# BEDROCK AND SURFICIAL GEOLOGIC MAP OF THE KIDD 7.5' QUADRANGLE, BEAVERHEAD COUNTY, SOUTHWEST MONTANA


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## Introduction

The Kidd 7.5' quadrangle covers an area that includes part of the northern Tendoy Mountains and Red Rock Valley in Beaverhead County, southwest Montana (Fig. 1). The structure and stratigraphy of the Kidd quadrangle are complex, exhibiting the effects of multiple tectonic events. Sevier-style deformation of Paleozoic rocks is present in the northwestern part of the quadrangle (e.g. Perry and others, 1985; McDowell, 1992). Synorogenic conglomerate shed from growing Laramide- and Sevier-style uplifts is exposed in the southern and northeastern parts of the quadrangle (e.g. Haley, 1986). Challis Volcanics Group rocks and Tertiary strata exposed in the southwestern-most part of the quadrangle are part of a supradetachment basin that formed due to gravitational collapse of the Sevier fold-thrust belt (Janecke, 1994; Janecke and others, 1999). Conglomerates and isolated basalt outcrops in the north-central part of the quadrangle were probably deposited in a Pliocene-Miocene extensional paleovalley sourced to the southwest in the modern Snake River Plain (Fritz and Sears, 1993; Sears and Fritz, 1998). And finally, Quaternary alluvial fans and modern fluvial deposits in the eastern half of the quadrangle record modern Basin and Range-style extension. Previously published mapping within the Kidd quadrangle is shown in Figure 2.

## Structure and Stratigraphy

The major northeast-dipping range-front normal fault on the eastern flank of the Tendoy Mountains is the Red Rock fault, which has been active since at least the latest Pleistocene (Stickney and others, 1987; Harkins and others, 2005). Regionally, the Red Rock fault is one of numerous active normal faults in the Centennial Tectonic Belt, an arm of the Intermountain Seismic Belt near the northeastern margin of the Basin and Range province that extends from Yellowstone, westward along the northern margin of the Snake River Plain. The Red Rock fault extends south of the map area where displacement increases (Harkins and others, 2005). The fault trace is obscured at McKnight Canyon, north of which the presence of the fault is questionable and drawn based on change in topographic slope. At the strike-position of McKnight Canyon in the Red Rock Valley, some northeast-southwest extensional strain is probably transferred from the Red Rock fault eastward to the southern extension of the Monument Hill fault system along a relay structure, based in part on study of the 1999 5.3 $m_b$ earthquake that had an epicenter located near the town of Kidd (Stickney and Lageson, 2002). This relay structure was proposed by Stickney and Lageson (2002) to be a south-southwest-dipping normal fault at depth in the footwall block of the Red Rock fault, representing a structural crossover zone at the surface between the Red Rock and Monument Hill fault systems. Stickney and Lageson (2002) suggest their proposition to be supported by the following: (1) fault-plane solutions of the 1999 earthquake; (2) the change in geomorphic character of the Red Rock Valley floor at the strike-position of the town of Kidd; (3) the change in structural expression of the Red Rock Valley north and south of the 1999 epicentral area; (4) a moment tensor solution consistent with a significant component of graben-parallel extension; and (5) the pre-existence of a regional, deep-rooted, right-stepping system of transfer faults associated with the southwest-plunging flank of the ancestral Blacktail-Snowcrest foreland uplift (see Skipp, 1988).

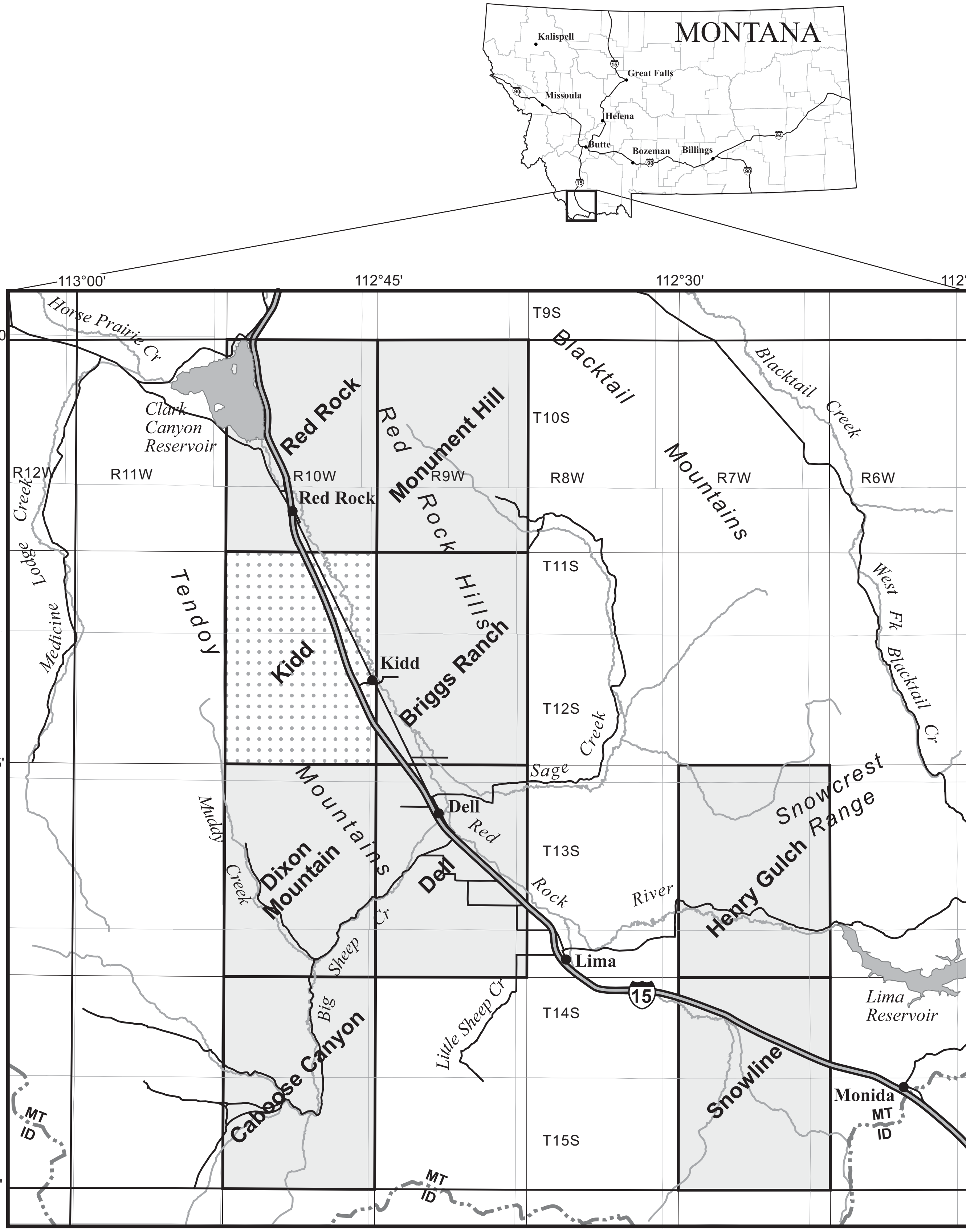


Figure 1. Location map for Kidd 7.5' quadrangle, showing relationship to other completed or in-progress quadrangle maps in the area. See web site (www.mbmg.mtech.edu) for status of maps.

