BEDROCK AND SURFICIAL GEOLOGIC MAP OF THE BRIGGS RANCH 7.5' QUADRANGLE, SOUTHWEST MONTANA

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INTRODUCTION

In this report, we present the results of geologic mapping of the Briggs Ranch 7.5-minute quadrangle located in the proximal foreland of the Cordilleran thrust belt in southwestern Montana. This work is a portion of a cooperative effort among the EDMap program of the U.S. Geological Survey, the Montana Bureau of Mines and Geology, the authors (Virginia Wesleyan College), and mappers from Lehigh University and Montana State University. The overall goal of the collaboration is to map the frontal Cordilleran thrust belt and later extensional features in the Lima region of southwestern Montana. Figure 1 shows the quadrangles completed or currently in preparation. Field mapping was done in the summer of 2005 using a combination of aerial photography and detailed field documentation of units, bedding orientation, and contacts. Locations were obtained by GPS, and data were recorded in the field using ArcPad 6.0 and a Trimble Geo XM combination GPS receiver and hand-held computer. Data were transferred to a laptop computer equipped with ArcGIS desktop 9.0 software where a digital map was created and spatial data were stored. This report accompanies a 1:24,000 geologic map of the Briggs Ranch 7.5' quadrangle with cross section.

The following summary is divided into three sections. The first is a discussion of the location of the mapping in the context of the regional geology. The second is an overview of the geology of the quadrangle organized by four distinct zones (figure 2): the Red Rock Valley floor, the alluvial fans, the Cretaceous-Paleocene Beaverhead Group, and the Tertiary rocks. Subsections of each zone describe the overall geology of the zone, emphasizing: 1) important stratigraphic and structural relationships; 2) the contributions of the present study to our understanding of stratigraphy, uplift history, and provenance; and 3) comparisons between our findings and previous studies and/or mapping in adjacent quadrangles. Finally, the third section is a description of map units with discussions on relevant issues pertaining to identification of stratigraphic units.

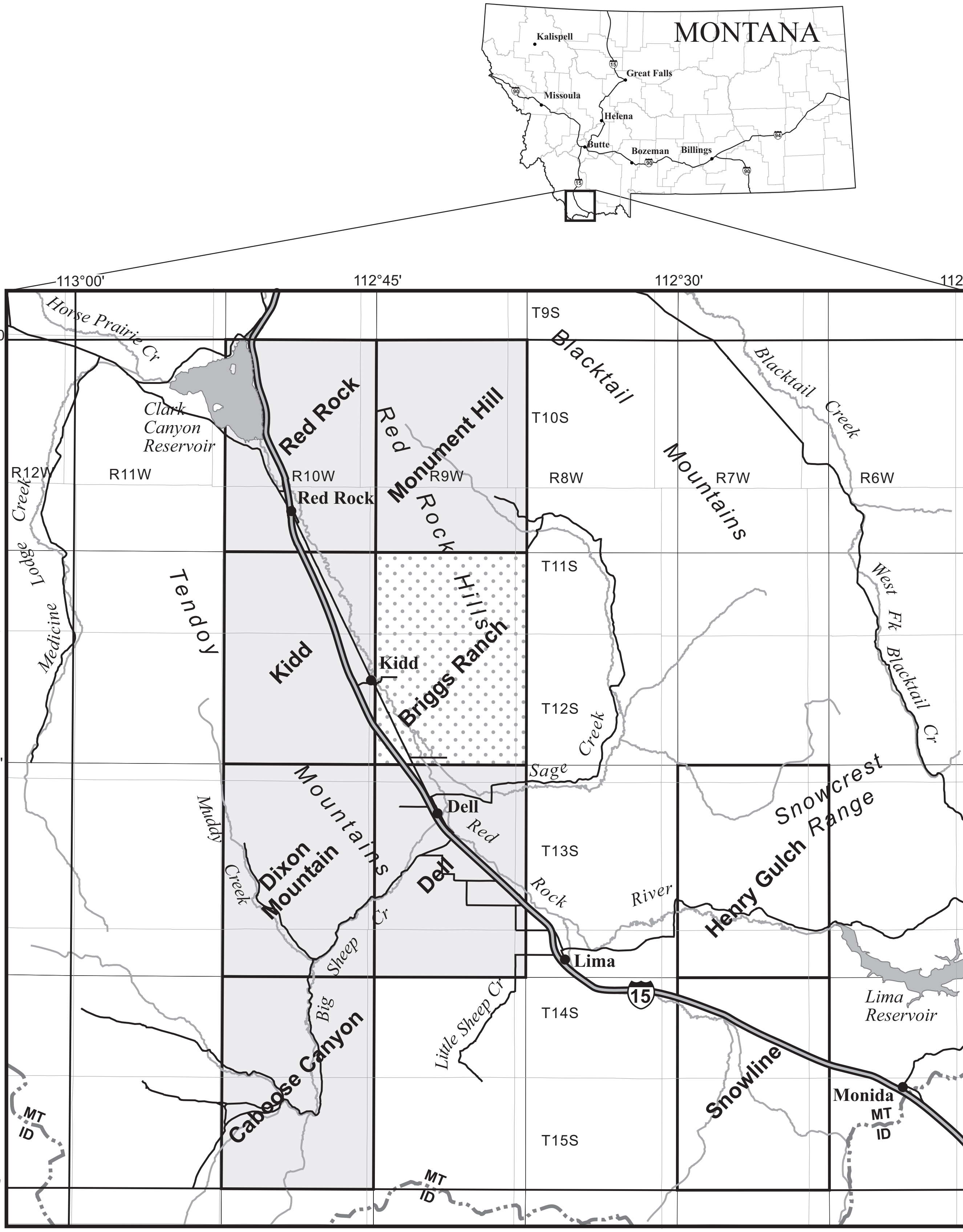

Figure 1. Location map for Briggs 7.5' quadrangle, showing relationship to other completed (shaded) or in-progress (named, but unshaded) quadrangle mapsin the area. See web site (www.mbmg.mtech.edu) for status of maps.

