Geologic Map of the Upper Clark Fork Valley

Southwestern Montana

Mapped and Compiled

by

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Geologic Summary

Three valleys are covered by this geologic map - Summit (Butte) Valley, the informally designated Buxton Valley south of Ramsay, and the Deer Lodge Valley (Fig. 1). These three valleys appear to be half grabens with range-front faults along the east sides of Summit and Buxton Valleys, and the west side of the Deer Lodge Valley.

The Summit Valley is characterized by Quaternary alluvium and a lack of bedrock exposures, but is surrounded by exposures of the Butte Quartz Monzonite pluton of the Cretaceous Boulder Batholith. The Buxton Valley is flanked by Butte Quartz Monzonite to the east and Eocene Lowland Creek Volcanics to the north. Remnants of the Lowland Creek Volcanics overlie a Cretaceous granitic pluton on the west. Tertiary sedimentary rocks that include mudstone, sandstone, conglomerate, and bentonite are exposed along most coulees in this valley. Near Anaconda in the southwestern part of the Deer Lodge Valley, metasedimentary rocks of the Proterozoic Belt Supergroup, granitic plutons, and Lowland Creek Volcanics are exposed. East and north of Anaconda, Butte Quartz Monzonite, Cretaceous Elkhorn Mountains Volcanics, and Lowland Creek Volcanics are exposed in the low foothills on the eastern side of the Deer Lodge Valley. The Cretaceous Mount Powell Batholith is exposed in the mountains on the west side of the valley. Broad gravel-veneered pediments that are prominent landforms on both the east and west sides of the Deer Lodge Valley, were developed on Tertiary sedimentary beds and on Butte Quartz Monzonite. Tertiary sedimentary beds that are poorly exposed in this valley are mainly mudstone and sandstone. Wisconsin-age glacial till is well preserved on the west side of the Deer Lodge Valley and large outwash plains extend to both sides of the valley.