Alluvial fans flank the Red Rock Valley and are sourced in the actively uplifting footwall blocks of the Red Rock and Monument Hill fault systems. Four fan deposits are mapped, each defined by an allostratigraphic package of poorly sorted and stratified gravel and sand with variably distinct surface and soil morphologic characteristics. Fan deposition and subsequent surface stabilization occurs in response to major changes in catchment hydrology driven by glacial-interglacial-scale climate changes (Ritter and others, 1993; Harkins and others, 2005). In southwestern Montana, large fans are known to aggrade during glacial periods, followed by incision and surface stabilization in the ensuing interglacial periods. Locally, small fans sourcing an easily erodible substrate continue to aggrade in the Holocene, but these deposits have a poor preservation potential. Fan-surface morphology, stratigraphic offset between units, and the amount of pedogenic carbonate in fan soils suggest that the four mapped fan deposits correspond temporally, from oldest to youngest, to pre-Bull Lake glaciation (Qaf1), Bull Lake glaciation (Qaf2; ~140 ka), Pinedale glaciation to early Holocene climate change (Qaf3; 10-20 ka), and middle Holocene fan deposition (Qaf4, ~3-4 ka). The ages of Qaf3 and Qaf4 are supported by limited carbon-14 numeric ages (Harkins and others, 2005).

Extension along the Red Rock fault system overprints significant Sevier-style structural deformation in the western part of the map area. The Tendoy Mountains reside at the frontal part of the Cordilleran fold-thrust belt, and the Kidd quadrangle encloses parts of two frontal thrust sheets that are characterized by different structural styles and detachment horizons. North of Limekiln Canyon is the so-called McKenzie thrust system (Perry and others, 1985), a series of closely spaced, west-dipping, imbricate thrust faults in Lower Mississippian Tendoy Group limestones and Upper Mississippian Snowcrest Range Group clastic and carbonate rocks. The basal detachment of the McKenzie thrust sheet is probably the Devonian Three Forks Formation (Perry and Hossack, 1984). Structurally, the McKenzie thrust system has been interpreted to be a leading imbricate fan (after Boyer and Elliot, 1982; McDowell, 1992) and a series of two, stacked, thrust duplexes with horses bound between the Three Forks (Devonian), Kibbey (Mississippian), and Conover Ranch (Mississippian) formations (Perry and others, 1985).

A lateral ramp marks the southern end of the McKenzie thrust system near Limekiln Canyon, where the basal detachment climbs from the Devonian Three Forks Formation to the level of the Mississippian Lombard Limestone (McDowell, 1992). South of this lateral ramp, the frontal thrust sheet is termed the Tendoy sheet and there is a change in structural style in favor of large, overturned folds and out-of-sequence thrusting in the Snowcrest Range Group and Pennsylvanian-Permian rocks (Perry and others, 1988; McDowell, 1992, 1997). Additionally, there is a recess in the frontal (Tendoy) thrust centered at McKnight Canyon providing a structural window that exposes synorogenic Beaverhead conglomerate.

At the southern margin of the McKenzie thrust system, faults trend at a high angle to the regional transport direction and some small-scale folds in Mississippian limestones have been mapped (McDowell, 1992). Although these transverse structures are coincident with a lateral ramp where the basal detachment climbs from Devonian to Upper Mississippian rocks (McDowell, 1992), many workers (e.g. Perry and others, 1988; Williams and Bartley, 1988; McDowell, 1992, 1998) have attributed them to interaction of eastward migrating thrust sheets with pre-existing, northeast-trending foreland structures; frontal thrust sheets of the Tendoy Mountains are thought to have been emplaced from mid-Campanian to Early Paleocene (Nichols and others, 1985; Perry and others, 1988), while palynological dating of synorogenic conglomerates indicates that the adjacent, northeast-trending, Blacktail-Snowcrest foreland uplift was largely emplaced before north-northwest-trending Sevier-style thrusting (Dyman, 1985; Nichols and others, 1985).

The southwestern corner of the map area is intersected by the Muddy Creek fault system, a series of *en echelon*, left-stepping normal faults that border the Muddy Creek half graben, which formed as a supradetachment basin in late middle Eocene to early Oligocene time at the breakaway of a regional, west-southwest-dipping detachment system (Janecke, 1994; Janecke and others, 1999). Deposits of the Muddy Creek half graben exposed in the Kidd quadrangle include pre- to early rift volcanic rocks of the Challis Volcanics Group, syn-rift tuffaceous shale, and syn-rift conglomerate that contains clasts of recycled Beaverhead Formation from the adjacent footwall to the east and reworked Challis volcanic rocks (Janecke and others, 1999). An isolated mound of Challis volcanic rocks is also exposed in the Red Rock Valley east of the Red Rock normal fault.

In the north-central part of the map area, just east of exposures of the McKenzie thrust system, a Pliocene(?)-Miocene(?) gravel and conglomerate of unknown affinity has previously been mapped (unit Tgr; Lonn and others, 2000). This unit, as well as newly mapped, isolated outcrops of basalt in the central part of the map area, is hypothesized to be correlative with the Sixmile Creek Formation (Monroe, 1976; Fritz and Sears, 1993), which is locally interpreted to have been deposited from mid-Miocene through Pliocene time in a northeast-trending, extensional graben and associated paleovalley (Fritz and Sears, 1993; Sears and Fritz, 1998). If so, this unit may have been sourced in part by a region presently coincident with the Snake River Plain that was previously uplifted by passage of the Yellowstone hotspot (Fritz and Sears, 1993). The modern, northwest-trending Red Rock Valley and associated bounding faults probably formed (or were reactivated) as the regional Basin and Range stress regime was modified by crustal adjustments that accommodated passage of the Yellowstone hotspot (Pierce and Morgan, 1992).

