

Bedrock and Surficial Geologic Map of the Monument Hill 7.5' Quadrangle Southwest Montana

Mapped and compiled by

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Summary

Key Contributions

This report contains findings that contribute to the understanding of the geology and geologic history of the Monument Hill 7.5' quadrangle, southwest Montana. The quadrangle contains areas previously mapped by Scholten and others (1955), Pecora (1981), Haley and Perry (1990), and Lonn and others (2000). Significant contributions from the new mapping include: 1) *the footwall of the Monument Hill fault is composed of Cretaceous Beaverhead Group, not Tertiary Sixmile Creek Formation (e.g. Lonn and others, 2000)*. The fault was previously mapped with Sixmile Creek in the footwall and Beaverhead in the hanging wall (Lonn and others, 2000). Reinterpretation of the footwall is consistent with normal-fault kinematics. The contact between the Beaverhead Group and overlying Sixmile Creek Formation is unconformable and is located east of the fault. This contact is dashed on the map because of difficulty involved in differentiating between the two units in this locality. 2) *The Sixmile Creek Formation, not the Renova Formation, dominates the Tertiary deposits of the map area*. These rocks were previously mapped as Tertiary undivided (Scholten and others, 1955; Pecora, 1981; Haley and Perry, 1990) and later divided by Lonn and others (2000) into the Sixmile Creek Formation and the Renova Formation. The new mapping reinterprets the distribution of these two Tertiary formations in the Monument Hill 7.5' quadrangle. 3) *The deposition of the Sixmile Creek Formation was controlled by paleotopography that developed subsequent to Paleocene Beaverhead deposition* (Haley and Perry, 1990). The evolving paleotopography guided the distribution of gravels, volcanoclastics, and volcanics in the Monument Hill area. 4) *The Monument Hill fault shows evidence for Holocene activity*. Fault scarp profiles and detailed mapping of alluvial fans provide strong evidence for multiple active strands in the fault system and Holocene rupture of the fault in the Monument Hill 7.5' quadrangle (Regalla, work in progress).

Introduction

This report accompanies a map at 1:24,000 scale and a cross section for the Monument Hill 7.5' quadrangle (Figure 1). The mapping of this quadrangle complements previous work in the area (Harkins and others, 2004a and 2004b) and furthers an ongoing effort to understand the evolution of Quaternary geology in southwest Montana. Fieldwork for this map was completed during the summer of 2004. Field mapping was done at 1:12,000 scale and compiled at 1:24,000 scale. The Monument Hill 7.5' quadrangle is located in the Red Rock Hills, on the western flank of the Blacktail-Snowcrest Laramide uplift (Kulik and Perry, 1988), just east of the Sevier thrust front in the proximal foreland basin. The region is characterized by grass- and sage-covered hills, and can be accessed by numerous unpaved roads maintained by the Bureau of Land Management. The quadrangle is named after Monument Hill that has an elevation of 8,188 feet and is capped by a cairn of basaltic cobbles. The highest elevation (9,240 ft) in the quadrangle is at the radio tower in the western part of the quadrangle. Relief is on the order of 2,000 ft.

