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Bedrock and Surficial Geologic Map of the Red Rock 7.5' Quadrangle, Beaverhead County, Southwestern Montana

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Bedrock and Surficial Geologic Map of the Red Rock 7.5' Quadrangle, Beaverhead County, Southwestern Montana

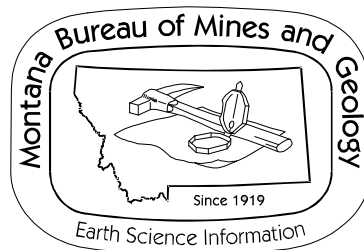
Mapped and compiled by:

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Introduction

The Red Rock 7.5 minute quadrangle, located in Beaverhead County, southwestern Montana, spans the Red Rock River Valley, an extensional graben formed between the Tendoy mountain front and the western flank of the Blacktail-Snowcrest uplift (Fig. 1). Notable landmarks within the quadrangle include the Clark Canyon Reservoir (Bureau of Reclamation dam number MT00569) located in the northwest area of the quadrangle and Interstate 15 which runs northwest-southeast through the quadrangle. The highest elevations in the map area are located within the Tendoy Mountains and the Red Rock Hills and are underlain by Paleozoic and Cenozoic bedrock. From these points, broad alluvial fans grade down to the Red Rock River Valley. The quadrangle contains about 3,000 ft of relief.

Mapping of the Red Rock quadrangle was done at a scale of 1:12,000 and was compiled at a scale of 1:24,000. Field work was completed in the summer of 2005 in collaboration with the mapping of the adjacent Briggs Ranch and Kidd quadrangles (Figs. 1 and 2). This strategy allowed for the comparison of structure and stratigraphy across quadrangle boundaries and provided a regional context for the mapping of each quadrangle. This new mapping complements previous mapping of the Monument Hill quadrangle (Newton and others, 2005), Dixon Mountain quadrangle (Harkins and others, 2004b), Caboose Canyon quadrangle (Harkins and others, 2004a), and Dell quadrangle (Aschoff and Schmitt, 2005) and collectively provides new detailed mapping and analysis of a portion of the Red Rock River Valley from Lima to the Clark Canyon Dam (Figs. 1 and 2). This report includes a map and cross section for the Red Rock quadrangle as well as a discussion of the stratigraphy and structure of the map area.

Key Contributions

Mapping of the Red Rock quadrangle supports previous mapping at a scale of 1:25,000 by Scholten and others (1955) and more recent mapping compiled at a scale of 1:100,000 by Lonn and others (2000). It contributes to the understanding of the geology of the area by subdividing previously grouped formations and by refining the extent and location of the Monument Hill fault system at a larger map scale. The Tendoy Group, the Snowcrest Range Group, and the Beaverhead Group have been subdivided into formations and members based upon previously published studies (Sando and others, 1985; Wardlaw and Pecora, 1985; Haley and Perry, 1991; Schmitt and others, 1995). Subdivision of the Tendoy and Snowcrest Range Groups aids in the recognition of imbricate thrusts within the McKenzie thrust sheet. Subdivision of the Beaverhead Group has revealed outcrops of limestone conglomerate and a mixed lens conglomerate in areas that have previously been mapped as quartzite conglomerate (Lonn and others, 2000) and has identified an andesitic to dacitic volcanic unit located stratigraphically between the limestone and quartzite conglomerate members. New mapping of the Red Rock quadrangle has also delineated the presence of both the Sixmile Creek and Renova Formations in the northern half of the quadrangle and has remapped Beaverhead outcrops in the northern segment of the quadrangle as Sixmile Creek Formation, based on the presence of volcanic clasts and interbedded rhyolites and basalts. Lastly, subdivision of Quaternary alluvial fans and detailed mapping of the Monument Hill fault system have provided refinements of the location, extent, total offset, and timing of offset of three fault strands, including a newly identified strand located 1.25 miles (2 km) southeast of the Clark Canyon Dam.