## Comparison with adjacent 7.5’ quadrangles

During mapping of the Kidd 7.5’ quadrangle, we attempted to maintain conformity of structures and unit contacts near the margins of the Kidd quadrangle with previously mapped and currently being mapped adjacent 7.5’ quadrangles. However, differences in mapping units used and slight differences in placement of unit contacts has resulted in minor differences between this map and adjacent 7.5’ quadrangle maps. Notably, unit Mmm was not used for mapping in the northwestern part of the Kidd quadrangle, while it was used in the McKenzie thrust system in the adjacent Red Rock quadrangle (Regalla and others, 2006); unit Qal was used for all modern Red Rock River floodplain alluvial deposits in the Kidd quadrangle instead of distinguishing older floodplain deposits from younger floodplain deposits and alluvium, as in the adjacent Red Rock (Regalla and others, 2006) and Briggs Ranch (Haley and others, in preparation) quadrangles; unit Ppp (Phosphoria and Park City Formations, undivided) in the Red Rock quadrangle was mapped as Pp (Phosphoria Formation) in the Kidd quadrangle, Paleozoic rocks in the southern part of the Kidd quadrangle near McKnight Canyon were mapped as Mississippian Lombard Formation (Mlb) instead of “Paleozoic sedimentary rocks, undivided (Pzs)” as in the adjacent Dixon Mountain quadrangle (Harkins and others, 2004); and the Beaverhead Group was mapped as a single unit, Kbe, in the Dixon Mountain quadrangle to the south, while we map the same rock unit as the lower (informal) member of the McKnight Canyon sequence of the Beaverhead Group (Kbll). Additionally, alluvial fans east of the Tendoy Range front near the southern margin of the Kidd quadrangle were mapped differently, both in terms of relative age of adjacent fan units and in position of unit contacts, than has been previously mapped in the Dixon Mountain quadrangle (Harkins and others, 2004). On the present map, the authors prefer the designation of a single, large fan surface resting on top of an older fan system based on the distribution of distributary and contributary channel patterns; a distributary channel pattern is only preserved on the younger fan (Qaf2).

**Acknowledgements**

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**Previously published geologic maps within the Kidd 7.5' quadrangle**

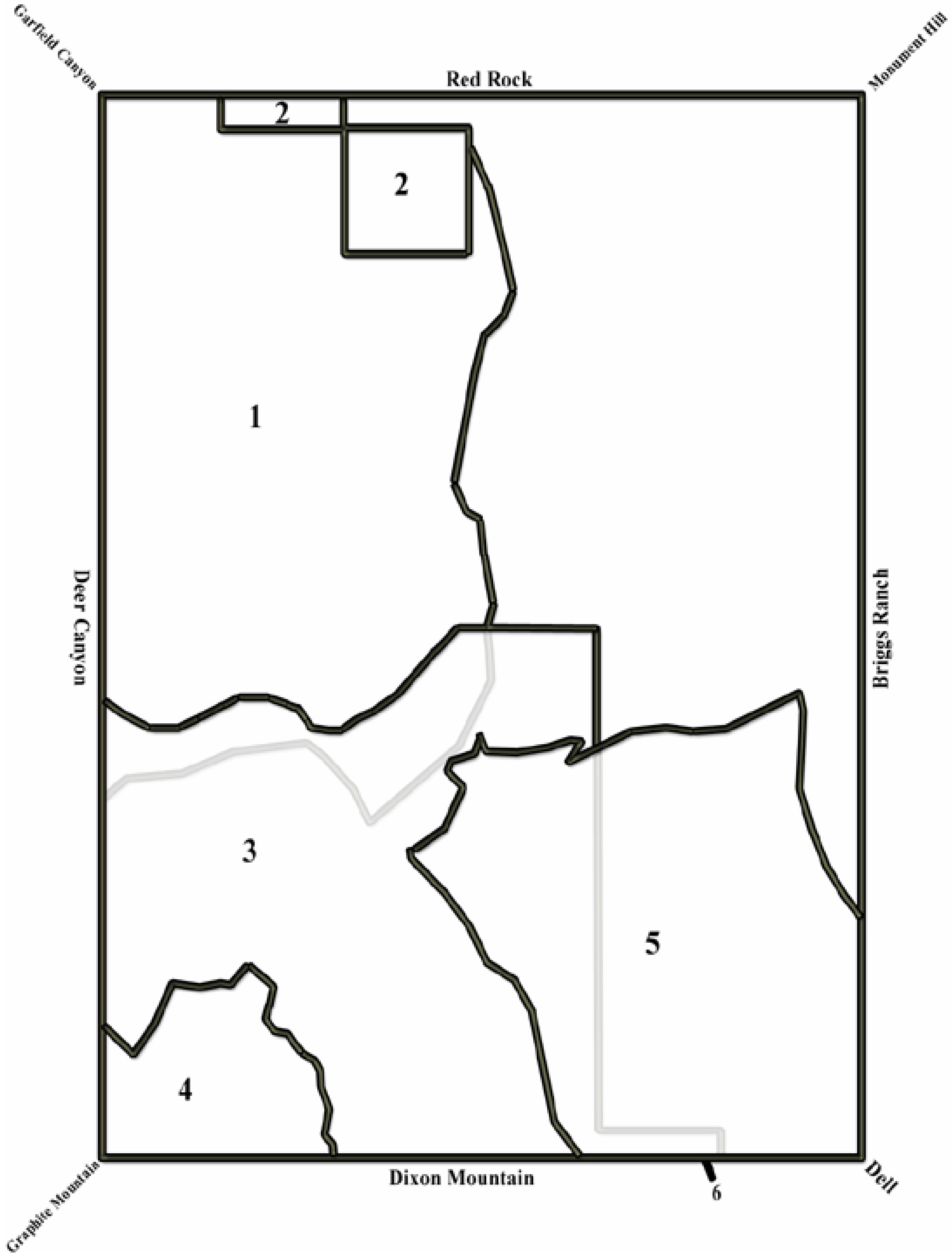
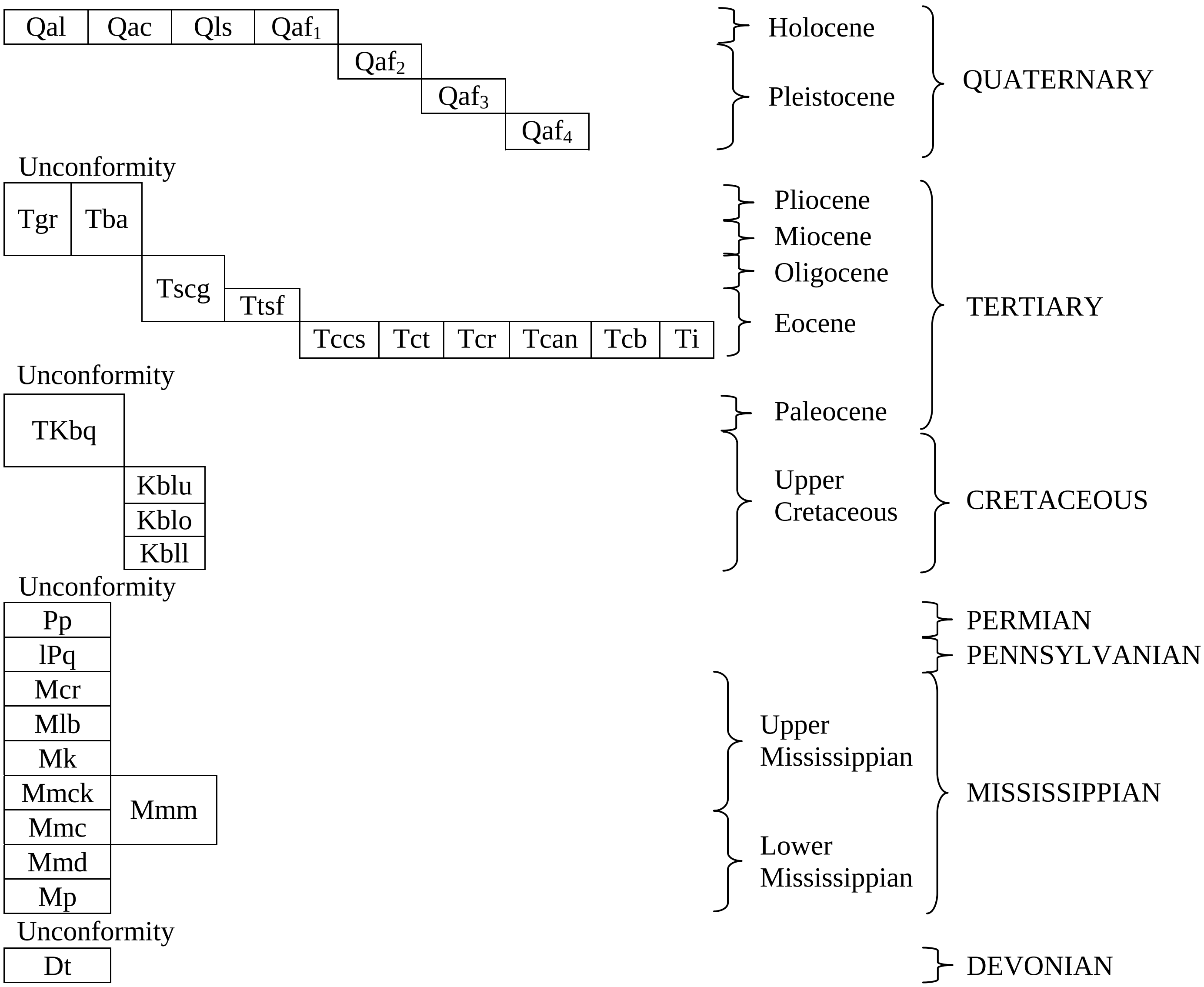



