GEOLOGIC MAP OF THE RED LODGE AREA, CARBON COUNTY, MONTANA

by

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Montana Bureau of Mines and Geology

Open-File Report MBMG 524

2005

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

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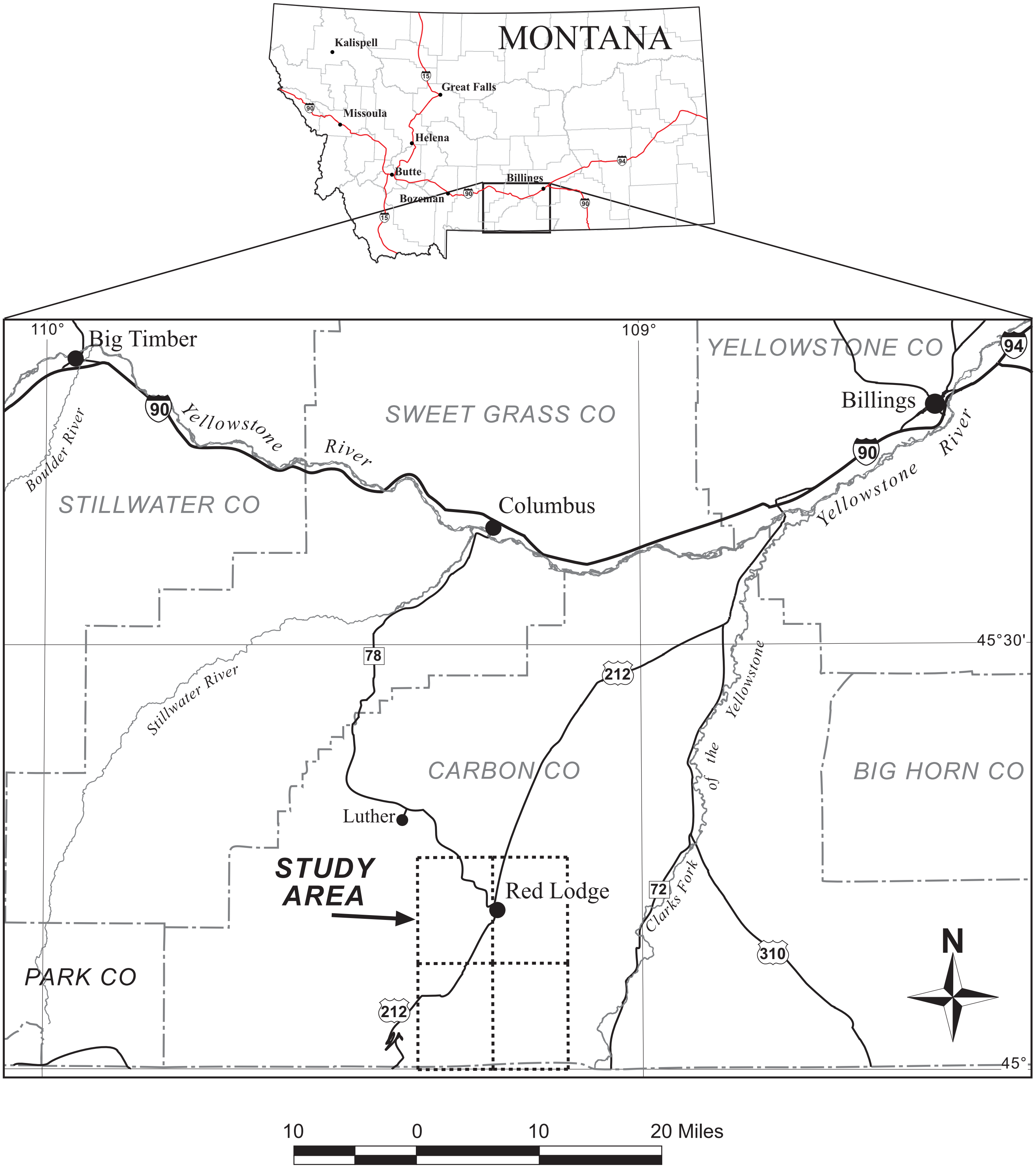
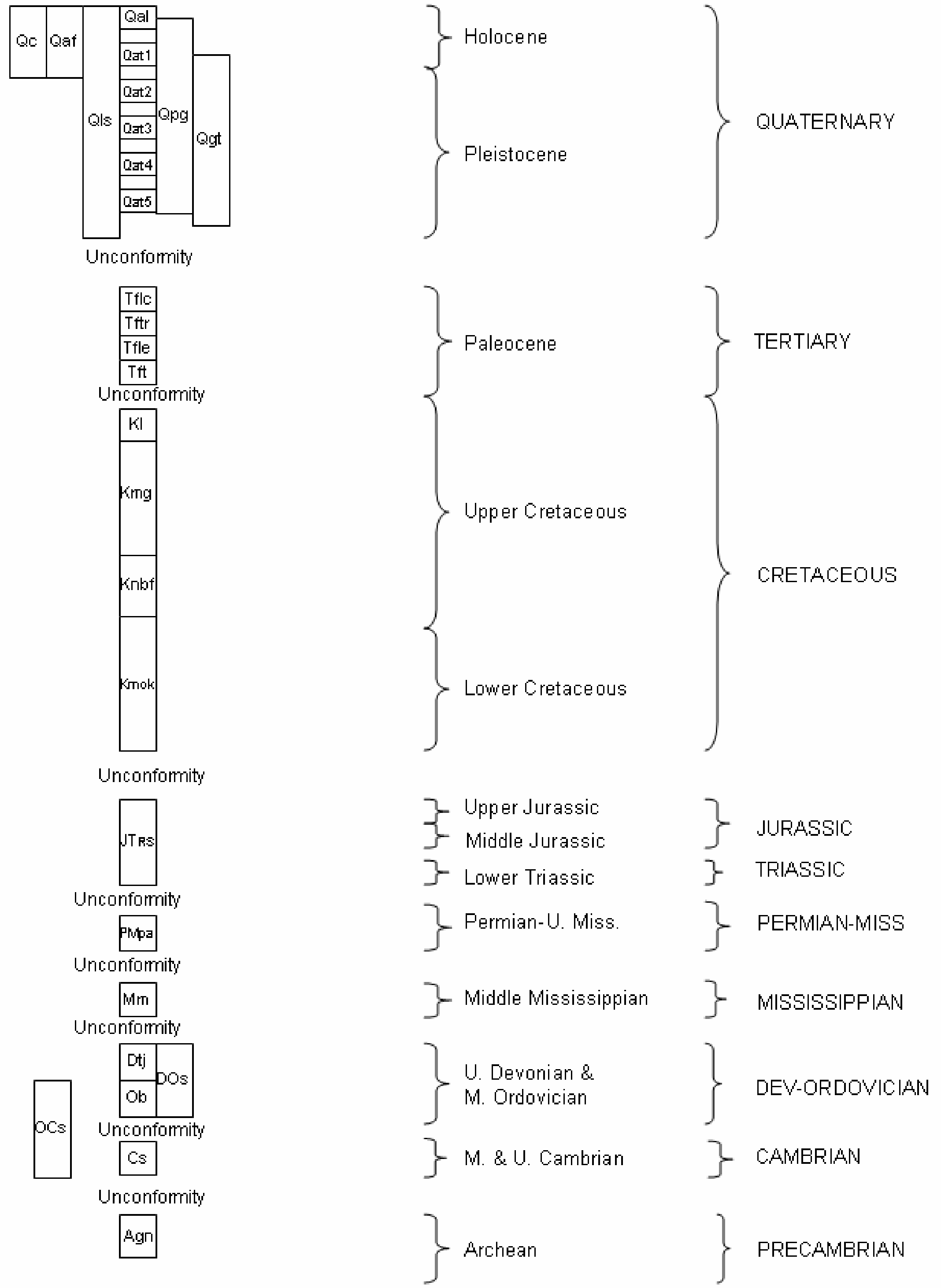