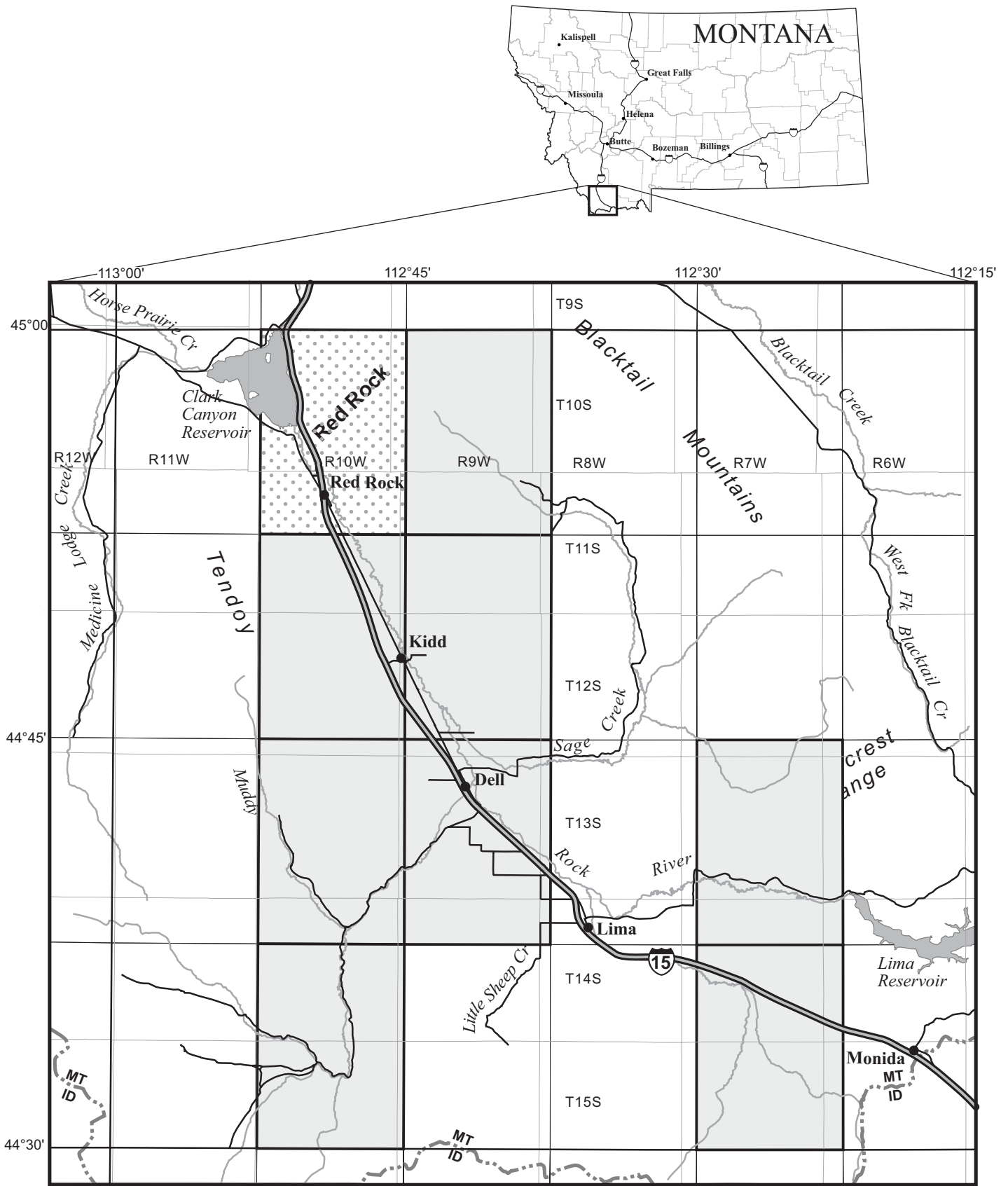


Figure 1. Location map for Red Rock 7.5' quadrangle, showing relationship to other completed or in-progress quadrangle maps in the area. See web site (www.mbgm.mtech.edu) for status of maps.

Digital topography of the Red Rock Valley

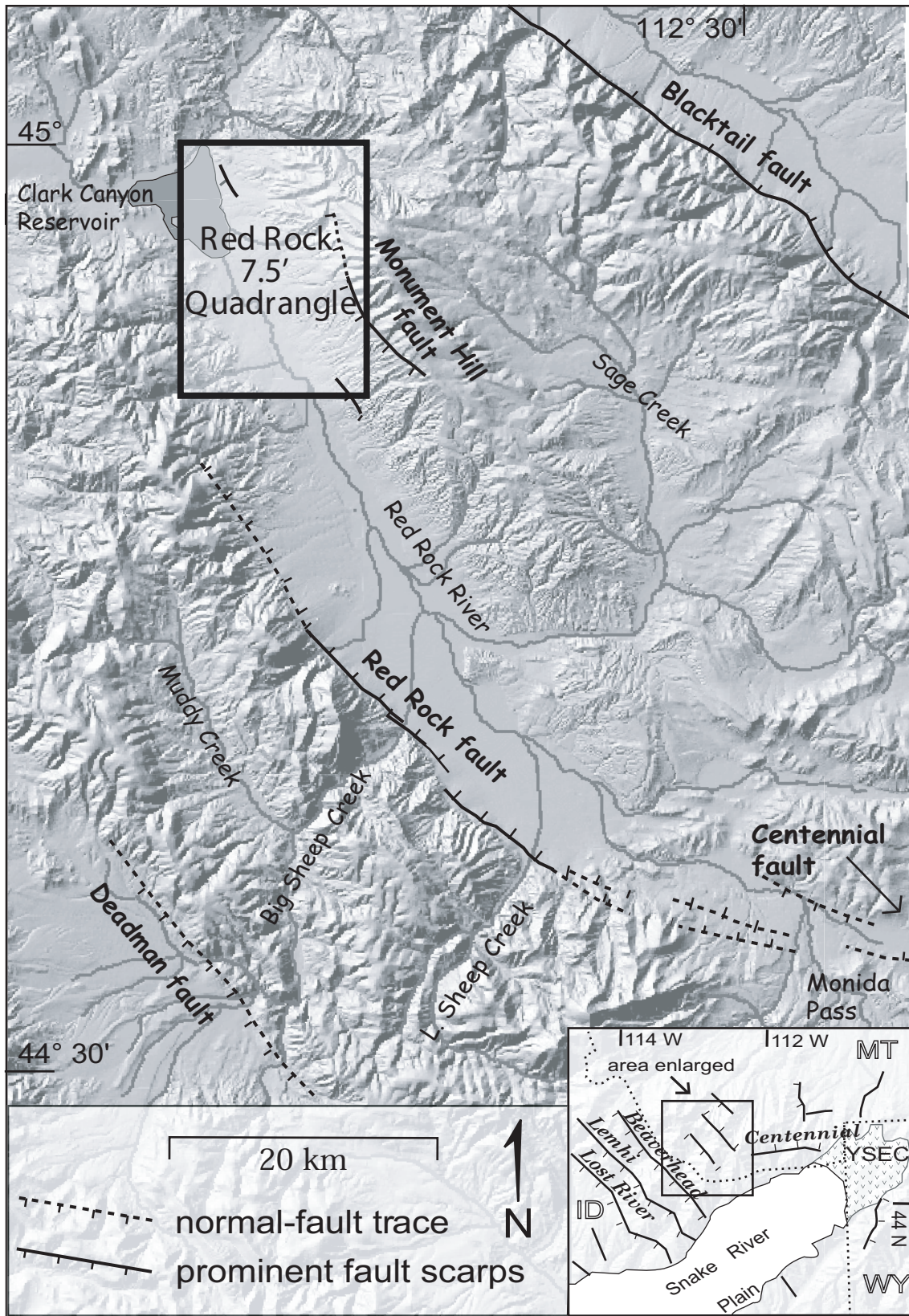


Figure 2. Digital Elevation Model (DEM) of the Red Rock valley showing location of the Red Rock 7.5' quadrangle. Mapped fault traces and scarps, and notable streams and rivers are labeled for reference. Inset shows regional tectonic setting.

Comparison with Adjacent 7.5' Quadrangles

The Red Rock quadrangle shares its eastern border with the Monument Hill quadrangle (Newton and others, 2005) and its southern border with the Kidd quadrangle (Wilson and Schmitt, in progress) (Fig. 1). Different naming conventions have been used for some units within these adjacent quadrangles due to different styles of outcrop. In the Monument Hill quadrangle, the Qafo (Alluvial fan deposit, older) of Monument Hill correlates to the Qaf4 (Alluvium of oldest alluvial fan deposits) of Red Rock, and the Qafy (Alluvial fan deposit, younger) of Monument Hill corresponds to the Qaf3 and Qaf2 (Alluvium of the third and second youngest alluvial fan and associated alluvial channel deposits) of Red Rock (Table 1). In the Kidd quadrangle, the Qal (Alluvium) correlates to both the Qal (Alluvium) and Qalo (Older alluvium) units in the Red Rock quadrangle. Additionally, while in the Kidd quadrangle the units Mmc (Mission Canyon Formation) and Mmck (McKenzie Canyon Formation) are mapped both as individual units and as the combined Mmm (McKenzie Canyon and Mission Canyon Formations, undivided), within the Red Rock quadrangle, the Mission Canyon and McKenzie Canyon Formations are everywhere mapped as Mmm (Table 1).

Monument Hill	Red Rock	Kidd	
Qafo	Qaf4	Qaf4	
Qafy	Qaf3, Qaf2	Qaf3, Qaf2	
-----	Ppp	Pp	
-----	Mmm	Mmm	Mmck Mmc

Table 1. Stratigraphic correlation of units mapped within the Red Rock 7.5' quadrangle compared to units mapped within the Monument Hill and Kidd 7.5' quadrangles.