Figure 2. Previously published mapping used for reference during mapping of the Kidd quadrangle. Numbered areas correspond to the following references: (1) McDowell (1992); (2) Sando and others (1985); (3 Williams (1984); (4) Janecke and others (1999); (5) Harkins and others (2005); (6) Lonn and others (2000), whole quadrangle. Names of adjacent quadrangles are also shown.

## Correlation of Map Units for the Kidd 7.5' Quadrangle



## Descriptions of Map Units for the Kidd 7.5' Quadrangle, MT

### QUATERNARY

See discussion of alluvial fans in the section on structure and stratigraphy. The amount of surface dissection and the stratigraphic level of inset units generally increase with older, topographically higher fans, a pattern illustrated well in the northeastern part of the map area. Along the Tendoy Range front near the mouths of Limekiln and Kelmbeck canyons, an area was mapped as Lombard Formation (Mlb), but some exposures appear to be complexly pedimented surfaces that have unknown relationships with adjacent Quaternary alluvial fans.

Qal *Alluvium (Holocene)*: Unconsolidated, sorted to poorly sorted deposit of fluvial silt, sand, and gravel, in and at grade with modern streams and channels; this unit underlies the floor of the Red Rock Valley; deposits in channels feeding presently developing alluvial fans are technically Holocene alluvium (Qal) but they were mapped as Qaf1 to keep the Qaf1 fan system intact and more clearly show the relationship of Qaf1 to other Quaternary fan systems.

$Qaf_1$ *Youngest alluvial fan and alluvial channel system deposit (~3-4 ka)*: Unconsolidated gravel, sand, and mud; well-defined bar-and-swale surface morphology; forms fan-shaped deposit at the Tendoy Range front and where streams spill onto the Red Rock River floodplain; thin, discontinuous pebble coatings of pedogenic carbonate observed in stream- and road-cuts; unit includes alluvial deposits in fan "feeder" channels.

$Qaf_2$ *Second youngest alluvial fan deposit (10-20 ka)*: Unconsolidated gravel, sand, and mud; poorly defined bar-and-swale surface morphology; continuous pebble coatings of pedogenic carbonate observed in stream- and road-cuts; units inset into channels are stratigraphically higher than $Qaf_1$ and lower than $Qaf_3$.

$Qaf_3$ *Third youngest* alluvial *fan deposit (~140 ka)*: Unconsolidated gravel, sand, and mud; no bar-and-swale surface morphology, but some cobbles and boulders may be present on the surface; units inset into channels are stratigraphically higher than $Qaf_2$ and lower than $Qaf_4$; small degree of surface dissection relative to $Qaf_4$; dissection most pronounced closest to the modern Red Rock River floodplain; coalesced pebble coatings of pedogenic carbonate observed in stream- and road-cuts.

$Qaf_4$ *Fourth youngest (oldest) alluvial fan deposit (>140 ka)*: Unconsolidated gravel, sand, and mud; coalesced pebble coatings of pedogenic carbonate observed in stream- and road-cuts; more pervasively dissected and inset units stratigraphically higher than $Qaf_3$; generally no cobbles and boulders present on the surface.

Qac Alluvium and *Colluvium (Holocene and Pleistocene)*: Unconsolidated hillslope deposits of gravel, sand, and mud.

Qls *Landslide deposit (Holocene and Pleistocene)*: Unconsolidated deposit of angular boulders of Pennsylvanian Quadrant Sandstone that forms hummocks at the base of Timber Butte.

## TERTIARY

Tertiary units exposed in the southwestern part of the map area have been described by Janecke and others (1999) and Dunlap (1982).

Tba *Basalt (Pliocene(?) and/or Miocene(?)*: black to dark-brown, aphanitic, variably vesicular basalt flow.

Tgr *Gravel and conglomerate of uncertain affinities (Pliocene(?) and/or Miocene?)*: Matrix- to clast-supported, pebble to cobble conglomerate; limestone clasts dominate, with approximately 15% sandstone, quartzite, and other types of clasts; poorly sorted, whitish, sand to granule matrix; crudely stratified in places; exhibits a distinctive rolling topography with gray-colored surfaces in the north-central part of the map area; limited exposures often resemble limestone-clast conglomerate of the Beaverhead Group in McKnight Canyon.