Figure 1. Location map of the study area.

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

af	**Artificial fill—**Mine tailings and fill in the Rock Creek valley in northern part of the town of Red Lodge.
Qal	**Alluvium (Holocene)**—Gravel, sand, silt, and clay along active stream channels.
Qc	**Colluvium (Holocene and Pleistocene)**—Locally derived slope-wash depositsmainly of sand, silt, and clay. Typically thin veneer concealing bedrock, but locally as thick as 30 ft (9 m). Commonly grades into Qal. Locally contains well-rounded cobbles derived from alluvial terrace gravel. May also contain glacial lake deposits behind end moraines.
Qaf	**Alluvial fan deposits (Holocene and Pleistocene)**—Gravel, sand, silt, and clay deposited in fans being formed by modern streams along major valley margins. Display characteristic fan-shaped map pattern and convex upward profile. Typically grade upstream into Qal. Thickness ranges from very thin at toe to as much as 50 ft (15 m) at heads of fans.
Qls	**Landslide deposits (Holocene and Pleistocene)**—Unconsolidated mixture ofsoil and blocks of bedrock transported down steep slopes by mass wasting. Characteristic hummocky surface with concentric swales and ridges near down-slope limits. Common along steep slopes below resistant rocks but can occur where steep slopes and moisture content produce unstable conditions. Large landslides are common in glacial moraines along the Beartooth mountain front.
Qpg	**Pediment gravel deposits (Holocene and Pleistocene?)**—Angular and subangular, coarse gravel derived from local bedrock; gravel deposits occur beneath smooth, concave-upward, pediment surfaces sloping away from the Beartooth Mountains. About 10 ft (3 m) thick.