Stratigraphy

The stratigraphy of the Red Rock quadrangle can be divided into the Paleozoic units of the frontal foreland Sevier thrust sheets and the Mesozoic to Cenozoic synorogenic conglomerates, paleovalley fill deposits, and alluvium of the Red Rock Hills (Figs. 3, 4 and 5). A conformable sequence of Mississippian through Permian carbonates and siliciclastics deposited on the North American passive margin are imbricated in the frontal thrusts of the Sevier thrust belt now exposed in the easternmost Tendoy Mountains in the McKenzie and Tendoy thrust systems. These units include the Tendoy Group (Sando and others, 1985), the Snowcrest Range Group (Wardlaw and Pecora, 1985), the Quadrant Sandstone, and the Phosphoria and Park City Formations, undivided (Cressman and Swanson, 1964). The Paleozoic units are unconformably overlain by the Cretaceous and Tertiary Beaverhead Group, a synorogenic conglomerate deposited in Sevier wedge top and foreland basins (Ryder and Scholten, 1973; Haley, 1986; Haley and Perry, 1991; Schmitt and others, 1995). The Beaverhead Group is unconformably overlain by two generations of Tertiary valley-fill deposits, the Eocene and early Miocene Renova Formation, and the mid-Miocene and late-Pliocene Sixmile Creek Formation (Kuenzi and Fields, 1971; Fields and others, 1985; Sears and Hurlow, 1995; Newton and others, 2005). Quaternary units dominate much of the low elevations in the quadrangle and include multiple generations of river alluvium, alluvial fans, colluvium, and landslide deposits (Harkins and others, 2005; Lonn and others, 2000).

Where possible, the Tendoy and Snowcrest Range Groups have been subdivided into the formations described in Sando and others (1985) and in Wardlaw and Pecora (1985). The Tendoy Group in the McKenzie thrust system (Fig. 3) locally consists of deeper water carbonates with interbedded fossiliferous and chert-rich horizons. These carbonates are regionally correlated to shallower-water carbonates of the Tendoy Group in other thrust sheets (Sando and others, 1985; McDowell 1992). Within the McKenzie thrust sheet, the Tendoy Group is divided into the Paine Limestone (not exposed in the Red Rock quadrangle), the Middle Canyon Formation, the Mission Canyon Formation, and the McKenzie Canyon Limestone. However, because of the lithologic similarity between the Mission Canyon and McKenzie Canyon Formations, and the inability to definitively recognize the McKenzie Canyon Formation outside of its type section at Bell Canyon (Sando and others, 1985), these two formations have been mapped as a single unit. The Snowcrest Range Group (Fig. 3) consists of subtidal to supratidal carbonates, evaporates, and siliciclastics deposited as a transgressive sequence on the North American margin (Wardlaw and Pecora, 1985). The group is subdivided within the Red Rock quadrangle into the Kibbey Sandstone, the Lombard Limestone, and the Conover Ranch Formation. Outside of the Tendoy Mountains, to the northeast of the Red Rock quadrangle, the Conover Ranch is late Mississippian and early Pennsylvanian in age (Wardlaw and Pecora, 1985). However, within the Red Rock quadrangle, only late Mississippian fossils have been found in the Conover Ranch Formation, making its age here only late Mississippian (Sando and others, 1985).

Stratigraphic Column of Paleozoic Units Mapped within the Red Rock 7.5' Quadrangle

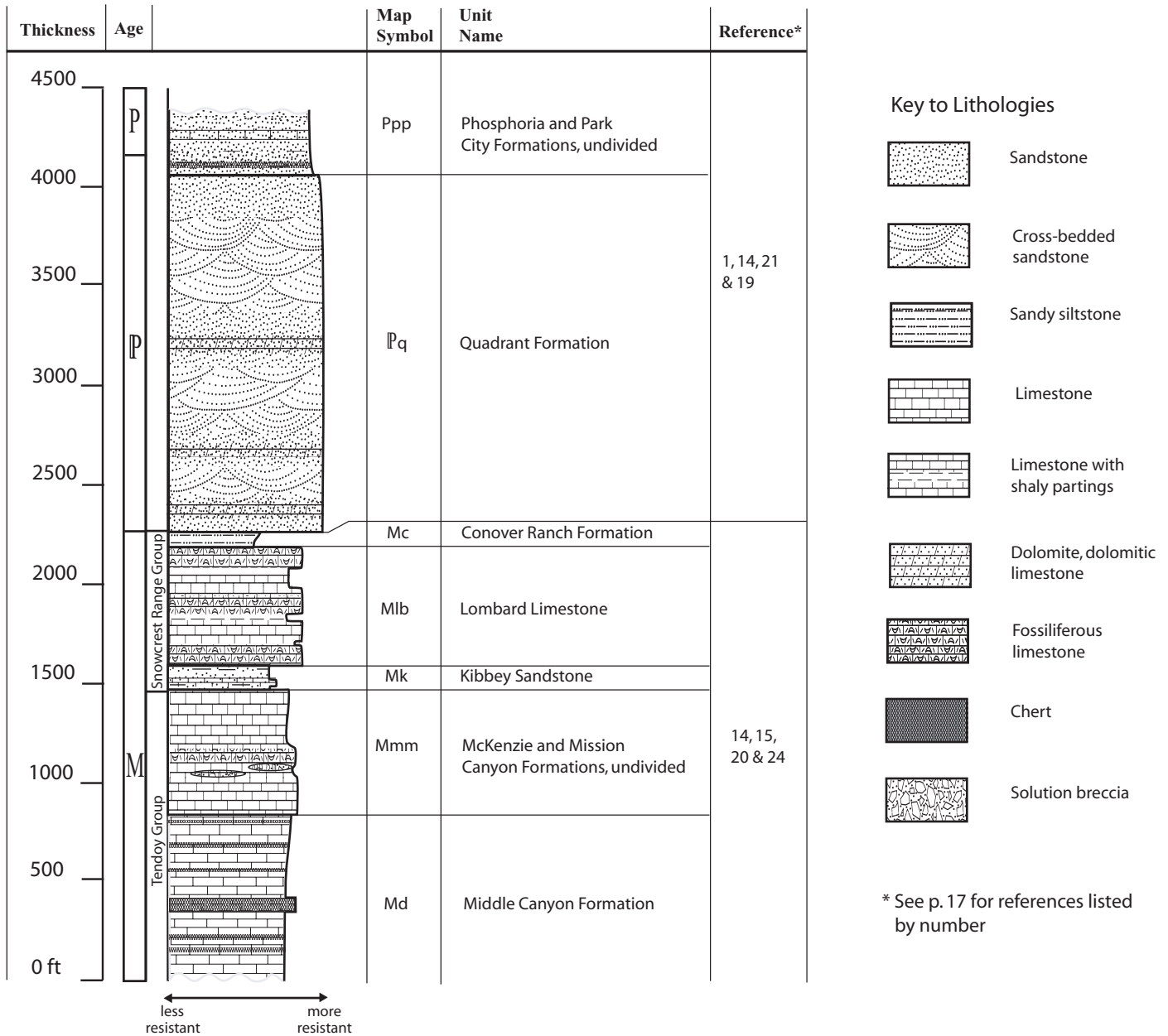


Figure 3. Stratigraphic column of Paleozoic units mapped within the Red Rock quadrangle. Unit thicknesses represent maximum exposed thicknesses within the quadrangle.

