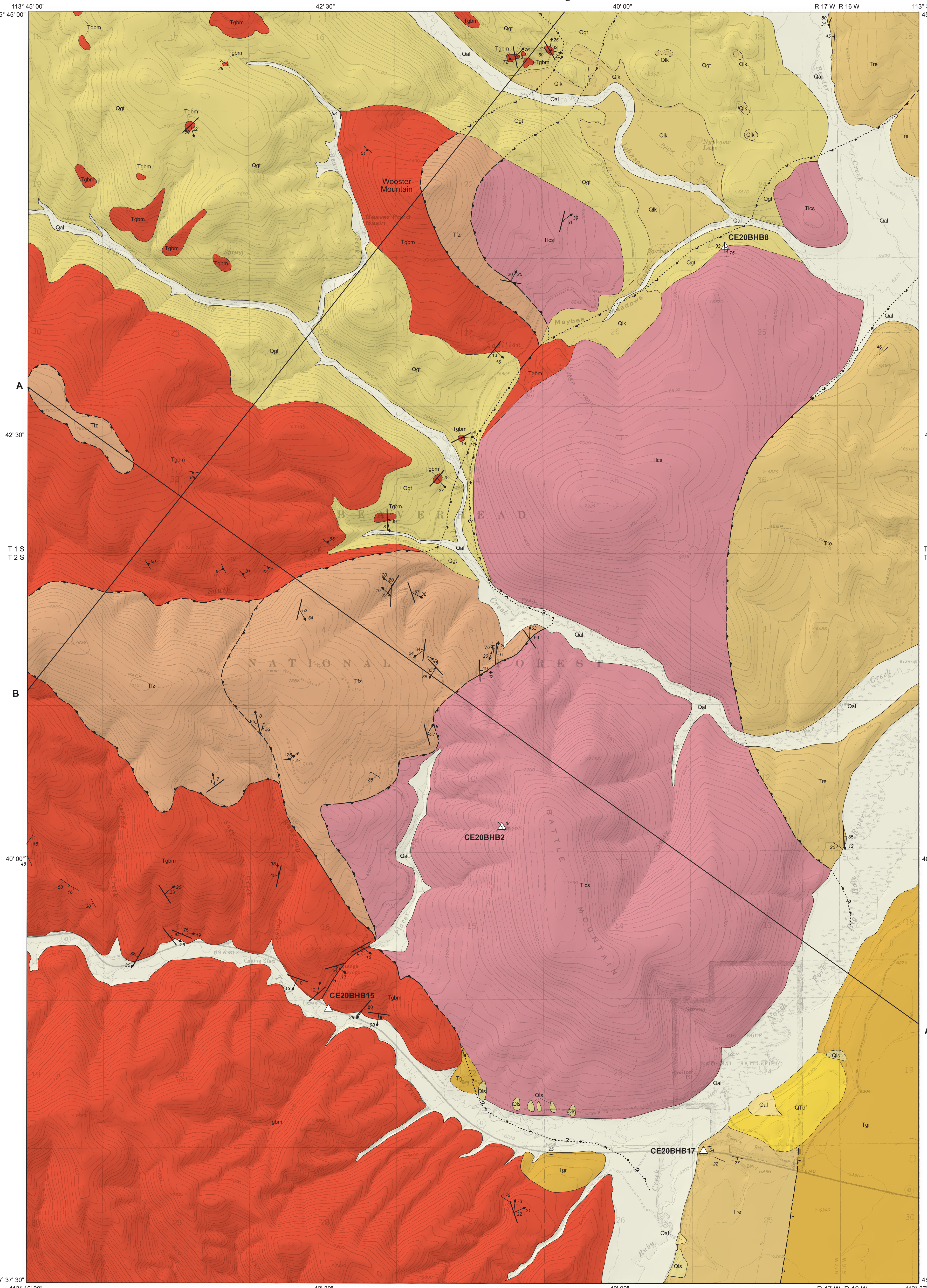


Big Hole Battlefield 1:24,000-scale quadrangle map
Base map produced by the United States Geological Survey
Control by: USGS and USC&GS
Compiled from aerial photographs taken 1965
Field checked: 1966
Projection: Polyconic
Grid:1000 meter Universal Transverse Mercator Zone 12
Vertical Datum: National Geodetic Vertical Datum of 1929
Horizontal Datum: 1927 North American Datum