Qgt **Glacial deposits, undivided (Holocene and Pleistocene)**—Unsorted clay- to boulder-size material transported and deposited by glaciers. Characteristic hummocky surface. Occur in valleys along the mountain front. Clasts are predominantly Archean metamorphic rocks with lesser amounts of quartzite, igneous rocks, dolomite, and limestone.

ALLUVIAL TERRACE GRAVELS

Qat1 **Alluvial gravel, terrace level 1 (Holocene)**—Gravel underlying terraces 10 to 20 ft (3-6 m) above altitude of Qal (present altitude of rivers). Mostly cobbles and pebbles with minor amounts of sand and silt. Clasts are mainly granitic igneous rocks, granitic gneiss, schist, and quartzite, with much less limestone and sandstone. Ten to 40 ft (3-12 m) thick.

Qat2 **Alluvial gravel, terrace level 2 (Pleistocene)**—Gravel underlying terraces 20 to 40 ft (6-12 m) above Qal. Mostly cobbles and pebbles with minor amounts of sand and silt. Clasts mainly granitic igneous rocks, granitic gneiss, schist, and quartzite, with much less limestone and sandstone. Ten to 40 ft (3-12 m) thick.

Qat3 **Alluvial gravel, terrace level 3 (Pleistocene)**—Gravel underlying terraces 50 to 90 ft (15-27 m) above present altitude of rivers. Mostly cobbles and pebbles and minor amounts of sand and silt. Clasts are mainly granitic igneous rocks, granitic gneiss, schist, and quartzite, with much less limestone and sandstone. Ten to 30 ft (3-9 m) thick.

Qat4 **Alluvial gravel, terrace level 4 (Pleistocene)**—Gravel underlying terraces 200 to 300 ft (60-90 m) above present altitude of rivers. Cobble- and pebble-size clasts are mainly granite, granitic gneiss, schist, and quartzite. Thickness as much as 20 ft (6 m).

Qat5 **Alluvial gravel, terrace level 5 (Pleistocene)**—Gravel underlying terraces 400 to 600 ft (120-185 m) above present altitude of rivers. Occurs mainly as small discontinuous erosional remnants. Cobble- and pebble-size clasts are mainly granite, granitic gneiss, schist, and quartzite. Calcite cement locally present, especially at base. Thickness from a very thin remnant to about 20 ft (6 m).

BEDROCK MAP UNITS

Tflc **Linley Conglomerate Member, Fort Union Formation (Paleocene?)**—Unit named by Calvert (1916) after exposures near the community of Linley (Linley no longer exists but was about 1 mile east-southeast of Luther). These rocks occur along the northern mountain front of the Beartooth Uplift (Calvert, 1916; Jobling, 1974; DeCelles and others, 1991) and are considered to be Laramide synorogenic deposits. Similar rocks occur along the eastern front of the Beartooth Uplift (Laramide synorogenic deposits of Flueckinger (1970) and Beartooth Conglomerate of DeCelles and others (1991)), and are included here with the Linley Conglomerate. Unconformably overlies the Tongue River Member of the Fort Union Formation, but also overlies an erosional unconformity cut into Upper Cretaceous rocks just south of the map area in Wyoming (DeCelles and others, 1991). The unit consists of mainly reddish-brown to gray- brown, interbedded conglomerate, coarse-grained sandstone, siltstone, and mudstone; the coarsest facies is generally nearest the mountain front. Conglomerate cobbles are mostly less than 6 inches in diameter and composed mainly of limestone, andesite porphyry, black chert, metamorphic rocks, and granitic rocks. Paleontologic data indicate the deposits are Paleocene (Flueckinger, 1970; Jobling, 1974; DeCelles and others, 1991). Changes in clast composition in the conglomerates record the unroofing of the Beartooth Uplift; clasts of younger stratigraphic units generally occur near the base and clasts of older rocks occur higher in the section (Flueckinger, 1970; Jobling, 1974; DeCelles and others, 1991). Thickness is about 600 ft (185 m) along the north front of the Beartooth

Uplift (Jobling, 1974). Flueckinger (1970) reports a total thickness of the section along the east front, including exposures in Wyoming, of about 4,200 ft (1,280 m), but exposures in the Red Lodge area and just to the west appear to be about 2,000 ft (610 m) thick. DeCelles and others (1991) report a thickness of more than 2,300 ft (700 m).

Tftr **Tongue River Member, Fort Union Formation (Paleocene)**—Gray to grayish-yellow, fine- to medium-grained sandstone, cross-bedded. Interbedded with brownish-gray carbonaceous shale and siltstone and coal beds. Sandstones ledge-forming, commonly support growths of pine trees. Thickness is variable but is as much as 2,800 ft (850 m) (Rawlins, 1986).