Stratigraphic Column of Cretaceous and Tertiary Units Mapped within the Red Rock 7.5' Quadrangle

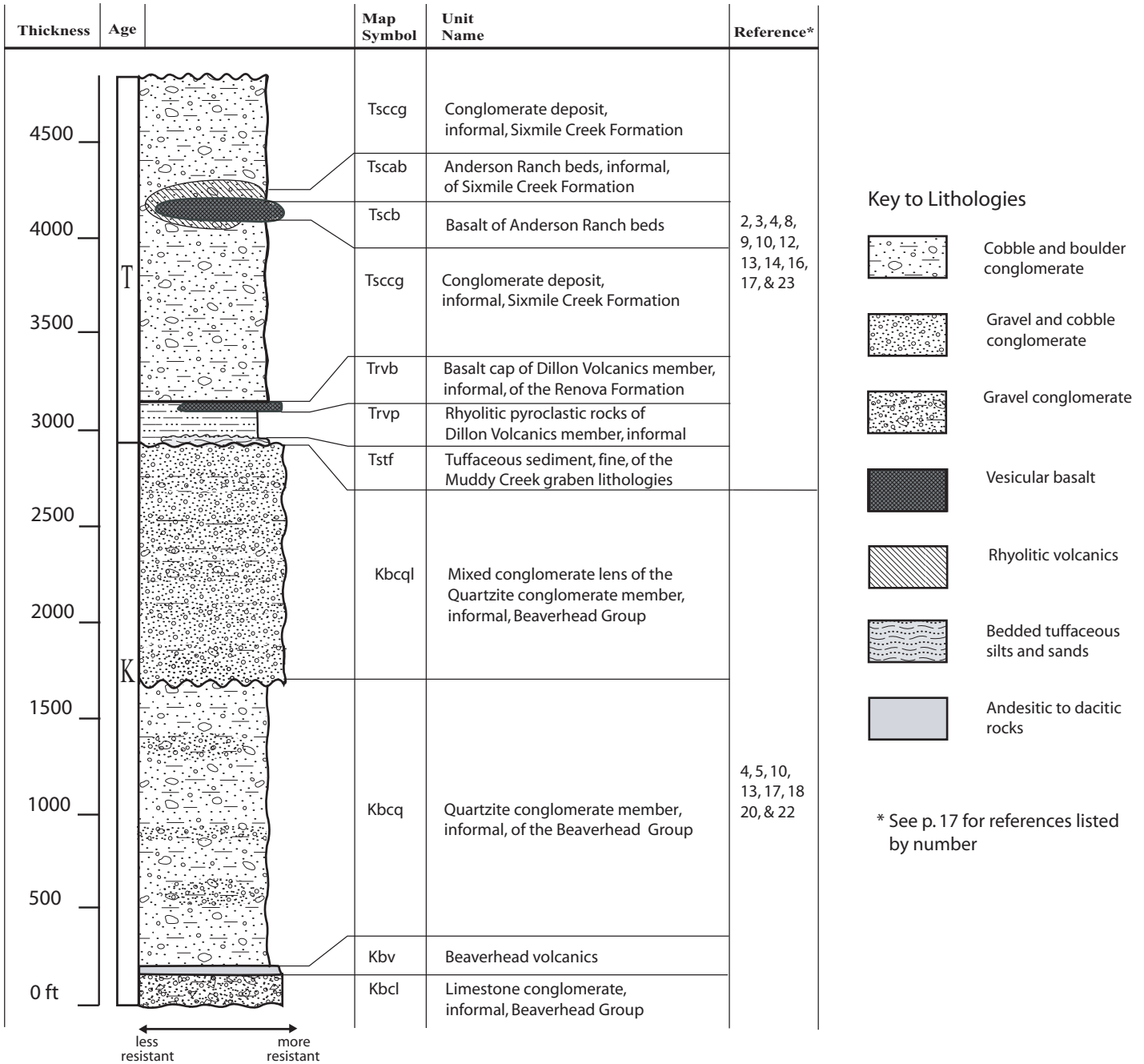
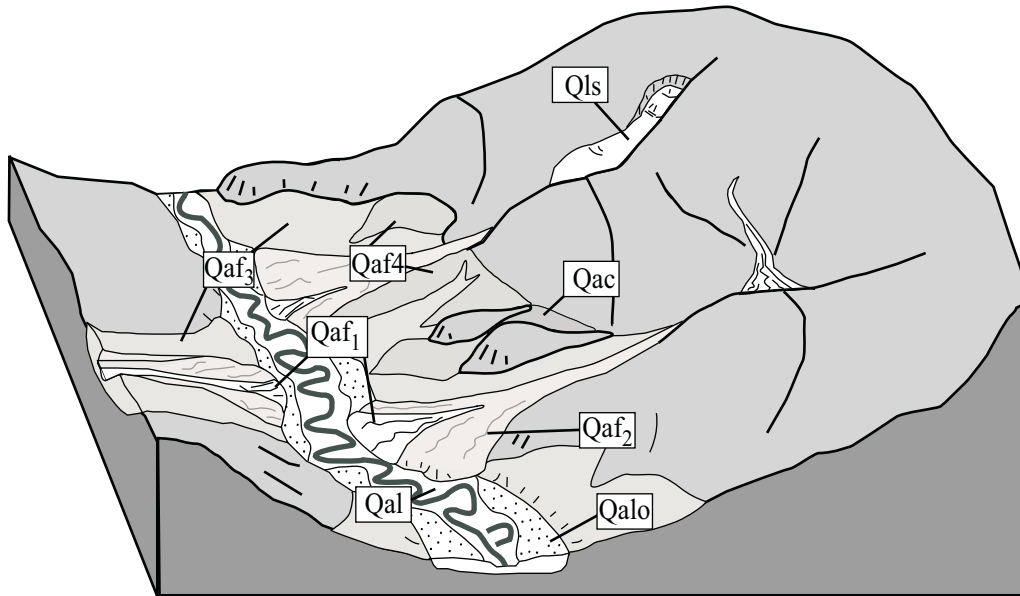


Figure 4. Stratigraphic column of Cretaceous through Tertiary units mapped within the Red Rock quadrangle. Unit thicknesses represent maximum exposed thicknesses within the quadrangle.