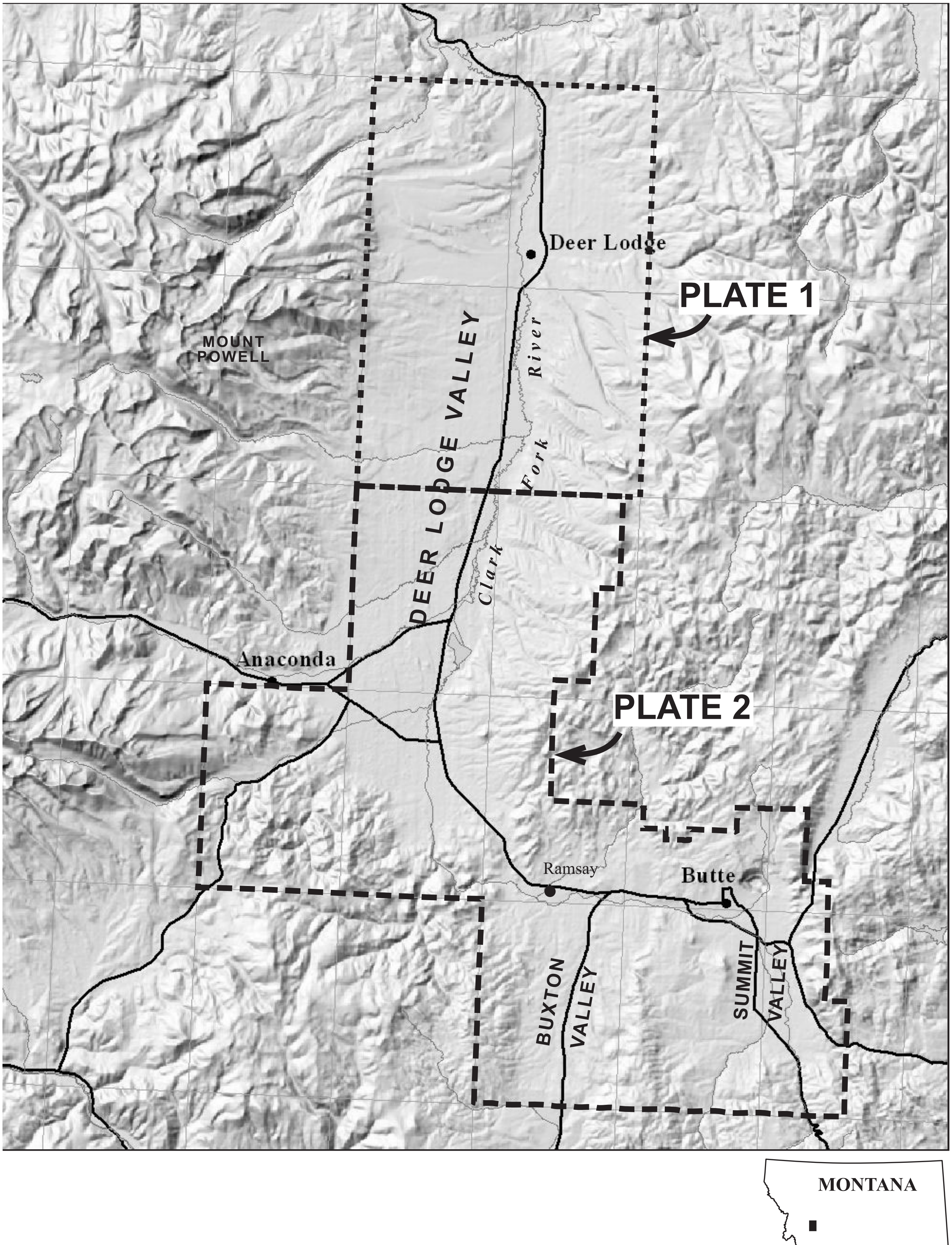
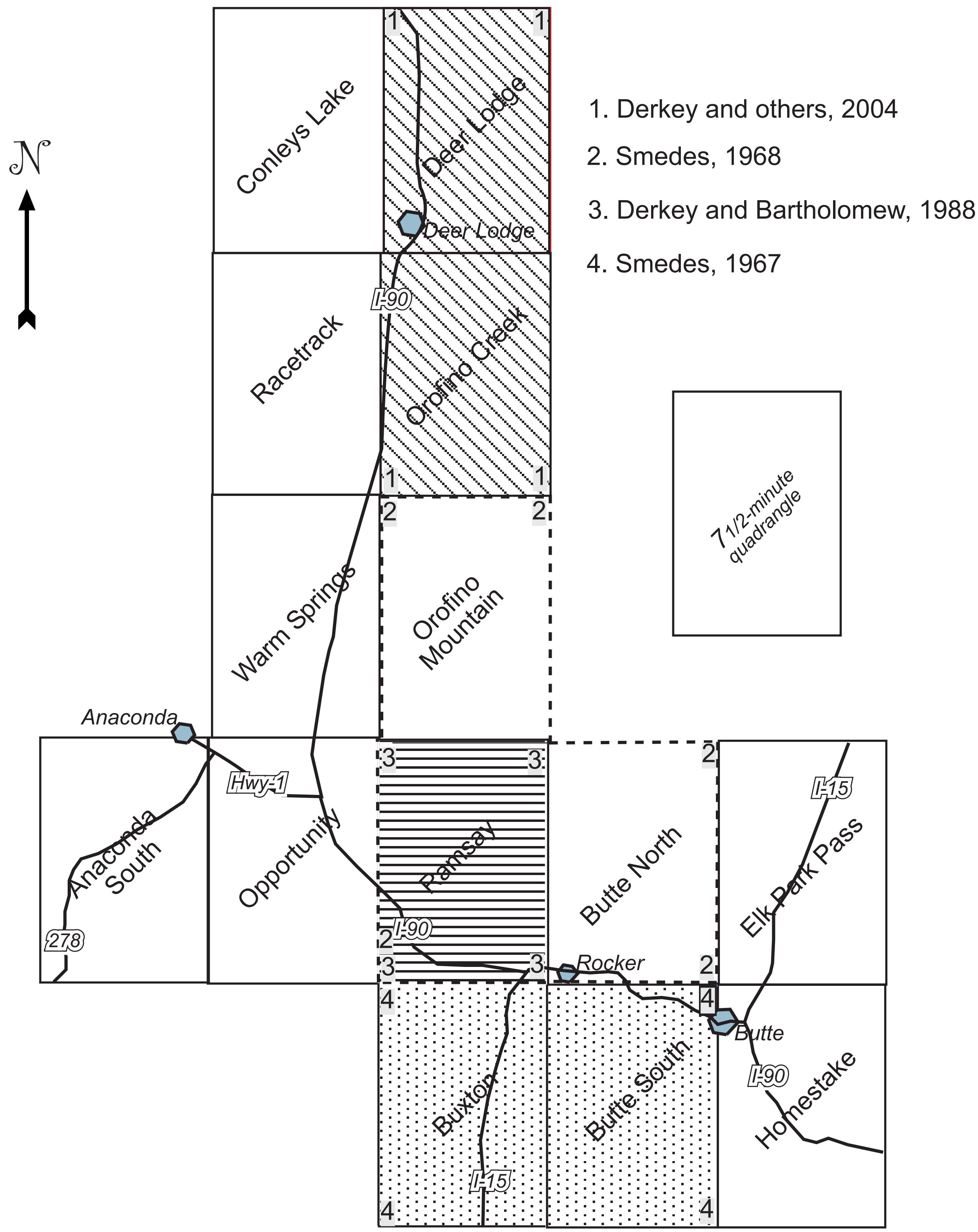
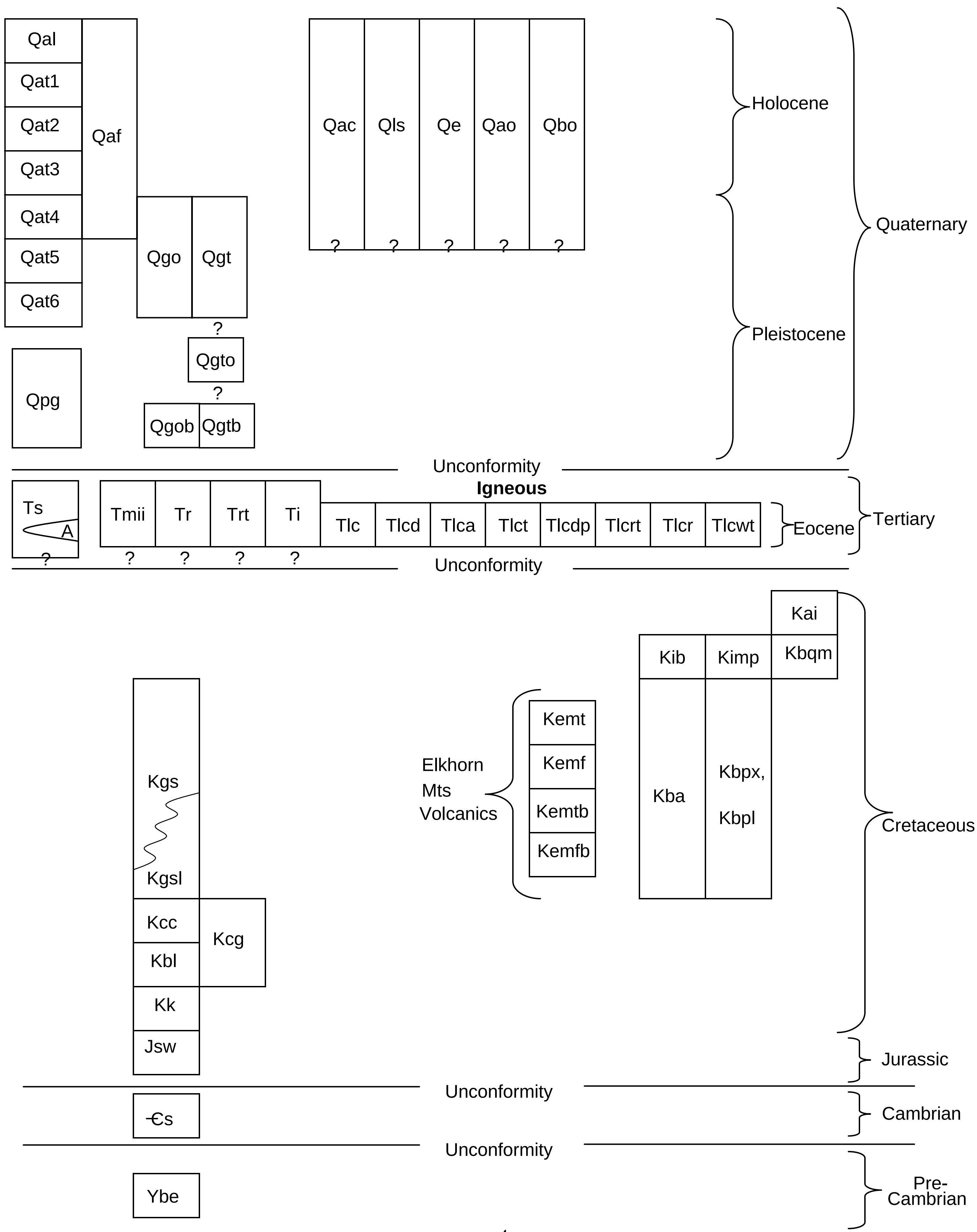


Figure 1. Location map showing area of map Plates 1 and 2 and locations of features mentioned in text.

Some previous geologic mapping in the Upper Clark Fork Valley area



Correlation of map units in the Upper Clark Fork Valley area



Description of Map Units in the Upper Clark Fork area

Note: Most map unit thicknesses and distances are given in feet. To convert feet to meters multiply feet by 0.30. To convert meters to feet multiply meters by 3.28.

