

Geologic Map
of the
Deer Lodge and Conleys Lake 7_{1/2}' Quadrangles
Powell County, Southwestern Montana

Mapped and Compiled
by
Richard B. Berg

Montana Bureau of Mines and Geology

Open File Report MBMG 509

2004

This map has been reviewed for conformity with technical and editorial standards of the Montana Bureau of Mines and Geology.

Partial support has been provided by the National Park Service Geologic Resources Division under Contract Number P2360031124.

Geologic Summary
Deer Lodge and Conleys Lake 7¹/₂ - minute quadrangles
Powell County, Southwestern Montana

The broad Deer Lodge Valley is a half graben bounded on the west by range-front faults, but lacking major faults on the east side. With the exception of a small remnant of metasedimentary rocks of the Proterozoic Belt Supergroup on the west side of the Deer Lodge Valley, all rocks exposed in these two quadrangles are Mesozoic or Cenozoic. The Swift Formation (Jurassic age) and Cretaceous sedimentary formations are exposed in the northern part of the Deer Lodge quadrangle. The Cretaceous Golden Spike Formation, exposed in the low hills in the northern part of the Conleys Lake quadrangle, consists of lava flows of andesitic composition interlayered with sandstone. On the east side of the Deer Lodge Valley a variety of volcanic rocks of the Elkhorn Mountains Volcanics and also other basaltic volcanics, all of Cretaceous age, are exposed over large areas.

A thick sequence of Tertiary sediments occupies the central part of the broad Deer Lodge Valley (Fig. 1). A well drilled about 7 miles south of the Grant Kohrs Ranch National Historic Site penetrated 10,052 ft of Tertiary sediments before encountering Eocene volcanic rocks. In spite of this great thickness of Tertiary sediments, Arikareean Cabbage Patch beds are thought to be the only beds exposed in this part of the Valley. Exposed Tertiary sediments consist of lake beds, fluvial deposits, and an ash bed traceable for 2 miles. Extensive pediments on both sides of the valley are covered with deposits of gravel derived from mountains flanking the Deer Lodge Valley. Deposits of glacial till are found in the northwestern part of the Conleys Lake quadrangle and also in the southeast corner of the Deer Lodge quadrangle. Large outwash deposits are prominent on both the east and west sides of the valley.

