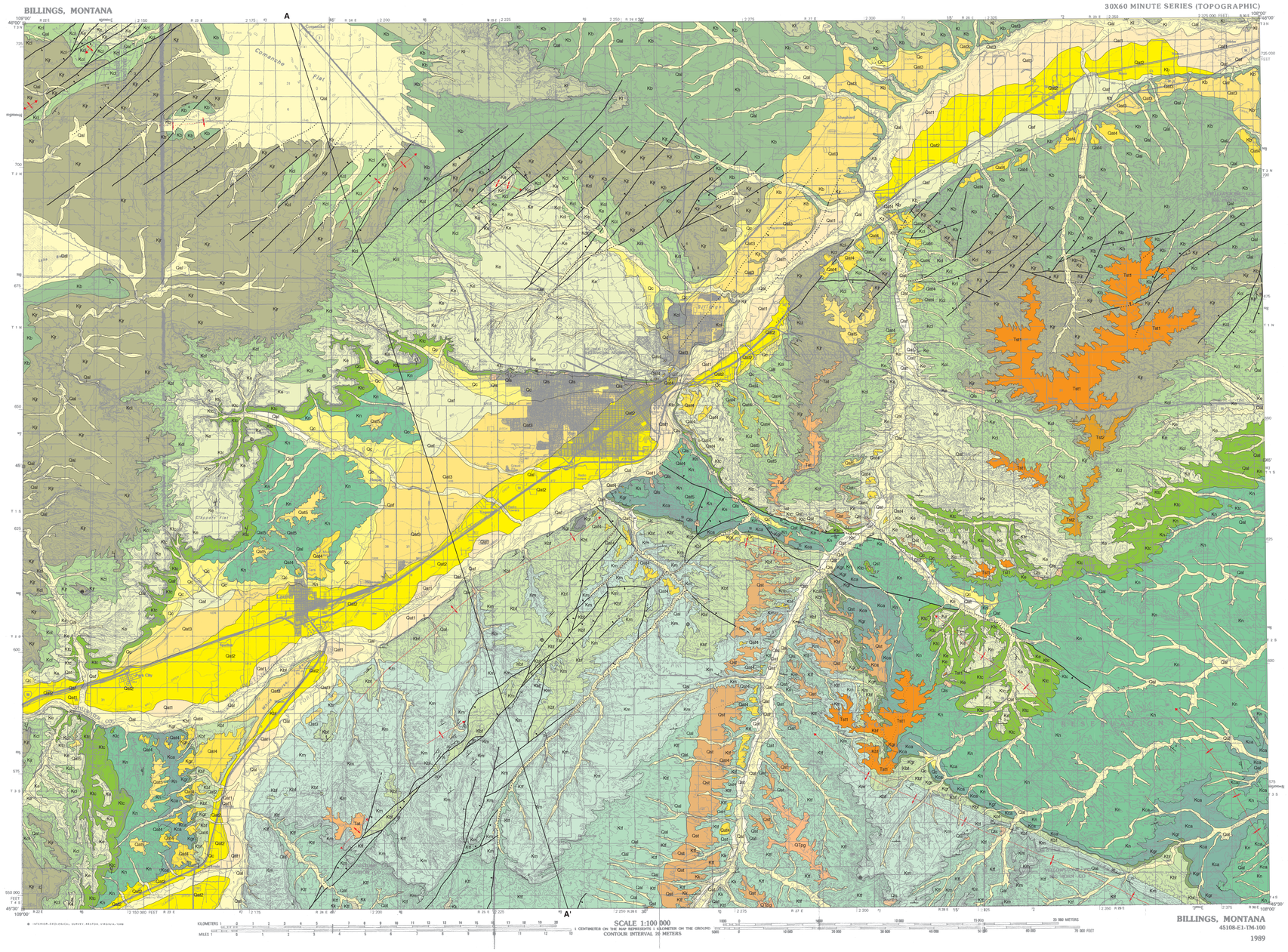
MONTANA BUREAU OF MINES AND GEOLOGY
A Department of Montana Tech of The University of Montana