QUATERNARY

Holocene Epoch

Qal **Alluvium** - Gravel, sand, silt, and clay along active channels of modern rivers, creeks, and intermittent streams.

Qat 1 **Alluvial terrace deposit, youngest** - Deposits on irregularly shaped, unpaired terraces 3-6 feet above the modern floodplain that consist of 3-6 feet of well to poorly sorted rock clasts derived from Tertiary and older strata (Derkey and others, 2004).

Qat 2 **Alluvial terrace deposit, second youngest** - Deposits on irregularly shaped, unpaired terraces 6-16 feet above the modern floodplain that consist of 3-6 feet of poorly sorted clasts similar to those in the youngest alluvial terrace deposits (Derkey and others, 2004).

Qat 3 **Alluvial terrace deposit, third youngest** - Deposits on irregularly shaped unpaired terraces 20-30 feet above the modern floodplain that consist of 3-6 feet of poorly sorted clasts similar to those in the younger alluvial terrace deposits (Derkey and others, 2004).

Holocene and Pleistocene Epochs

Qac **Alluvium and colluvium** - Alluvium and colluvium are combined where it is not practical to distinguish between them.

Qls **Landslide deposits** - Occur on some of the steeper slopes developed on the poorly consolidated Tertiary sedimentary rocks. Unconsolidated mixture of fine-grained sedimentary rock and soil characterized by hummocky topography.

Qaf **Alluvial fan deposits** - Small alluvial fans are common at the mouths of drainages emerging from the east side of the Deer Lodge Valley. Large fans are present at the mouths of Prairie and Spring gulches on the west side of the Deer Lodge Valley (Warm Springs 7½' quadrangle) and at the mouth of Taylor Creek (Conleys Lake 7½' quadrangle).

Qe **Eolian deposits** - Unstratified, well-sorted, light-brown (5YR 6/4) deposits of wind-blown silt and fine-grained sand. Large deposit in southern part of Orofino Creek 7½' quadrangle (Derkey and others, 2004).

Qao **Older alluvium** - Light-orange to tan, coarse sand with conglomeratic layers, flat-lying with local crossbeds locally accentuated by magnetite wisps and layers. Primarily massive deposits but, where excavated, sedimentary fluvial structures (including bedding) are revealed. Soft-sediment deformation occurs in the more clay-rich layers. Exposed beds are as much as to 8-feet-thick and near horizontal, and fining-upward sequences are repeated as observed in the McDermott Pit west of the Basin Creek road

(Butte South 7½' quadrangle). Composed almost exclusively of decomposed granite, mainly quartz, feldspar and biotite, with rounded pebbles of aplite and quartz more likely to be preserved in channels. Present-day conditions indicate that the Butte Quartz Monzonite decomposes rapidly and fills the valley that may have been a closed basin in the past because of faulting (Alden, 1953).

Where exposed in the Continental and Berkeley Pit areas, the alluvium contains large, rounded Butte Quartz Monzonite and aplite boulders in addition to quartz vein fragments. No volcanic clasts were found. Light-brown waxy, clay layers and sandy layers with smaller clasts, typically fining-upward are interbedded in the very coarse material. These deposits are interpreted to be alluvial fans that contain detritus derived from the north and east. There is no evidence that this older alluvium (Qao) is entirely Quaternary and it may extend into the Tertiary.

Volcaniclastic, light-gray, clay-rich sediments are exposed in a gully in the NE¼ sec. 24, T. 12 N., R. 8 W. in the Butte South 7½' quadrangle; they may underlie the Qao. Tertiary (?) volcanic or intrusive igneous rock clasts occur on the surface in the same area, perhaps remnants of landslides.

Pleistocene Epoch

Qat 4 **Alluvial terrace deposit, fourth youngest** - Preserved on paired terraces above the modern drainages, these terraces are moderately to well stratified, and moderately to well sorted (Derkey and others, 2004).

Qat 5 **Alluvial terrace deposit, fifth youngest** - Occur mainly on paired terraces and are more stratified and better sorted than glacial outwash deposits. Also contain more fine-grained material than glacial outwash deposits (Derkey and others, 2004).

Qat 6 **Alluvial terrace deposit, sixth youngest** - Deposits are better stratified and sorted than glacial outwash deposits and contain a greater percentage of sand (Derkey and others, 2004).

Qgo **Glacial outwash deposit** - Poorly sorted deposits of well-rounded material that ranges in size from boulder to sand. Outwash deposits extensive on both the east and west sides of the Deer Lodge Valley. Deposits on the east side of the valley consist mainly of basalt and porphyritic volcanic rock boulders, cobbles, and pebbles. Prominent outwash deposits at the mouths of Lost Creek, Warms Springs Creek and Mill Creek on the west side of the Deer Lodge Valley consist primarily of Precambrian Belt rocks and intrusive igneous rocks. These latter outwash deposits form easily recognizable plains visible from the air or air photos with abandoned braided stream channels and large flat plains with a consistent trend to the north and northeast toward the Clark Fork River. Outwash deposits farther north on the west side of the Deer Lodge Valley consist of 80-95 percent granite clasts with the remainder quartzite. The quartzite content increases with distance from the mountain front. Near the Clark Fork River outwash contains an estimated 50 percent quartzite and 50 percent granite.

Qgt **Glacial till -** Glacial till forms prominent deposits at the mouth of Racetrack Creek, Tin Cup Joe Creek, and along Rock Creek. Till deposits consist almost entirely of granitic material that ranges in size from pebble to boulder. Granite boulders do not show evidence of weathering.

Qgto **Glacial till older** - Scattered granite boulders on the slopes between Robinson Creek and La Marche Creek along the front of the Flint Creek Range are interpreted to be remnants of older glacial till in this area. Similar deposits just to the north of this area on both sides of Mullan Gulch. Mutch (1961) has mapped large areas of older glacial till in the mountains west of the Conleys Lake 7½' quadrangle.

Qgob **Glacial outwash of Bull Lake Glaciation** - Poorly exposed, poorly stratified, unconsolidated, poorly sorted, generally reddish-brown deposits containing subangular to rounded cobble- to boulder-size clasts in a clayey to silty sand matrix (Derkey and others, 2004).

Qgtb **Glacial till of Bull Lake Glaciation** - Poorly exposed, nonstratified, unconsolidated, poorly sorted, generally reddish-brown deposits containing subangular to rounded cobble- to boulder-size, matrix-supported clasts in a clayey to silty sand matrix. Clasts are primarily derived from volcanic rocks and most clasts are deeply weathered (Derkey and others, 2004).

Qpg **Pediment gravel deposit** - Poorly sorted and poorly stratified gravels that range in thickness from 1 to 20 feet. Subrounded cobbles and pebbles in a sandy matrix with local development of caliche. Pediment gravels on the east side of the Deer Lodge Valley consist mainly of basalt and porphyritic volcanic rock fragments with rare granite and quartzite. Pediment gravels on the west side of the Deer Lodge Valley, where examined on the surface, consist of an estimated 90 percent clasts of metasedimentary rocks of the Belt Supergroup (mainly quartzite) with the remainder granite. Rare exposures cut through the pediment gravel show a greater abundance of granite that has weathered to crumbly material.