Location Map

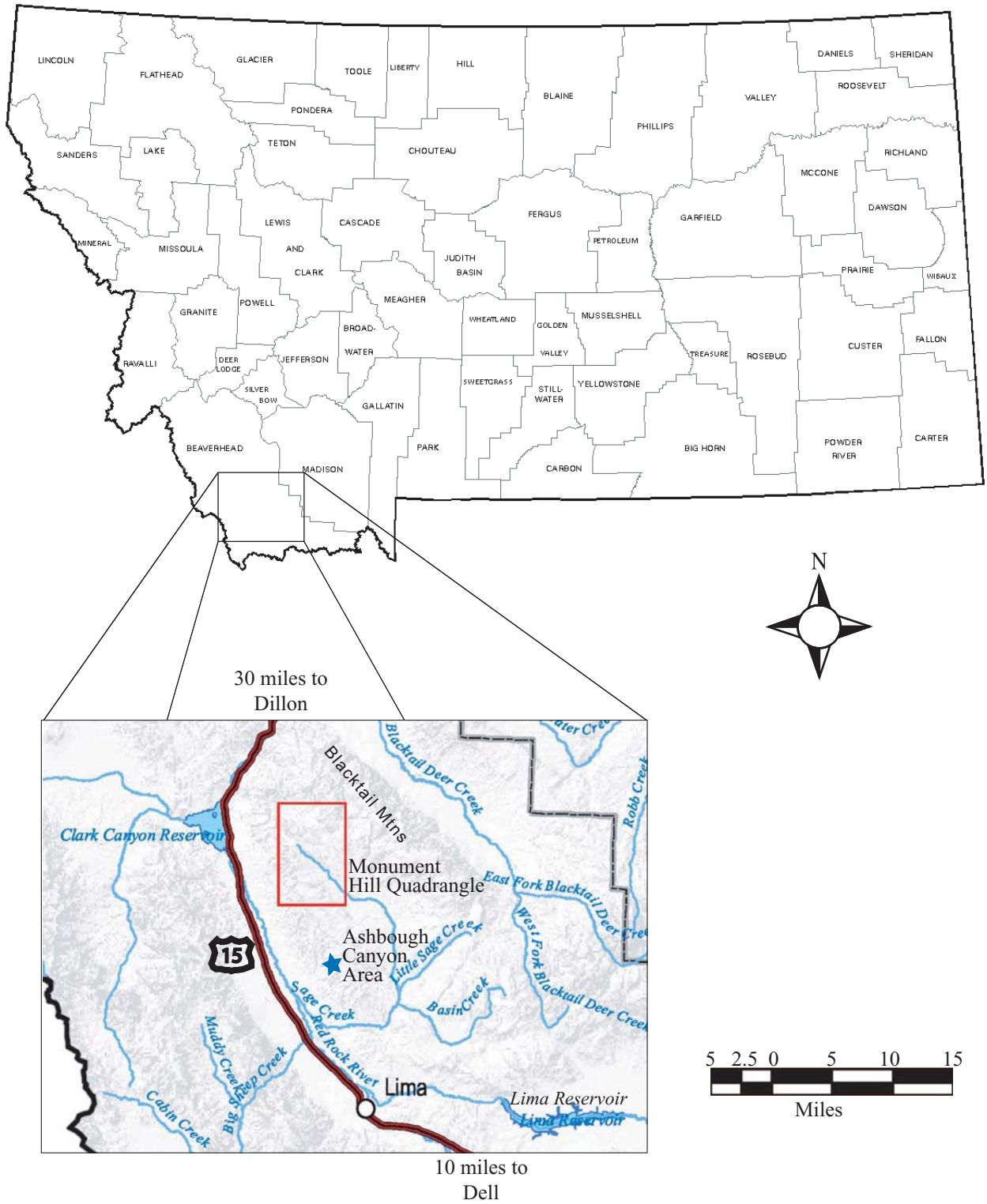


Figure 1. The Monument Hill 7.5' quadrangle is located in the Blacktail Mountains of southwest Montana.

Stratigraphy

Three major unconformities separate four distinct stratigraphic packages in the Monument Hill 7.5' quadrangle -- the Paleozoic, Cretaceous, Tertiary, and Quaternary (Fig. 2). The Paleozoic stratigraphy consists of limestones, limey shales, and sandstones deposited on the western margin of North America. The distribution of these rocks is related to the Blacktail Uplift, the exposed core of which is exposed to the northeast of the quadrangle.

The Tertiary-Cretaceous Beaverhead Group (Fig. 3) is synorogenic and was deposited in the foreland basin of the Sevier orogeny. Disagreement exists regarding the source of the Beaverhead Group quartzite clasts. Janecke and others (2000) believe that the source area for the Beaverhead Group is far to the west, while J. G. Schmitt (personal communication, 2004) believes that the Beaverhead quartzite is derived from hinterland thrust sheets exposed in the Beaverhead Range to the west.