GEOLOGIC SETTING

The Briggs Ranch quadrangle is located in the southwestern Montana re-entrant of the Montana Fold and Thrust Belt between the Snake River Plain and the southwest Montana transverse zone. It is located in a zone of impingement between two very different styles of Cretaceous to early Tertiary compressional deformation. To the west is the northwest-trending fold and thrust belt with its east- to northeast-directed, mostly thin-skinned thrust sheets. To the east is the Laramide-style Blacktail-Snowcrest Uplift, a northeast- to southwest-trending basement-cored anticlinorium, that is bounded on its southeast flank by the blind, northwest-dipping, sub-Snowcrest Range fault (Perry and others, 1983; Perry and others, 1988). The overlap of these very different uplifts and the structural response to this overlap have been the subjects of numerous studies in this part of Montana (Scholten and others, 1955; Ryder and Scholten, 1973; Perry and others, 1988; Kulik and Perry, 1988; Williams and Bartley, 1988). Much of the region is underlain by the upper Cretaceous to Tertiary(?) Beaverhead Group comprising a thick, extensive (more than 600 square miles), accumulation of variously sourced synorogenic conglomerate shed from rising uplifts. The Beaverhead Group and its importance in unraveling the uplift history of this complex region has also been the subject of considerable study (Lowell, and Klepper, 1953; Ryder, 1968; Wilson, 1970; Ryder and Scholten, 1973; Nichols and others, 1985; Haley, 1985; Haley and Perry, 1991; Azevedo, 1993; and Schmitt and others, 1995).

The Briggs Ranch quadrangle is located approximately 4 miles (6.5 km) east of the easternmost thrust (the Tendoy Thrust) of the fold and thrust belt. As such it occupies the proximal foreland basin of the Montana Fold and Thrust Belt. The Briggs Ranch quadrangle is located about 10 miles (16 km) northwest of the nearest exposed Paleozoic rocks deformed along the southeast limb of the Blacktail-Snowcrest Uplift. The plunging nose of that uplift is probably located at depth beneath the Briggs Ranch quadrangle but is buried by the thick accumulation of Cretaceous and younger conglomerates of the above-mentioned foreland basin and later extensional basins. None of the rocks or structures in the Briggs Ranch quadrangle can be shown with certainty to be related to the Blacktail-Snowcrest Uplift.

Superimposed on these compressional structures are two stages of extension. The earlier (Eocene-Miocene) comprises northeast-trending half-grabens (the Ruby Graben and Beaverhead Graben of Sears and others, 1995). The later (Pliocene to Quaternary) trends northwest-southeast and includes the seismically active Red Rock normal fault and associated Red Rock Valley half-graben that dominates the topography today. Several recent studies address the evolution of this phase of deformation (Fields and others, 1985; Fritz and Sears, 1993; Sears and others, 1995; Janecke et al, 2000; Hurlow, 1995; Harkins and others, 2005).

SUMMARY OF THE GEOLOGY OF THE BRIGGS RANCH QUADRANGLE

The Briggs Ranch quadrangle can be divided geologically into four northwest-southeast trending belts or zones (figure 2). These are, from southwest to northwest: 1) the floor of the Red Rock half-graben, 2) the modern alluvial fans that flank the Red Rock Valley half-graben, 3) an outcrop belt of conglomerates of the Beaverhead Group comprising three mappable units plus a number of igneous intrusions, and 4) an outcrop belt of Tertiary sedimentary, volcanic, and volcaniclastics rocks of the Renova and Sixmile Creek formations. In this section, we will summarize the geology of each of these zones emphasizing the observations and contributions of our mapping.

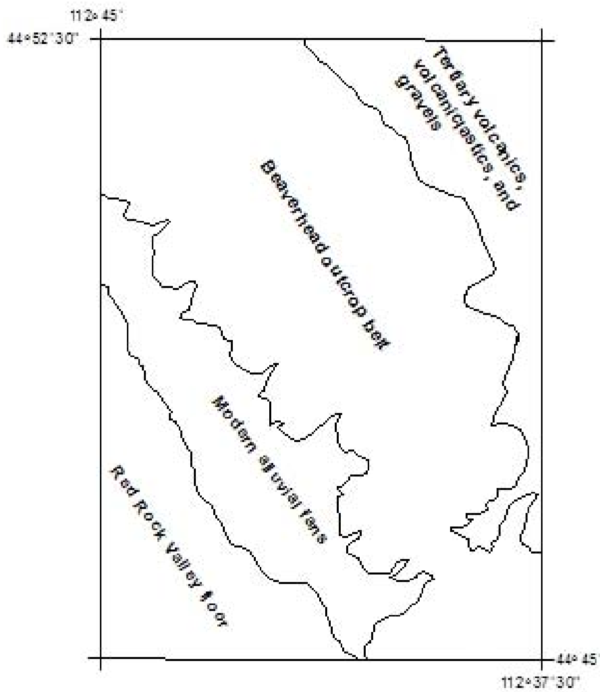

Figure 2. The four outcrop belts or zones in the Briggs Ranch quadrangle

The Red Rock Valley Floor

This zone is composed entirely of Quaternary alluvium of the Red Rock River and its floodplain (except in the extreme southwest corner where the toe of an alluvial fan from the west side of the valley is present). It is characterized by flat topography and is currently under intense irrigation and cultivation. This human alteration has obscured subtle details of Quaternary geology and we have designated it all as Qal in our mapping. The unit may in fact contain multiple generations of Quaternary deposits identified in adjacent mapping (Aschoff and Schmitt, 2004) but we were unable to recognize them here. The Red Rock Valley is a half-graben bordered on the west side, outside the Briggs Ranch quadrangle, by the seismically active Red Rock Fault.

Modern Alluvial Fans

A belt of large, overlapping alluvial fans marks the east side of the Red Rock Valley half-graben. These fans were mapped by a combination of stereographic aerial photography and extensive field checking by both longitudinal and cross-fan traverses. Four generations of fan surfaces are recognized based on incised elevation relative to one another, degree of preservation of bar-and-swale surface topography, vegetation, and soil development. The Buck Creek alluvial fan, at the extreme northwest end of this belt, was mapped by a group from Lehigh University headed by David Anastasio and Christine Regalla as an extension of their mapping of the Red Rock quadrangle. That group is studying the alluvial fans in an effort to better understand the evolution of the Red Rock Valley and the relative roles of Pleistocene and Holocene climate and tectonism in fan development (D.A. Anastasio, oral commun., 2005). Our mapping attempts to extend the detail of their mapping into the Briggs Ranch quadrangle.