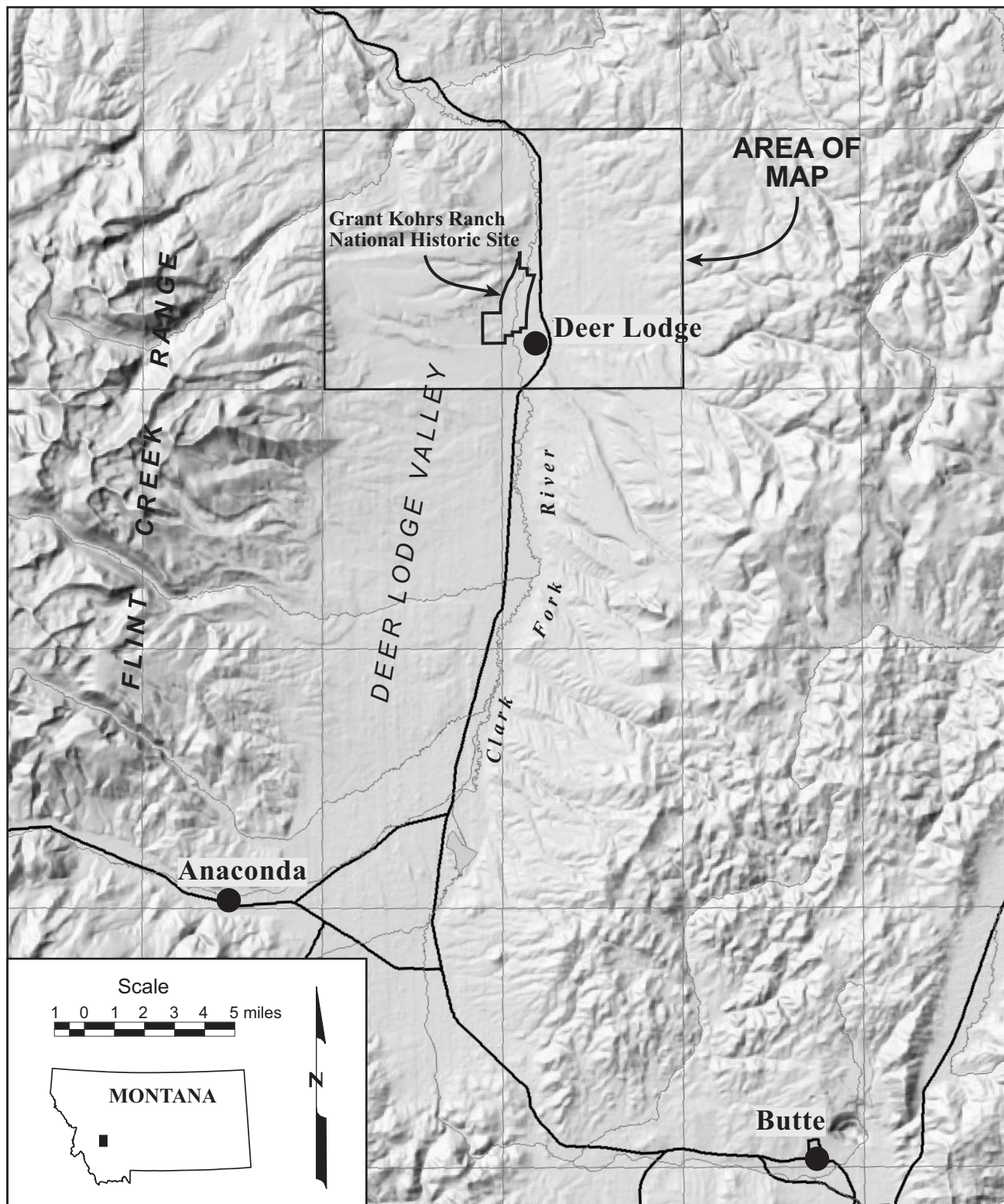
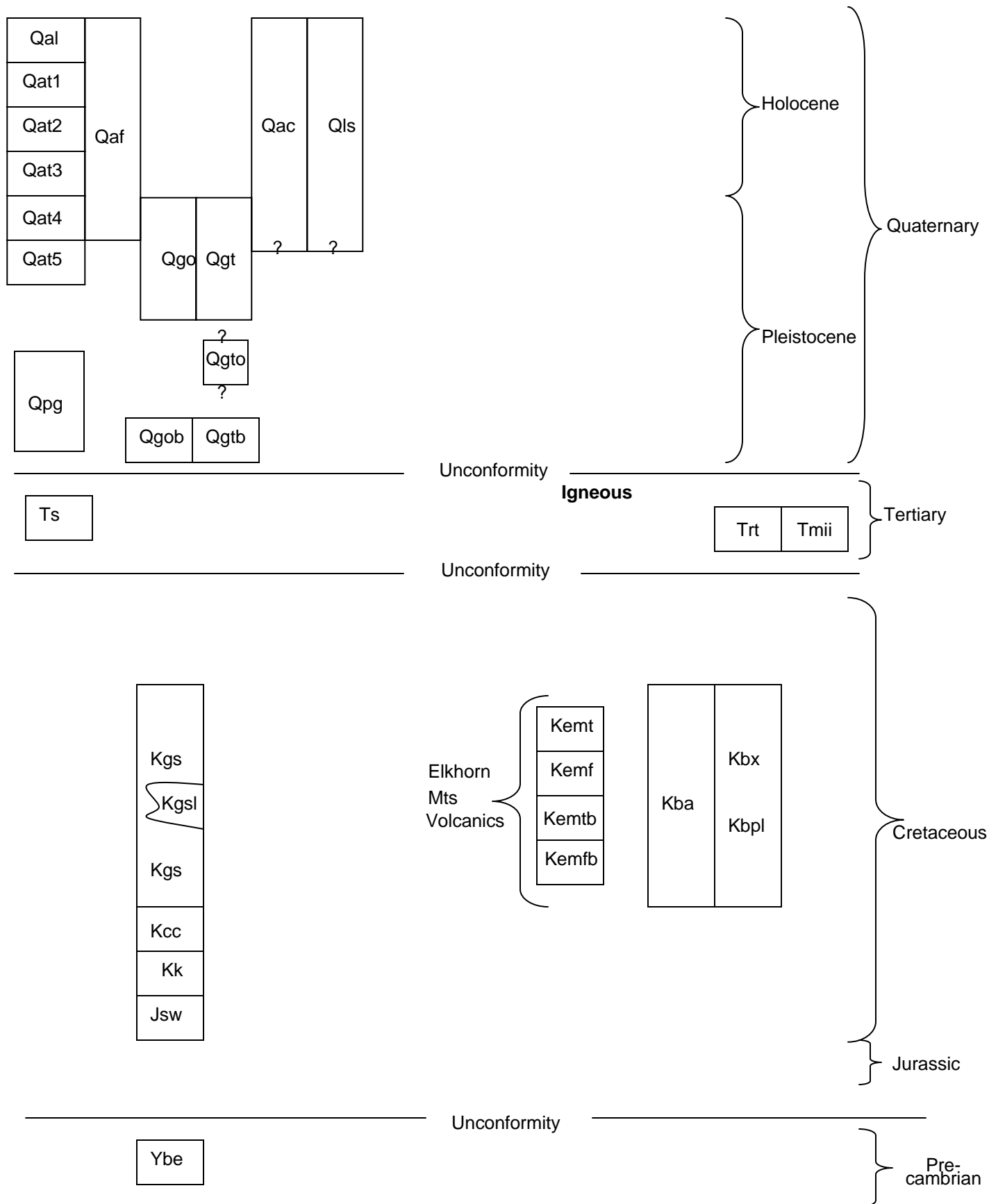


Figure 1. Location map showing area of map and locations of features mentioned in text.