Qbo **Aplite boulders -** Unit includes boulders that have been transported in landslides or debris flows, those that have moved a short distance by downhill creep, and those formed by in-place weathering of underlying aplite dikes in the Butte Quartz Monzonite and other granitic plutons of the Boulder Batholith. In the Rocker Valley, impressively large (some as large as a car) as well as smaller, subrounded to subangular, aplite boulders strewn across the hillsides are interpreted as lag deposits resulting from large landslides generated from the fault-bounded valley margins. Boulders of coarse-grained granite of the Boulder Batholith are nearly absent because they decompose more rapidly than the aplite. One example of an intact debris flow is exposed in a gully in the SE¼ sec. 30, and SW¼ sec. 29, T. 3 N., R. 8 W. (Sawmill Gulch) where coarse-grained granitic boulders of the Butte Quartz Monzonite are preserved along with aplite boulders. These boulders mantle the hillsides on the Buxton and Butte South 7½' quadrangles. In an area 4 miles south of Silver Bow, these boulders were previously identified as remnants of glacial moraines (Atwood, 1916), but this interpretation is discounted today. Indeed, the theory and deposits were mentioned in Alden (1953) when he described them as possibly resulting from sliding down from the ridges to the foothills on the sand from decomposed granite instead of from glacial activity. The concentrations of aplite boulders shown on the Buxton 7½' quadrangle range from the transported boulders that predominate to those that are remnants of underlying aplite dikes in the Butte Quartz Monzonite and other plutons of the Boulder Batholith. Examples of concentrations of boulders formed by in-place weathering of aplite dikes can be seen in secs. 7, 17 and 18, T. 2 N., R. 8 W.

TERTIARY

Ts Sedimentary rocks, undivided

Buxton Area

Very pale orange (10 YR 8/2), sandy and silty claystone is the dominant lithology of the area although poorly exposed except along coulees. Bedding is not generally recognizable except where there are rare granule and pebble beds. Some beds have a large volcanic ash component that has altered to form bentonitic exposures with rare concretionary masses of clinoptilolite and local development of porcellanite. A distinctive brown, resistant bed from 1 to 2 feet thick, that weathers with a hackly surface, is exposed in the southern part of the quadrangle. Glass shards in this bed are recognizable with a hand lens, and root casts occur in most exposures. Perhaps this bed is partly silicified volcanic ash.

A - Arkose Thin beds of a distinctive resistant arkose are exposed on both the east and west sides of the Buxton area. On the west side of the valley, the arkose beds are close to if not lying directly on gray granite typical of the Boulder Batholith. At one locality on the west side, these beds overlie volcanic rocks of the Eocene Lowland Creek Volcanics. On the east side of the valley, arkose beds are situated part way up the gentle slope below exposures of granite farther to the east. The arkose on the east side of the valley is lithologically similar to that on the west side, but it cannot be demonstrated conclusively that they are the same beds. Bentonite beds are exposed at several localities below the exposures of arkose on the east side of the valley. Generally only one bed of arkose that ranges from 1 to 12 feet in thickness is exposed, but near the southern boundary of the Buxton quadrangle at Slab Creek, three beds of arkose are exposed over a stratigraphic distance of 200 feet. Not only is the arkose thickest at Slab Creek but also contains larger clasts with aplite boulders up to 1.5 feet long. Some exposures of the arkose show graded bedding where the upper bed of the sequence is fine grained with biotite flakes 1-2 mm in diameter oriented on the bedding plane. Because of this alignment of biotite and general lack of rounded granules, some of the arkose resembles a foliated quartzofeldspathic gneiss. On a weathered surface, the arkose ranges in color from moderate yellowish brown (10 YR 5/4) to dark yellowish brown (10 YR 4/2). The arkose consists of angular grains of quartz, potassium feldspar, plagioclase, biotite flakes, and rare rhyolite pebbles. Some intergranular voids are partly filled with chalcedony that also occurs along fractures. Much of the chalcedony appears black because of included iron or manganese minerals and fluoresces yellowish green under short wavelength ultraviolet light. Local silicification of the arkose may explain its resistance to erosion and the scattered exposures on the west side of the valley may be those localities where it has been silicified. This arkose was derived from the granite exposed in the low mountains west of the Rocker Valley. Its high porosity and generally angular grains indicate rapid deposition in a fluvial environment. It is postulated that during periods of unusual runoff from the mountains, grus resting on the granite was quickly deposited in the valley, forming these arkose beds.

Southern Deer Lodge Valley

Highly variable, silty to sandy mudstone to conglomeratic deposits; some sediment is of volcanic origin and some derives from the Butte Quartz Monzonite. Beds appear to be flat-lying, with low-angle dips measured in gullies; many apparent dips measured may be simply expressions of fluvial structures. Volcanic fragments increase in abundance to the north while clasts related to the Butte Quartz Monzonite (mostly aplite and vein quartz) dominate to the south. Chalcedonic quartz, white vein quartz, and Butte Quartz Monzonite clasts are common south of Interstates 90 and 15 transitioning to black tourmaline and aplite cobbles and porphyritic volcanic clasts to the north and slightly south of the Interstate and Rocker. Conglomerates and cobble layers in finer grained rocks are heterolithologic. As exposed in excavations for borrow material for reclamation in 2003, typical fine-grained mudstone and siltstone sediments contain large (3-5 foot) boulders of Butte Quartz Monzonite and Lowland Creek Volcanics near the contact with bedrock. Rare vertebrate bone fragments were found in other localities west of Rocker.

Northern Deer Lodge Valley

Predominately massive sandy or silty mudstone with blocky fracture and grayish-orange (10YR 7/4) to very pale-orange (10 YR 8/2) color. Biotite flakes recognizable on most exposures, muscovite less common, and glass shards recognizable in some beds. Sand, granule, and pebble conglomerate beds as much as 6 feet thick with granite and quartzite clasts are generally poorly sorted. Several bentonite beds, although not exposed, recognized by typical crumbly weathering of bentonitic clay. Light-gray (N 9) ash beds are exposed at several localities and are easily recognizable because they appear white in contrast to the grayish-orange color of under- and over-lying beds. At some localities the ash beds are relatively resistant and form small ledges. Thickness ranges from 3 to 6 feet. One ash bed is traceable for 2 miles from the SE¼ sec. 34, T. 7 N., R. 10 W., to the NE¼ NE¼ sec. 1, T. 7 N., R. 10 W., just north of Tin Cup Joe Creek on the Conleys Lake 7½' quadrangle. Another ash bed is exposed over part of the distance and is 18 feet above the lower bed. Ash from this and other exposures of what may be the same bed has an index of refraction of approximately 1.498 and consists of shards in the medium sand size range and rare diatoms. Tertiary sedimentary beds overlie the Eocene Lowland Creek Volcanics in the subsurface in the Deer Lodge Valley (McLeod, 1987). These Tertiary beds are considered to range in age from Eocene to Pliocene (Rasmussen and Prothero, 2003; Konizeski and others, 1961). Generally poor exposures in this valley have hampered study of Tertiary sedimentary beds. However, on the basis of a detailed paleontological study (Rasmussen, 1977), the Arikareean Cabbage Patch Beds in the northern part of the Deer Lodge Basin were correlated with similar beds in the Flint Creek Basin, in the vicinity of Drummond, in the Blackfoot Basin, in the Divide Basin, and in the Three Forks area. Cabbage Patch Beds are exposed between Mullan Gulch and Dry Gulch in the northern part of the Conleys Lake 7½' quadrangle. Because of similar lithology with abundance of volcanic ash, the authors interpret the Cabbage Patch Beds to continue south into the northern half of the Racetrack 7½' quadrangle.