As a whole, the belt is dominated by a Pleistocene surface designated as surface 3. This surface is probably pre-Pinedale (C. Regalla, oral commun., 2005) and is characterized by a distinctive scarp separating the fan toes from the present depositional surface. This surface is locally intricately incised by recent drainage. Fan surface 2 is likely the Pinedale surface (C. Regalla, oral communication, 2005). Its only extensive development is as a part of the Ashbough Canyon fan, the largest and youngest fan in the Briggs Ranch quadrangle. Modern active fans are generally small, fan-shaped deposits at the mouths of channels incised into the older fan surfaces. The exceptions are found on the Ashbough Canyon and Little Ashbough Canyon fans, which have relatively large active tracts imposed on the older surfaces. The toes of the modern fans are flush with the floor of the Red Rock Valley. A surface older than surface 3 (surface 4) was recognized as remnants high above surface 3 in the vicinity of Ashbough Canyon and Little Ashbough Canyon. Because of their isolated and discontinuous nature, their correlation with surfaces in adjacent quadrangles is uncertain.

The Beaverhead Group Outcrop Belt

Northeast of the Red Rock Valley, the Red Rock Hills are largely underlain by extensive cobble to boulder conglomerates of the Cretaceous to Tertiary Beaverhead Group. The many studies in the Beaverhead Group (e.g. Lowell and Klepper, 1953; Ryder, 1968; Ryder and Scholten 1973; Haley, 1985; Haley and Perry, 1991) have shown it to be a highly variable and complex assemblage of coarse synorogenic detritus that records the uplift and erosion of both the Laramide-style Blacktail-Snowcrest Uplift and the impinging Sevier-style thrust belt. Compared to other areas in the region, the Beaverhead Group in the Briggs Ranch quadrangle had not been studied in a lot of detail. Haley (1985) measured and described a section of the Red Butte Conglomerate in Spring Gulch in the extreme southeast portion of the quadrangle; Haley (1985) and Haley and Perry (1991) formally defined the Red Butte Conglomerate in this area and mapped its lower boundary with older quartzite conglomerates and an older limestone conglomerate in the vicinity of Ashbough Canyon. We hoped to expand on this earlier mapping and, perhaps, find other units within the Beaverhead Group that could further elucidate the deformational history of this area. In this effort we were disappointed. We recognized only the three previously identified units including the extensive quartzite conglomerate that underlies most of the map area, the thin Ashbough Canyon limestone conglomerate (a distinctive lithosome within the quartzite conglomerate) and the younger Red Butte Conglomerate.

A notable revision in our mapping is the nature of the lower contact between the Ashbough Canyon conglomerate and the quartzite conglomerate. Haley and Perry (1991) mapped this contact as a bedding-parallel thrust fault placing older Ashbough Canyon conglomerate on younger quartzite conglomerate. This interpretation was largely based on sheared quartzite clasts below the contact. Our observations reveal that, although shearing along the contact is certainly present, it is local and not pervasive along the entire contact. We feel that the contact is primarily depositional, an interpretation supported by the existence of a thin, red paleosol separating the units. The shearing could easily be explained by lithologic differences between the two units. The Ashbough Canyon limestone conglomerate is very well indurated with clasts and matrix behaving as a single lithology. On the other hand, the quartzite conglomerate contains very hard quartzite clasts in a matrix of poorly cemented sandstone. Bedding plane slip between these dissimilar units during deformation would be expected, which could account for the shearing of individual, relatively free moving, quartzite cobbles below the contact.

The Red Butte Conglomerate sits with apparent angular unconformity on those older units. This relationship, plus the presence of inclusions of both quartzite clasts and recycled boulders of Ashbough limestone conglomerate in the Red Butte strata, require that the Red Butte Conglomerate be the youngest of the three (Haley, 1985; Haley and Perry, 1991).

A number of studies have addressed the provenance of the various conglomerates of the Beaverhead Group. The large number of Proterozoic quartzite clasts in the quartzite conglomerate requires a thrust belt source, as these units do not exist in the craton where Cambrian Flathead Sandstone sits directly on basement. Thus a Blacktail-Snowcrest source can be ruled out. (Ryder and Scholten, 1973). Haley (1985) suggested that the quartzite may have come from western thrust sheets, perhaps the unroofing of the basement involved Cabin thrust sheet. According to this model, quartzite conglomerate deposition would have been cut off by the rising Tendoy thrust sheet and resultant deposition of the Red Butte Conglomerate. Janecke and others (2000) suggested that Cretaceous paleovalleys carried quartzite gravels into the Tendoy area from the Carmen and Hayden Creek-Cobalt structural culminations 60 miles or more to the northwest. Although they were specifically addressing the “Divide” quartzite conglomerate (located along the Continental Divide, approximately 15 miles south of the Briggs Ranch quadrangle) a similar source is plausible for the quartzite conglomerates in the present study. In this model, the quartzite gravels from the north were carried by large braided streams flowing south along the axis of the deepening foreland basin in front of the thrust belt. Nothing in our mapping settles the ultimate question of quartzite conglomerate provenance. However, our interpretation of the Ashbough Canyon conglomerate as a lithologically distinct lens of temporary deposition in an otherwise huge, long-lived system of quartzite bearing rivers makes the interpretation of Janecke and others (2000) attractive.

The Ashbough Canyon conglomerate is overwhelmingly dominated by clasts of Mississippian limestone. Its nearly monomict nature and the fact that it is a lens hosted by the extensive, very different quartzite conglomerate, suggests that it came from a nearby smaller uplift, that eroded building an alluvial fan into the foreland basin. This fan was soon overwhelmed by the continued accumulation of quartzite gravel. The limestone clasts do not show imbrication nor are they distinctively thrust-belt or Blacktail-Snowcrest lithologies (Haley, 1985). Nevertheless, we favor a thrust belt source for these conglomerates.

The Lima conglomerate to the south is known to have a Blacktail-Snowcrest source (Ryder and Scholten, 1973; Nichols and others, 1985; Haley, 1985). It is extensive, covering tens of square miles, and nearly 6400 feet (about 2000 meters) thick (Ryder, 1968). It contains a distinct, inverted clast stratigraphy recording the unroofing of that relatively simple anticlinorium (Ryder and Scholten; 1973). This is in stark contrast to the much more limited Ashbough Canyon conglomerate. One intriguing possibility for a source for this conglomerate is the “McKenzie thrust system” of Perry and others (1988) located 7 miles (11 km) to the northeast. This duplex repeats Mississippian stratigraphy numerous times in the adjacent Kidd 7.5’ quadrangle. It could be expected to have formed an impressive culmination of Mississippian carbonates at the front of the thrust belt – the erosion of which could have formed an alluvial fan that reached the Briggs Ranch area. According to this model, the rise of the “McKenzie culmination” would have produced one or more alluvial fans that prograded into the foreland temporarily forcing quartzite deposition to shift eastward. Quartzite conglomerate deposition would have resumed once the culmination eroded down or its active fans shifted to a new area.