Correlation of Map Units



Descriptions of Map Units

QUATERNARY

Holocene Epoch

- Qal Alluvium** - Gravel, sand, silt, and clay along active channels of rivers, creeks, and intermittent streams.
- Qat Alluvial terrace deposit** - Used only in cross section.
- Qat 1 Alluvial terrace deposit, youngest** - Deposits on irregularly shaped, unpaired terraces 3 - 6 ft above the modern floodplain that consist of 3 - 6 ft 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 ft above the modern floodplain that consist of 3 - 6 ft 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 ft above the modern floodplain that consist of 3 - 6 ft 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** - Colluvium and alluvium are combined where it is not practical to distinguish between them.
- Qls Landslide deposit** - 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 deposit** - With the exception of the large alluvial fan along Taylor and La Marche creeks on the west side of the Deer Lodge Valley, alluvial fans are small deposits of gravel, sand, silt, and clay formed where tributaries enter the Clark Fork River flood plain and along some of the major streams. Alluvial fans are well developed on the east side of the Clark Fork River flood plain, but not along the west side of this river.
- Qat 4 Alluvial terrace deposit, fourth youngest** - Preserved on paired terraces above the modern drainages and 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 highly stratified and better sorted than glacial outwash deposits. Also contain more fine-grained material than glacial outwash deposits (Derkey and others, 2004).
- Qgo Glacial outwash deposit** - Poorly sorted deposits of well - rounded material that ranges in size from boulder to sand. There are extensive outwash deposits on both the east and west sides of the Deer Lodge Valley. Outwash deposits on the east side of the valley consist mainly of basalt and porphyritic volcanic rock boulders, cobbles, and pebbles. On the west side of the valley outwash deposits consist of 80 - 95 percent granite clasts with the remainder quartzite. On the west side of the Deer Lodge Valley the percent of quartzite 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 also along Rock Creek. Till deposits consist almost entirely of granitic material that ranges in size from pebble to boulder. Granite boulders in these deposits do not show evidence of weathering.
- Qgto Glacial till older** - Scattered granite boulders on the slopes along the front of the Flint Creek Range between Robinson and La Marche creeks are interpreted to be remnants of older glacial till. Similar deposits are found on both sides of Mullan Gulch just north of this area. Mutch (1961) mapped large areas of older glacial till in the mountains west of the Conleys Lake 7 $\frac{1}{2}$ ' quadrangle.
- Qpg Pediment gravel deposit** - Poorly sorted and poorly stratified gravels that range in thickness from 1 - 20 ft. 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 metasedimentary rocks derived from the Belt Supergroup (mainly quartzite) with the remainder granite. In those rare instances where a complete section of the pediment gravel is exposed, crumbly, strongly weathered granite cobbles and boulders are present in the lower part of the gravel deposit.
- 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).

TERTIARY

Ts Sedimentary rocks, undivided - 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 in most exposures, muscovite less common, and glass shards recognizable in some beds. Sand, granule, and pebble conglomerate beds up to 6 ft thick, containing granite and quartzite clasts, are generally poorly sorted. Several bentonite beds can be recognized by typical crumbly weathering of bentonitic clay.

Light gray (N 9) ash beds are exposed at several localities and easily recognizable because these beds appear white in contrast to the grayish orange color of underlying and overlying beds. At some localities the ash beds are relatively erosion resistant and form small ledges. Thickness ranges from 3 to 6 ft. One ash bed is traceable for 2 miles from the SE $\frac{1}{4}$ sec. 34, T.7 N., R. 10 W., to the NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 1, T. 7 N., R. 10 W., a short distance north of Tin Cup Joe Creek on the Conleys Lake 7 $\frac{1}{2}$ ' quadrangle. Another ash bed is exposed over part of the distance and is 18 ft 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 sparse 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 detailed 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 a similar beds in the Flint Creek Basin, in the vicinity of Drummond, in the Blackfoot Basin, the Divide Basin, and the Three Forks area. Cabbage Patch Beds are exposed between Mullan Gulch and Dry Gulch in the northern part of the Conleys Lake 7 $\frac{1}{2}$ ' quadrangle. Because of similar lithology and abundance of volcanic ash, the Cabbage Patch Beds are interpreted to continue south of the Conleys Lake 7 $\frac{1}{2}$ ' quadrangle.

Tmii Mafic to intermediate intrusive bodies - Dark-gray alkali dikes intrude the Carter Creek Formation in the northwestern part of the Deer Lodge 7 $\frac{1}{2}$ ' 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 7 $\frac{1}{2}$ ' quadrangle (Derkey and others, 2004).

CRETACEOUS

Golden Spike Formation

- Kgs Golden Spike Formation - (sedimentary beds) (Upper Cretaceous)** - Lava flows of andesitic composition with intervening sandstone, conglomerate, and volcanoclastic beds with minor limestone and rare black shale. The non-volcanic sandstone consists mainly of quartz, lithic fragments, biotite, and muscovite whereas the volcanoclastic beds consist mainly of plagioclase feldspar, volcanic glass, and volcanic rock fragments in a fine-grained matrix (Mackie, 1986). Lava flows form prominent outcrops, and the sandstone beds are generally very poorly exposed. Brownish gray (5YR 4/1) limestone occurs in float and rare outcrops 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 SE_{1/4}, NE_{1/4} sec. 12, T. 8 N., R.10 W., where a pisolitic limestone bed about 4 ft thick overlies an andesite flow. Just below this limestone bed the andesite shows evidence of weathering - local bleaching accompanied with the development of hematite. There is a small exposure of black shale northwest of the power line road in the NW_{1/4} SW_{1/4} 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 7_{1/2}' 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 those 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.
- 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 7_{1/2}' quadrangle, but subdivided to the south (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).
- 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).

Elkhorn Mountains Volcanics (See Fig. 2 for a schematic cross section of these units.)

Kem Elkhorn Mountains Volcanics - Used only in cross section.

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).

Kemtbf Tuff and tuff breccia - Dark-gray to green groundmass in a crystal lithic tuff that is easily distinguished by its 1- to 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).

Kcc Carter Creek Formation - Local exposures in small fault slices within the northern part of the Deer Lodge 7 $\frac{1}{2}$ ' 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 ft (Derkey and others, 2004).