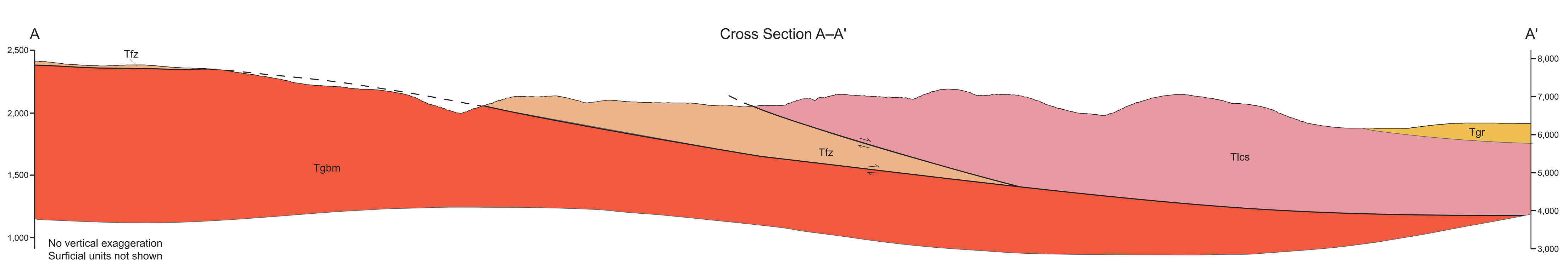
Shaded relief created from 10 meter digital elevation model from U.S. Geological Survey National Elevation Dataset.

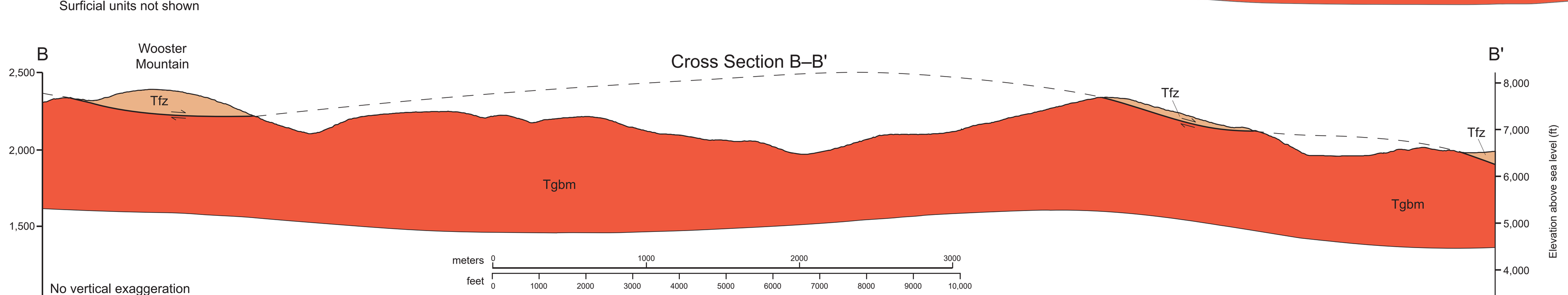
UTM GRID AND 2019 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24,000

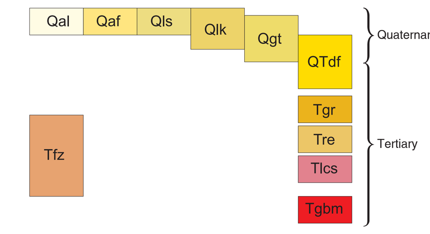
CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

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



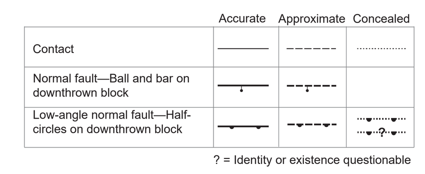


CORRELATION DIAGRAM



MAP SYMBOLS

Contacts and Faults



Inclined beds, showing strike and dip

Preferred orientation foliation, showing strike and dip

Gneissic layering, showing strike and dip

Inclined cleavage, showing strike and dip

Mylonitic foliation with stretching lineation, showing strike and dip

Fault plane, showing strike and dip with slickenlines, showing plunge and trend

Geochronology sample location

INTRODUCTION AND BACKGROUND

The Big Hole Battlefield 7.5′ quadrangle is in the northwest half of the Wisdom 30′ x 60′ quadrangle and connects areas of recent STATEMAP mapping in southwest Montana by the Montana Bureau of Mines and Geology (MBMG; fig. 1). This study continues detailed mapping along the Anaconda Detachment Zone (ADZ; fig. 1; Elliott and others, 2013; Elliott, 2015, 2017; Scarberry and others, 2019; Howlett and others, 2020; Elliott and Lonn, in review). The main goals of this investigation are to trace the ADZ and other structures along the Big Hole Valley, to trace known Cenozoic stratigraphy into an area where it had not been subdivided, and to identify phases of extension that created the Big Hole Valley intermontane basin.