The Tertiary Sixmile Creek Formation is composed of clastics, volcanoclastics, and volcanics. These deposits were generated by uplift associated with the passage of the Yellowstone hot spot (Pierce and Morgan, 1992). The volcanics and volcanoclastics in the Monument Hill 7.5' quadrangle are mapped as part of the Sixmile Creek Formation. Previous mapping has described these units as Tertiary Renova Formation (Lonn and others, 2000), but based on stratigraphic relationships placing Sixmile Creek conglomerates above and below the volcanic units, and good correlation with nearby sections of well constrained age (Fritz and Sears, 1993), along with detailed descriptions of the Renova Formation (Kuenzi and Fields, 1971; Fields and others, 1985; Sears and others, 1995), it is more likely that these volcanics and volcanoclastics are of Sixmile Creek age. The Sixmile Creek gravels are locally derived and locally homogeneous. However, significant regional variability exists laterally, suggesting deposition in numerous small drainage basins. The gravels in the northeast are derived from the transverse drainages in the Blacktail Range. The gravels in the western portion of the map are derived from the Beaverhead quartzite conglomerate, making the Beaverhead-Sixmile Creek contact obscure in this area because both are unconsolidated, quartzite-clast-bearing conglomerates. However, basalt clasts are a distinguishing characteristic of the Sixmile Creek conglomerates. In other places, outside the quadrangle, the contact is clearly distinguishable. Vegetation and soil color variations on aerial photographs were used to estimate the location of the contact where obscure. The basalts of the Sixmile Creek Formation were deposited in Tertiary paleovalleys but now typically crop out on the modern topographic high points, indicating an inverted topography. Quaternary deposition has been controlled by climate variations leading to multiple Quaternary alluvial deposits (Harkins and others, 2004a) and by active extension associated with the passage of the Yellowstone hot spot (Pierce and Morgan, 1992).

Structure

Structural features exposed in the Monument Hill 7.5' quadrangle include folding of Paleozoic rocks in the northeast portion of the map and active Quaternary normal faulting in the southwest portion of the map. Paleozoic units form the western dip-slopes of the Blacktail-Snowcrest uplift. The Lombard Formation of the Snowcrest Range

Group exhibits mesoscopic, east-vergent, asymmetric, open folding. Older Paleozoic units fold disharmonically between bedding-plane-parallel decollements and likely accommodate similar shortening to that observed in the Lombard Formation with variable folding (Pecora, 1981; Harkins, 2004a). Although much of the Paleozoic section does not crop out in the map area, it can be characterized as having Sevier-Laramide age disharmonic folds with an enveloping surface dipping 15° to the west (Pecora, 1981). These units are unconformably overlain by synorogenic Beaverhead conglomerate. A large paleovalley incised into Mesozoic and Paleozoic rocks has been filled with Tertiary and younger volcanics and sedimentary rocks in the central portion of the map area. The active Monument Hill fault system crops out in the southwest portion of the map where it cuts the Cretaceous Beaverhead Group and underlying Mesozoic and Paleozoic units. The fault strand that crops out in the Monument Hill 7.5' quadrangle likely dips west at approximately 55° (Stickney and Lageson, 2002). Fault displacement is estimated at 1,100 ft. (333 m) using empirical fault strike length/fault displacement relationships (Densmore and others, 2004; Schlische and others, 1996).

Acknowledgments

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Stratigraphic Column of Units Mapped within the Monument Hill 7.5' Quadrangle