Kk Kootenai Formation - 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, cited personal communication from A.B. French, 1989).

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 as large as 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).

MPzs Mesozoic and Paleozoic sedimentary beds (used only in cross section; not exposed in these quadrangles).

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.

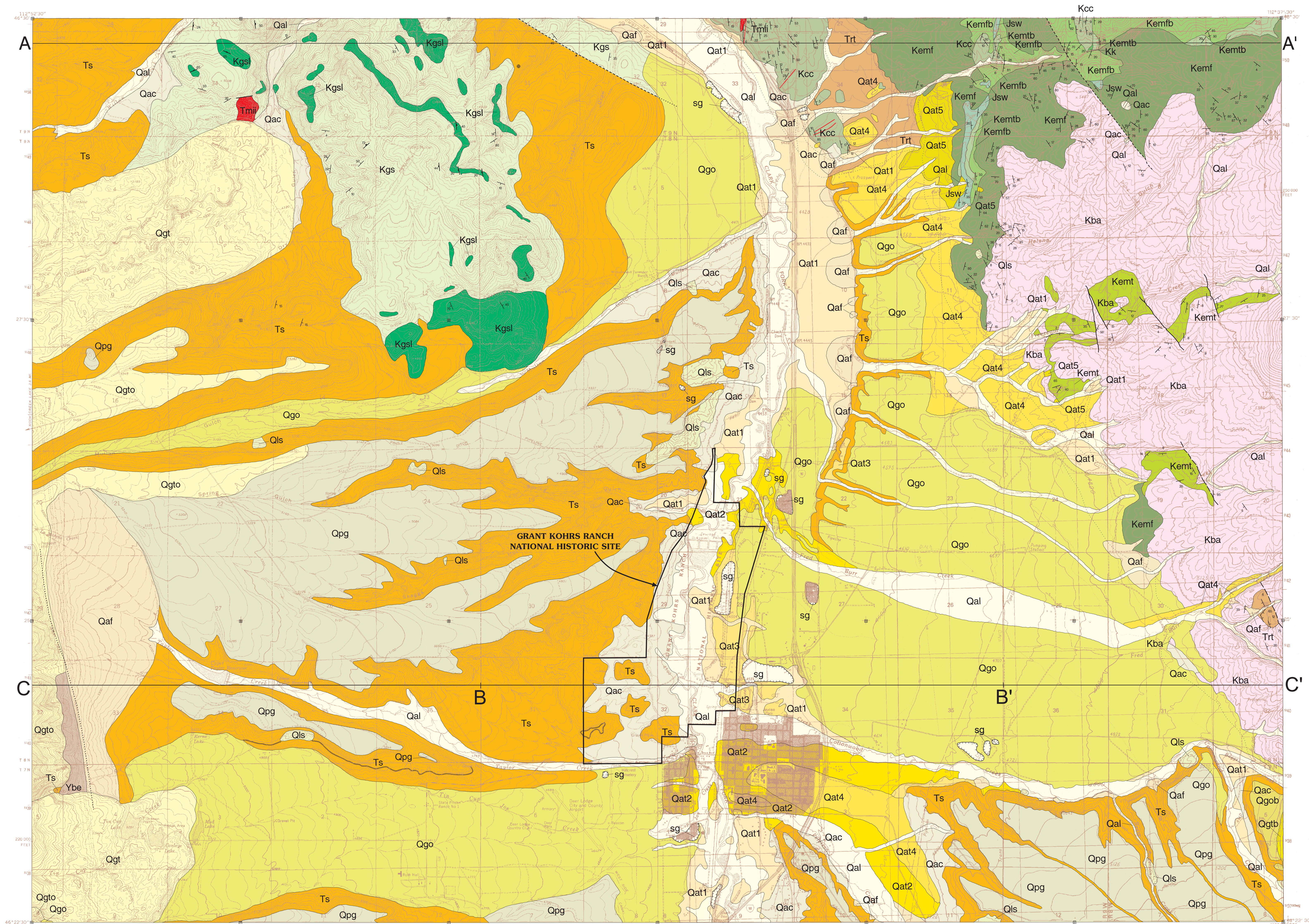
References

- Derkey, R.E., Watson, S.M., Bartholomew, M.J., Stickney, M.C., and Downey, P.J., 2004, Geologic map of the Deer Lodge 15' quadrangle, southwest Montana: Montana Bureau of Mines and Geology Open-File Report 271, scale 1:48,000 with 23 p. text.
- Gwinn, V.E., 1961, Geology of the Drummond area, central-western Montana: Montana Bureau of Mines and Geology Geologic Map GM 4, scale 1:63,360.
- Gwinn, V.E., and Mutch, T.A., 1965, Intertongued upper Cretaceous volcanic and nonvolcanic rocks, central-western Montana: Geological Society of America Bulletin, v. 76, p. 1125-1144.
- Hanneman, D.L., 1989, Cenozoic basin evolution in a part of southwestern Montana: Missoula, University of Montana, Ph.D. dissertation, 347 p. 8 plates.
- Hanneman, D.L., Wideman, C.J., and Halvorson, J.W., 1994, Calcic paleosols: Their use in subsurface stratigraphy: American Association of Petroleum Geologists Bulletin, v. 78, no. 9, p. 1360-1371
- Konizeski, R.L., 1957, Paleoecology of the middle Pliocene local fauna, western Montana: Bulletin of the Geological Society of America, v. 68, no. 2, p. 131- 150.
- Konizeski, R.L., McMurtrey, R.G., and Brietkrietz, Alex, 1961, Preliminary report on the geology and ground-water resources of the northern part of the Deer Lodge Valley, Montana: Montana Bureau of Mines and Geology Bulletin 21, 24 p., map scale 1:63,360.
- Lewis, R.S., 1998, Geologic map of the Butte 1⁰ x 2⁰ quadrangle, Montana (compiled and mapped by R.S. Lewis) Montana Bureau of Mines and Geology Open File MBMG 363, scale 1:250,000.