The Big Hole Battlefield quadrangle is in the area of rolling hills connecting the Anaconda and Beaverhead ranges, which form the west and northwest margins of the Big Hole Valley (fig. 1). The quadrangle encompasses a small area of flat valley bottom in the southeast, but is mostly rolling glaciated uplands with a topographic relief of about 550 m (1,800 ft). The forested slopes north of Trail Creek have been burned by multiple wildfires during the past 20 y, and deadfall makes some areas impassible. This, and the general lack of outcrop, makes mapping challenging.

PREVIOUS MAPPING

The Big Hole Battlefield 7.5′ quadrangle is included in the Dillon 1° x 2° quadrangle (Ruppel and others, 1993, 1:250,000-scale). Lopez and others (2005, 1:48,000), and Desmarais (1983, 1:50,000) mapped adjoining areas.

GEOLOGIC SUMMARY

Cenozoic Rocks

The deposits of Battle Mountain were mapped as Tertiary Bozeman Group sediments (“Tbz”) by Ruppel and others (1993). However, the presence of rhyolite within the sequence and a new igneous U-Pb zircon age of 51.4 ± 1 Ma (CE20BHB2, table 1; Mosolf and Kylander-Clark, 2023) indicates that the mixed sedimentary and volcanic rocks forming the bulk of the Big Hole Battlefield quadrangle are part of the Lowland Creek volcanic field. The Lowland Creek volcanic field is an 80-km-long (50 mi) belt of flows, tuffs, and plugs dated between 48 and 53 Ma (Dudás and others, 2010; Scarberry and others, 2019). The Tlcs in the Big Hole Battlefield quadrangle is characteristic of the edges of the suite where thin volcanic lenses are interlayered with thick sedimentary layers.

The younger, non-volcanic sediments exposed in the eastern parts of the quadrangle closely resemble the Renova (Tre) and Sixmile Creek (Tsc) Formations of the Bozeman Group, which have been identified and dated in adjacent parts of the Big Hole Valley by Roe (2010), Elliott (2015, 2017, 2022), Howlett and others (2020), and Elliott and Lonn (2021).

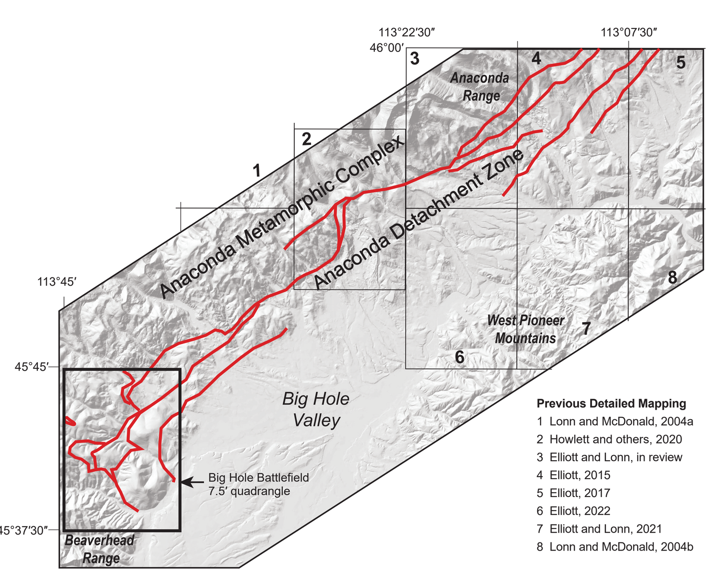


Figure 1. Location and tectonic setting of the Big Hole Battlefield 7.5′ quadrangle. The red lines are faults.

Structure

The dominant structure in the region is the ADZ, a zone of detachment faults and cataclasite that extends about 120 km (75 mi) in a sinuous line east and north from Big Hole Battlefield, and appears to die out near the southern edge of the map area. Locally, the footwall of the ADZ is a body of biotite–muscovite granite and granodiorite (Tgbm) called the Trail Creek Pluton of the Chief Joseph Plutonic Metamorphic Complex (Desmarais, 1983). Tgbm is dated within the quadrangle at 63.3 ± 0.6 Ma (CE20BHB15, table 1; Mosolf and Kylander-Clark, 2023).