Quaternary Stratigraphic Units Mapped within the Red Rock 7.5' Quadrangle



Symbol	Unit name	Age estimate	Reference*
Qal	Alluvium	Late Holocene-Modern	7 & 14
Qalo	Older alluvium	Pleistocene	
Qaf ₁	Youngest alluvial fan and associated terrace deposits	Holocene-Modern	7
Qaf ₂	Second youngest alluvial fan and associated terrace deposits	Latest Pleistocene	
Qaf ₃	Alluvium of third youngest alluvial fan and associated terrace deposits	Late Pleistocene	
Qaf ₄	Alluvium of oldest alluvial fan and associated terrace deposits	Middle Pleistocene (?)	
Qls	Landslide	variable Quaternary	7 & 14
Qac	Alluvium and colluvium	variable Quaternary	

* See p. 17 for references listed by number

Figure 5. Schematic diagram of Quaternary stratigraphic relationships within the Red Rock quadrangle.

In the Red Rock 7.5' quadrangle, the Beaverhead Group (Haley and Perry, 1991, Schmitt and others, 1995) (Fig. 4) is divided into three informal members - a lower limestone conglomerate (Kbcl), an upper quartzite conglomerate (Kbcq), and a middle volcanic unit (Kbv). The Red Rock Hills are dominated by the quartzite conglomerate member, a poorly sorted conglomerate dominated by rounded quartzite cobbles and boulders. The limestone conglomerate member consists of locally derived clasts of Mississippian carbonates and is distinguished from the quartzite conglomerate member by the lack of quartzite clasts.

The Renova Formation is dominated by fine-grained siliciclastics and volcanoclastics with only minor components of conglomerate (Kuenzi and Fields, 1971) and is capped by the Dillon basalt cap (Lonn and others, 2000) (Fig. 4). The Sixmile Creek Formation is dominated by mixed quartzite, limestone, and volcanic-clast conglomerates (Kuenzi and Fields, 1971) with interbedded basaltic lenses and rhyolitic volcanics of the Anderson Ranch Formation (Kreps and others, 1992; Newton and others, 2005). These two units are distinguished in the map area based on the relative abundance of conglomeratic versus volcanic components. In this report, the Anderson Ranch lithologies (Tsca) are considered to be beds within an informal conglomerate member (Tscg) of the Sixmile Creek Formation (Fig. 4).

Quaternary deposits include modern and older river alluvium, alluvium and colluvium, landslide deposits, and four newly identified generations of alluvial fans. The subdivision of Quaternary alluvial fans is based on stratigraphic position, amount of soil carbonate development, surface morphology, degree of bar and swale modification, degree of incision by modern channels, vegetation patterns, and correlation with alluvial fans of known ages on the western side of the Red Rock Valley (Harkins and others, 2005).

Structure

The structures of the Red Rock quadrangle include the Sevier foreland thrusts of the McKenzie thrust system that are overprinted by Tertiary to Quaternary extensional structures. The McKenzie thrust sheet crops out below the Tendoy thrust sheet south of the quadrangle boundary and overlies structures associated with the Armstead thrust sheet near the northwestern quadrangle boundary. The McKenzie sheet extends about three to four miles farther east than the Tendoy sheet and exposes deeper-water equivalents of the Tendoy Group (Sando and others, 1985; Perry and others, 1989; McDowell, 1992). The McKenzie thrust system in the Red Rock quadrangle is an intensely imbricated thrust sheet with a decollement in the Logan Gulch member of the Devonian Three Forks Formation. The trailing edge of the thrust sheet consists of blind and emergent imbricates with a detachment in the Mississippian Kibbey Sandstone (Perry and others, 1989; McDowell, 1992). An exposure of Lombard Limestone on the east side of the Red Rock River indicates that the McKenzie thrust sheet extends across the Red Rock Valley under a cover of alluvium. Within the map area, disharmonic folds are observed in the Lombard Limestone in association with blind thrusts and in the Middle Canyon Formation near its contact with the underlying Middle Canyon Formation.

The Monument Hill fault system is a Tertiary and Quaternary extensional system located in the Red Rock Hills and consists of three recognized fault strands that are either fully

or partially exposed in the Red Rock quadrangle (Fig. 2). The main strand lies at an average elevation of 7,300 ft (2,225 m) in the Red Rock Hills, is approximately 7 miles (11 km) long, and is recognizable in the field and from aerial photos by the presence of faceted spurs, aligned springs, and scarps in alluvium (Scholten and others, 1955). Two smaller strands lie at lower elevations within alluvial fans on the east side of the Red Rock Valley, are 0.5-1.25 miles (1-2 km) long, and are recognizable by aligned springs and scarps in alluvium. All three strands offset the two oldest generations of alluvial fans but do not offset the two youngest generations of fans, indicating a late Pleistocene rupture. Length-scaling relationships that define linear relationships between strike-length of a fault and total displacement suggest an estimated offset of about 1,300 ft (400 m) for the main strand of the Monument Hill fault system.

Acknowledgments

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Age	Scholten and others (1955)		Sando and others (1985); Wardlaw and Pecora (1985)		Lonn and others (2000)			This study *					
Q	Alluvium	Landslides			Alluvium	Alluvial fan deposit	Landslide Deposit	Qal	Qls	Qac	Qaf1		
	Terrace gravels and alluvial fans				Older alluvium	Older alluvial fan deposit		Qao			Qaf2		
T	Clark Canyon basaltic lava flows				Sixmile Creek Formation			Tsccg	<table border="1" style="display: inline-table; vertical-align: middle;"> <tr><td>Tsca</td></tr> <tr><td>Tscab</td></tr> </table>		Tsca	Tscab	Qaf3
	Tsca												
	Tscab												
	Cook Ranch Formation				Basalt cap, Dillon Volcanics member			Trvb				Qaf4	
		Rhyolitic pycroclastic rocks, Dillon Volcanics member			Trvp								
		-----			Tstf								
K	Beaverhead Formation				Quartzite conglomerate, Beaverhead Group			<table border="1" style="display: inline-table; vertical-align: middle;"> <tr><td>Kbcql</td></tr> </table>	Kbcql	Kbcq			
Kbcql													
					Kbv								
					Kbcl								
P	-----				Phosphoria and Park City Formations, undivided			Ppp					
P	Phosphoria Formation	Quadrant Sandstone			Quadrant Sandstone	Pq							
M	Amsden Formation		Snowcrest Range Group		Snowcrest Range Group			Mc					
	Big Snowy Group				Conover Ranch Formation	MIb							
					Lombard Limestone	Mk							
	Madison Group	Mission Canyon Formation	Tendoy Group		McKenzie Canyon Limestone	Tendoy Group			Mmm				
Lodgepole Formation		Mission Canyon Limestone			McKenzie Canyon, Kibbey, Mission Canyon, Middle Canyon, and Paine Formations, undivided	Mission Canyon Formation	Mmd						
		Middle Canyon Formation					-----						
		Paine Limestone					Lodgepole Formation						

* See Figures 3 and 4 for unit names.