- Mackie, T.L., 1986, Tectonic influences on the petrology, stratigraphy and structures of the Upper Cretaceous Golden Spike Formation, central-western Montana: Pullman, Washington State University, M.S., thesis, 132 p.
- McLeod, P.J., 1987, The depositional history of the Deer Lodge basin, western Montana: Missoula, University of Montana, M.S. thesis, 61 p.
- Mutch, T.A., 1961, Geology of the northeast flank of the Flint Creek Range, western Montana; Montana Bureau of Mines and Geology Geologic Map GM 5, scale 1:63,360.
- Rasmussen, D.L., 1977, Geology and mammalian paleontology of the Oligocene-Miocene Cabbage Patch Formation, central-western Montana: Lawrence, University of Kansas, Ph.D. dissertation, 775 p.
- Rasmussen, D.L., and Prothero, D.R., 2003, Lithostratigraphy, biostratigraphy, and magnetostratigraphy of the Arikareean strata west of the Continental Divide in Montana: *in* Reynolds, R.G., and Flores, R.M., eds., *Cenozoic systems of the Rocky Mountain Region*, Denver, CO, Rocky Mountain SEPM, p. 479-499.
- Ruppel, E.T., 1961, Reconnaissance geologic map of the Deer Lodge quadrangle, Powell, Deer Lodge and Jefferson Counties, Montana: U.S. Geological Survey Mineral Investigations Field Studies Map MF-174, scale 1:48,000.
- Sears, J.W., Webb, B., and Taylor, M., 2000, Bedrock geology of the Garrison and Luke Mtn. 7.5' quadrangles, Powell Co., Montana: Montana Bureau of Mines and Geology MBMG Open File 403, scale 1:24,000.
- Waddell, A.M., 1997, Cordilleran partitioning and foreland basin evolution as recorded by the sedimentation and stratigraphy of the Upper Cretaceous Carten Creek and Golden Spike Formations, central-western Montana: Missoula, University of Montana, M.S. thesis, 148 p.
- Wallace, C.A., 1986, Preliminary geologic map of the Butte 1° x 2° quadrangle, western Montana: U.S. Geological Survey Open-file Report 86-0292, 17 p., 1 sheet, 1 slide, geologic map. Scale 1:250,000.
- Watson, S.M., 1987, The Boulder batholith as a source for the Elkhorn Mountains Volcanics, southeast quarter of the Deer Lodge 15-minute quadrangle, southwestern Montana: Missoula, University of Montana, M.S. Thesis, 100 p.

Weed, W.H., 1912, Geology and ore deposits of the Butte district, Montana: U.S. Geological Survey Professional Paper 74, 262 p.

Williams, H.G., 1951, Geology and ore deposits of an area east of Warm Springs, Montana: unpublished M.S. thesis, Montana School of Mines, Butte (now Montana Tech), 74 p.



Topographic base for east half is Deer Lodge 1:24,000 scale USGS quad; contour interval 40 feet.
 Topographic base for west half is Conleys Lake 1:24,000 scale USGS quad; contour interval 20 feet.

Scale 1:24,000

Produced under National Park Service contract #P2360031124.
 GIS production: Ken Sandau and Paul Thale, MBMG. Map layout: Susan Smith, MBMG.

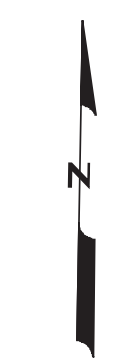
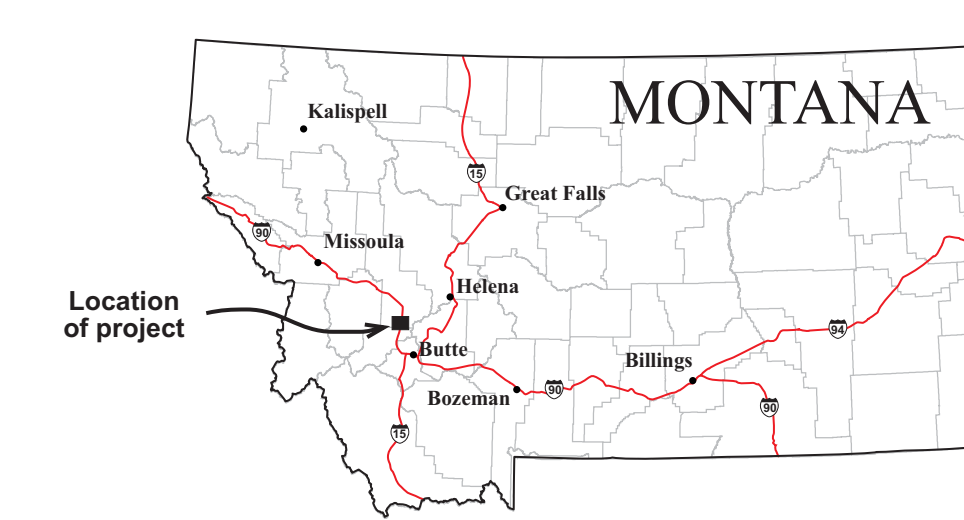
MAP SYMBOLS