Within the Big Hole Battlefield quadrangle ADZ faults form dip slopes covered with cataclasite (fig. 2) and mylonite (fig. 3; map unit Tfz). Unlike the ADZ to the northeast, detachment faults within the Big Hole Battlefield quadrangle dip shallowly east–southeast, based on fault traces and direct measurements, but slip lineations show no statistical preferred orientation (figs. 4A, 4C). In the northern end of the map area an early detachment with north-northeast-trending slip lineations turns northwest, perpendicular to the general trace of the ADZ. The northwest segment separates Tgbm from Tertiary sediments in the north-adjacent Bender Point quadrangle and forms a slickensided dip-slope coated with hydrothermal chalcedony (figs. 4B, 5) on the north side of Johnson Creek. The chalcedony itself is not slickensided, suggesting the fault was active before silicification occurred. This adds another small piece of evidence that northeasterly extension occurred earlier than east and southeast extension on the ADZ (Elliott, 2019).

Economic Geology

Placer Creek is named for the gold dredge deposits that remain along the banks of the creek. Small gold prospects and placer workings are scattered across the quadrangle, but very little gold was ever produced (Lyden, 1948).

There is a previously undescribed barite showing in the northeastern corner of the map that appears to have been uncovered by Forest Service road construction. The 2-m-wide (79 in) wide barite zone (fig. 6) has veins up to 50 cm (19 in) wide and crystals up to 30 cm (12 in) across. The barite is white to colorless. In a talus pile below the Forest Service road (FS8205), approximately 2 m^3 (2 yd^3) was quarried from a single, vertical vein that is 50–60 cm (19–24 in) wide and contains crystals up to 20 cm (8 in) across. The host rock is limonite-stained, fine- to coarse-grained volcaniclastic sandstone and siltstone (Tlcs) that contains granite clasts and large muscovite flakes. Fresh surfaces are chalky white, with only about 1 percent dark minerals. A sample of the barite vein host rock yielded a U-Pb zircon maximum depositional age of 64.5 ± 1.2 Ma (CE20BHB8, table 1; Mosolf and Kylander-Clark, 2023). This age is old for the Lowland Creek volcanic field (Dudás and others, 2010; Scarberry and others, 2019), suggesting that the dated zircons were derived solely from local granite bedrock (Tgbm) that unconformably underlies Tlcs to the southeast of the sample location.

DESCRIPTION OF MAP UNITS

Qal **Alluvium (Holocene)**—Modern stream and floodplain deposits. Thickness as much as 40 m (130 ft).

Qaf **Alluvial fan deposits (Holocene–Pleistocene)**—Angular to subrounded, unsorted, cobble to boulder gravel fans. Thickness probably less than 10 m (33 ft).

Qls **Landslide deposits (Holocene–Pleistocene)**—Unstratified, unsorted mixtures of sediment deposited by mass wasting. Color, composition, and grain size reflect the parent rock and transported surficial material. Thickness probably less than 60 m (200 ft).

Qlk **Lacustrine deposit (Holocene–Pleistocene)**—Mud and silt deposits deposited in standing water. Qlk fills basins within Qgt, and may be glacial and/or post-glacial. 1–4 m (3–13 ft) thick.

Qgt **Glacial till (Pleistocene)**—Unsorted clay to boulder deposits in lateral, ground, and medial moraines. Characterized by hummocky terrain scattered with large subangular to subrounded granite boulders. Thickness may be as much as 120 m (400 ft).

QTdf **Debris flow (younger than Miocene?)**—Subangular to subrounded, poorly sorted, boulder–cobble gravel, sand, silt and clay in mass movement deposit in southeastern corner of quadrangle. Clasts include both massive and mylonitic Tgbm, Tlcs, white quartz, black schist, and quartzite. Does not include any identifiable Quaternary sediments. Clasts vary between angular and very well-rounded. Thickness unknown, but probably less than 10 m (33 ft).

Tgr **Gravel (Miocene?)**—Gravel of sub-angular to very-well-rounded pebble- to boulder-sized quartzite, mica schist, granite, and rhyolite. Many broken clasts. Poorly exposed as float. May be equivalent to Miocene Sixmile Creek Formation gravel and conglomerate based on fossil ages on the east side of the Big Hole Valley (Hanneman, 1984; Roe, 2010). Thickness unknown, but may be 1,000 m (3,300 ft) or more.