Tmii **Mafic to intermediate intrusive bodies** - Dark-gray alkali dikes intrude the Carter Creek Formation in the northwestern part of the Deer Lodge 7½ ' quadrangle (Derkey and others, 2004).

Trt **Rhyolite tuff, tuffaceous sediments, and fossiliferous limestone** - White to buff, tuffaceous rocks with sparse coarser-grained, well-indurated tuff-breccia lenses containing darker volcanic fragments. Fossiliferous limestone interbedded with siliceous tuff crops out near the northwestern corner of the Deer Lodge 7½' quadrangle (Derkey and others, 2004).

Eocene
Lowland Creek Volcanics

Tlc **Lowland Creek Volcanics -** Grouped where previously mapped by Derkey and Bartholomew (1988) on the Ramsay 7½' quadrangle. Predominantly a porphyritic dacite. Thick, well-indurated lava flows have local flow breccias. Composition averages 10-25 percent plagioclase, 2-7 percent biotite, 1-5 percent hornblende, 1-5 percent quartz, and 1 percent pyroxene (Derkey and Bartholomew, 1988).

Ti **Intrusive dikes** - Light colored porphyritic rhyolite dikes that cut the Butte Quartz Monzonite and are related to the Lowland Creek Volcanics.

Following units are in the Deer Lodge Valley

Tlcd **Dacite flows, aphantic** - Medium- to dark-gray aphanitic sills or flows with well-developed columnar jointing and closely spaced, platy horizontal jointing. Contains 20-25 percent plagioclase, 2-3 percent clinopyroxene, 1-2 percent hornblende, and 1 percent quartz set in a microcrystalline groundmass (Derkey and others, 2004).

Tlca **Quartz-latitic, welded ash-flow tuff, crystal rich -** Pale-red, reddish-orange, and light-gray, well-indurated, crystal-rich, massive to flow foliated, ash-flow tuff. Locally contains lithic fragments. Contains 10-25 percent plagiclase (An_{31}), 1-5 percent quartz, 2-7 percent biotite, 1-5 percent hornblende, and 1 percent pyroxene set in a glassy and microcrystalline groundmass (Derkey and others, 2004).

Tlct **Quartz-latitic tuff, crystal rich** - Very light gray to yellowish- and greenish-gray, massively bedded air-fall and ash-flow tuff that is poorly to moderately indurated, easily eroded, crystal-rich, with sparse, moderately flattened pumice lumps. Small exposures of thinly bedded and cross-bedded, water-laid tuff that occur at the same stratigraphic position are considered part of this unit (Derkey and others, 2004).

Following units used in the Buxton-Ramsay area

Tlcdp **Porphyritic dacite** - Medium light-gray to medium dark-gray and grayish-red, massive to flow-banded porphyritic flows and autoclastic breccia. Contains 7-10 percent plagioclase (An_{25}), 1-5 percent hornblende, and 1-2 percent biotite phenocrysts set in a microcrystalline groundmass (Derkey and Bartholomew, 1988).

Tlcrt **Rhyodacite tuff** - Yellowish-gray to very light-gray, easily eroded, poorly to moderately indurated, crystal-rich ash-flow tuff with about 15 percent moderately flattened pumice lumps and 2-3 percent mixed subangular to rounded volcanic rock fragments generally less than 8 cm in diameter (Derkey and Bartholomew, 1988).

Tlcr **Rhyolite** - Weathers reddish brown forming rounded to angular outcrops with locally prominent platy jointing. Phenocrysts 1-4 mm across are 75 percent potassium feldspar, 20 percent quartz, and 5 percent biotite in a microcrystalline groundmass that constitutes 30-50 percent of the rhyolite. Sparse rhyolite xenoliths and rare angular xenoliths of fine-grained, black, igneous rock.

Tlcwt **Welded tuff** - Weathers light gray to reddish brown with quartz and feldspar phenocrysts. Ranges from slightly welded tuff in which partially collapsed pumice fragments have weathered to leave cavities on the surface to densely welded tuff in which pumice fragments are highly elongate and the rock exhibits a granular texture.

Tr **Rhyolite** - Light- to medium-gray or pinkish, with 5-10 percent plagioclase phenocrysts (1-2 mm) and quartz (1 mm) in a fine-grained siliceous groundmass (Derkey and others, 2004).

CRETACEOUS

Kai **Aplite, intrusive** - Dikes of mappable extent associated with the Boulder Batholith (Derkey and others, 2004). Some are pegmatitic.

Kbqm **Butte Quartz Monzonite and aplite of the Boulder Batholith** - Coarse- and fine-grained, light-gray to pink to bluish quartz monzonite (Watson, 1987; Smedes and others, 1988). Composed of normally zoned plagioclase (45-50 percent), orthoclase (20-30 percent), and quartz (5-10 percent). Contains numerous quartz and aplite veins that range in width from a few inches to several feet. Intrudes the basal part of the Elkhorn

Mountains Volcanics and interbedded basalt flows (Kba) (Derkey and others, 2004).

Kib Granitic plutons probably related to the Boulder Batholith.

Kimp **Intrusive rocks of the Mount Powell Batholith** - This granitic pluton consists of quartz, zoned plagioclase, microcline, muscovite, and biotite (Mutch, 1961). Where exposed near the range-front fault at the western boundary of the Racetrack 7½' quadrangle, this pluton is locally sheared with epidotization of feldspars and is silicified next to the fault.

Kba **Basalt flows and flow breccias** - Because of poor exposure, basalt was mapped as a single lithologic, but probably not stratigraphic, unit in the Deer Lodge 7½' quadrangle, but subdivided to the south (Derkey and others, 2004).

Kbpl **Basalt flows and flow breccias, plagioclase basalt** - Dark-gray porphyritic basalt containing 5-7-mm, light-gray plagioclase phenocrysts that are especially distinct on weathered surfaces, and 1-3-mm augite phenocrysts (Derkey and others, 2004).