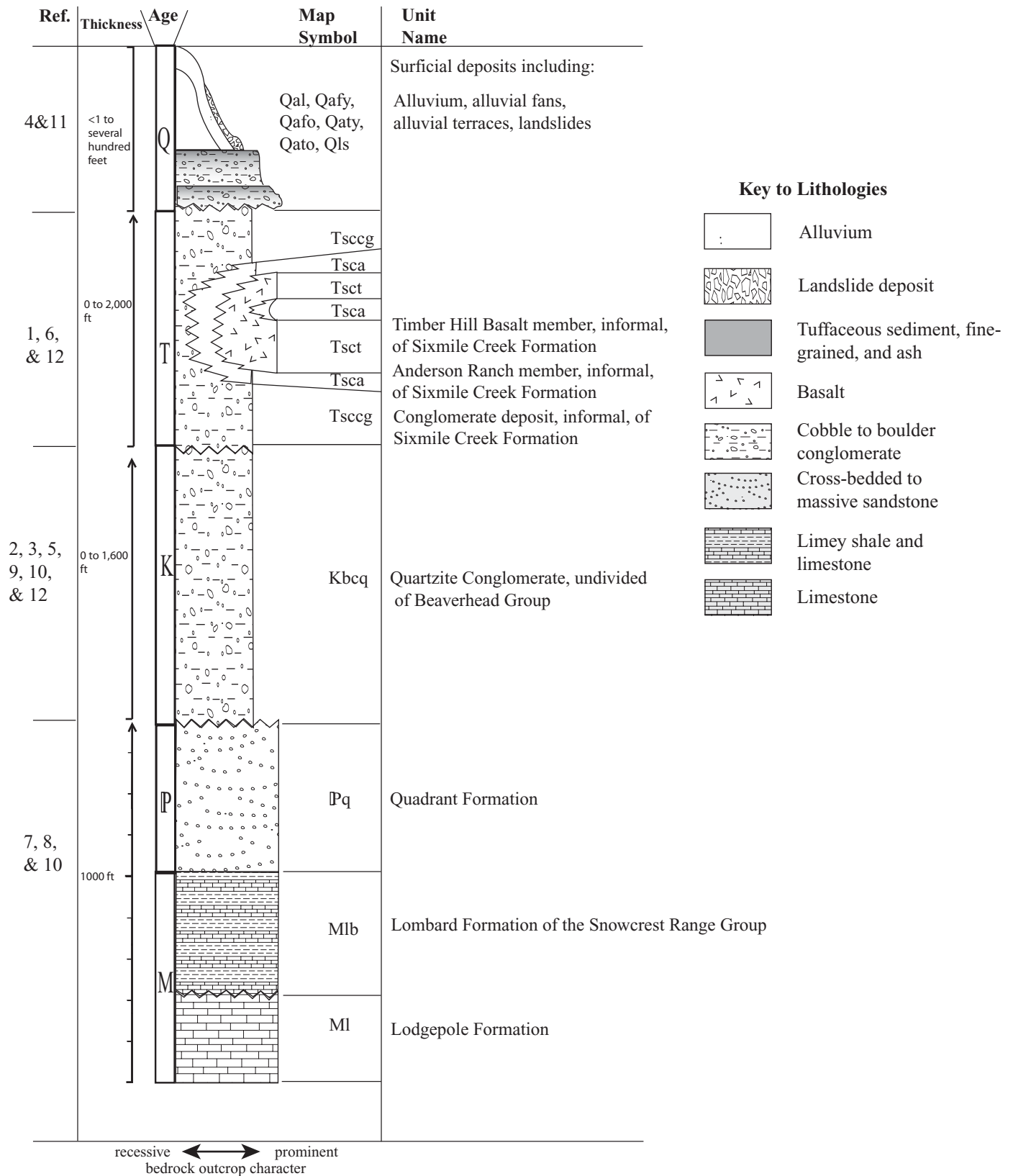


Figure 2. Stratigraphic column of units mapped within the Monument Hill 7.5' quadrangle. Unit thicknesses are all approximate. Compiled from noted references.

Key to references on stratigraphic column, previous page; full citation in References Cited section.

1. Fritz and others, 1993
2. Haley, 1986
3. Haley and Perry, 1990
4. Harkins and others, 2004a, b
5. Janecke and others, 2000
6. Kreps and others, 1992
7. Lonn and others, 2000
8. Pecora, 1981
9. Ryder and Scholten, 1973
10. Scholten and others, 1955
11. Stickney and Lageson, 2002
12. Schmitt and others, 1995

Beaverhead Group Stratigraphy in the Ashbough Canyon Area South of Monument Hill Quadrangle