Table 2. Stratigraphic correlation of units mapped within the Red Rock quadrangle.

Description of Map Units
Red Rock 7.5' Quadrangle Beaverhead County, Southwestern Montana

Quaternary

- Qal *Alluvium* - unconsolidated, well to poorly sorted fluvial deposits of silt, sand, and gravel in active stream channels and modern floodplain.
- Qao *Older alluvium* - unconsolidated, well to poorly sorted fluvial deposits of silt, sand, and gravel in older floodplain deposits.
- Qls *Landslide deposit* - unconsolidated deposit of poorly sorted, angular, locally derived debris; forms hummocky topography.
- Qaf₁ *Youngest alluvial fan and alluvial channel deposits* - unconsolidated, poorly to moderately sorted silt to cobbles deposited in active fans and alluvial channels; characterized by unmodified bar and swale morphology and supports only sparse sagebrush; incised into older deposits; probable Holocene age.
- Qaf₂ *Second youngest alluvial fan and associated alluvial channel deposit* - unconsolidated, poorly to moderately sorted, silt to cobbles in inactive fans and alluvial channels; characterized by slightly modified bar and swale morphology, stage I+ to II soil carbonate development, and support of abundant grass and sagebrush vegetation; both incises and buries older units; probable latest Pleistocene age.
- Qaf₃ *Alluvium of third youngest alluvial fan and associated alluvial channel deposits* - unconsolidated, poorly to moderately sorted silt to cobbles in inactive fans and alluvial channels; characterized by subdued bar and swale morphology, stage II+ to III soil carbonate development, and support of dominantly grass with little sagebrush; incised into oldest alluvial surface, and occupies a position 5-15 ft (2-5 m) above the modern channel; probable late Pleistocene age.
- Qaf₄ *Alluvium of oldest alluvial fan deposits* - unconsolidated, poorly to moderately sorted silt to cobbles; characterized by a lack of bar and swale morphology, ~1 ft (30 cm) or more of loess, highly weathered cobbles, and stage III to III+ soil carbonate development, and a dominance of grass over sagebrush; incised by younger alluvial surfaces, and occupies a position 30-40 ft (10-12 m) above the modern channel; probable middle Pleistocene age.
- Qac *Alluvial fan and colluvial deposits of unknown age and affinity* - unconsolidated, poorly sorted silt through cobble size deposit which grades into the oldest fan surfaces at high elevations.

Tertiary

Sixmile Creek Formation

- Tsccg *Conglomerate member, informal, of the Sixmile Creek Formation - poorly indurated, poorly to moderately well sorted, clast-supported, pebble to cobble, quartzite conglomerate with rare sandy lenses; lithologies include reworked quartzite and limestone clasts of the Beaverhead Group, and locally derived, sub-angular basaltic and volcanic clasts; interbedded with Anderson Ranch member volcanics; unconformably overlies the Beaverhead Group and Renova Formation; unit is distinguishable from lithologically similar Beaverhead Quartzite conglomerate by the presence of volcanic clasts and by the formation of subdued, rounded topography and orange-red soils; correlated with the Big Hole River and Sweetwater Creek members, informal, of the Sixmile Creek Formation of Fritz and Sears (1993). Maximum exposed thickness 1,700 ft (520 m).*
- Tsca *Anderson Ranch beds of the conglomerate member, informal, Sixmile Creek Formation – light-gray to tan, rhyolitic volcanics occurring as lenses within the conglomerate deposits of the Sixmile Creek Formation; unit is distinguished from the older, Renova Formation, volcanics by its stratigraphic position within Sixmile Creek conglomerates. Maximum exposed thickness 200 ft (60 m).*
- Tscab *Basalt of Anderson Ranch beds of the Sixmile Creek Formation – chocolate-brown to reddish-black, vesicular basalt; where present, forms a cap on top of conglomerate deposits within the Sixmile Creek Formation; distinguished from the older Dillon Basalt member of the Renova Formation by its stratigraphic position within the Sixmile Creek and by a lack of associated volcanoclastics. Anderson Ranch beds were not observed between the basalt and the underlying conglomerate but may occur. Correlates to the Tscb of Newton and others (2005) and may be a time equivalent of the Timber Hill Basalt of Fritz and Sears (1993). Exposed thickness 80 ft (24 m).*

Renova Formation

- Trvb *Basalt cap of Dillon Volcanics member, informal, of the Renova Formation – brown to black, vesicular and amygdaloidal basalts, interbedded basaltic, pebble to cobble agglomerates with hydrothermal veining; distinguished from the younger basalts of the Anderson Ranch member, informal, of the Sixmile Creek Formation by its stratigraphic position below Sixmile Creek Conglomerates, its association with agglomeratic and pyroclastic units, and the presence of hydrothermal mineral precipitation. Maximum exposed thickness 500 ft (152 m).*

- Trvp *Rhyolitic pyroclastic rocks of Dillon Volcanics member, informal, of the Renova Formation* - rhyolitic airfall and pyroclastic flow tuffs, tuffaceous mudstone, and pebble- to cobble-size volcanoclastics associated with the Dillon Basalt cap. Exposed thickness 200 ft (60 m).
- Tstf *Tuffaceous sediment, fine, of the Muddy Creek graben lithologies* – thin- to medium-bedded, buff-colored, tuffaceous silts and sands with quartz and biotite phenocrysts; channel forms preserved; likely derived from fluviially reworked sediments of Muddy Creek graben equivalent volcanics; correlated to the Facies A, ash-flow tuffs of the Challis Volcanics Group of Janecke and others (1999). Exposed thickness ~10 ft (~3m).

Cretaceous

Beaverhead Group

- Kbcq *Quartzite conglomerate member, informal, Beaverhead Group* – poorly indurated, poorly sorted, rounded quartzite cobble and boulder conglomerate in a sandy matrix; clasts are derived from western sources including the Precambrian Belt Supergroup and Ordovician Kinnikinic Formation; includes minor amounts of limestone and volcanics of unknown source. Quartzite conglomerate of Haley and Perry (1991). Maximum exposed thickness 1,500 ft (450 m).
- Kbcql *Mixed conglomerate lens of the Quartzite conglomerate member* - moderately well indurated, moderately well sorted, clast-supported, sand to cobble size, quartzite and limestone conglomerate; interbedded gravel beds and sandy lenses; contained within the Quartzite conglomerate of the Beaverhead Group. Maximum exposed thickness 1,250 ft (380 m).
- Kbv *Beaverhead volcanics* - gray to blue-green, andesitic to dacitic rocks of uncertain age; found between the limestone and quartzite conglomerates of the Beaverhead Group; may correlate to a member of the Cold Springs Creek volcanics (Schmitt and others, 1995; Ivy, 1989). Maximum exposed thickness 40 ft (12 m).
- Kbcl *Limestone conglomerate, informal, Beaverhead Group* – well indurated, moderately to well sorted, clast-supported, sub-angular to sub-rounded, limestone pebble and gravel conglomerate in a sandy carbonate matrix; clasts derived from various Mississippian carbonate units exposed in thrust sheets to the west; unconformably overlies Mississippian carbonates. Only upper 175 ft (50 m) exposed.