The Red Butte Conglomerate probably was sourced from a combination of the Tendoy thrust and deformed older conglomerates (including quartzite conglomerates and the Ashbough Canyon conglomerate) in the foreland. Haley (1985) and Haley and Perry (1991) present the evidence including clast imbrication, key clasts such as recycled Ashbough Canyon conglomerate and oncolitic limestone of probable Beaverhead affinity from the area of the Tendoy thrust, and the mapped angular unconformity between the Red Butte Conglomerate and older units. The reader is referred to Haley and Perry (1991) for a detailed argument for the Red Butte Conglomerate provenance.

Tertiary Outcrop Belt

The Briggs Ranch quadrangle occupies a critical position in settling differences between Lonn and others (2000) and the later mapping Newton and others (2005) in the Tertiary units exposed in this region. Newton and others (2005) considered the interbedded volcanic and coarse conglomerates in the Monument Hill 7.5’ quadrangle to be Sixmile Creek rather than Renova as Lonn and others (2000) had mapped them. This revision was based on the fact that the volcanic rocks are interbedded with very coarse gravels typical of the Sixmile Creek Formation. The extensive, fine-grained fluviolacustrine sediments interbedded with volcanic rocks of the Sage Creek Basin to the east have long been considered to be Renova, an identification verified by mammalian fauna (Fields and others, 1985). In the Briggs Ranch quadrangle, interbedded volcaniclastics, marls, and lava flows lie in clear unconformity directly on the Beaverhead Group conglomerates. These, in turn, are unconformably overlain by coarse quartzite conglomerates assigned to the Sixmile Creek Formation. A Renova designation, specifically Dillon volcanic sequence, for these rocks is clearly appropriate. North of the headwaters of Little Ashbough Creek (an area designated as “The Basin” along the eastern margin of the Briggs Ranch quadrangle) these volcanic rocks pinch out beneath the Sixmile Creek Formation in an angular unconformity so that Sixmile Creek gravels lie directly on Beaverhead Group conglomerates. Thus it appears that the higher volcanic rocks in the Monument Hill quadrangle are likely within the younger Sixmile Creek Formation and are distinct from the Renova volcanic rocks that dominate so much of the Sage Creek Basin. The Sixmile Creek volcanics are generally missing from the

Briggs Ranch quadrangle except for one small, isolated outcrop in the northeast corner tentatively assigned to the Sixmile Creek Formation. The relationship of Beaverhead Renova, and Sixmile Creek strata is shown in figure 3. In general, the Tertiary rocks were deposited in early normal faulted basins that formed after the main compressional events had ceased. By Sixmile Creek time, these basins were united as a paleovalley that extended at least from the Big Hole area to the Snake River Plain (Fritz and Sears, 1993).

Fritz and Sears (1993) maintain that the Sixmile Creek gravels had a source area to the northwest near the head of this paleovalley. However, we feel that local recycling of Beaverhead quartzite conglomerate cannot be ruled out. Despite our best efforts, we could not distinguish a significant difference in clast composition between Beaverhead quartzite conglomerates and those of the Sixmile Creek Formation. Where these units are in contact, they are virtually indistinguishable by standard lithologic mapping techniques. This suggests to us that the Sixmile Creek gravels may have been largely locally derived from reworking the quartzite clasts of the Beaverhead Group. This happens today in nearly every modern drainage that cuts these conglomerates. Certainly in Miocene time, the Beaverhead quartzite conglomerates could have underlain highlands to the west of the

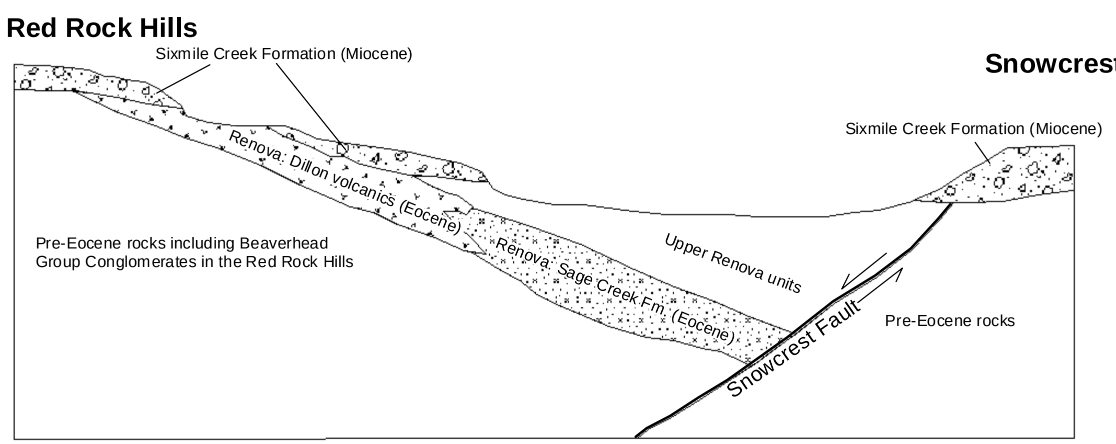

Figure 3. Simplified cross section (not to scale) between the study area in the Red Rock Hill and the Snowcrest Range showing the relationships between the Tertiary Renova and Sixmile Creek Formation and between those units and the Beaverhead Group. The dip in the Renova is due to rotation along the Snowcrest fault. The basin formed from this movement controlled deposition of the Sixmile Creek formation. Modified from Sears et al., (1995) and Lonn, et al., (2000).

main Sixmile Creek paleovalley and reworking of quartzite clasts from there could hardly have been avoided (Figure 3).

Tertiary Intrusions

One of the more significant contributions of our mapping is the documentation of bimodal Tertiary Intrusions into the Beaverhead outcrop belt. These igneous rocks were mapped by Lonn, et al. (2000) as outliers of Renova (Dillon) basalts. These outcrops differ significantly from the Basalt flows in that they are more massive, non-vesicular, are unassociated with volcaniclastics, and have clear cross-cutting relationships with the Beaverhead Conglomerate. These intrusions do not seem to cut rocks younger than Beaverhead and may have provided a local source for the volcanic rocks in the Renova. Clearly further study of these rocks and the nearby Renova volcanics is merited.