Prepared in Cooperation with the U.S. Geological Survey and the U.S. Department of Energy National Petroleum Technology Office

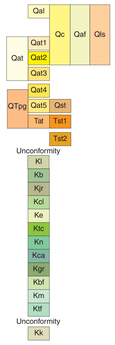
GEOLOGIC MAP SERIES NO. 59
Billings 30' x 60' Quadrangle, Lopez 2000

BILLINGS, MONTANA

30X60 MINUTE SERIES (TOPOGRAPHIC)



CORRELATION OF MAP UNITS



MAP SYMBOLS

Contact: Dashed where approximately located, dotted where concealed

Fault: Dashed where approximately located, dotted where concealed, queried where uncertain, bar and ball on downthrown side. Several faults have been reactivated at different times and show vertical and strike-slip displacements

Horizontal beds

Strike and dip of inclined beds

32

Anticline: Showing trace of axial plane and direction of plunge, dotted where concealed

Syncline: Showing trace of axial plane and direction of plunge, dotted where concealed

Monocline: Showing axial plane trace of anticlinal flexure and direction of plunge; dashed where approximately located, dotted where concealed; shorter arrow on more steeply dipping limb

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DESCRIPTION OF MAP UNITS

Qal **Alluvium** (Holocene): Gravel, sand, silt, and clay along active channels of rivers, creeks, and tributaries. Coarse, well-rounded gravel restricted mainly to Pryor Creek and Yellowstone River drainages. Most sediment in tributary drainages is sand, silt, and clay derived from local Cretaceous sandstone and shale bedrock.

Qc **Colluvium** (Holocene and Pleistocene): Locally derived slope-wash deposits mainly of sand, silt, and clay. Typically thin veneer concealing bedrock, but locally as thick as 30 feet. Commonly grades into Qal. Locally contains well-rounded cobbles derived from alluvial terrace gravel.

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 toes to as much as 50 feet at heads of fans.

Qls **Landslide deposits** (Holocene and Pleistocene): Unconsolidated mixture of soil and blocks of bedrock transported down steep slopes by mass wasting; locally consist of internally cohesive, rotated slump blocks. Characterize hummocky surface with concentric swales and ridges near downslope limits. Common along steep slopes beneath the Eagle Sandstone, Judith River Formation, and along steep slopes underlain by Cretaceous shales, but can occur where slope and moisture content produce unstable conditions. Numerous small slides and some with minor amounts of downslope displacement (R.B. Colton, U.S. Geological Survey, 1995, written communication) are not shown because of bedrock emphasis of this map.

QTpg **Pediment gravel deposits** (Pleistocene and Pliocene?): Angular and subangular coarse gravel derived from local bedrock, mostly limestone, form smooth surfaces sloping away from the Pryor and Big Horn mountains. About 10 to 30 feet thick.

—**ALLUVIAL TERRACE GRAVELS**—

Qat1 **Alluvial gravel, terrace level 1** (Holocene and Pleistocene): Gravel underlying terraces about 10 to 20 feet above present altitude of Yellowstone River. 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. Twenty to 40 feet thick (Gosling and Pashley, 1973).

Qat2 **Alluvial gravel, terrace level 2** (Pleistocene): Gravel underlying terraces about 20 to 40 feet above present elevation of Yellowstone River. 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. Forty to 60 feet thick (Gosling and Pashley, 1973).

Qat3 **Alluvial gravel, terrace level 3** (Pleistocene): Gravel underlying terraces about 50 to 90 feet above present altitude of Yellowstone River. 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. This deposit grades from about 20 to 30 feet at its southern edge to about five feet at its northern limit (Gosling and Pashley, 1973), where it is overlain by colluvium and alluvial fan deposits of silty clay.

Qat4 **Alluvial gravel, terrace level 4** (Pleistocene): Gravel underlying terraces about 200 to 300 feet above present altitude of Yellowstone River. These terraces locally exhibit a relatively steep gradient toward the Yellowstone River valley and may actually include several levels of terraces that are difficult to distinguish. Cobble- and pebble-size clasts are mainly granite, granitic gneiss, schist, and quartzite. Thickness up to about 20 feet.