Kbpx **Basalt flows and flow breccias, large-pyroxene basalt** - Dark-green porphyritic basalt contains augite phenocrysts as large as 1 cm. The dark-green matrix has a distinct hackly fracture (Derkey and others, 2004).

Elkhorn Mountains Volcanics (Cretaceous)

Kemt **Welded ash-flow tuff -** Brown to red-brown to red-gray to dark-gray, crystal-poor (<5 percent), containing abundant lithic fragments of the underlying andesite units. Variable colors are due to intensity of degree of welding (Derkey and others, 2004).

Kemf **Andesitic lava flows, fine-grained** - Medium- to dark-brown and dark-green, fine-grained, nearly aphyric lava flows (Derkey and others, 2004).

Kemtb **Tuff and tuff breccia** - Dark-gray to green groundmass in a crystal lithic tuff that is easily distinguished by its 1-2-mm equidimensional, white plagioclase phenocrysts. Locally contains abundant lithic fragments up to 7 cm in diameter (Derkey and others, 2004).

Kemfb **Andesite flows, flow breccia and tuff breccia -** Dark-gray to purplish-gray containing locally distributed white plagioclase phenocrysts that are typically flattened and irregular in shape and resemble rolled oats resulting in the field name “oatmeal andesite” (Derkey and others, 2004).

Golden Spike Formation

Kgs **Golden Spike Formation** - **(Upper Cretaceous)** - Lava flows of andesitic composition with intervening sandstone, conglomerate, and volcaniclastic beds with minor limestone and rare black shale. The nonvolcanic sandstone consists mainly of quartz, lithic fragments, biotite, and muscovite, whereas the volcaniclastic beds consist mainly of plagioclase feldspar, volcanic glass, and volcanic rock fragments in a fine-grained matrix (Mackie, 1986). Lava flows form prominent outcrops, but the sandstone beds are generally very poorly exposed. Brownish-gray (5YR 4/1) limestone occurs in float and rare outcrop above a lava flow in secs. 35 and 36, T. 9 N., R. 10 W., and also on the north side of Cottonwood Draw in the SE¼ NE¼ sec. 12, T. 8 N., R. 10 W. A pisolitic limestone bed about 4 feet thick overlies an andesite flow. Just below the limestone beds, the andesite shows evidence of weathering - local bleaching accompanied by the development of hematite. There is a small exposure of black shale northwest of the power line road in the NW¼ SW¼ sec. 36, T. 9 N., R. 10 W.

Kgsl **Lava flow unit (informal) of the Golden Spike Formation** - Andesite flows are intermittently exposed in the low hills near the northern boundary of the Conleys Lake 7½' quadrangle. Plagioclase phenocrysts (most from 3 mm to 1 cm) range from sparse to abundant and at some localities define flow foliation. Smaller pyroxene phenocrysts are less prominent. Flow banding prominent in some exposures, particularly that just north of Mullan Gulch, is highly variable in attitude. Several individual flows can be recognized in some of the larger exposures where tops of flows are marked by flow breccias.

Kcc **Carter Creek Formation** - Local exposures in small fault slices within the northern part of the Deer Lodge 7½' quadrangle. Consists of coarse-grained, salt-and-pepper, cross-bedded sandstone, white to pale-green tuffaceous beds, and beds of fine-grained, gray to brownish-gray limestone lenses up to 20 inches thick containing no visible fossils. Thickness is more than 500 feet (Derkey and others, 2004). Previous work incorrectly refers to this as the “Carten” Creek Formation (Waddell, 1997).

Kcg **Colorado Group, undivided (Cretaceous)** - Exposed on two hills on the lower southeast corner of the Warm Springs 7½' quadrangle. Metamorphosed, dark gray and tan, layered shale, siltstones, and sandstones, typical Colorado Group as identified by Hugh Dresser (oral communication, 2004). Intruded by felsic bodies, some sill-like and some irregular dikes in the Homestead Creek area.

Kbl **Blackleaf Formation (Lower Cretaceous)** - Fine- to medium-grained quartzose sandstone and quartz-pebble conglomerate exposed only along the western flank of the Boulder Batholith in the southeastern part of the Orofino Creek 7½' quadrangle, where it is metamorphosed (Derkey and others, 2004).

Kk **Kootenai Formation (Lower Cretaceous)** - Consists of four recognizable lithologic units that from bottom to top are lower calcareous member, upper clastic member, gastropod limestone member, and upper quartzite (Derkey and others, 2004 citing oral communication from A.B. French, 1994).

JURASSIC

Jsw **Swift Formation** - Medium- to light-gray, tan and pink chert-clast-rich sandstone that contains scattered chert pebble conglomerate lenses and beds with pebbles up to 2-3 cm in diameter. Contains secondary quartz veins that locally make up over 50 percent of the rock, particularly near faults (Derkey and others, 2004).

CAMBRIAN

Cs **Sedimentary rocks undivided** - Compiled by Lewis (1998) as Silver Hill Formation.

PRECAMBRIAN

Ybe **Belt Supergroup undivided (Proterozoic)** - Siltite, argillaceous quartzite, and quartzite are found in float along the range-front fault north of Robinson Gulch. These metasedimentary rocks are interpreted to belong to the Belt Supergroup. They were also mapped in outcrop as “Miller Peak argillite” (Noel, 1956) and compiled on the Butte 1° x 2° quadrangle as Mount Shields Formation quartzite and argillite (Lewis, 1998).

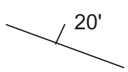
Map Symbols

Contact– Dotted where concealed

Fault– Dashed werhere Approximately located. Dotted where concealed. Bar and bell on dwon-thrown side.

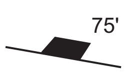
Thrust Fault– Teeth on upper plate; dotted where concealed.