Structural Geology

The scattered Beaverhead outcrops show a wide variety of orientations suggesting significant and complex deformation. However few large structures could be clearly identified. This is in part because Beaverhead conglomerates tend to be thick, massive, and contain no real internal stratigraphic markers. A few high-angle faults were identified where there is enough stratigraphic variation to show offset. Otherwise there are probably many faults that are unidentified.

The Monument Hill fault is currently the subject of detailed investigation by David Anastasio and his students at Lehigh University. Newton et al. (2000) have traced the Monument Hill fault into the Briggs Ranch quadrangle where indicated on our map. Because it is essentially contains non-outcropping quartzite conglomerates in both the hanging wall and the footwall, its trace and extent across the Briggs Ranch quadrangle cannot be delimited with certainty. The north end of the Ashbough Canyon Conglomerate is highly deformed and is probably faulted out. As this location lies along the strike of the Monument Hill fault we have projected the fault to this area. Future work by the Lehigh University group may confirm or reject this hypothesis.

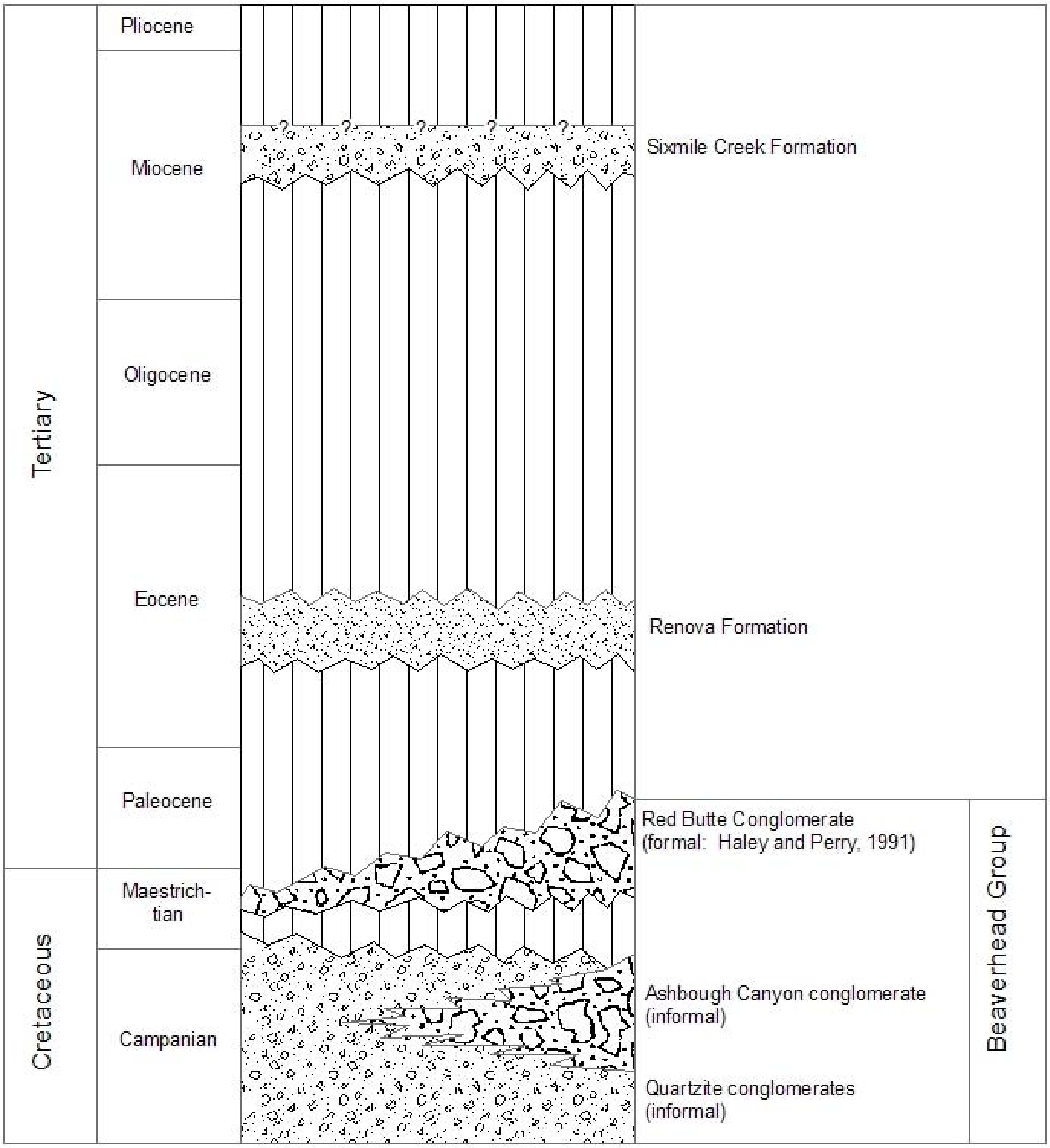

Figure 4. Stratigraphic relationships of Cretaceous and Tertiary map units in the Briggs Ranch Quadrangle. Modified from Fields et al. (1985) and Perry and Haley (1991)

UNIT DESCRIPTIONS AND DISCUSSIONS

Quaternary

Qal – HOLOCENE ALLUVIUM – Unconsolidated deposit of silt, sand, and/or gravel in the active channel and flood plain of modern streams. Includes deposits in active, incised channels of older alluvial fans.

Qat – STREAM TERRACE DEPOSITS – Unconsolidated gravel forming elevated terraces.

Qao – OLDER ALLUVIUM – Unconsolidated mud, sand, and gravel, typically 10 to 20 feet (3 to 6 meters) above the active stream channels.

Qls – LANDSLIDE DEPOSITS – Unconsolidated deposit of locally derived fine- to coarse-grained debris characterized by hummocky topography and poor drainage.

ALLUVIAL FAN DEPOSITS – Small to large fan-shaped bodies of unconsolidated fine to coarse-grained detritus. Four generations of fan surfaces are recognized:

Qaf_1 – Mostly small, active fan-shaped deposits of poorly sorted fine- to coarse-grained alluvium. Also includes larger, active tracts of the Ashbough Canyon and Little Ashbough Canyon fans. Surface characterized by obvious bar and swale topography and sagebrush vegetative cover. Toes of fans are flush with active alluvial surfaces.