Tscg *Conglomerate and sandstone (Oligocene(?) and Eocene)*: Poorly sorted, pebble to boulder, matrix- to clast-supported conglomerate; clasts predominantly limestone; occasional well-rounded quartzite clasts; minor subrounded, fine-grained, tan-white clasts of friable volcanic rocks.

Ttsf *Tuffaceous shale (Eocene)*: Whitish, poorly exposed, loosely consolidated, tuffaceous shale, mudstone, and siltstone.

Tccs *Conglomerate and sandstone of Challis Volcanics Group (Eocene)*: Well-rounded to angular, poorly exposed, clast-supported and partially matrix-supported, pebble to boulder conglomerate with minor sandstone interbeds; multiple types of volcanic clasts present in the conglomerate.

Tct *Tuff of Challis Volcanics Group (Eocene)*: Densely welded, white to tan-gray tuff with abundant quartz and sanidine phenocrysts 0.2-1.0 cm in length.

Tcr *Rhyolite of Challis Volcanics Group (Eocene)*: Whitish to gray-pink, porphyritic volcanic rock; hard and indurated; exhibits multiple fracture sets; subhedral sanidine phenocrysts; approximately 1-5 mm across and minor muscovite phenocrysts.

Tcan *Andesite of Challis Volcanics Group (Eocene)*: Aphanitic, red to red-brown, variably vesicular andesite; some occurs as amalgamated breccia; locally intermixed with inclusions and fingers of a very fine-grained, aphanitic, gray-black basalt.

Tcb *Basalt of Challis Volcanics Group (Eocene)*: Black to dark-brown, aphanitic, variably vesicular basalt.

Ti *Intrusive rocks (Pliocene(?) through Eocene(?))*: Black, highly weathered, mafic to intermediate, poorly exposed dike or sill exposed within Kblo; plagioclase phenocrysts abundant; minor inclusions of black to brown, well-rounded pebbles of sedimentary rock; 65-130 ft (20-40 m) thick.

**TERTIARY AND CRETACEOUS**

The quartzite conglomerate in the northeastern part of the map area has been described by Ryder (1968), Haley (1986), and others.

TKbq *Quartzite conglomerate, informal member, Beaverhead Group (Tertiary and Upper Cretaceous)*: Cobble to boulder conglomerate with well-rounded clasts of predominantly pink quartzite and light-green argillite.

**CRETACEOUS**

Conglomerates in the McKnight Canyon area constitute the type section of the originally defined Beaverhead Formation (Lowell and Klepper, 1953) and have subsequently been described and studied by Wilson, (1967, 1970), Ryder (1968), Ryder and Scholten (1973), Haley (1986), Perry and others (1988), and Corner (1992). The Beaverhead Formation was elevated to group rank by Nichols and others (1985). Stratigraphic nomenclature purposed for the Beaverhead Group by Haley and Perry (1991) is used in this report, so the quartzite conglomerate and the conglomerates in the McKnight Canyon area are all informal members of the Beaverhead Group.

Kblu *Upper limestone conglomerate, informal member, Beaverhead Group (Upper Cretaceous)*: Reddish-brown, primarily clast-supported, limestone-clast, pebble to boulder conglomerate with minor interbedded sandstone and siltstone; locally more matrix-supported and larger clast sizes than lower limestone conglomerate member; some 2- to 6-foot-thick horizons near the base of the member are dominated by 90-95%, well-rounded, quartzite and argillite clasts (Corner, 1992); 5,336 ft (1,626 m) thick (Corner, 1992).

Kblo *Oncoid limestone, sandstone, and siltstone, informal member, Beaverhead Group (Upper Cretaceous)*: Massive to thick-bedded, light-gray wackestone, packstone, and oncolitic grainstone in lower part, grading upward into interbedded siltstone and sandstone; 1,857 ft (566 m) thick (Corner, 1992).

Kbll *Lower limestone conglomerate, informal member, Beaverhead Group (Upper Cretaceous)*: Reddish-brown, predominantly clast-supported, limestone-clast, pebble to boulder conglomerate with occasional interbeds of sandstone and siltstone; scour-and-fill structures and imbricated clasts common; 3,820 ft (1,164 m) thick (Corner, 1992).

## PERMIAN

Pp *Phosphoria Formation*: Gray to yellowish-brown, fine-grained, salt-and-pepper sandstone with occasional interbeds of chert, dolomite, and dark-gray, phosphatic mudstone; approximately 490 ft (150 m) thick.

## PENNSYLVANIAN

lPq *Quadrant Formation*: Tan to whitish, clean, hard, cross-bedded sandstone and orthoquartzite; dolomitic in lower part; ridge-former; approximately 720 ft (220 m) thick.

## MISSISSIPPIAN

### Snowcrest Range Group

The Snowcrest Range Group was defined by Wardlaw and Pecora (1985) and includes Upper Mississippian rocks equivalent to the Big Snowy Group and the Amsden Group in central Montana, the Big Snowy Group and the Amsden Formation in southwest Montana, and the Scott Peak, South Creek, and Surrett Canyon Formations in the Lemhi Range and Beaverhead Mountains to the west of the Tendoy Mountains (McDowell, 1992).

Mcr *Conover Ranch Formation*: Red siltstone and mudstone; forms a topographic swale between adjacent, more resistant units; 65-130 ft (20-40 m) thick.

Mlb *Lombard Formation*: Light- to dark-gray, thin- to thick-bedded micrite and fossiliferous wackestone and packstone; shaly interbeds and disharmonic deformation very common; brachiopods, conodonts, and oncolites common; approximately 330-650 ft (100-200 m) thick; significant tectonic thickening and deformation in the southern part of the map area.

Mk *Kibbey Formation*: Yellowish siltstone, sandstone, and mudstone; very poorly exposed; forms topographic swale between adjacent limestone units; approximately 195 ft (60 m) thick.

### Tendoy Group

Lower Mississippian units exposed in the McKenzie thrust system (northern part of the Kidd quadrangle) are apparently more extensive than elsewhere in southwest Montana, and units regionally included in the Madison Group are instead defined here to be part of the Tendoy Group (Sando and others, 1985). Lower Mississippian rocks are unique in this area because they represent a continuous sequence of craton-margin carbonate deposition that extends stratigraphically above the Mission Canyon Formation (Sando and others, 1985). Elsewhere, the Mission Canyon Formation is observed to be bounded above by a regional unconformity beneath the overlying Snowcrest Range Group. The type section of the Tendoy Group is 2,657 ft (810 m) thick as measured at Bell Canyon and the Bell Canyon-McKenzie Canyon divide (northern part of Kidd quadrangle; Sando and others, 1985). Thicknesses stated in descriptions below are from Sando and others (1985) and should be thought of as maximum thicknesses; thicknesses vary greatly in the map area due to the highly imbricated nature of the McKenzie thrust system.