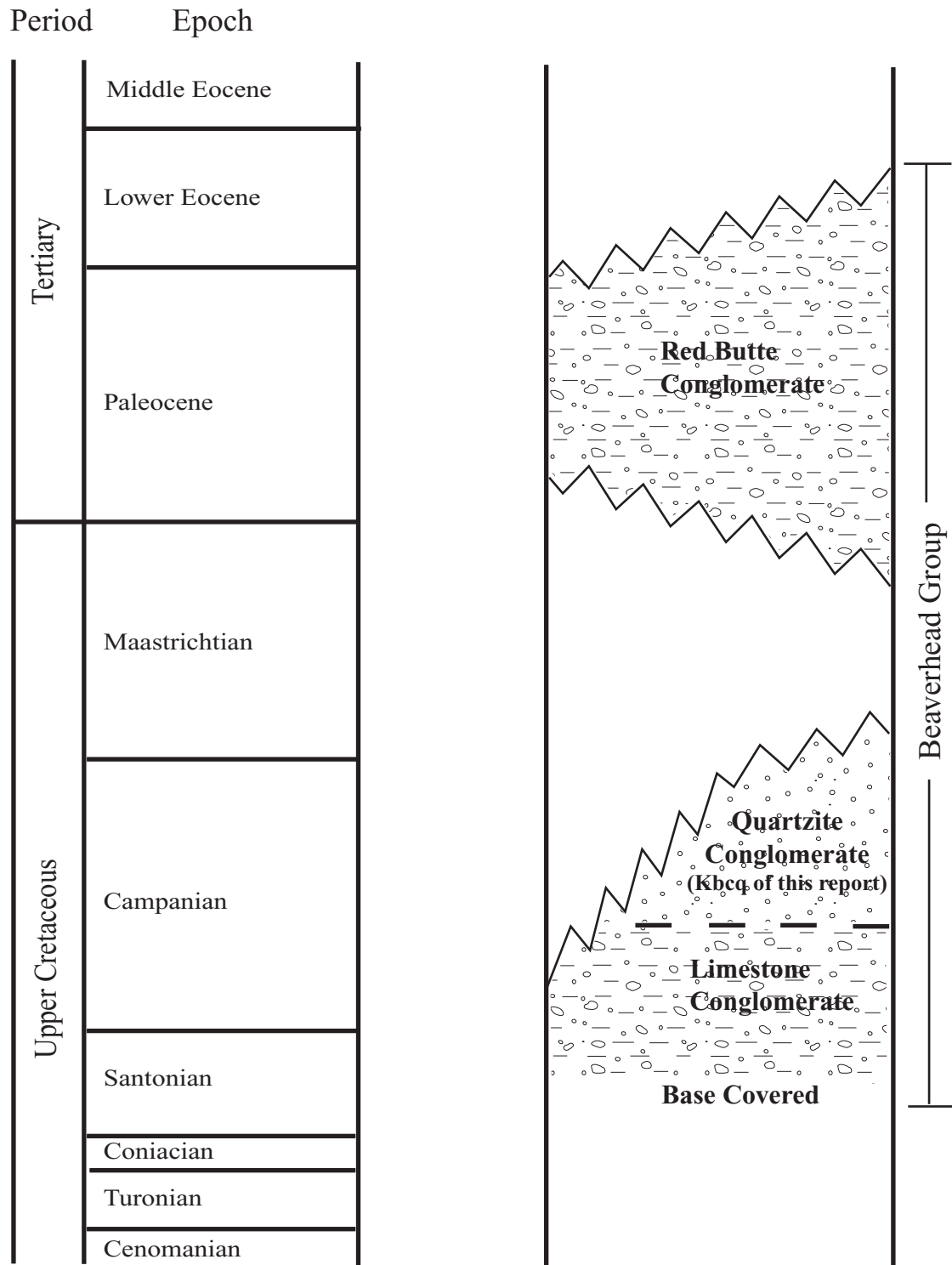


Figure 3. Stratigraphic column of Beaverhead Group members in the Ashbough Canyon area (see Fig. 1). Adapted from Haley and Perry (1990).

Unit Descriptions

- Qal Alluvium- Unconsolidated, well to poorly sorted deposit of silt, sand, and gravel in the active channel and/or flood plain of modern streams.
- Qafy Alluvial fan deposit, younger- Unconsolidated, poorly sorted, angular to rounded, silt- to boulder-sized, locally derived clasts in active, modern alluvial fans. Bar and swale surface morphology with sage vegetation and fan-shaped depositional patterns are characteristic.
- Qafo Alluvial fan deposit, older- Alluvial fans elevated 30 ft (10 m) or more above the modern drainage. Thick loess, significantly buried bar and swale surface morphology, stage III to III+ Carbonate classification, 10yr, 4/2 wet, 6/2 dry Munsell soil color, and a grassy surface are all characteristic.
- Qaty Alluvial terrace deposit, younger- Well-sorted silt, sand, and gravel with characteristic flat-top morphology and sage vegetation; 10 to 15 ft (3 to 5 m) above modern channel.
- Qato Alluvial terrace deposit, older- Well-sorted silt, sand, and gravel with characteristic flat-top morphology and sage vegetation; 15 to 30 ft (5 to 10 m) above modern channel.
- Qac Alluvial fan and colluvial deposits of unknown age affinity- consists of unconsolidated deposits of poorly sorted silt to cobbles that grade into the oldest fan surfaces.