Tfz **Fault zone rocks (Oligocene–Eocene)**—Rare outcrops of mylonite and cataclasite in an area of float of granite (Tgbm), volcanic sediments (Tlcs), chalcedony, vein quartz, and feldspathic quartzite and quartzite breccia (figs, 2, 3, 5). Float is angular to subrounded boulders up to 1 m (3.3 ft) across, but mostly 2–15 cm (4–6 in).

Fault rocks include variably deformed hydrothermal deposits of colorless to blue opalescent chalcedony, white bull quartz, quartz breccia, quartz mylonite, red jasperoid, and silica-cemented breccia.

Feldspathic quartzite found within Tfz is derived from the Proterozoic Belt Supergroup, and is coarse to very coarse, well-sorted, with only 2–5 percent feldspar, though some is very clean, with traces of secondary biotite and chlorite. Quartzite is white to salmon-colored with a rusty stain. Bedding planes are defined by grain size. Locally laminated with up to 30 percent feldspar and metamorphic muscovite.

Tre **Renova Formation (Oligocene–Eocene)**–Pale reddish gray, thinly bedded, ashy shale, siltstone, sandstone, conglomerate, and mudstone (fig. 7). Is poorly to well indurated. Has large white micas, some dark mica flakes and books, and woody plant impressions. Some thin, coarse, immature grussy sand beds are similar to the “two-mica sands” of the Cabbage Patch Member of the Renova Formation exposed in the southeast and northeast Big Hole Valley (Thomas, 1995; Elliott, 2017; Lonn and others, 2019).

A sample from the southeastern corner of the quadrangle yielded a maximum depositional age of 51.9 ± 0.6 Ma (CE20BHB-17, table 1; Mosolf and Kylander-Clark, 2023).

Tlcs **Sedimentary facies of the Lowland Creek volcanic field (early Eocene)**—Conglomerate, sandstone, and claystone, with thin rhyolite layers, including rhyolite tuff and ash. Light gray to light reddish gray, locally red, weathering to pale yellow. Does not crop out—is seen mostly as float. Loose, rounded cobbles are commonly broken. Forms rare large shelves or boulders of well-lithified, clast-supported, pebble–cobble, silica-cemented conglomerate. Clasts include granite (Tgbm), chalcedony, frosted quartz, feldspar, mica crystals, rhyolite (white to pink including quart-eye tuff and red porphyry), rounded feldspathic quartzite (Belt Supergroup), mica schist, and aplite. Well-lithified sandstone resembles basal deposits exposed closer to the Lowland Creek volcanic type section (Scarberry and others, 2019). Well-lithified float/subcrop is surrounded by brown and gray clay-rich soils.

A sandstone sample from the northeastern part of the Big Hole Battlefield quadrangle has a maximum depositional U-Pb zircon age of 64.5 ± 1.2 (CE20BHB-8, Mosolf and Kylander-Clark, 2023). Rhyolite tuff interlayered with Tlcs on Battlefield Mountain yielded an igneous age of 51.4 ± 1.0 Ma (CE20BHB-2, table 1; Mosolf and Kylander-Clark, 2023).

Tgbm **Biotite–muscovite granite (Paleogene)**—White, coarse-grained, biotite–muscovite granite. Weathers pale orange. Biotite dominates to the south, though muscovite is locally present. Biotite forms irregular blobs with a brassy tarnish. Muscovite is colorless to silver, and up to 1 cm across. Variably porphyritic, with potassium feldspar phenocrysts up to 4 cm long. Varies between massive, having a weak preferred orientation foliation, and mylonitic (fig. 3A) with chloritic slickenlines. Within the detachment fault zone, Tgbm is locally thinly interlayered with probable Belt Supergroup quartzite (fig. 8), representing a margin of the Tgbm intrusion.

Howlett and others (2020) obtained U-Pb ages of 60.87 ± 0.59 Ma and 65.4 ± 3.9 Ma for Tgbm. A sample from this mapping yielded a U-Pb zircon age of 63.3 ± 0.6 Ma (CE20BHB-15, table 1; Mosolf and Kylander-Clark, 2023).

