluvium and talus of underlying Quadrant Formation. Thickness approximately 295 m (970 ft) in map area.

IPq **Quadrant Formation (Pennsylvanian)**—White to light yellowish brown, fine-grained, vitreous, quartz sandstone. Beds are mostly thick to massive, occasionally with faint cross-laminations. Thickness 60–100 m (196–330 ft).

IPMsr **Snowcrest Range Group (Pennsylvanian and Mississippian)**—Brandon (1983) mapped this unit as Amsden Formation but based on nearby mapping (McDonald and others, 2012) is herin reinterpreted as Snowcrest Range Group. Total thickness approximately 178 m (550 ft).
Conover Ranch Formation: Pale reddish brown to pale reddish purple, dark gray to blue-gray, thin-bedded calcareous mudstone and subordinate limestone to fossiliferous limestone, calcareous sandstone and siltstone, and limestone–pebble conglomerate. Mudstone with characteristic light tan, yellow, green, and maroon oval spots a few millimeters (⅛–¼ in) across.
Lombard Formation: Upper part is light olive gray, thin- to thick-bedded fossiliferous limestone with thin interbedded silty limestone, siltstone, and shale. Lower part is olive gray and medium red to pale reddish purple calcareous mudstone.
Kibbey Formation: Pale red, pale gray, and pale yellow, thin- to medium-bedded siltstone, sandstone, and mudstone. Interbedded limestone and evaporate solution breccia in middle part of formation.

Mmc **Mission Canyon Formation (Mississippian)**—Light gray, thick-bedded, fossiliferous, cliff-forming limestone with irregular chert bands, and local solution breccia zones in the upper part. Regionally up to 360 m (1,190 ft) thick (McDonald and others, 2012).

Ml **Lodgepole Formation (Mississippian)**—Gray, fossiliferous, thin-bedded, slope-forming limestone. Basal Cottonwood Canyon Member is a thick dark shale and siltstone. Regionally around 300 m (990 ft) thick (McDonald and others, 2012).

Dj **Jefferson Formation (Devonian)**—Light brown to gray petroliferous dolomite, thick to thin bedded. Locally laminated, shaly and/or has solution breccia. Thickness 184 m (604 ft).

Єrl **Red Lion Formation (Cambrian)**—Tan, purple, and purplish gray siltstone. Thin-bedded. Upper part is medium gray, fine to coarsely crystalline dolomite (Brandon, 1983). Thickness approximately 30 m (100 ft).

Єpi **Pilgrim Formation (Cambrian)**—Light gray, fine to medium crystalline medium- to thick-bedded dolomite to light gray to medium gray sandy dolomite (O'Neill and others, 1996). Locally vuggy, potentially due to dissolution. Thickness approximately 40 m (130 ft).

Єp **Park Formation (Cambrian)**—Pale olive or grayish green, finely micaceous fissile shale and minor thin-bedded, yellowish brown, medium-grained dolomite and yellowish gray, thin, platy, calcareous fine-grained sandstone, siltstone, and mudstone (O'Neill and others, 1996). Generally, forms topographic lows within the Cambrian section and does not outcrop. Thickness approximately 70 m (230 ft).

Єm **Meagher Formation (Cambrian)**—Dark to medium gray and tannish brown, fine- to medium-grained limestone, dolomitic limestone, and dolomite that is locally mottled yellowish gray, light gray, pink, or red (O'Neill and others, 1996). Locally contains thin beds of conglomerate with 1-cm clasts. Distinguished from Pilgrim Formation based on its darker gray coloration. Thickness approximately 90 m (295 ft).

Єw **Wolsey Formation (Cambrian)**—Olive green, grayish red, and reddish brown micaceous glauconitic siltstone and olive green, fissile micaceous shale; grayish red and yellowish gray argillaceous fine-grained platy sandstone; and medium gray, fine-grained limestone. Lower part contains iron-rich glauconitic sandstone and deep red pelletal hematite layers (O'Neill and others, 1996). Generally forms topographic lows within the Cambrian section and does not outcrop. Thickness approximately 120 m (394 ft).