Qaf_2 – Inactive alluvial fan surfaces 3 to 20 feet (1 to 6 meters) above active fan surfaces (Qaf_1) and incised channels (Qal). Composed of poorly sorted fine to coarse-grained alluvium. Bar and swale topography is evident, but not as obvious as Qaf_1. Surface vegetation is a mixture of sagebrush and grasses.

Qaf_3 – Inactive fan surfaces 3 to 40 feet (1 to 12 meters) above Qaf_2 and 10 to 75 feet (3 to 22 meters) above active fan surfaces (Qaf_1) and incised channels (Qal). Bar and swale topography is obscured by soil and/or loess. Vegetation is dominated by grasses.

Qaf_4 – Inactive fan (and perhaps pediment) surface 5 to 110 feet (2 to 35 meters) above Qaf_3 and up to 170 feet (50 meters) above active channels (Qal). Similar in character to Qaf_3 but distinguishable in the in the area around Ashbough Canyon as an obvious, tabular, topographically higher surface.

Tertiary and Cretaceous Sedimentary Units

SIXMILE CREEK FORMATION

Tsc – SIXMILE CREEK QUARTZITE GRAVEL – Poorly consolidated, poorly exposed, pebble to boulder conglomerate. Clasts dominated by very well rounded, dense, white to tan and pink quartzite with subordinate argillite, limestone, dolostone and chert. Basalt clasts are rare and local. The Sixmile Creek Formation is poorly indurated and so yields no good outcrops. Its outcrop area is characterized by high, rounded hills covered by quartzite-cobble debris. Thickness is highly variable but probably reaches at least 1,600 feet (490 meters) in the Briggs Ranch quadrangle. The Sixmile Creek Formation unconformably overlies conglomerates of the Beaverhead Group and volcanic rocks of the Renova Formation. In the southeastern part of the Briggs Ranch quadrangle, where it is in contact with the Ashbough Canyon conglomerate and the Red Butte Conglomerate (both of the Beaverhead Group), it is easily distinguished by abundant boulders of white quartzite and a paucity of limestone clasts compared with the underlying units. Northwest of the Renova pinchout in "The Basin" area, however, where the Sixmile Creek Formation overlies quartzite conglomerates of the Beaverhead Group, determination of the contact is much more problematic due to a strong lithologic similarity between the two units. We attempted to extend the contact as mapped by Newton and others (2005) in the Monument Hill quadrangle into the Briggs Ranch quadrangle adopting their interpretation of a paleovalley fill for this unit. It should be noted, however, that this is at considerable variance with the mapping by Lonn and others (2000), who place the contact approximately 4,000 feet to the west. We feel that the conflict is not resolvable by simple field mapping and thus the contact in this area should be viewed as uncertain.

Tscv – SIXMILE CREEK VOLCANIC ROCKS, UNDIFFERENTIATED – Massive basalt. Unlike the Monument Hill quadrangle to the north, the Briggs Ranch quadrangle lacks extensive Sixmile Creek volcanic rocks. An exception is a single, small, isolated outcrop along Burnt Willow Creek in the northwest corner of the quadrangle.

RENOVA FORMATION

Trv – DILLON VOLCANIC MEMBER (INFORMAL) – Highly vesicular and amygdaloidal basalt flows and agglomerates interbedded with volcaniclastic sandstone and dense, rhyolitic lava flows. Thickness reaches about 280 feet in "The Basin" where its thickest and most continuous exposures are found. This unit rests unconformably on the Beaverhead Group and is overlain unconformably by the Sixmile Creek gravels. Northwest of "The Basin" the unit is eroded away completely and is not found at all in the Monument Hill quadrangle to the north (Newton and others, 2005). Scholten and others (1955) called the basalt exposures in the Briggs Ranch quadrangle the "Sage Creek Basalt" and Lonn and others (2000) mapped this unit as the informal "Hall Spring Basalt and older basalt, Dillon Volcanic Member" of the Renova Formation. The presence of rhyolite and abundant volcaniclastics, however, resemble other Dillon Volcanic Member units (Lonn and others, 2000) and so we opt for the more general “Dillon Volcanic Member”.

Trs – SAGE CREEK MEMBER – This unit covers a small area in the Briggs Ranch quadrangle only in Little Spring Gulch on the extreme eastern edge of the map. There it is poorly consolidated with no good outcrops but the hillsides are characterized by mixture of cobble-sized gravel with abundant, white, finer-grained volcaniclastic material that gives the hillsides a distinctive white color visible both from the ground and on aerial photographs. The description of Lonn and others (2000) of better exposures outside this map area as “poorly sorted tuffaceous mudstone, pebbly to cobbly tuffaceous mudstone, sandstone, and conglomerate” is probably apt. This member is separated from the Dillon volcanic member by a belt of Sixmile Creek gravel and so the relationship between these two units is not discernable. Lonn and others (2000, fig. C1) shows them intertonguing. Fields and others (1985) place these lithologies above the volcanic units. The Sage Creek Member’s lower contact is not exposed in the map area. It is overlain unconformably by gravels of the Sixmile Creek Formation. The Sage Creek Member is distinguished from the Sixmile Creek and Beaverhead quartzite gravels by the white volcaniclastic material and the notably smaller clast size of the gravels. These seldom exceed cobble size in this unit, whereas boulder gravels are not unusual in the other formations. Colorful rhyolite clasts described by Tabrum and others (1996) are also present and distinctive.