- Contact—Dotted where concealed
- Fault—Dashed where approximately located; dotted where concealed; bar and ball on down-thrown side
- Strike and dip of bedding, or planar features in igneous rocks
- Strike and dip of joint
- Mafic to intermediate dikes
- Ash bed
- Sand and gravel pit

MAP UNITS

- | | |
|--|---|
| Qal Alluvium of modern channels and flood plains | Ts Sediment or sedimentary rocks, undivided |
| Qat Alluvium of alluvial terrace level (only on cross section) | Trt Rhyolite tuff |
| Qat1 Alluvium of youngest alluvial terrace level | Tmi Intrusive rocks, alkalic, undivided |
| Qat2 Alluvium of second youngest alluvial terrace level | Kba Basalt |
| Qat3 Alluvium of third youngest alluvial terrace level | Kem Elkhorn Mountain Volcanics (only on cross section) |
| Qac Alluvium-colluvium | Kerf Welded ash-flow tuff |
| Qls Landslide deposit | Kerl Andesitic lava flows, fine-grained |
| Qaf Alluvial fan deposit | Kermb Tuff and tuff breccia |
| Qat4 Alluvium of fourth youngest alluvial terrace level | Kermb Andesite flows, flow breccia and tuff breccia |
| Qat5 Alluvium of fifth youngest alluvial terrace level | Kgs Golden Spike Formation |
| Qgo Glacial outwash deposit | Kgs Lava flow unit, informal, of Golden Spike Formation |
| Qgob Glacial outwash of Bull Lake glaciation | Kcc Carter Creek Formation |
| Qgt Glacial till | Kk Kootenai Formation |
| Qgo Glacial till, older | Jsw Swift Formation |
| Qgg Pediment gravel deposits | Ybe Belt Supergroup, undivided |
| | MP2a Sedimentary rocks, undivided (only on cross section) |

See Plate 2 for cross section.

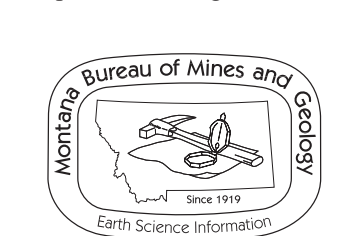


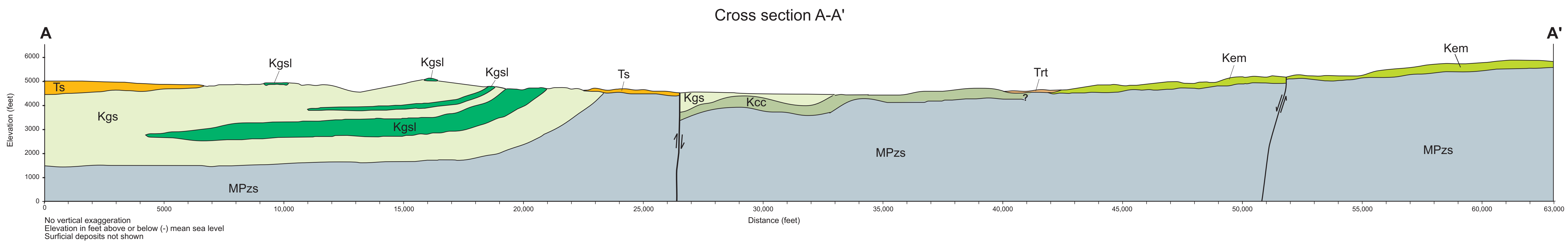
Montana Bureau of Mines and Geology
 Open File Report 509
 Geologic Map of the Deer Lodge and
 Conleys Lake 7 1/2' Quadrangles
 Powell County, Southwestern Montana