Qls Landslide deposit- Unconsolidated deposit of locally derived angular, unsorted debris with characteristic hummocky topography and head scarp.

Sixmile Creek Formation (Tertiary)- Informal member names from Fritz and Sears (1993). Age dates from tephra beds ranging from 3.7 to 16 Ma (Fritz and Sears, 1993). Deposits filled extensive paleovalleys during the Tertiary.

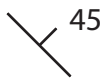
Tsccg Conglomerate deposit, informal, of Sixmile Creek Formation- Unconsolidated gravel conglomerates consisting of poorly sorted, well-rounded, sand- to boulder-sized, mostly quartzite clasts with minor amounts of basalt, volcanoclastic, gneissic, Belt argillite, Flathead Sandstone, limestone, and conglomerate clasts in a sandy matrix. Distinguished from the Beaverhead Group in this area by presence of Archean gneiss, Flathead Sandstone, and basalt clasts, as well as rounded, recycled Beaverhead Red Butte conglomerate clasts. Correlated with the Big Hole River and Sweetwater Creek members, informal, of Sixmile Creek Formation of Fritz and Sears (1993). The thickness of this unit is regionally variable. On the Monument Hill quadrangle, it is as much as 2,000 ft (610 m) thick.

Tsca Anderson Ranch member, informal, of Sixmile Creek Formation- White, volcanoclastic, fluvial tephra interbedded with light-brown silt, sand, and gravel found in patches scattered among the basalt and gravel deposits of the Sixmile Creek Formation. This unit is poorly exposed or absent in places but can be as much as 1,000 ft (305 m) thick.

- Tscb Basalt member, informal, of Sixmile Creek Formation- Black, dense, very fine-grained basalt flows. Characterized by horizontal banding and columnar jointing. Variable vesicle distribution defines paleo-horizontal orientation of unit. Phenocrysts composed of plagioclase and olivine. Described by Fritz and Sears (1993) as a single basalt flow (Timber Hill basalt) and dated as 6.0 ± 0.1 Ma (Kreps and others, 1992). This unit represents multiple basalt flows. The basalt unit can be as much as 800 ft (244 m) thick in the Monument Hill quadrangle.
- Kbcq Quartzite conglomerate, informal and undivided, of Beaverhead Group- Unconsolidated gravel conglomerate consisting of poorly sorted, well-rounded, sand- to boulder-sized quartzite clasts derived from the west and composed mainly of Precambrian Belt Supergroup and Ordovician Kinnikinic Formation clasts with minor amounts of limestone, siltstone, and volcanic clasts of unknown origin (Haley, 1986) in a sandy matrix. Tertiary sediments unconformably overlie the conglomerate to the east and Quaternary alluvium overlies it to the west (Haley, 1986). The quartzite conglomerate is likely latest Cretaceous in age. Although a precise age is not known, the underlying volcanic rocks in the Bannack Pass area have been dated at 76 and 79 Ma (Kalakay, 2001), and the overlying Red Butte conglomerate (informal, of Beaverhead Group; see p. 7) is dated as Paleocene (Haley and Perry, 1990). The thickness of the Beaverhead quartzite conglomerate varies regionally. In the Red Rock Hills area, it ranges from approximately 1,000 to 1,600 ft (305 to 488 m) thick.

- 1Pq Quadrant Formation- Buff-colored, medium-grained, thick-bedded, cross-bedded sandstone. Characteristically forms talus slopes. The Quadrant Formation is approximately 700 ft (213.5 m) thick (Pecora, 1981).
- MIb Lombard Formation of Snowcrest Range Group- Thick-bedded, light-gray, typically tight (nonporous), cliff-former, disharmonically folded where exposed in northeast part of map area. Upper unit is 300 ft (91.5 m) thick, made of crinoidal limestone and interbedded limey shale. Middle unit is 220 to 580 ft (67 to 177 m) thick, made of thin- to thick-bedded limestone with 1- to 3-ft (0.3- to 0.9-m)-thick interbeds of mudstone and siltstone (Tysdal, 1988). Lower unit described by Tysdal is not exposed in the Monument Hill quadrangle but does crop out farther east.
- MI Lodgpole Formation of Madison Group- Light-gray, thinly bedded, fine- to medium-grained limestone interbedded with silty mudstone and calcareous siltstone. Approximately 400 to 480 ft (122 to 146 m) thick (Pecora, 1981).
NOTE: the overlying Mission Canyon Formation of Madison Group is not present in map area. Regionally, Mission Canyon ranges from 0 to 400 ft (0 to 122 m) thick. Its absence on outcrop in quadrangle area is attributed to pre-Tertiary and/or post-Mississippian regional erosion that is schematically shown on Stratigraphic Column, p. 5.