Permian

- Ppp *Phosphoria and Park City Formations, undivided* – dark-gray weathering, brown phosphatic and calcareous sandstone and mudstone, with gray to black chert and interbedded limestone. Maximum exposed thickness 330 ft (100m).

Pennsylvanian

Pq *Quadrant Formation* – Buff-colored, thick to massively bedded, cross-bedded calcareous sandstone and dolostone; forms prominent cliffs and talus slopes. Exposed thickness ,800 ft (550m).

Mississippian

Snowcrest Range Group: includes Conover Ranch Formation, Lombard Limestone, and Kibbey Sandstone (Sando and others, 1985)

Mc *Conover Ranch Formation* – fine-grained, moderately well sorted, reddish-brown siltstone, and interbedded micritic limestone; poor outcrop due to extensive weathering; 65-100 ft (20-30 m) thick in map area.

Mlb *Lombard Limestone* – medium-gray, thin- to medium-bedded, fossiliferous limestone interbedded with gray, calcareous siltstone; unit is often disharmonically folded. Maximum thickness 590 ft (180 m).

Mk *Kibbey Sandstone* – medium-grained, golden-brown sandstone and siltstone with rare interbedded micrite; poor outcrop due to extensive weathering; often forms a reddish- to yellowish-brown soil. Maximum thickness 190 ft (58 m).

Tendoy Group: includes McKenzie Canyon Formation, Mission Canyon Formation, Middle Canyon Formation, and Paine Limestone (not exposed in map area) (Sando and others, 1985).

Mmm *McKenzie Canyon and Mission Canyon Formations, undivided* – thick- to medium- or thin-bedded, fossiliferous, medium-grained limestone; occasional thin chert interbeds and less abundant chert nodules; solution breccia of the McKenzie Formation rarely present; unit includes the Mission Canyon and McKenzie Canyon Formations of Sando and others (1985) and begins at the first massive gray limestone bed above the chert-rich Middle Canyon Formation. Maximum thickness 650 ft (200m).

Mmd *Middle Canyon Formation* – dark- to medium-gray limestone with abundant chert conformably overlying the Paine Limestone (not exposed in map area); lower member – medium- to dark-gray limestone with ribbon chert; middle member – dark-gray limestone and abundant tabular dark-gray chert; upper member – medium- to dark-gray limestone with ribbon dark-gray and brown chert and recrystallized calcite. Maximum exposed thickness 820 ft (250 m).

Map Symbols for the Red Rock 7.5' Quadrangle



Contact, dashed where inferred



Normal fault, dashed where inferred, dotted where concealed



Thrust fault, dashed where inferred, dotted where concealed



Fault with unknown sense of displacement, dotted where concealed



Anticlinal axial trace, dashed where approximate



Synclinal axial trace, dashed where approximate



Strike and dip of bedding

Key to references for stratigraphic columns

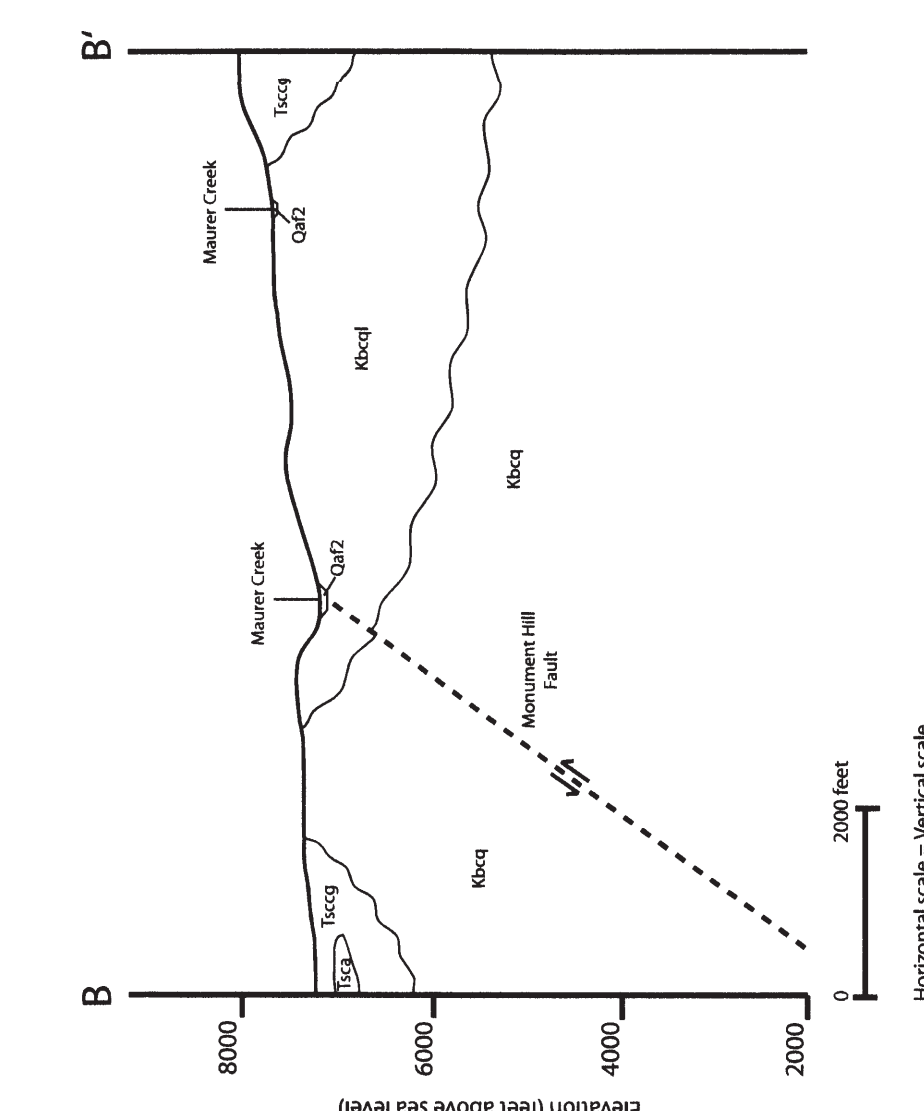
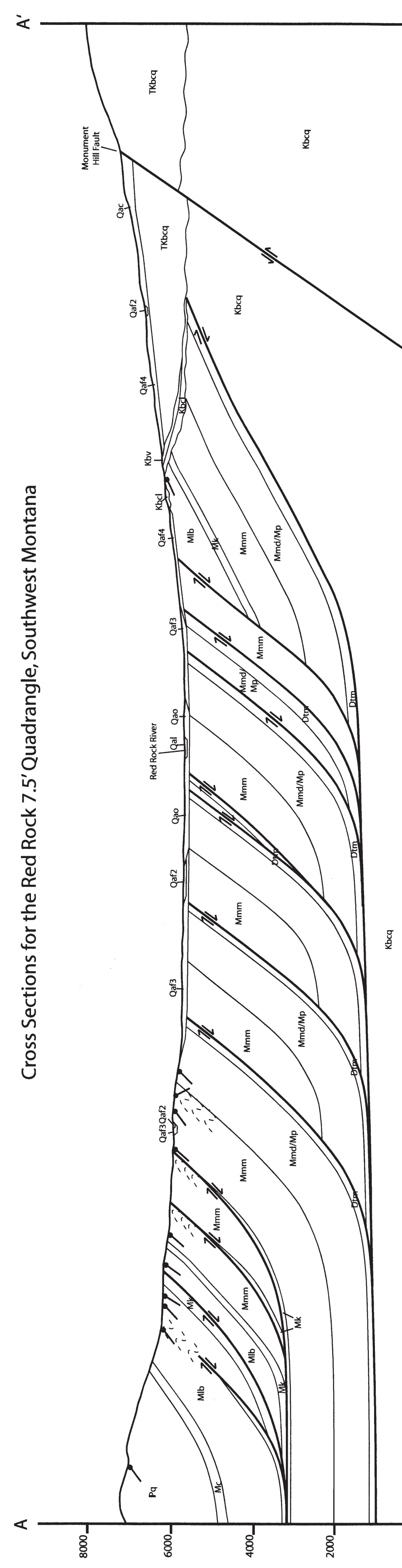
1. Cressman and Swanson, 1964
2. Dunlap, 1982
3. Fritz and Sears, 1993
4. Fields and others, 1985
5. Haley, 1986
6. Haley and Perry, 1991
7. Harkins and others, 2005
8. Harkins and others, 2004b
9. Ivy, 1989
10. Janecke, 1999
11. Janecke and others, 2000
12. Kreps and others, 1992
13. Kuenzi and Fields, 1971
14. Lonn and others, 2000
15. McDowell, 1992
16. McDowell and Fritz, 1995
17. Newton and others, 2000
18. Ryder and Scholten, 1973
19. Scholten and others, 1955
20. Sando and others, 1985
21. Saperstone, 1986
22. Schmitt and others, 1995
23. Tabrum and others, 1996
24. Wardlaw and Pecora, 1985