Mapped and compiled by Richard B. Berg

2004

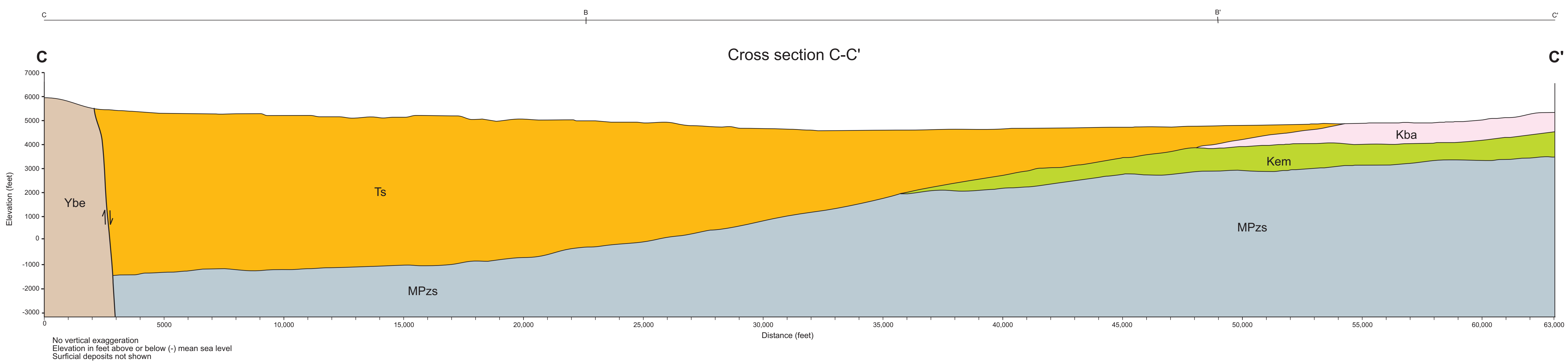
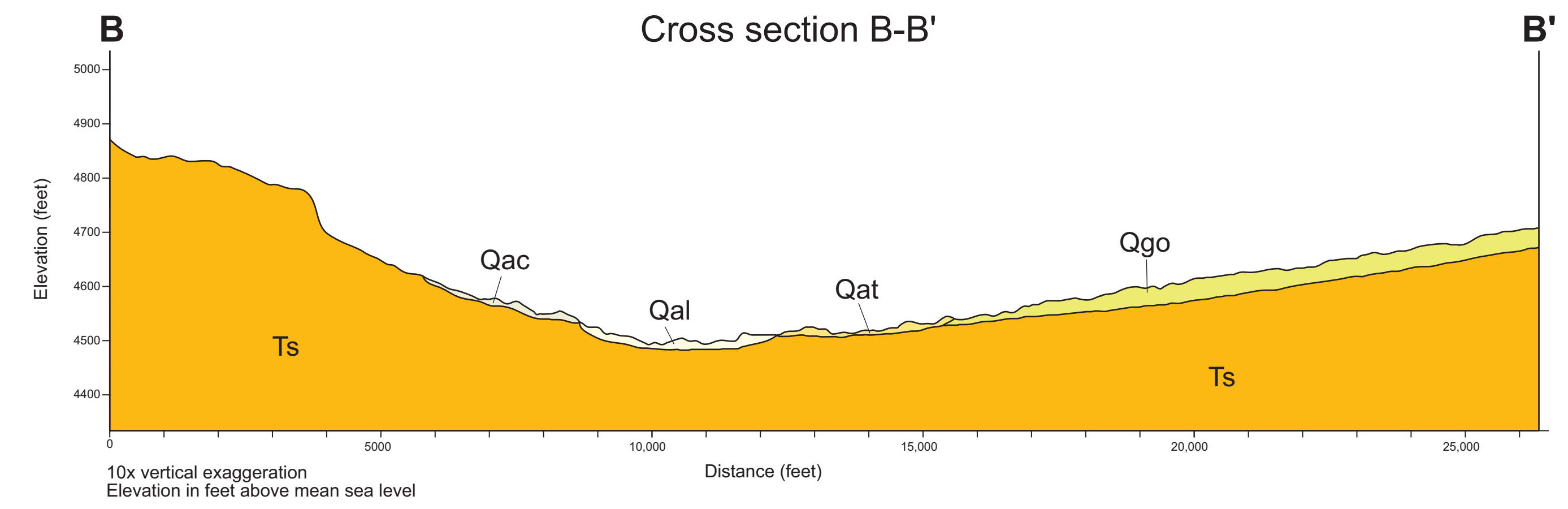
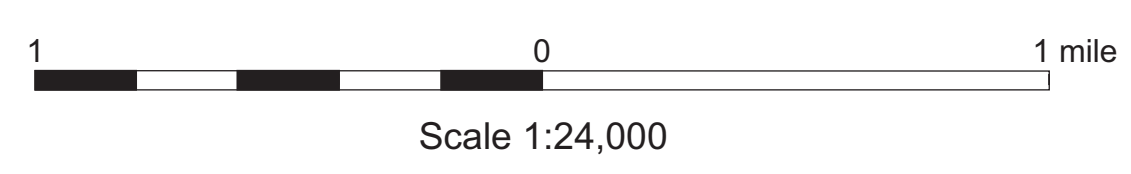
Maps may be obtained from
 Publications Office
 Montana Bureau of Mines and Geology
 1300 West Park Street, Butte, Montana 59701-8997
 Phone: (406) 496-4167 Fax: (406) 496-4451
<http://www.mbmng.mtech.edu>