Map and Cross-Section Symbols



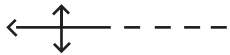
Bedding strike and dip where measured



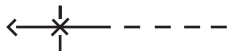
Contact; dashed where inferred, dotted where concealed



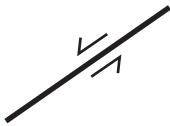
Normal fault; ball and bar on the downthrown or hanging-wall side; dashed where approximate



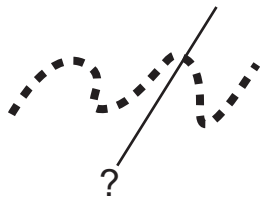
Axial trace of anticline showing plunge; dashed where approximate



Axial trace of syncline showing plunge; dashed where approximate



Fault; arrows show direction of slip (cross section only)



Schematic representation of disharmonic folding within Snowcrest Range Group where observed on west flank of Blacktail-Snowcrest Range (cross section only)

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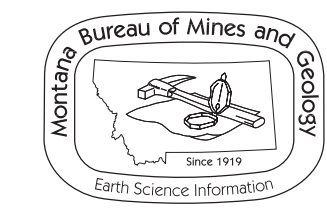
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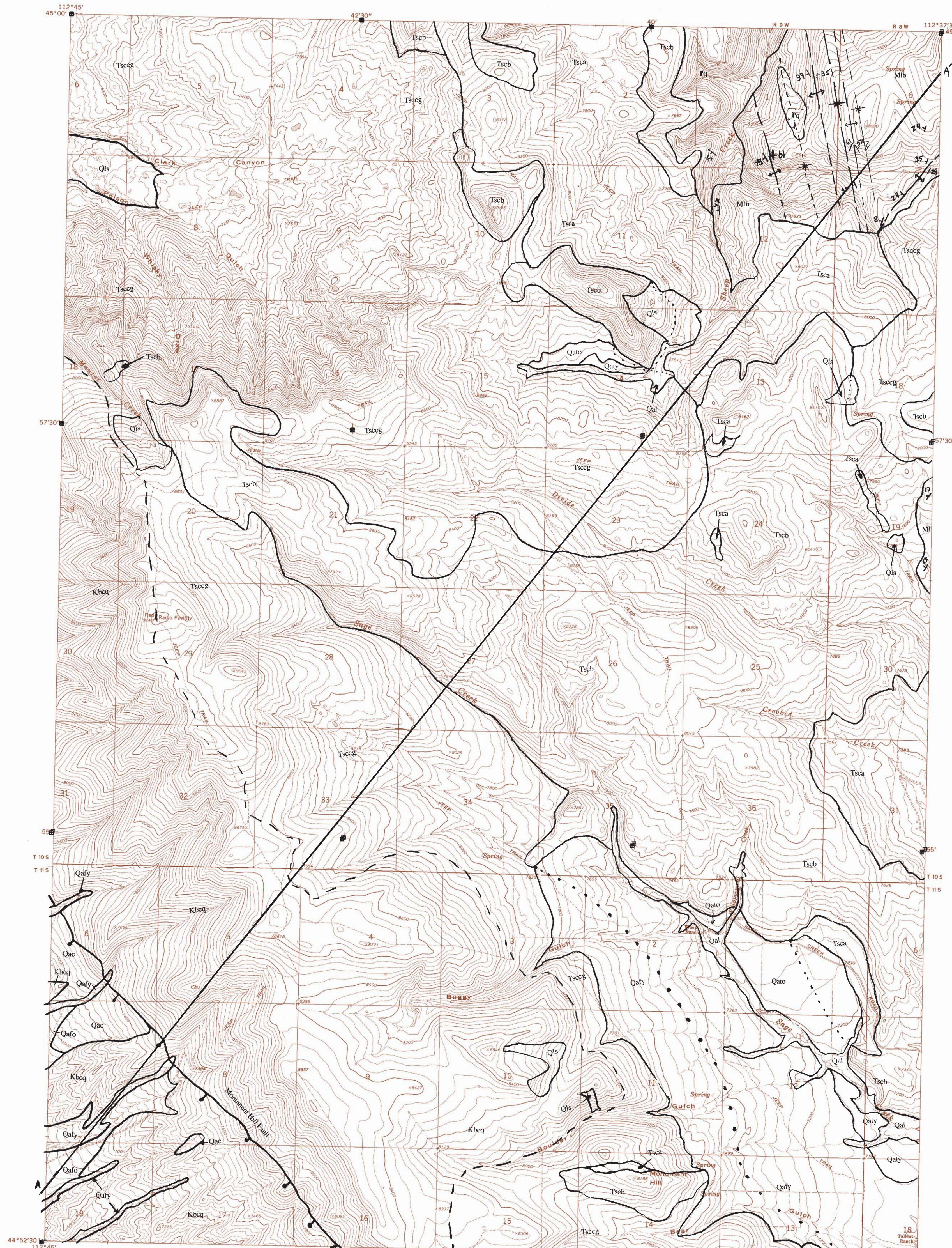
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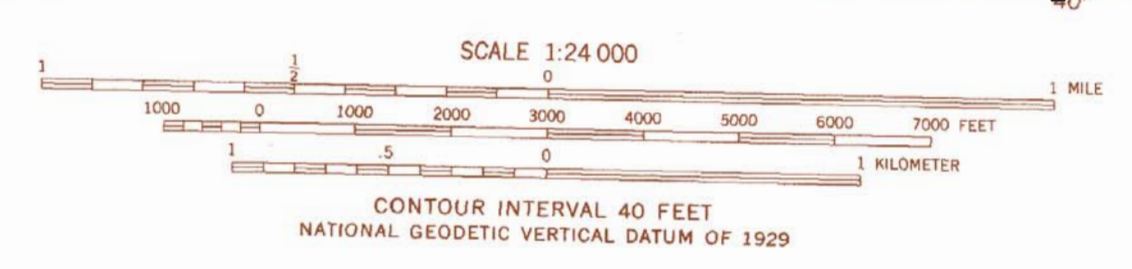
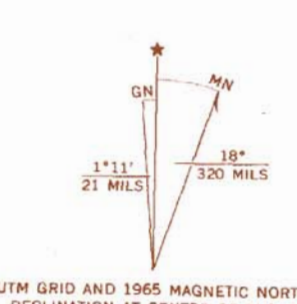
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 Topography by photogrammetric methods from aerial
 photographs taken 1964. Field checked 1965
 Polyconic projection. 1927 North American datum
 10,000-foot grid based on Montana coordinate system,
 south zone.