Tfle **Lebo Member, Fort Union Formation (Paleocene)**—Predominantly dark-gray to olive shale, and thin, interbedded, yellowish-gray sandstone and siltstone, locally includes yellowish-gray claystone. Typically forms smooth grassy slopes below the Tongue River Member. Thickness 200 to 500 ft (60-150 m).

Tft **Tullock Member, Fort Union Formation (Paleocene)**—Yellowish-gray, fine- to medium-grained, ledge-forming sandstone, cross-bedded in part. Interbedded with gray to greenish-gray claystone, siltstone, and minor carbonaceous shale. Supports growths of pine trees. Thickness is variable; from about 400 ft (120 m) to as much as 1,500 ft (460 m) in the Bear Creek area (Rawlins, 1986).

TKi **Intermediate and felsic intrusive rocks (Tertiary or Late Cretaceous)**—Laccoliths, plugs, dikes, sills and irregular-shaped bodies of fine-grained and porphyritic rhyolite, dacite, quartz latite, andesite, and diorite (Van Gosen and others, 2000).

Kl **Lance Formation (Upper Cretaceous)**—Interbedded light-brownish-gray, cliff- and ledge-forming, fine-grained, thick-bedded to massive sandstone, and medium-gray, fissile shale. Sandstone beds are much thicker and more continuous than sandstone beds in the Hell Creek. Sandstone beds support growths of pine trees. Occurs only in the southeast part of the quadrangle, interfingers with and changes facies into Hell Creek lithologies in the Joliet area; the name Lance is used in the Red Lodge area. Total thickness of the formation is about 350 ft (105 m).

Kmg **Montana Group (Upper Cretaceous)**—Bearpaw Shale, Judth River Formation, Claggett Shale, Eagle Sandstone, and Telegraph Creek Formation. Shown only on cross section.

Knbf **Niobrara, Carlile, Greenhorn, and Belle Fourche Formations, undivided (Upper Cretaceous)**—Shown only on cross section.

Kmok **Mowry Shale, Thermopolis Shale, Fall River Sandstone, and Kootenai Formation,undivided (Upper and Lower Cretaceous)**—Shown only on cross section.

JTRs **Sedimentary rocks, undivided (Jurassic and Triassic)**—Includes Morrison Formation, Ellis Group, and Chugwater Formation.

PMpa **Phosphoria, Tensleep, and Amsden Formations, undivided (Permian, Pennsylvanian, and Upper Mississippian)**—Formations not mapped separately because of narrow outcrop width. Phosphoria is light-gray limestone, sandstone and quartzite, commonly grayish-pink, cherty; thickness is 50 to 75 ft (15-23 m). The Tensleep Sandstone is light-brown to very pale-orange sandstone, fine-grained, well sorted, well rounded, cross-bedded. Locally contains thin limestone beds, locally cherty near the top, and locally silicified to form quartzite; about 250 ft (75 m) thick. The Amsden Formation is interbedded grayish-pink to light-red mudstone, limestone, and siltstone. Limestones are commonly cherty. Unconformably overlies karst surface developed on limestone of the Madison Group. Characteristically produces pink stain on underlying cliffs of Madison Group; thickness about 200 ft (60 m) but locally tectonically thinned to only a few feet along mountain front. Total thickness of lumped unit is about 500 ft (150 m).

Mm **Madison Group, undivided (Middle Mississippian)**—Limestone and dolomitic limestone, light-gray to light-brownish-gray. Thick-bedded to massive in the upper part (Mission Canyon Limestone) and thin-bedded to thick-bedded in the lower part (Lodgepole Limestone). Also contains thin, interbedded, gray shales. Fossiliferous and cherty beds are present throughout. Collapse features and caves are common at the upper karst surface. Thickness of the Madison is 800 to 1,000 ft (240-305 m).

Dtj **Three Forks and Jefferson Formations, undivided (Upper Devonian)**—The Jefferson is dolomitic limestone, light-brownish-gray, fetid, poorly exposed; locally occurs as float only. The Three Forks is mainly yellowish-weathering, argillaceous limestone and medium-gray shale, very poorly exposed.

DOs **Sedimentary rocks, undivided (Upper Devonian and Ordovician)**—Includes Jefferson and Three Forks Formations, and Big Horn Dolomite. The Jefferson and Three Forks Formations as described above. The Big Horn Dolomite is cliff-forming dolomite and dolomitic limestone, very light gray to very pale orange, lower part massive, thin- to thick-bedded in upper part. Has characteristic pock-marked surface due to differential weathering. Total thickness of this interval is about 600 ft (185 m).