BEAVERHEAD GROUP

TKbr – RED BUTTE CONGLOMERATE – Well-indurated pebble to boulder conglomerate dominated by gray Paleozoic limestone clasts with subordinate, but still common, white and pink quartzite clasts. Clast sizes for these lithologies range from small pebbles to boulders 2 feet (60 centimeters) in diameter. Limestone clasts are typically subangular to rounded and quartzite clasts are well rounded. Haley and Perry (1991) noted that this “textural inversion” suggested that the quartzite clasts were recycled. At the type section at Red Butte near Dell and in outcrops along Spring Gulch in the Briggs Ranch quadrangle, boulders of recycled limestone conglomerate (probably the Ashbough Canyon conglomerate) reach 4 feet (1.5 meters) in diameter. Bedding ranges from well-stratified moderately sorted, pebble to small cobble conglomerate to chaotic, unstratified lenses of poorly sorted cobble and boulder conglomerate. Both clast- and matrix-supported conglomerates are common. Interbedded sandstone lenses are moderately to poorly sorted and hematitic, as is the matrix of the conglomerate itself. The resultant red color is a distinctive characteristic of this unit and gives Red Butte (the type area in the adjacent Dell quadrangle) its name. The thickness of this unit is very difficult to measure due to the fact that the lower contact is exposed only where most of the formation has been eroded away. A minimum thickness of 500 feet (150 meters) is a very conservative estimate. Exposures of the Red Butte Conglomerate-Ashbough Canyon conglomerate contact between Ashbough and Little Ashbough canyons indicate that the Red Butte Conglomerate rests in a profound angular unconformity on the Ashbough Canyon conglomerate (Haley and Perry, 1991). A similar relationship presumably exists between the Red Butte Conglomerate and the underlying quartzite conglomerates of the Beaverhead Group as well. The Red Butte Conglomerate is overlain unconformably by both Renova and Sixmile Creek Formations. The distinctive clast composition of intimately admixed quartzite and limestone, the overall red color of the formation and its well-indurated nature easily distinguish the Red Butte Conglomerate from other Beaverhead units and from gravels of the Sixmile Creek Formation.

TKbq – QUARTZITE CONGLOMERATE (INFORMAL) – Moderately well to poorly consolidated pebble to boulder conglomerate. Clasts dominated by very well rounded, dense, white to tan and pink quartzite with subordinate argillite, limestone, dolostone and chert. Exposures of consolidated conglomerate are rare, small and restricted to the bottoms of channels or areas near igneous intrusions. The vast, highly dissected, treeless, quartzite gravel covered terrain that constitutes much of the Red Rock Hills is underlain by these conglomerates. The thickness of this accumulation is extremely difficult to determine due to the paucity of outcrops and fact that the base of this unit is not present in the Briggs Ranch quasrangle. A reasonable minimum is 2,000 feet (610 meters) but it may be many times that. The quartzite conglomerate is variously unconformably overlain by the Red Butte Conglomerate, the Renova Formation, and the Sixmile Creek gravels. Although the quartzite conglomerate is easy to differentiate from the other limestone-dominated Beaverhead conglomerates, it is largely indistinguishable from the lithologically similar Sixmile Creek gravels. The problematic nature of the contact with that unit is discussed above in the section on the Sixmile Creek Formation. This unit comprises the Kidd quartzite conglomerate lithosome of Ryder and Scholten (1973).

Tkba – ASHBOUGH CANYON CONGLOMERATE (INFORMAL) –Well-indurated pebble to boulder conglomerate composed almost exclusively of medium to dark gray Mississippian limestone clasts. The matrix is fine-grained and brightly hematitic. This unit comprises a lithologically distinctive tongue of monomict limestone conglomerate, up to 400 feet (120 meters) thick, within the Beaverhead quartzite conglomerates. It occupies a north-south trending, 3.25 mile (5.6 kilometer) long outcrop belt in the vicinity of Ashbough Canyon. The beds dip generally to the west. The original total extent of this layer is unknown as it is truncated to the north by the Monument Hill fault and is covered to the south by young alluvial fans flanking the Red Rock Valley. Like the quartzite conglomerate that surrounds it, the Ashbough Canyon conglomerate is overlain in angular unconformity by the Red Butte Conglomerate, that it most closely resembles lithologically. It is readily distinguished from the Red Butte Conglomerate, however, by its stratigraphic position, limited thickness and its lack of the distinctive admixed quartzite clasts. The Ashbough Canyon conglomerate was first recognized as a distinct lithosome by Haley (1985), and was designated “the Ashbough Canyon occurrence”. Subsequently, it has appeared on maps by Haley and Perry (1991) as “lower limestone conglomerate” and by Lonn and others (2000) as simply “limestone conglomerate of the Beaverhead Group”.

INTRUSIVE IGNEOUS ROCKS

Ti – TERTIARY DIKES AND SILLS – Tabular bodies of basalt and rhyolite. Basaltic intrusions dominate, some with tiny phenocrysts of olivine. Rarer rhyolite bodies have phenocrysts of sanidine. Lonn and others (2000) mapped several of these intrusions as outliers of basalts of the Dillon volcanic member of the Renova Formation. This seems reasonable at first, especially on aerial photographs because some of them outcrop at the same elevation as nearby flows. However, detailed mapping reveals their vertical or high-angle tabular shape and their crosscutting relationship with Beaverhead strata. These bodies are found intruding only Beaverhead Rocks and may have provided a local source for the volcanic rocks in the Renova Formation.

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Geologic Map of the Briggs Ranch 7.5' Quadrangle, Southwest Montana