Lineament

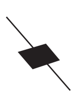


Strik and dip of beds

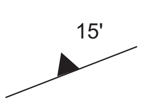
Horizontal beds



Altitude of inclined joint



Vertical joint



Planar fabric in igneous rocks

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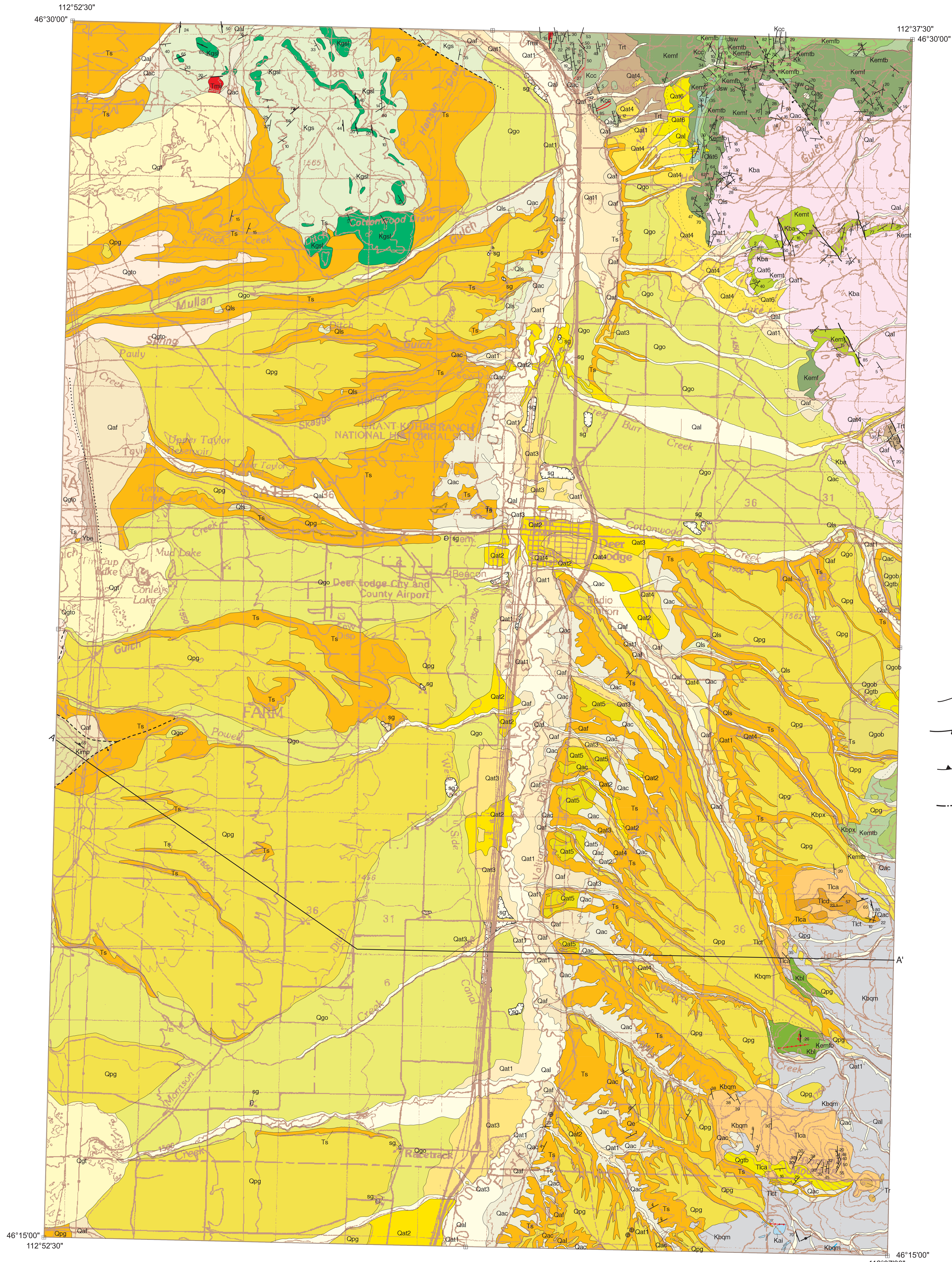


MAP UNITS

Qal	Alluvium of modern channels and flood plains	Tlca	Lowland Creek Volcanics, ash-flow tuff
Qat1	Alluvium of youngest alluvial terrace level	Tlct	Lowland Creek Volcanics, tuff
Qat2	Alluvium of second youngest alluvial terrace level	Tlcdp	Porphyritic dacite
Qat3	Alluvium of third youngest alluvial terrace level	Tlcrt	Rhyodacite tuff
Qaf	Alluvial fan deposit	Tlcr	Rhyolite
Qac	Alluvium-colluvium	Tlcwt	Welded tuff
Qls	Landslide deposit	Kai	Aplite, intrusive
Qe	Eolian deposit	Kib	Granitic plutons
Qao	Alluvium, older, undivided	Kimp	Intrusive rocks of the Mount Powell batholith
Qbo	Aplite boulders	Kbqm	Butte Quartz Monzonite and aplite
Qat4	Alluvium of fourth youngest alluvial terrace level	Kgs	Golden Spike Formation
Qat5	Alluvium of fifth youngest alluvial terrace level,	Kgsl	Lava flow unit, informal, of Golden Spike Formation
Qat6	Alluvium of sixth youngest alluvial terrace level,	Kba	Basalt
Qgo	Glacial outwash deposit	Kbpx	Basalt flows and flow breccias, large-pyroxene basalt
Qgt	Glacial till, late Wisconsin	Kbpl	Basalt flows and flow breccias, plagioclase basalt
Qgto	Glacial till, older	Kemt	Welded ash-flow tuff
Qpg	Pediment gravel deposits	Kemf	Andesitic lava flows, fine-grained
Qgob	Glacial outwash of Bull Lake glaciation	Kemtb	Tuff and tuff breccia
Qgtb	Glacial till of Bull Lake glaciation	Kemfb	Andesite flows, flow breccia and tuff breccia
Ts	Sediment or sedimentary rocks, undivided	Kcg	Colorado Group, undivided
Tmii	Intrusive rocks, alkalic, undivided	Kcc	Carter Creek Formation
Tr	Rhyolite or rhyolitic sediment	Kbl	Blackleaf Formation
Trt	Rhyolite tuff	Kk	Kootenai Formation
Ti	Intrusive rocks, undivided	Jsw	Swift Formation
Tlc	Lowland Creek Volcanics	Ꞓs	Sedimentary rocks, undivided
Tlcd	Lowland Creek Volcanics, dacite flows	Ybe	Belt Supergroup, undivided

MAP SYMBOLS

- Contact—Dotted where concealed
- Fault—Dashed where approximately located; dotted where concealed; bar and ball on down-thrown side
- Thrust fault—Teeth on upper plate; dotted where concealed
- Lineament
- 30 Strike and dip of beds
- Horizontal beds
- 75 Attitude of inclined joint
- Vertical joint
- 15 Planar fabric in igneous rocks
- Chalcedony and quartz veins and zones of silicification
- Aplite dikes
- Mafic to intermediate dikes
- sg Sand and gravel pit
- A Arkose bed
- Abandoned placer
- M Mount Mazama Ash bed
- m Area modified by man