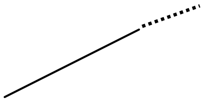
O€s **Sedimentary rocks, undivided (Ordovician and Cambrian)**

Ob **Bighorn Dolomite (Middle Ordovician)**—Cliff-forming dolomite and dolomitic limestone, very light gray to very pale orange, lower part massive, thin- to thick-bedded in upper part. Has characteristic pock-marked surface due to differential weathering. Thickness about 400 ft (120 m).

Ꞓs **Sedimentary rocks, undivided (Middle and Upper Cambrian)**—Light-reddish sandstone and quartzite, greenish-gray shale and sandy shale, gray, thin-bedded limestone, and greenish-gray flat-pebble limestone conglomerate. Includes the Flathead, Wolsey, Meagher, Park, and Pilgrim Formations. Thickness is 600 to 800 ft (180-245 m).

Agn **Gneissic rocks (Archean)**–-Predominantly granitic gneiss and migmatite; commonly consists of alternating bands of more felsic and more mafic gneiss; contains inclusions of metasedimentary rocks (granitic gneiss of Van Gosen and others, 2000).

MAP SYMBOLS



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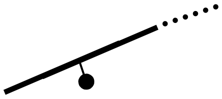
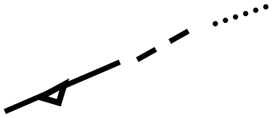
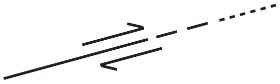


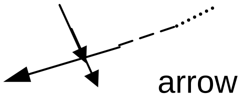
Fault—Dotted where concealed. Bar and ball on down-thrown side, where known.



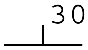
Reverse Fault—Dashed where approximately located; dotted where concealed. Teeth on upper plate or up-thrown block.



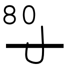
Strike slip fault--Dashed where approximately located; dotted where concealed. Arrows indicate relative sense of movement.



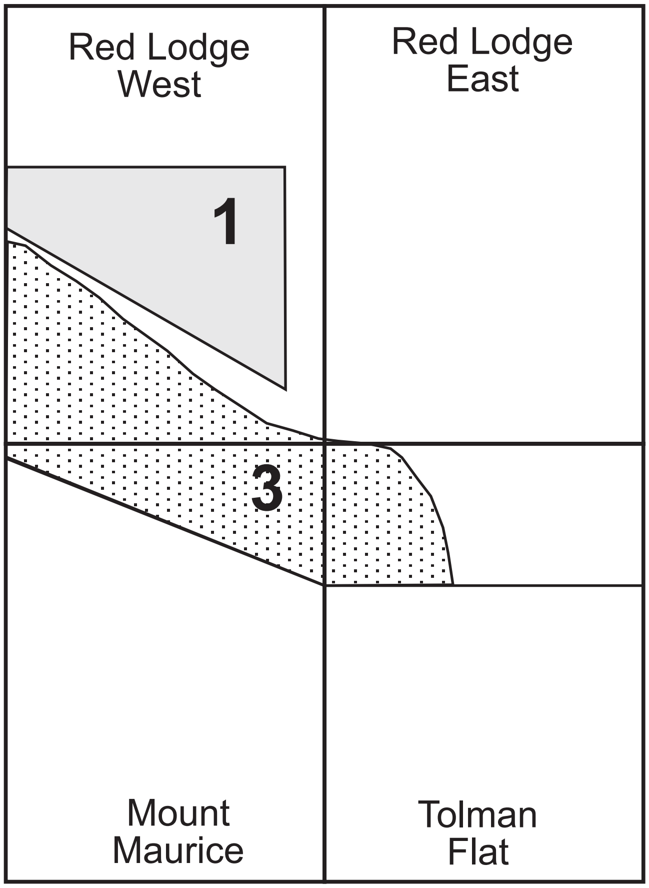
Monocline—Showing trace of axial plane and direction of plunge; longest arrow indicates steepest limb of monocline; dashed where approximately located; dotted where concealed.



Strike and dip of beds



Strike and dip of overturned beds



SOURCES OF GEOLOGIC MAPPING

1. Flueckinger, L.A., 1970, Stratigraphy, petrography, and origin of Tertiary sediments off the front of the Beartooth Mountains, Montana-Wyoming: State College, Pennsylvania State University, Ph.D. dissertation, 249 p. Plate 1, scale 1:62,500.

2. Lopez, D.A., 2001, Geologic map of the Red Lodge 30' x 60' quadrangle, south-central Montana: Montana Bureau of Mines and Geology Open File Report MBMG-423, scale 1:100,000. ***(Covers entire map area)***

3. Van Gosen, B.S., Elliott, J.E., LaRock, E.J., duBray, E.A., Carlson, R.R., and Zientek, M.L., 2000, Generalized geologic map of the Absaroka-Beartooth study area, south-central Montana: U.S. Geological Survey Miscellaneous Field Studies Map MF-2338, scale 1:126,720.