Timothy S. Turk, Mark T. Messina, and J. Christopher Haley

MBMG 562
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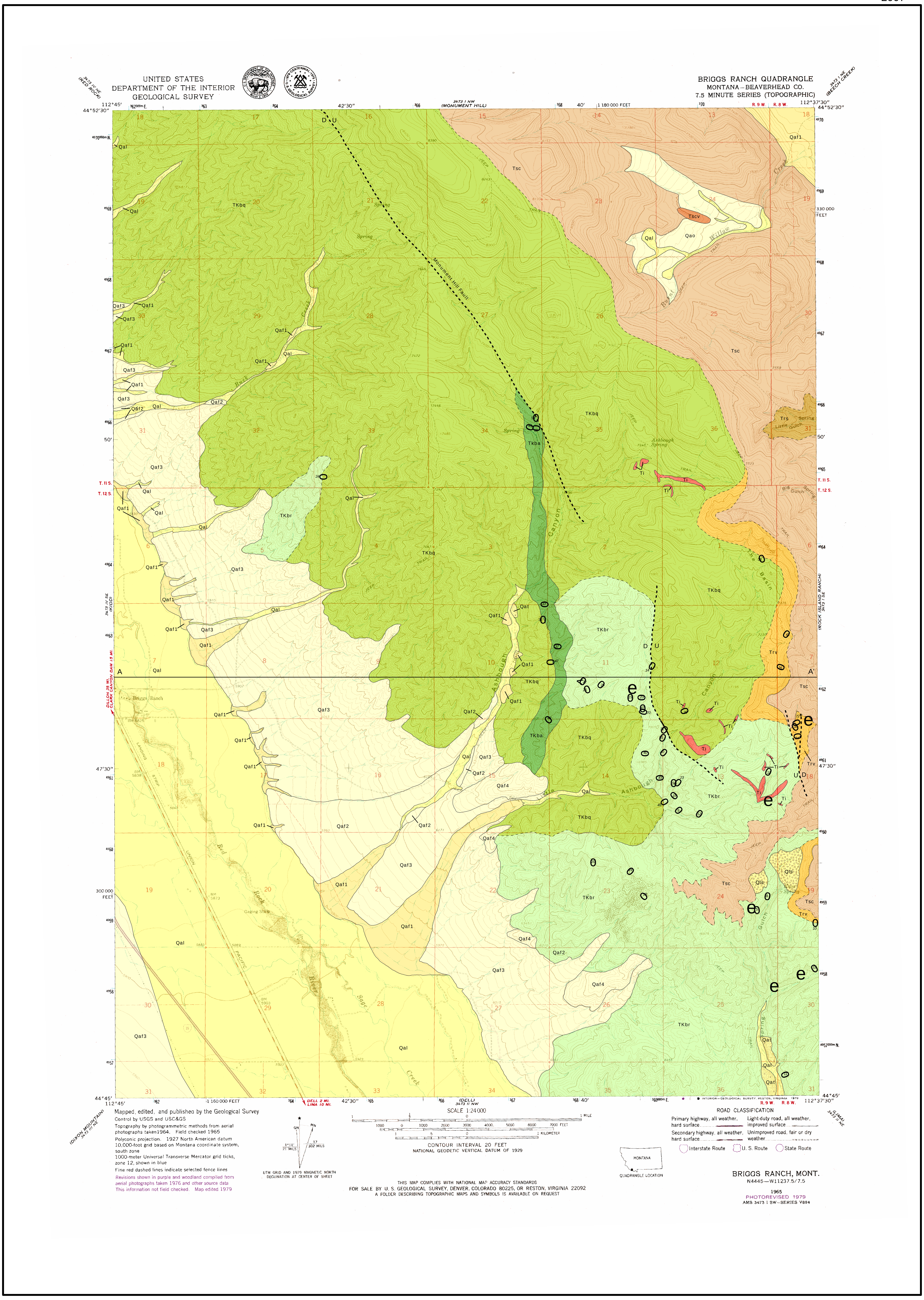
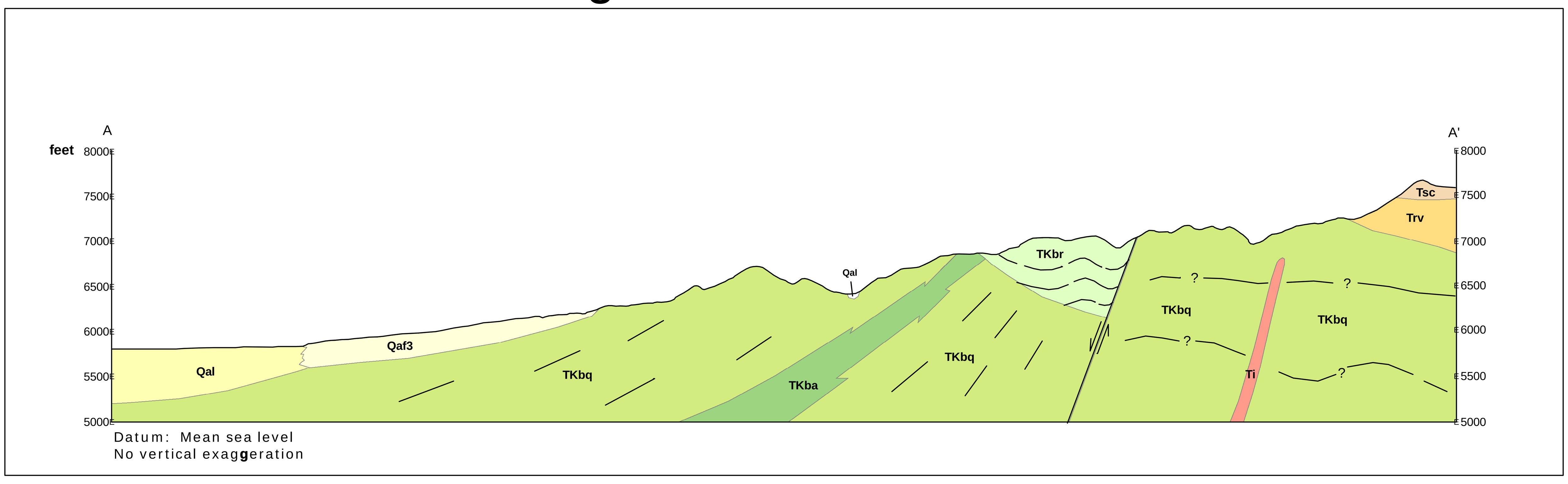


Geologic Cross-section A - A'



Legend

Units

- **Qls - Landslide deposit (Holocene)**
- **Qal - Modern alluvium (Holocene)**
- **Qat - Stream terrace deposits**
- **Qao - Alluvium, older, undivided (Pleistocene?)**
- **Qaf1 - Modern alluvial fan deposit (Holocene)**
- **Qaf2 - Alluvial fan deposit, older than Qaf1 (Pleistocene - Holocene)**
- **Qaf3 - Alluvial fan deposit, older than Qaf2 (Pleistocene)**
- **Qaf4 - Alluvial fan deposit, older than Qaf3 (Pleistocene)**
- **Tsc - Sixmile Creek Formation, gravel, undivided (Miocene - Pliocene)**
- **Tscv - Sixmile Creek lava flow (Miocene - Pliocene)**
- **Trv - Renova Formation, Dillon volcanic member (Eocene - Oligocene)**
- **Trs - Renova Formation, Sage Creek member (Eocene - Oligocene)**
- **Ti - Intrusive rocks, basalt and rhyolite (Tertiary)**
- **TKbr - Red Butte Conglomerate, Beaverhead Group (Upper Cretaceous - Paleocene)**
- **TKba - Ashbough Canyon conglomerate, Beaverhead Group (Upper Cretaceous - Paleocene)**
- **TKbq - Quartzite conglomerate, Beaverhead Group (Upper Cretaceous - Paleocene)**

Symbols

- Horizontal bedding plane
- Vertical bedding plane
- Strike and dip of beds
- Contact
- Contact, approximate
- Fault (U = upthrown block, D = downthrown block)
- Fault, approximate (U = upthrown block, D = downthrown block)