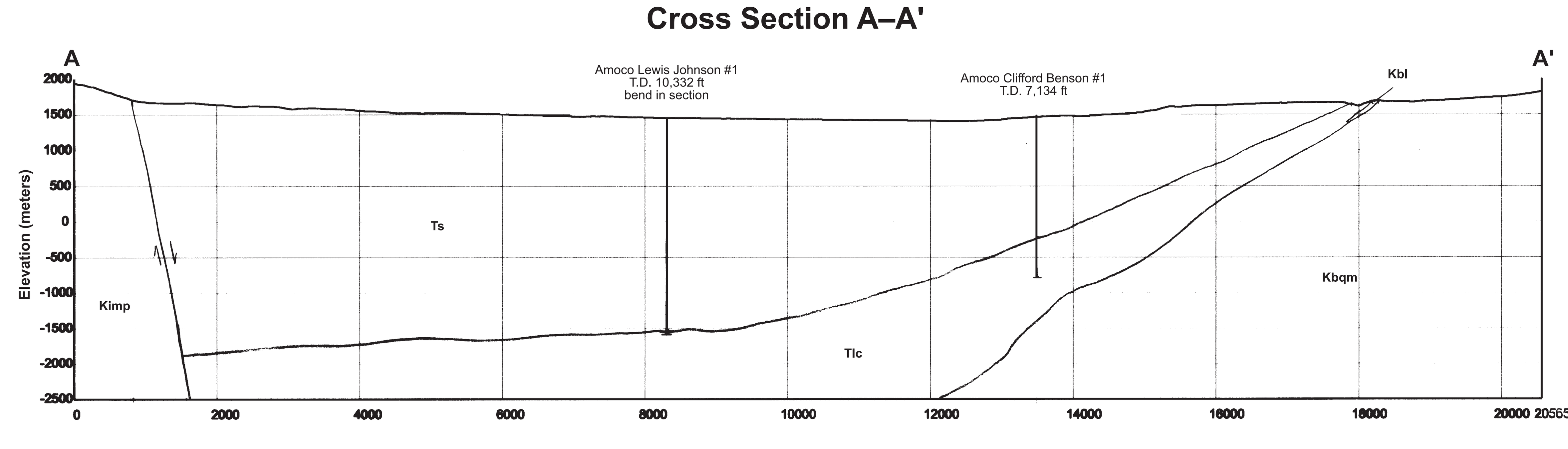
Scale 1:50,000

0 — 5 Miles

Contour Interval 50 meters

N

Cross Section A–A'



No vertical exaggeration
Elevation in meters above or below (-) mean sea level
Surficial deposits not shown

Montana Bureau of Mines and Geology
Open File 506, Plate 1 (North)

Geologic Map of the Upper Clark Fork Valley Southwestern Montana

Mapped and Compiled by
Richard B. Berg and Phyllis Hargrave

2004

Partial support has been provided by the STATEMAP component of the National Cooperative Geologic Mapping Program of the U.S.Geological Survey under Contract Number 03HQAG0090.

GIS production: Ken Sandau and Paul Thale, MBMG. Map layout: Susan Smith, MBMG.

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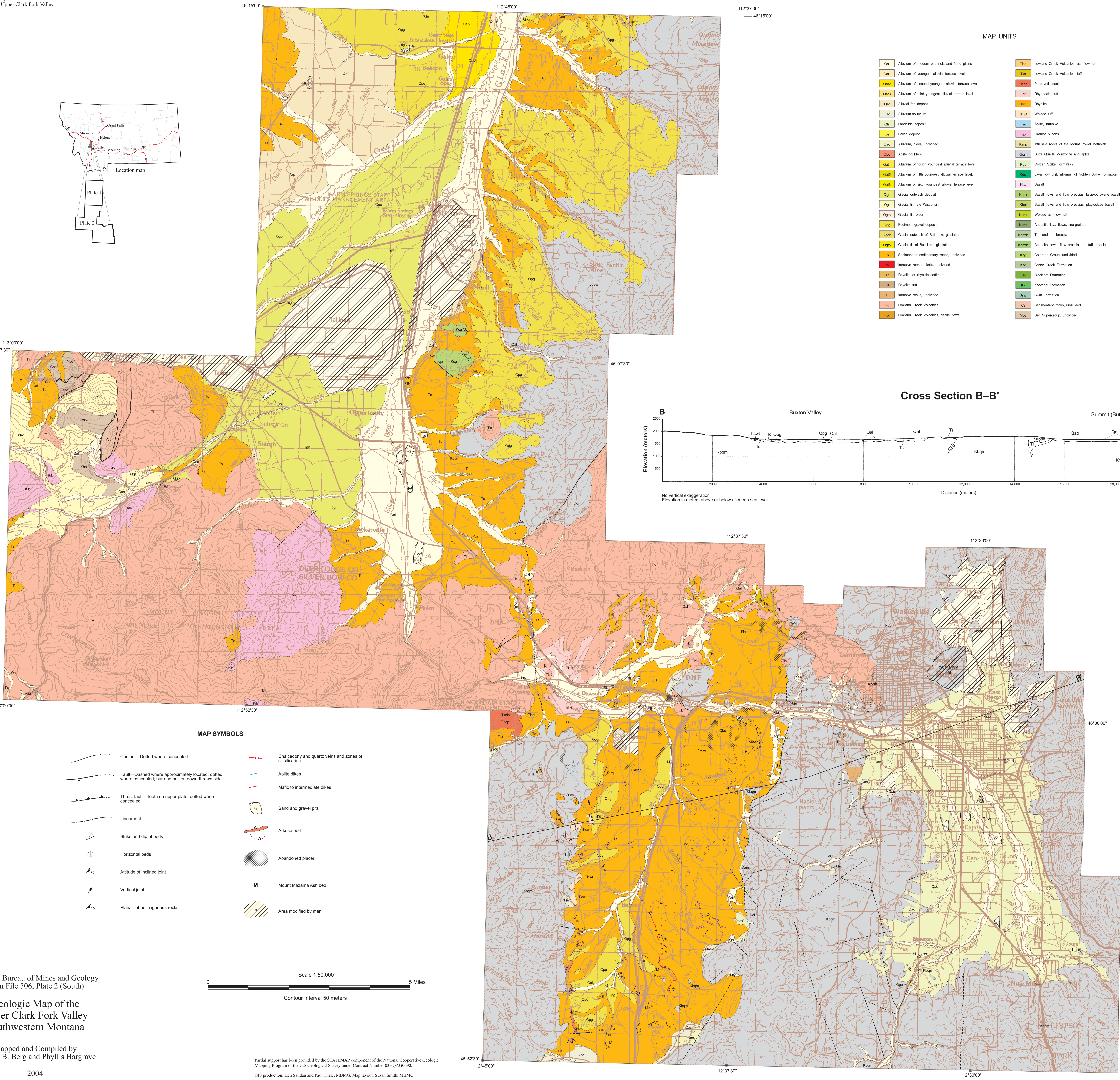
A Department of Montana Tech of The University of Montana



Location map

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- Attitude of inclined joint
- Vertical joint
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- Chalcedony and quartz veins and zones of silicification
- Aplite dikes
- Mafic to intermediate dikes
- Sand and gravel pits
- Arkose bed
- Abandoned placer
- M Mount Mazama Ash bed
- Area modified by man

Montana Bureau of Mines and Geology
Open File 506, Plate 2 (South)

Geologic Map of the Upper Clark Fork Valley Southwestern Montana

Mapped and Compiled by
Richard B. Berg and Phyllis Hargrave

2004

Scale 1:50,000
0 5 Miles
Contour Interval 50 meters

Partial support has been provided by the STATEMAP component of the National Cooperative Geologic Mapping Program of the U.S.Geological Survey under Contract Number 03HQAG0090.

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