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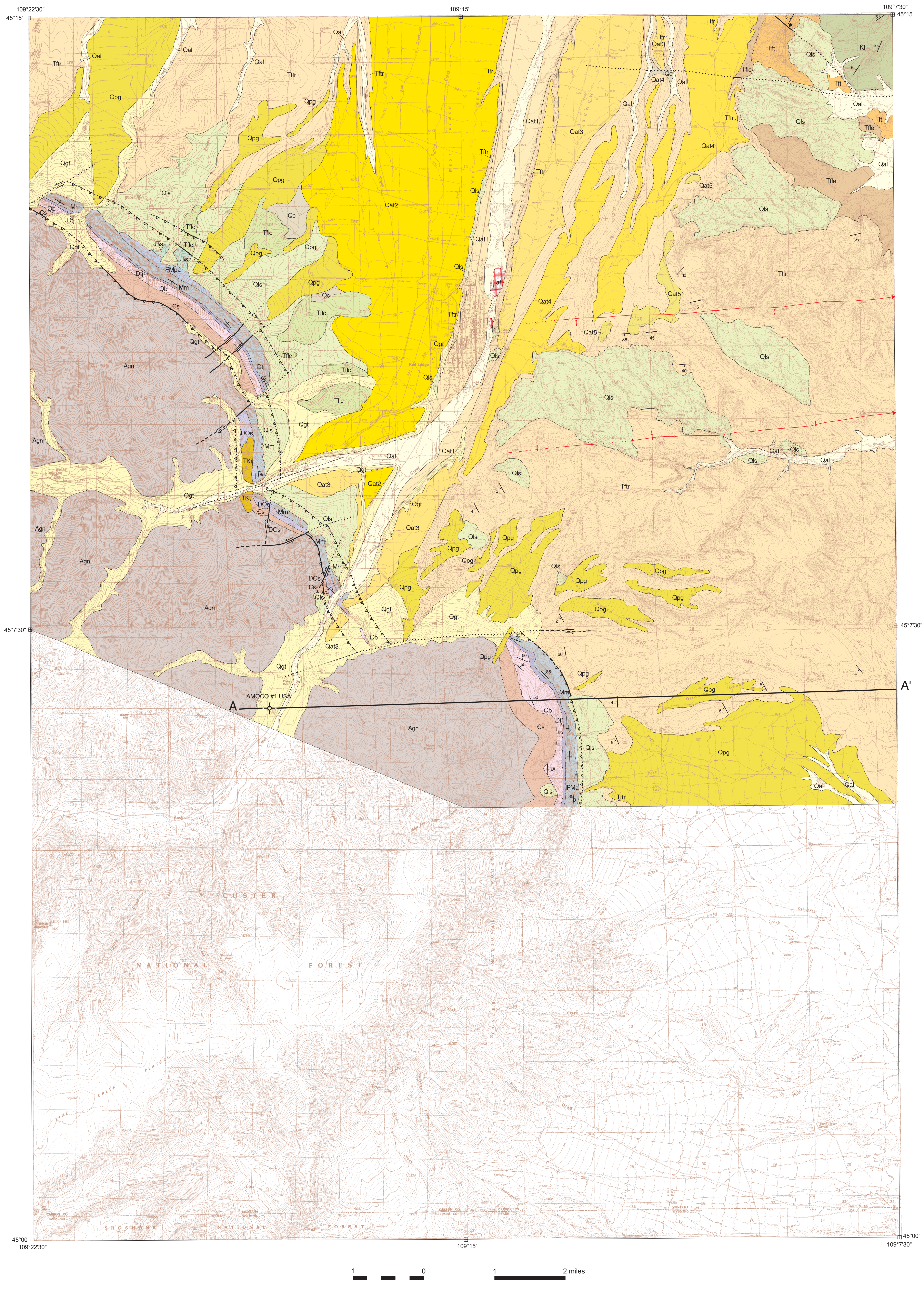


MAP UNITS

Qal	Alluvium of modern channels and flood plains
Qc	Colluvium
Qaf	Alluvial fan deposit
Qls	Landslide deposit
Qpg	Pediment gravel deposit
Qat1	Alluvium of youngest alluvial terrace
Qgt	Glacial till
Qat2	Alluvium of second youngest alluvial terrace
Qat3	Alluvium of third youngest alluvial terrace
Qat4	Alluvium of fourth youngest alluvial terrace
Qat5	Alluvium of fifth youngest alluvial terrace, oldest
Tflc	Linley Conglomerate Member of Fort Union Formation
Tftr	Tongue River Member of Fort Union Formation
Tft	Tullock Member of Fort Union Formation
Tfle	Lebo Member of Fort Union Formation
TKi	Intrusive rocks, undivided
Kl	Lance Formation
JTRs	Sedimentary rocks, undivided
PMpa	Phosphoria, Quadrant, and Amsden Formations, undivided
IPMa	Amsden Formation
Mm	Madison Group, undivided
Dtj	Three Forks and Jefferson Formations, undivided
DOs	Sedimentary rocks, undivided
Ob	Bighorn Dolomite
Ꞓs	Sedimentary rocks, undivided
Agn	Gneissic rocks
af	Artificial fill - mine tailings