Mmck *McKenzie Canyon Formation*: Light- to dark-gray, thin- to medium-bedded, partly cherty micrite; minor crinoidal wackestone; variably thick evaporite solution breccia near top of unit; fenestral structures abundant; often difficult to differentiate from underlying Mission Canyon Formation; 460 ft (140 m) thick (Sando and others, 1985).

Mmc *Mission Canyon Formation*: Light-gray, generally thick-bedded, crinoidal wackestone; partly cherty; contact with underlying Middle Canyon Formation is usually associated with a slight break in slope; 578 ft (176 m) thick (Sando and others, 1985).

Mmm *McKenzie Canyon and Mission Canyon Formations, undivided*: This unit encompasses the rugged, densely forested, and poorly exposed south side of Limekiln Canyon.

Mmd *Middle Canyon Formation*: Dark-gray, thin- to medium-bedded, largely recrystallized, silty micrite; very cherty, especially in middle part; contains chert ribbons and nodules; generally distinguished in the field based on high relative abundance of chert and more thinly-bedded nature than Mission Canyon Limestone; 873 ft (266 m) thick (Sando and others, 1985).

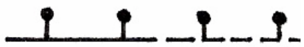
Mp *Paine Formation*: Thin-bedded, dark-gray, silty micrite; shaly partings common; rare conodonts and crinoids; may exhibit disharmonic deformation; commonly crops out as fins of limestone poking up through yellow-brown, shaly interbeds, especially in southern part of McKenzie thrust system; 748 ft (228 m) thick (Sando and others, 1985); equivalent to the Paine Member of the Lodgepole Limestone elsewhere in Montana.

**DEVONIAN**

Dt *Three Forks Formation*: Orange, yellow, and red siltstone and mudstone; minor brachiopod and crinoidal wackestone; approximately 197 ft (60 m) thick.

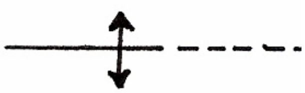
## Map Symbols


Contact; dashed where approximate, dotted where concealed.


Normal fault; dashed where approximate, dotted where concealed. Barbs on downthrown block.


Detachment fault; dashed where approximate, dotted where concealed. Half-circles on downthrown block.


Thrust fault; dashed where approximate, dotted where concealed. Teeth on upthrown block.


Anticline; dashed where approximate, dotted where concealed.


Syncline; dashed where approximate, dotted where concealed.


Overturned syncline; dashed where approximate, dotted where concealed.

Strike and dip of beds

Strike and dip of overturned beds

## Cross Section A-A' and B-B' Units and Symbols

**UNITS**

| | |
|---|---|
| QTaf | Alluvial and fluvial deposits, undivided; includes Qal, Qaf1, Qaf2, Qaf3, Qaf4, and Tgr (Quaternary and Tertiary) |
| Tcb | Basalt of Challis Volcanics Group (Eocene) |
| Tcan | Andesite of Challis Volcanics Group (Eocene) |
| Tcs | Conglomerate and sandstone (Oligocene(?) and Eocene) |
| Tccs | Conglomerate and sandstone of Challis Volcanics Group (Eocene) |

| | |
|---|---|
| TKbq | Quartzite conglomerate, Beaverhead Group (Tertiary and Cretaceous) |
| TKb | Conglomerate, undivided, Beaverhead Group (Tertiary and Cretaceous) |
| Kblu | ‘Upper limestone conglomerate’, Beaverhead Group (Cretaceous) |
| Pp | Phosphoria Formation (Permian) |
| lPq | Quadrant Formation (Pennsylvanian) |
| Mcr | Conover Ranch Formation (Mississippian) |
| Mlb | Lombard Formation (Mississippian) |
| Mmck | McKenzie Canyon Formation (Mississippian) |
| Mmc | Mission Canyon Formation (Mississippian) |
| Mmd | Middle Canyon Formation (Mississippian) |
| Mp | Paine Formation (Mississippian) |
| Dt | Three Forks Formation (Devonian) |
| Po | Older Paleozoic rocks, undivided |

**SYMBOLS**

Contact, formation boundary

Inferred or approximately located contact, formation boundary

Fault, arrows show relative offset

Inferred or approximately located fault, arrows show relative offset

No vertical exaggeration
Datum: mean sea level
West part of B-B’ is constrained by seismic data interpreted by Janecke and others (1999)

## References


Boyer, S.E., and Elliot, D., 1982, Thrust systems: American Association of Petroleum Geologists Bulletin, v. 60, p. 1196-1230.

Corner, H.J., 1992, The stratigraphy and provenance of the Upper Cretaceous Beaverhead Group at McKnight Canyon, southwestern Montana: Pullman, Washington State University, M.S. thesis, 99 p.

Dunlap, D.G., 1982, Tertiary geology of the Muddy Creek Basin, Beaverhead County Montana: Missoula, University of Montana, M.S. thesis, 133 p.

Dyman, T.S., 1985, Measured stratigraphic sections of Lower Cretaceous Blackleaf Formation and lower Upper Cretaceous Frontier Formation (lower part) in Beaverhead and Madison counties, Montana: Pullman, Washington State University, Ph.D. dissertation, 230 p.

Fritz, W.J., and Sears, J.W., 1993, Tectonics of the Yellowstone hotspot wake in southwestern Montana: Geology, v. 21, p. 427-430.

Haley, J.C., 1986, Upper Cretaceous (Beaverhead) synorogenic sediments of the Montana-Idaho thrust belt and adjacent foreland: relationships between sedimentation and tectonism: Baltimore, MD, The Johns Hopkins University, Ph.D. dissertation, 542 p.

Haley, J.C., and Perry, W.J., Jr., 1991, The Red Butte Conglomerate – a thrust-belt-derived conglomerate of the Beaverhead Group, southwestern Montana: U.S. Geological Survey Bulletin 1945, 19 p.

Harkins, N.W., Anastasio, D.J., and Pazzaglia, F.J., 2005, Tectonic geomorphology of the Red Rock fault, insights into segmentation and landscape evolution of a developing range front normal fault: Journal of Structural Geology, v. 27, p. 1925-1937.

Harkins, N.W., Latta, D.K., Anastasio, D.J., Pazzaglia, F.J., 2004, Surficial and bedrock geologic map of the Dixon Mountain 7.5’ quadrangle, southwest Montana: Montana Bureau of Mines and Geology Open File Report 495, scale 1:24,000.

Janecke, S.U., 1994, Sedimentation and paleogeography of an Eocene to Oligocene rift zone, Idaho and Montana: Geological Society of America Bulletin, v. 106, p. 1083-1095.

Janecke, S., McIntosh, W., and Good, S., 1999, Testing models of rift basins: structure and stratigraphy of an Eocene-Oligocene supradetachment basin, Muddy Creek half graben, southwest Montana: Basin Research, v. 11, p. 143-165.