Qat5 **Alluvial gravel, terrace level 5** (Pleistocene): Gravel underlying terraces about 400 to 500 feet above present altitude of Yellowstone River. Occur 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 ranges from a very thin remnant to about 20 feet.

Qat **Alluvial gravel undivided** (Holocene and Pleistocene?): Gravel, sand, silt, and clay underlying terraces about 20 to 200 feet above present altitude of modern streams and rivers. Equivalent to Qat1–Qat4. Mapped only in Pryor Creek drainage. Clasts are mainly andesite, with much less limestone, quartzite, and sandstone. Much of gravel apparently derived from within present Pryor Creek drainage and from reworking of higher level terrace gravel.

Tat **Alluvial gravel, terrace level 6** (Pliocene?): Gravel underlying remnant of terrace about 900 feet above present altitude of Yellowstone River. Composed mainly of well-rounded cobbles of granitic gneiss, schist, and quartzite. Locally contains high but variable percentage of quartzite and siliceous siltstone and mudstone apparently derived from the Mowry Shale. Scattered cobbles at these higher levels are common, indicating terrace was once much more widespread. Assumed to be Pliocene because terrace gravel of similar altitude in Pryor Creek drainage contains radiometrically dated Pliocene ash bed (see Tst). About 30 to 40 feet thick.

—**ALLUVIAL TERRACES OF THE ANCESTRAL SHOSHONE RIVER**—

Qst **Ancestral Shoshone River gravel, terrace level 1** (Pleistocene): Gravel and sand underlying terraces about 400 feet above present altitude of Pryor Creek in its lower reaches. But because of the much steeper gradient of present day Pryor Creek, near the Pryor Mountains this terrace is below the level of Pryor Creek. Transported by ancestral Shoshone River that flowed through Pryor Gap (Mackin, 1937). Commonly calcite-cemented near base. Clasts are mainly cobbles and pebbles of dark-colored andesitic rocks (Absaroka Volcanics), and lesser amounts limestone and quartzite. Age estimated to be about 1.4 m.y. (Reheis, 1985). Ten to 50 feet thick in map area.

Tst1 **Ancestral Shosone River gravel, terrace level 2** (Pliocene): Gravel and sand underlying terraces about 650 feet above present altitude of Pryor Creek (about 900 feet above the present Yellowstone River). Cobbles and smaller clasts are mostly andesite (Absaroka Volcanics), with lesser amounts of limestone and quartzite. Locally calcite-cemented at base. Pliocene age established from ash bed dated 2.02 m.y. (Huckleberry Ridge Ash) in this terrace gravel in T. 3 S., R. 28 E., section 7 (Izett and Wilcox, 1982). Thickness is 20 to 30 feet.

Tst2 **Ancestral Shosone River gravel, terrace level 3** (Pliocene): Gravel and sand underlying terraces about 750 feet above present day Pryor Creek (1,000 feet above the present day Yellowstone River). Cobbles and gravel are similar to Tst1, except for the presence of at least 25% granitic cobbles. These granitic cobbles were probably derived from the Clarks Fork drainage in the Beartooth Mountains, which is thought to have been a tributary of the Ancestral Shoshone River before being captured by the Yellowstone River drainage system (Mackin, 1937). About 20 to 30 feet thick.

—**BEDROCK MAP UNITS**—

Kl **Lance Formation** (Upper Cretaceous): Interbedded light-brownish gray, cliff and ledge-forming, fine-grained, thick-bedded to massive sandstone, medium-gray fissile shale, and a few thin beds of coal. Sandstone beds support growths of pine trees. In the Pompey's Pillar area, a thin section of Fox Hills Sandstone is included at the base of the Lance (Edith Wilde, Montana Bureau of Mines and Geology, 1996, personal communication). Along the north-central margin of the quadrangle, beds mapped as Lance resemble the Hell Creek of other areas (Edith Wilde, Montana Bureau of Mines and Geology, 1996, personal communication). Total thickness of the formation is about 350 feet.