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Cross Sections for the Red Rock 7.5' Quadrangle, Southwest Montana

Key to Symbols:

Qal	Alluvium	Qaf	Youngest alluvial fan and fan channel deposits	Qbf	Second youngest alluvial fan and fan channel deposits	Qcf	Alluvium of third youngest alluvial fan and channel deposits	Qdf	Alluvium of oldest fan and associated terrace deposits	Qef	Alluvial fan and colluvial deposits	Qgf	Conglomerate deposit, Simile Creek Formation	Qhf	Anderson Ranch member, Simile Creek Formation	Qif	Mixed conglomerate lens, Quartzite Conglomerate, Beaverhead Group	Qjf	Quartzite conglomerate, Beaverhead Group	Qkf	Beaverhead volcanics	Qlf	Limestone conglomerate, Beaverhead Group	Qmf	Beaverhead Group, undivided	Qnf	Quadrant Formation	Qof	Conover Ranch Formation	Qpf	Lombard Limestone	Qqf	Kibbey Sandstone	Qrf	McKenzie and Mission Canyon Formations	Qsf	Middle Canyon Formation	Qtf	Paine Limestone	Quf	Three Forks—Maywood Formations, und.
Qob	Older Alluvium	Qo1	Youngest alluvial fan and fan channel deposits	Qo2	Second youngest alluvial fan and fan channel deposits	Qo3	Alluvium of third youngest alluvial fan and channel deposits	Qo4	Alluvium of oldest fan and associated terrace deposits	Qoc	Alluvial fan and colluvial deposits	Qog	Conglomerate deposit, Simile Creek Formation	Qoh	Anderson Ranch member, Simile Creek Formation	Qoi	Mixed conglomerate lens, Quartzite Conglomerate, Beaverhead Group	Qoj	Quartzite conglomerate, Beaverhead Group	Qok	Beaverhead volcanics	Qol	Limestone conglomerate, Beaverhead Group	Qom	Beaverhead Group, undivided	Qon	Quadrant Formation	Qoo	Conover Ranch Formation	Qop	Lombard Limestone	Qoq	Kibbey Sandstone	Qor	McKenzie and Mission Canyon Formations	Qos	Middle Canyon Formation	Qot	Paine Limestone	Qou	Three Forks—Maywood Formations, und.

Map Symbols

- Contact, dashed where inferred
- Normal fault, dashed where inferred, dotted where concealed
- Thrust fault, dashed where inferred, dotted where concealed
- Fault with unknown sense of displacement, dotted where concealed
- Anticlinal axial trace, dashed where approximate
- Synclinal axial trace, dashed where approximate
- Strike and dip of bedding

Mapped, edited, and published by the Geological Survey
Base from U.S. Geological Survey
Red Rock 7.5' topographic quadrangle
Map date: 1965; Photorevised 1979
Projection: Polyconic
UTM zone 12; 1927 NAD

SCALE 1:24,000

CONTOUR INTERVAL 40 FEET
DOTTED LINES REPRESENT 20-FOOT CONTOURS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

UTM GRID AND 1979 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET

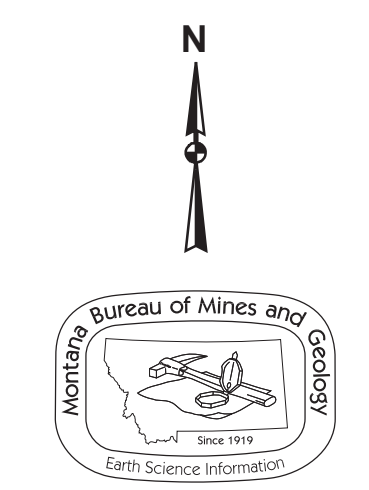
MBMG Open File 533
Bedrock and Surficial Geologic Map of the
Red Rock 7.5' Quadrangle, Beaverhead
County, Southwest Montana

mapped and compiled by
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David J. Anastasio, and Frank J. Pazzaglia

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