Lonn, J.D., Skipp, B.S., Ruppel, E.T., Janecke, S.U., Perry, W.J., Sears, J.W., Bartholomew, M.J., Stickney, M.C., Fritz, W.J., Hurlow, H.A., and Thomas, R.C., 2000, Geologic map of the Lima 30’ x 60’ quadrangle, southwest Montana: Montana Bureau of Mines and Geology Open-File Report MBMG 408, scale 1:100,000, text 25 p.

Lowell, W.R., and Klepper, M.R., 1953, Beaverhead Formation – A Laramide deposit in Beaverhead County, Montana: Geological Society of America Bulletin, v. 64, p. 235-244.

McDowell, R.J., 1992, Effects of synsedimentary basement tectonics on fold-thrust belt geometry, southwestern Montana: Lexington, University of Kentucky, Ph.D. dissertation, 289 p.

McDowell, R.J., 1997, Evidence for synchronous thin-skinned and basement deformation in the Cordilleran fold-thrust belt: the Tendoy Mountains, southwestern Montana: Journal of Structural Geology, v. 19, p. 77-87.

McDowell, R.J., 1998, Along-strike variations in structural geometry of thrust sheets in the Tendoy Mountains, southwestern Montana: The Mountain Geologist, v. 35, no. 1, p. 31-40.

Monroe, J.S., 1976, Vertebrate paleontology, stratigraphy and sedimentation of the upper Ruby River basin, Madison County, Montana: Missoula, University of Montana, Ph.D. dissertation, 301 p.

Nichols, D.J., Perry, W.J., Jr., and Haley, J.C., 1985, Reinterpretation of the palynology and age of Laramide syntectonic deposits, southwestern Montana, and revision of the Beaverhead Group: Geology, v. 13, p. 149-153.

Perry, W.J., Jr., and Sando, W.J., 1983, Sequence of deformation of Cordilleran thrust belt in Lima, Montana region, *in* Powers, R.B., ed., Geologic studies of the Cordilleran thrust belt: Rocky Mountain Association of Geologists 1982 Symposium, v. 1, p. 137-144.

Perry, W.J., Jr., and Hossack, J.R., 1984, Structure of the frontal zone, southwest Montana sector of Cordilleran thrust belt: Geological Society of America Abstracts with Programs, v. 18, p. 622.

Perry, W.J., Jr., Sando, W.J., and Sandberg, C.A., 1985, Structural geometry of newly defined Blacktail salient of Montana thrust belt and adjacent foreland, southwest Montana: American Association of Petroleum Geologists Bulletin, v. 67, p. 725-743.

Perry, W.J., Jr., Haley, J.C., Nichols, D.J., Hammons, P.M., and Ponton, J.D., 1988, Interaction of Rocky Mountain foreland and Cordilleran thrust belt in Lima region, southwest Montana, *in* Schmidt, C.J., and Perry, W.J., Jr., eds., Interaction of the Rocky Mountain foreland and the Cordilleran thrust belt: Geological Society of America Memoir 171, p. 267-290.

Pierce, K.L., and Morgan, L.A., 1992, The track of the Yellowstone hot spot: volcanism, faulting, and uplift, *in* Link, P.K., Kuntz, M.A., and Platt, L.B., eds., Regional geology of eastern Idaho and western Wyoming: Geological Society of America Memoir 179, p. 1-53.

Regalla, C.A., Reyman, D.K.S., Anastasio, D.J., and Pazzaglia, 2006, Bedrock and surficial geologic map of the Red Rock 7.5' quadrangle, Beaverhead County, southwestern Montana: Montana Bureau of Mines and Geology Open-File Report 533, 20 p., scale 1:24,000.

Ritter, J. B., Miller, J.R., Enzel, Y., Howes, S.D., Nadon, G., Grubb, M.D., Hoover, K.A., Olsen, T., Reneau, S.L, Sacks, D., Summa, C.L., Taylor, I., Touysinhthiphonexay, K.C.N., Yodis, E.G., Schneider, N.P., Ritter, D.F., and Wells, S.G., 1993, Quaternary evolution of Cedar Creek alluvial fan: Montana. Geomorphology, v. 8, p. 287–304.

Ryder, R.T., 1968, The Beaverhead Formation – a late Cretaceous-Paleocene syntectonic deposit in southwestern Montana and east-central Idaho: University Park, Pennsylvania State University, Ph.D. dissertation, 143 p.

Ryder, R.T., and Scholten, R., 1973, Syntectonic conglomerates in southwestern Montana; their nature, origin and tectonic significance: Geological Society of America Bulletin, v. 84, p. 773-796.

Sando, W.J., Sandberg, C.A., and Perry, W.J., Jr., 1985, Revision of Mississippian stratigraphy, northern Tendoy Mountains, southwest Montana: U.S. Geological Survey Bulletin 1651, p. A1-A10.

Sears, J.W., and Fritz, W.J., 1998, Cenozoic tilt domains in southwestern Montana: interference among three generations of extensional fault systems, *in* Faulds, J.E., and Stewart, J.H., eds., Accommodation zones and transfer zones: the regional segmentation of the Basin and Range Province: Geological Society of America Special Paper 323, p. 241-247.

Skipp, B., 1988, Cordilleran thrust belt and faulted foreland in the Beaverhead Mountains, Idaho and Montana, *in* Schmidt, C.J., and Perry, W.J., Jr., eds., Interaction of the Rocky Mountain foreland and the Cordilleran thrust belt: Geological Society of America Memoir 171, p. 237-266.

Stickney, M.C., Bartholomew, M.J., and Wilde, E.M., 1987, Trench logs across the Red Rock, Blacktail, Lima Reservoir, Georgia Gulch, Vendome and Divide faults, Montana: Geological Society of America, Rocky Mountain Section, 40th Annual Meeting Abstracts with Programs, v. 19, no. 5, p. 336-337.

Stickney, M.C., and Lageson, D.R., 2002, Seismotectonics of the 20 August 1999 Red Rock Valley, Montana, earthquake: Bulletin of the Seismological Society of America, v. 92, n. 6, p. 2449-2464.

Wardlaw, B.R., and Pecora, W.C., 1985, New Mississippian-Pennsylvanian stratigraphic units in southwest Montana and adjacent Idaho: U.S. Geological Survey Bulletin 1656, p. B1-B8.

Williams, N.S., 1984, Stratigraphy and structure of the east-central Tendoy Range, southwestern Montana: Chapel Hill, University of North Carolina, M.S. thesis, 104 p.