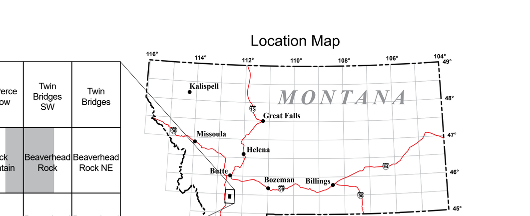
Єf **Flathead Formation (Cambrian)**—Red to tan to white, thin-bedded to massive, fine- to coarse-grained quartzitic sandstone and arkosic sandstone, locally conglomeratic. Locally contains interbeds of gray to purple to red shale. Thickness 40–100 m (136–233 ft).

Xag **Amphibolite Gneiss (Paleoproterozoic)**—Black to gray, muscovite–biotite–amphibolite gneiss. Locally contains foliation parallel sills of black amphibolite, and muscovite–biotite–garnet schist. Prevailing foliation is generally consistent across compositional boundaries. Foster and others (2006) estimate a crystallization age of 1.89 ± 0.02 Ga based on interpretation of a series of discordant U-Pb zircon ages.

REFERENCES

Albright, L.D., 2004, Historical Mining Districts of Montana, 1860–1972 (CD): Montana Bureau of Mines and Geology Open-File Report 466.
Brandon, W.C., 1984, An origin for the McCartney's Mountain salient of the southwestern Montana fold and thrust belt: Missoula, University of Montana, M.S. thesis, 128 p., plate 2, scale 1:63,360.
Chadwick, R.S., 1981, Chronology and structural setting of volcanism in southwestern and central Montana: Montana Geological Society 1981 Field Conference and Symposium Guidebook, Southwest Montana, p. 301–310.
Dolan, M., McCarthy, Y., and Hendrix, M.S., unpublished, Geologic map of southern McCartney Mountain, southwest Montana, 1 sheet, scale 1:24,000.
Dyman, T.S., and Nichols, D.J., 1988, Stratigraphy of mid-Cretaceous Blackleaf and lower part of the Frontier Formations in parts of Beaverhead and Madison Counties, Montana: U.S. Geological Survey Bulletin 1773, 31 p.
Foster, D.A., Mueller, P.A., Mogk, D.W., Wooden, J.L., and Vogl, J.J., 2006, Proterozoic evolution of the western margin of the Wyoming craton: Implications for the tectonic and magmatic evolution of the northern Rocky Mountains: Canadian Journal of Earth Sciences, v. 43, no. 10, p. 1601–1619.
Fritz, W.J., Sears, J.W., McDowell, R.J., and Wampler, J.M., 2007, Cenozoic volcanic rocks of southwestern Montana: Northwest Geology, 36, p. 91–110.
Gibson, R.I., 2007, Mesozoic sedimentation in southwest Montana: Northwest Geology, v. 36, p. 57–66.
Hoffman, D.S., 1971, Tertiary vertebrate paleontology and paleoecology of a portion of the Lower Beaverhead River Basin, Madison and Beaverhead Counties, Montana: Missoula, University of Montana, Ph.D. dissertation, 168 p., 1 plate, scale 1:48,000.
Kalakay, T.J., John, B.E., and Lageson, D.R., 2001, Fault-controlled pluton emplacement in the Sevier fold-and-thrust belt, SW Montana: Journal of Structural Geology, v. 23, p. 1151–1165.
Lopez, D. A., and Schmidt, C. J., 1985, Seismic profile across the leading edge of the fold and thrust belt in southwestern Montana, *in* Gries, R.R., and Dyer, R.C., eds., Seismic exploration of the Rocky Mountain region: Rocky Mountain Association of Geologists and Denver Geophysical Society, p. 45–50.
McDonald, C., Elliott, C.G., Vuke, S.M., Lonn, J.D., and Berg, R.B., 2012, Geologic map of the Butte South 30′ x 60′ quadrangle, southwestern Montana: Montana Bureau of Mines and Geology Open-File Report 622, 1 sheet, scale 1:100,000.
McHugh, J.B., 2003, Microfaunal sucession and stratigraphy of the Bone Basin Member (Renova Formation) at McCarty's Mountain and Mantle Ranch, southwest Montana: Pocatello, Idaho State University, M.S. thesis, 142 p.
Montana Department of Environmental Quality, Abandoned Mines Historical Narratives, available at http://deq.mt.gov/Land/AbandonedMines/linkdocs/ [Accessed 10/09/2018].