Figure 2. Detachment surface dip slope. (A) Slickensided detachment surface in Tgbm. Red line is parallel to slip lineations, which plunge less than 10° to the east–southeast. (B) Low outcrops of white quartz breccia on detachment dip-slope (Tfz).

Figure 3. Brittle–ductile nature of deformation in the Big Hole Battlefield quadrangle. (A) Mylonitic Tgbm and vein quartz breccia from detachment fault zone. (B) Brecciated Tlcs with fractured rhyolite clasts and rounded quartzite cobble. Long edge of photo is 60 cm.

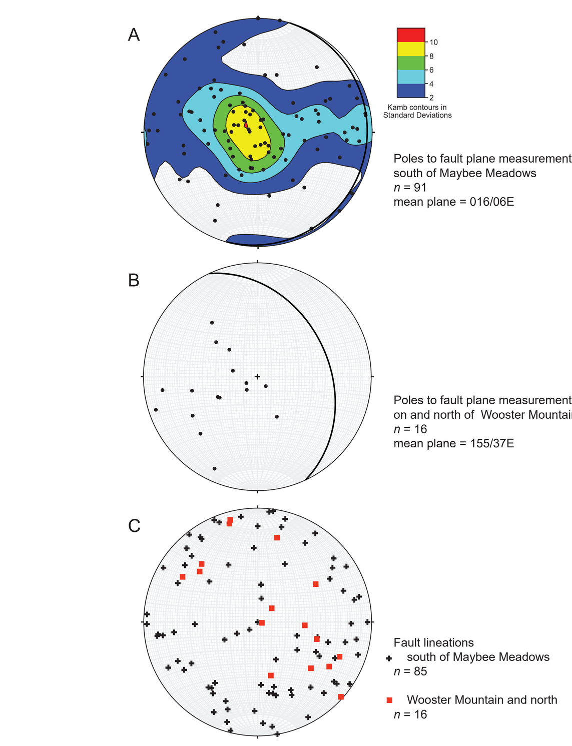


Figure 4. Equal area, lower hemisphere stereonet plot of fault data. (A) The main detachment surface in the southern two-thirds of the Big Hole Battlefield quadrangle dips very shallowly east–southeast. (B) The Bender Creek fault dips moderately towards the northeast. (C) Fault striation orientations display no preferred orientation.

Figure 5. Chalcedony coating on striated detachment surface near northern edge of map surface appears to post-date movement. Finger at bottom for scale.

Figure 6. Coarse crystalline barite. (A) *In situ* crystals. Knife is 1.6 cm wide. (B) Large barite crystals with 10 cm rock pick for scale.

Figure 7. Renova Formation siliciclastic rocks. Thinly bedded sandstone and shale on the east side of Bender Creek. Sandstone bed on left side is 10 cm thick.

Figure 8. One centimeter thick, bedding-parallel injections of granite (Tgbm) in Belt Supergroup quartzite.

Table 1. LA-ICPMS U-Pb zircon ages for the Big Hole Battlefield quadrangle.

Sample No.	Latitude (°N)	Longitude (°W)	Unit	RockType	Age (Ma)	2σ error (Ma)	Type of Age
CE20BHB2	45.6698	113.6844	Tlcs	rhyolite ash	51.4	1	crystallization
CE20BHB8	45.7268	113.6531	Tlcs	sandstone	64.5	1.2	maximun depositional age
CE20BHB15	45.6519	113.7086	Tgbm	granite/granodiorite	63.3	0.6	crystallization
CE20BHB17	45.6379	113.6561	Tre	sandstone	51.9	0.6	maximun depositional age

Note: Data and methods are reported in Mosolf and Kylander-Clark (2023).
Latitudes and longitudes are in the 1984 World Geodetic Survey (WGS84) datum.

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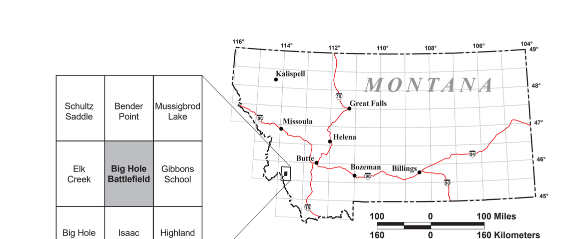

Location Map

MBMG
Montana Bureau of Mines and Geology

Geologic Map 97

Geologic Map of the Big Hole Battlefield 7.5' Quadrangle, Southwestern Montana

Mapped by Colleen G. Elliott

2024
https://doi.org/10.59691/QIYJ2150

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