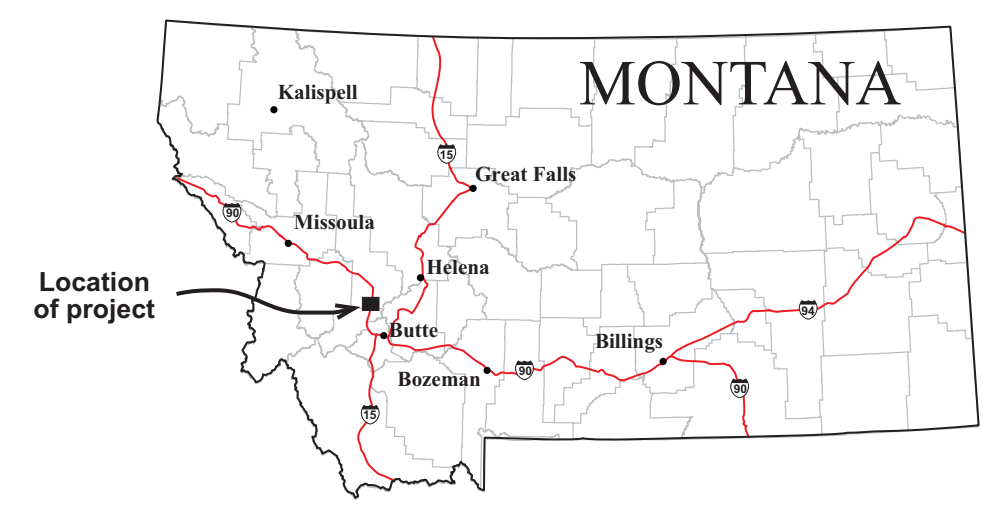
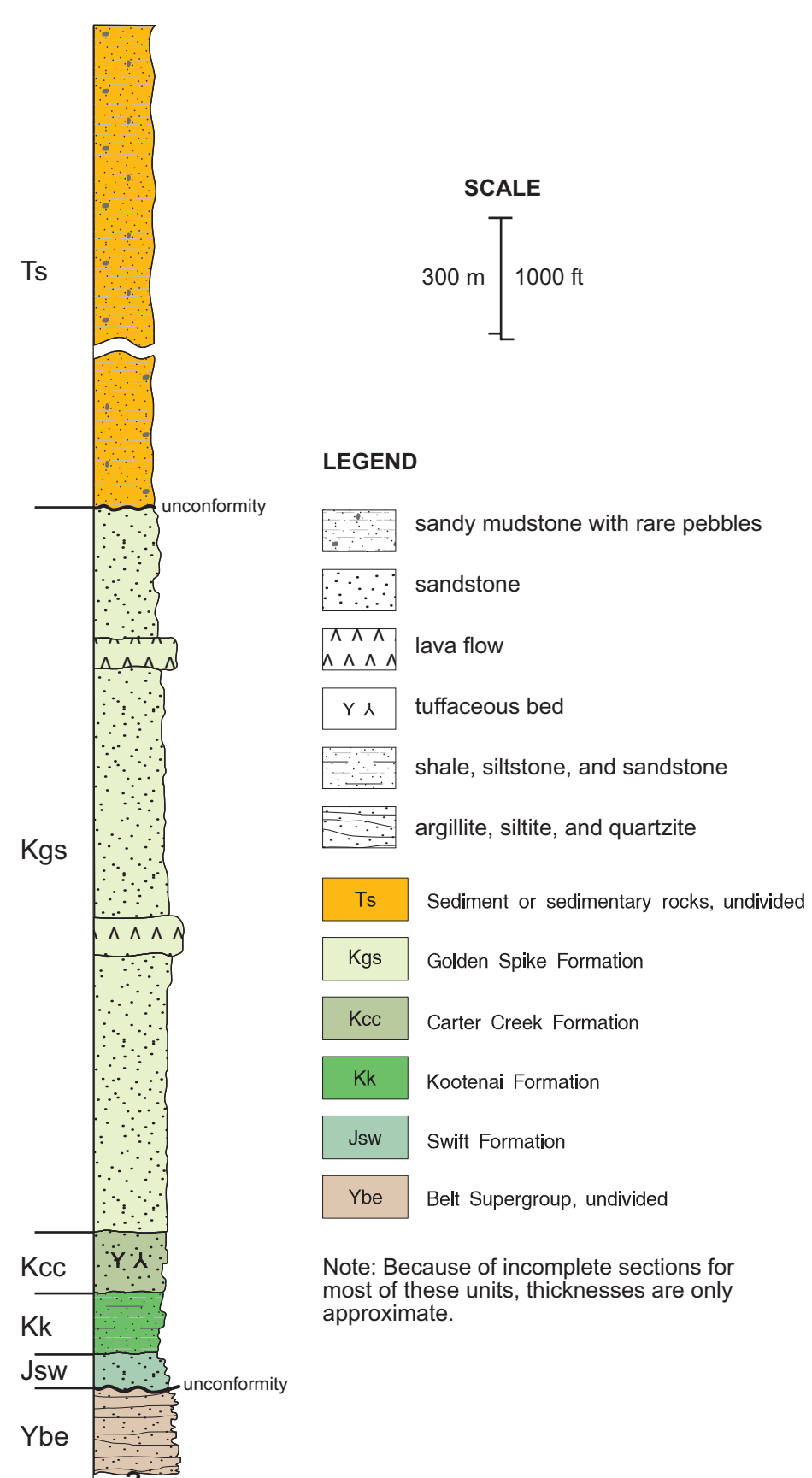


LEGEND

Qd	Alluvium of modern channels and flood plains
Qac	Alluvium-colluvium
Qat	Alluvium of alluvial terrace level
Qgo	Glacial outwash deposit
Ts	Sediment or sedimentary rocks, undivided
Trt	Rhyolite tuff
Kba	Basalt
Kem	Elkhorn Mountain Volcanics
Kgs	Golden Spike Formation
KgsL	Lava flow unit, informal, of Golden Spike Formation
Kcc	Carter Creek Formation
Ybe	Belt Supergroup, undivided
MPzs	Mesozoic and Paleozoic sedimentary rocks



Stratigraphic Column for the Northern Deer Lodge Valley



Sources of Geologic Information

1 Conleys Lake	2 Deer Lodge
-------------------	-----------------

Montana Bureau of Mines and Geology
 Open File Report 509
Geologic Map of the Deer Lodge and Conleys Lake 7 1/2' Quadrangles
 Powell County, Southwestern Montana
 Mapped and compiled by Richard B. Berg
 2004

Produced under National Park Service contract #P2360031124.
 GIS production: Ken Sandau and Paul Thale, MBMG. Map layout: Susan Smith, MBMG.

Maps may be obtained from
 Publications Office
 Montana Bureau of Mines and Geology
 1300 West Park Street, Butte, Montana 59701-8997
 Phone: (406) 496-4167 Fax: (406) 496-4451
<http://www.mbg.mt.gov>

1 Mapped by Berg, 2004
 2 Modified from Derkey and others, 2004