MAP SYMBOLS

Contact: dotted where concealed

Fault: dotted where concealed; bar and ball on downthrown side where known

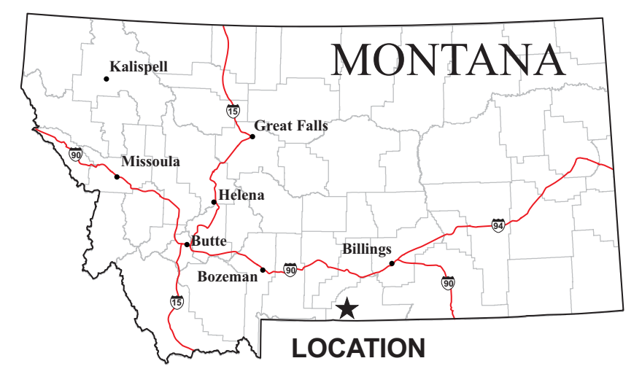
Reverse fault: dashed where approximately located; dotted where concealed; teeth on upper plate or upthrown block

Strike slip fault: dashed where approximately located; dotted where concealed

Monocline: Showing axial plane and direction of plunge; dashed where approximately located, dotted where concealed; longest arrow indicates steepest limb of monocline

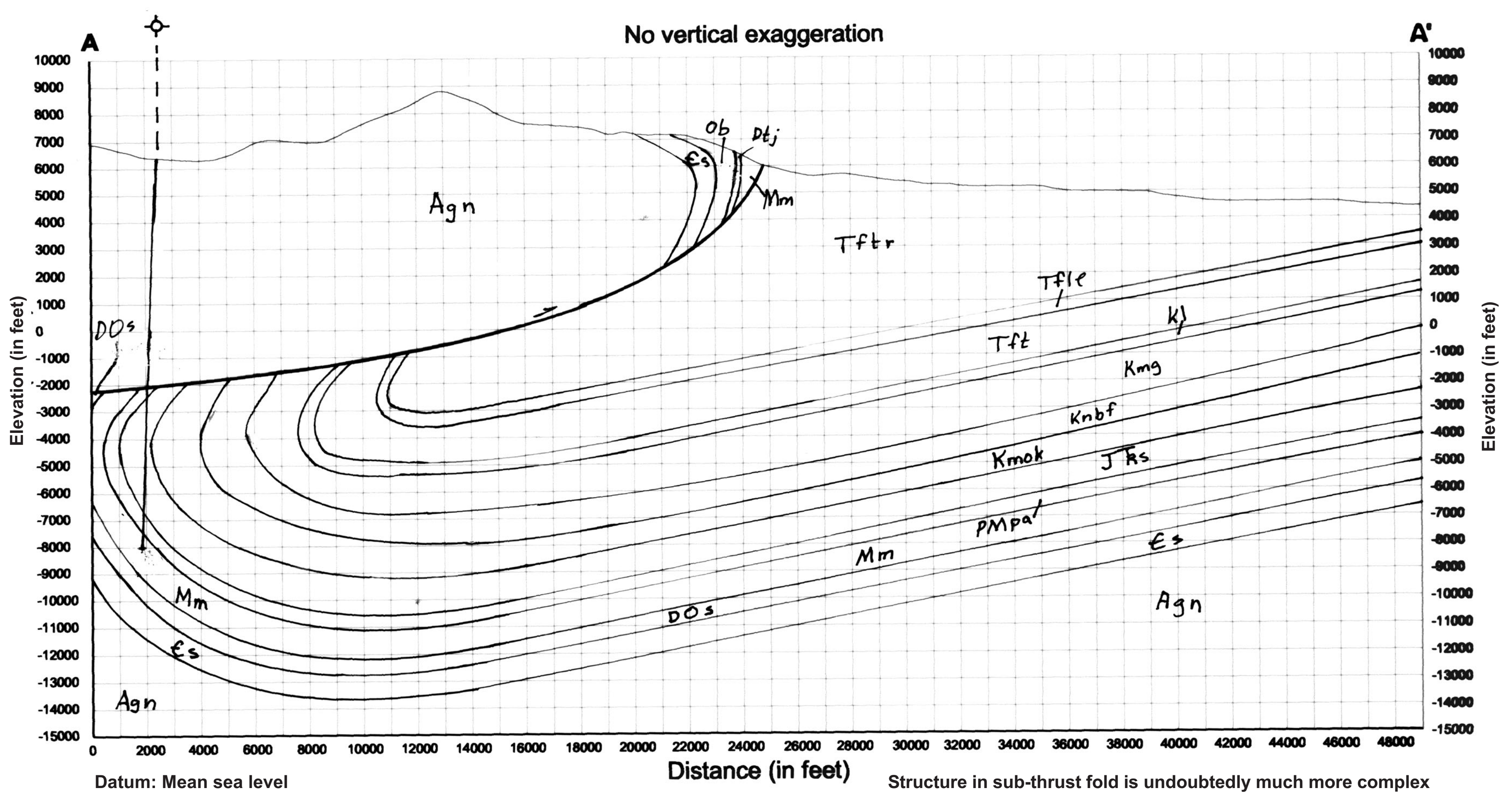
30 **Strike and dip of beds**

80 **Strike and dip of overturned beds**



Red Lodge Cross Section

No vertical exaggeration



Datum: Mean sea level
Surficial deposits are not shown

Amoco #1 USA was not drilled straight; trace of well bore on profile is approximate and penetrations of formation are shown at approximately true depths.

Structure in sub-thrust fold is undoubtedly much more complex than shown, but data are not sufficient to identify other smaller faults and structures. Approximate elevation of stratigraphic units interpreted from data from Amoco well shown (Compare with Wise, 1997).

Archean rocks in upper plate are characterized by brittle deformation along numerous small faults and fractures; these rocks are not folded like the overlying Paleozoic stratigraphic section.

SOURCES OF GEOLOGIC MAPPING