 1000-meter Universal Transverse Mercator grid ticks,
 zone 12, shown in blue



Cross-Section Explanation

- Qafo Alluvial fan deposit, older
- Tscgg Conglomerate deposit of Sixmile Creek Formation
- Tscac Anderson Ranch member, informal, of Sixmile Creek Formation
- Tscab Basalt of Anderson Ranch member, Sixmile Creek Formation
- Kbcq Quartzite conglomerate of Beaverhead Group
- *Kbcl Limestone conglomerate of Beaverhead Group
- *KJkm Kootenai and Morrison Formations, undivided
- *Rd Dinwoody Formation
- *Pp Phosphoria Formation
- *Pq Quadrant Formation
- *PMsr Snowcrest Range Group, undivided (includes Lombard Fm.)
- *Mmc Mission Canyon Formation
- MI Lodgepole Formation

For unit descriptions refer to the text.
 *Refer to Lonn and others (2000) for descriptions of subsurface units.

..... Schematic representation of mapped folds in Lombard Fm.

Folding of the upper Paleozoic strata is disharmonic (e.g. Scholten and others, 1955; Pecora, 1981; Harkins and others, 2004a, 2004b) making uncertain the depth to which folds mapped in the Lombard Formation of the Snowcrest Range Group can be projected into depth. Bedding-parallel décollements also occur between formations where changes in lithology and fold geometry occur.

Presence and thickness of subsurface units are unknown owing to extensive regional post-Mississippian and pre-Tertiary erosion.