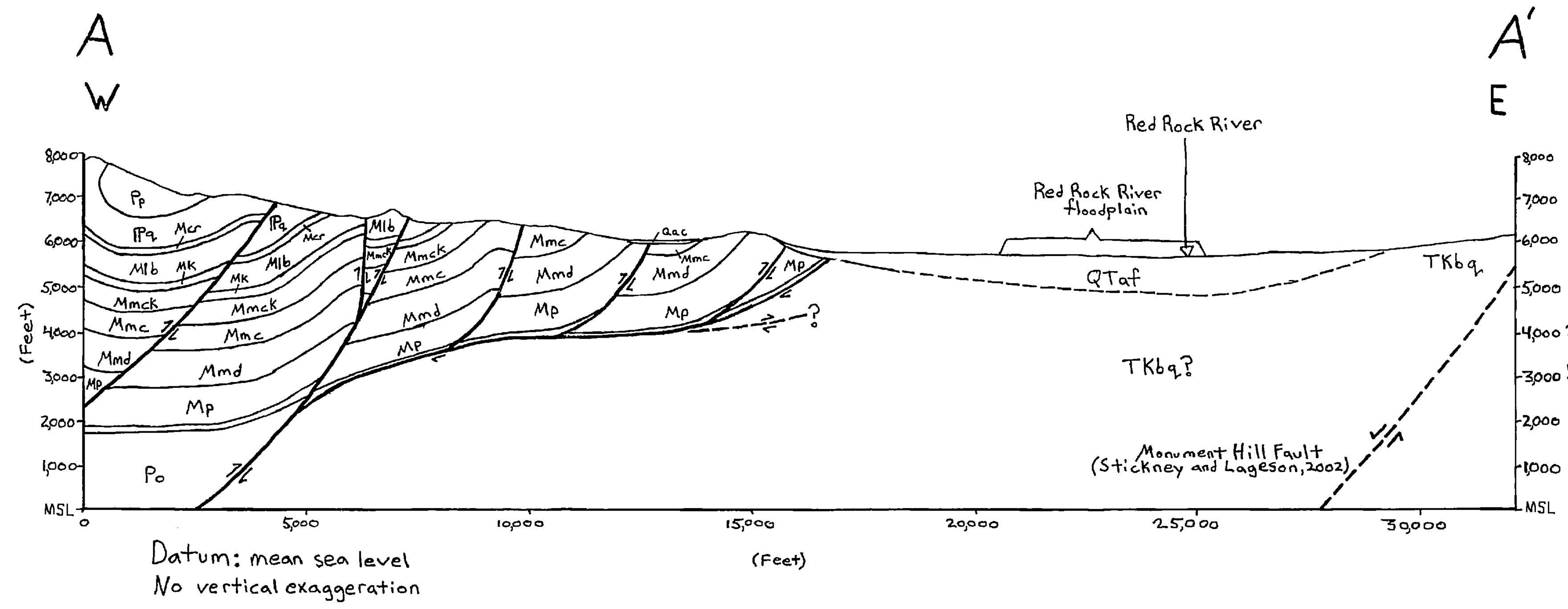
Williams, N.S., and Bartley, J.N., 1988, Geometry and sequence of thrusting, McKnight and Kelmbeck Canyons, Tendoy Range, southwestern Montana, *in* Schmidt, C.J., and Perry, W.J., Jr., eds., Interaction of the Rocky Mountain foreland and the Cordilleran thrust belt: Geological Society of America Memoir 171, p. 307-318.

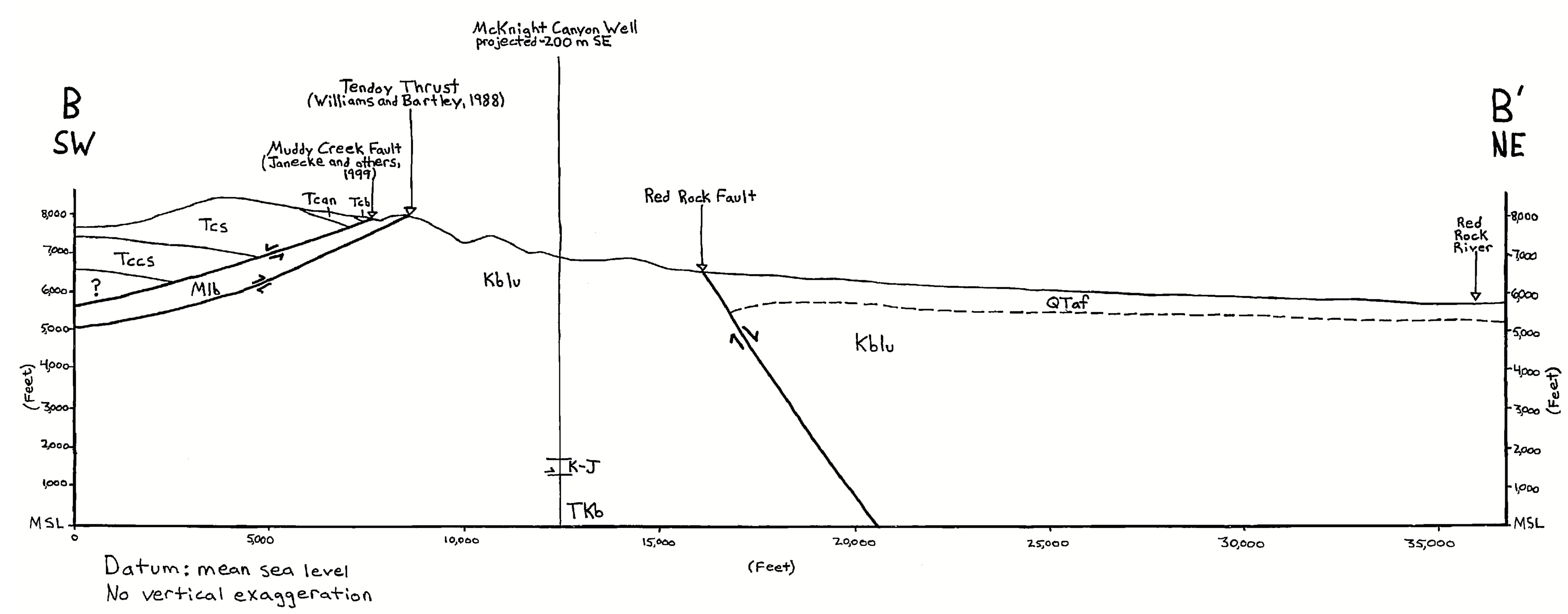
Wilson, M.D., 1967, The stratigraphy and origin of the Beaverhead Group in the Lima area, southwestern Montana: Evanston, IL, Northwestern University, Ph.D. dissertation, 171 p.

Wilson, M.D., 1970, Upper Cretaceous-Paleocene synorogenic conglomerates of southwestern Montana: American Association of Petroleum Geologists Bulletin, v. 54, p. 1843-1867.


Base from U.S. Geological Survey
Kidd 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




MBMG Open File 546

# Bedrock and Surficial Geologic Map of the Kidd 7.5' Quadrangle, Beaverhead County, Southwest Montana

mapped and compiled by

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2006

**Map Symbols**

For a more detailed description of the map units and symbols, please refer to the text accompanying this map.

- 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
- 45 Strike and dip of bedding

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