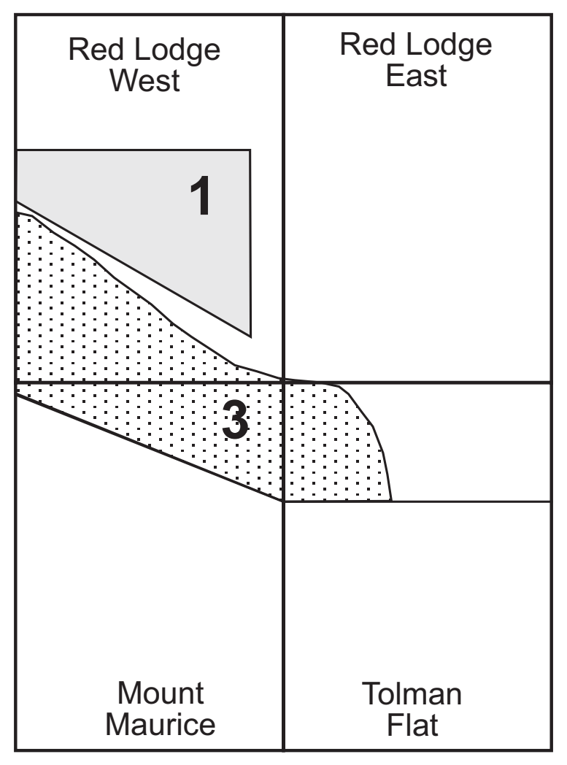
Base map from USGS 7.5' quadrangles
1:24,000 scale reduced by 50% to 1:48,000 scale:

Red Lodge East 7.5' topographic quadrangle
Map date: 1969, revised 1985
Projection: polyconic
UTM zone 12; 1927 NAD

Red Lodge West 7.5' topographic quadrangle
Map date: 1986
Projection: Lambert Conformal Conic
UTM zone 12; 1927 NAD

Tolman Flat 7.5' topographic quadrangle
Map date: 1969, revised 1985
Projection: polyconic
UTM zone 12; 1927 NAD

Mount Maurice 7.5' topographic quadrangle
Map date: 1986
Projection: Lambert Conformal Conic
UTM zone 12; 1927 NAD



1. Flueckinger, L.A., 1970, Stratigraphy, petrography, and origin of Tertiary sediments off the front of the Beartooth Mountains, Montana-Wyoming: State College, Pennsylvania State University, Ph.D. dissertation, 249 p. Plate 1, scale 1:62,500.
2. Lopez, D.A., 2001, Geologic map of the Red Lodge 30' x 60' quadrangle, south-central Montana: Montana Bureau of Mines and Geology Open File Report MBMG-423, scale 1:100,000. ***(Covers entire map area)***
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MBMG Open File 524

Geologic Map of the Red Lodge Area Carbon County, Montana

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Maps may be obtained from: Publications Office
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Fax: (406) 496-4451
http://www.mbmg.mtech.edu

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