O'Neill, J.M., Klepper, M.R., Smedes, H.W., Hanneman, D.L., Fraser, G.D., and Mehnert, H.H., 1996, Geologic map and cross sections of the central and southern Highland Mountains, southwestern Montana, U. S. Geological Survey Miscellaneous Investigations Series Map I-2525, 1:50,000 scale.
Pardee, J.T., 1950, Late Cenozoic block faulting in western Montana: Geological Society of America Bulletin, v. 61, no. 4, p. 359.
Peters, J.F., 1971, Stratigraphy and structure of the Rock Creek area, Beaverhead County, Montana: Oregon State University, M.S. thesis, 112 p., 1 plate, scale 1:24,000.
Petkewich, R.M., 1972, Tertiary geology and paleontology of the Beaverhead East area, southwestern Montana: Missoula, University of Montana, Ph.D. dissertation, 365 p., 1 plate, scale 1:42,240.
Riel, S.J., 1961, A basal Oligocene local fauna from McCarty's Mountain, southwest Montana: Missoula, University of Montana, M.S. thesis, 74 p., 2 plates, scale 1:2,852 and 1:9,250.
Ruppel, E.T., 1982, Cenozoic block uplifts in east-central Idaho and southwest Montana: Geological Survey Professional Paper 1224, 24 p.
Ruppel, E.T., O'Neill, J.M., and Lopez, D.A., 1993, Geologic map of the Dillon 1º x 2º quadrangle, Idaho and Montana: U.S. Geological Survey Miscellaneous Investigations Series Map I-1803-H, scale 1:250,000.
Scarberry, K.C., Elliott, C.G., and Yakovlev, P.V., 2019, Geology of the Butte North 30′ x 60′ quadrangle, southwest Montana: Montana Bureau of Mines and Geology Open-File Report 715, 30 p., 1 sheet, scale 1:100,000.
Schmidt, C. J., O'Neill, J. M., and Brandon, W. C., 1988, Influence of Rocky Mountain foreland uplifts on the development of the frontal fold and thrust belt, southwestern Montana, *in* Schmidt, C. J., and Perry, W. J.,eds., Interactions of the Rocky Mountain foreland and the Cordilleran thrust belt: Geological Society of America Memoir 171, p. 171–201.
Schmidt, C. J., Genovese, P. W., and Chase, R. B., 1993, Role of basement fabric and cover-rock lithology on the geometry and kinematics of twelve folds in the Rocky Mountain foreland, *in* Schmidt, C.J., Chase, R.B., and Erslev, E.A., eds., Laramide basement deformation in the Rocky Mountain foreland of the western United States: Geological Society of America Special Paper 280, p. 1–44.
Sears, J.W., and Fritz, W.J., 1998, Cenozoic tilt domains in southwestern Montana: Interference among three generations of extensional fault systems, *in* Special Paper 323: Accommodation zones and transfer zones; the regional segmentation of the Basin and Range Province: Geological Society of America, p. 241–247.
Sears, J.W., Hendrix, M.S., Thomas, R.C., and Fritz, W.J., 2009, Stratigraphic record of the Yellowstone hotspot track, Neogene Sixmile Creek Formation grabens, southwest Montana: Journal of Volcanology and Geothermal Research, v. 188, p. 250–259.
Stickney, M.C., 2007, Historic earthquakes and seismicity in southwestern Montana: Northwest Geology, v. 37, p. 167–186.
Tysdal, R.G., Dyman, T.S., and Lewis, S.E., 1994, Geologic map of Cretaceous strata between Birch Creek and Brownes Creek, eastern flank of Pioneer Mountains, Beaverhead County, Montana: U.S. Geological Survey Miscellaneous Investigations Series Map I-2434, scale 1:24,000.
Yakovlev, P.V., 2019, Geologic map of the Glen 7.5′ quadrangle, southwestern Montana: Montana Bureau of Mines and Geology Geologic Map 74, 1 sheet, scale 1:24,000.

Location Map



MBMG
Montana Bureau of Mines and Geology

MBMG Geologic Map 88

Geologic Map of the Beaverhead Rock Area, East 1/3 Block Mountain through West 2/3 Beaverhead Rock 7.5′ Quadrangles, Southwest Montana

Mapped and compiled by
Petr V. Yakovlev

2022

https://doi.org/10.59691/ETWD7625