Kb **Bearpaw Shale** (Upper Cretaceous): Dark-gray shale, commonly weathering dark brownish-gray, fissile, fossiliferous, brownish-gray calcareous concretions and nodules are common. Middle part of formation contains numerous thin mostly greenish-gray bentonite beds; thin sandstone beds are common near the top. The thickness is about 800 feet but thins westward to 200 to 300 feet.

Kjr **Judith River Formation** (Upper Cretaceous): Interbedded brownish-gray sandy shale and light-brown to pale yellowish-brown argillaceous, very fine to fine-grained lenticular sandstone in beds up to 10 ft thick. Locally a massive cliff-forming sandstone, resembling those in the Eagle Sandstone, occurs at the base and is commonly correlated with the Parkman Sandstone. Sandstones friable to moderately well indurated, cross-bedded, and burrowed to bioturbated and support growths of pine trees. In the western part of the quadrangle, greenish-gray and pale maroon-gray mudstones and easily eroded sandstones occur near the top of the formation. The thickness ranges from 250 to 350 feet because of lenticularity of the sandstones and eastward regional thinning.

Kcl **Claggett Shale** (Upper Cretaceous): Brownish-gray fissile shale with minor interbeds of light brownish-gray, very argillaceous sandstone. Light brownish-gray to light-brown, calcareous concretions common, usually fossiliferous. The upper contact is gradational and conformable and is placed at the change to ledge-forming sandstones of the Judith River Formation. Thickness of the formation is 100 to 400 feet thinning westward.

Ke **Eagle Sandstone** (Upper Cretaceous): Light brownish-gray to very pale-orange very fine to fine-grained, cross-bedded sandstone, burrowed to bioturbated in part. Locally contains calcareous, light-brown sandstone concretions up to 15 feet in diameter. Up to four sandstone intervals 10 to 50 feet thick can be present with intervening sandy shale as thick as 50 feet. Ranges from 100 to 350 feet because of lensing of sandstone intervals.

Klc **Telegraph Creek Formation** (Upper Cretaceous): Shale and sandy shale, brownish-gray to medium dark-gray with thin, interbedded sandstone. Dusky-red concretions common near base. Sandstone beds thicker and more abundant upward, grading into Eagle Sandstone. Contact with Eagle is placed at the base of the first cliff-forming sandstone. Maximum thickness about 150 feet.

Kn **Niobrara Shale** (Upper Cretaceous): Shale, olive-gray and dark brownish-gray, fissile, and contains abundant thin bentonite beds. Upper half calcareous, containing few very thin bentonite beds, and near top contains thin beds of very calcareous-laminated sandstone, siltstone, and sandy limestone. Concretions medium light-gray to pale yellowish-brown and from a few inches to one or two feet in diameter commonly present. Inoceramus prisms common. Upper contact placed at change from calcareous shales to non-calcareous shales of Telegraph Creek. Zone of dusky-red concretions in Telegraph Creek just above contact also helps establish its position. Basal contact is placed below ledge-forming zone of closely spaced, fossiliferous gray septarian concretions with veins brown calcite. In the Billings area about 700 feet thick.

Kca **Carlile Shale** (Upper Cretaceous): Shale, dark-gray to dark bluish-gray fissile. Interval about mid-section contains laminae and thin beds of argillaceous, platy, light brownish-gray to light olive-gray sandstone that locally supports growth of pine trees, but otherwise nearly bare of soil and vegetation. Septarian nodules and concretions common, ranging from light-gray to dark yellowish-orange. Approximately 250 to 300 feet thick.

Kgr **Greenhorn Formation** (Upper Cretaceous): Shale, dark bluish-gray, calcareous, fossiliferous. Typically poorly exposed, but forms very light brownish-gray soil upon weathering. Locally, the lower contact is marked by zone of closely spaced, gray, calcareous, septarian concretions at the base of the Greenhorn. Upper contact marked by change to non-calcareous shale. Thickness 50 to 75 feet.

Kbf **Belle Fourche Shale** (Upper Cretaceous): Shale, dark-gray, fissile, containing several thick bentonite beds in lower part. Thin sandstone bed commonly contains small chert pebbles, and zone of very dusky-purple to glossy grayish-black, ironstone concretions near base. Light-gray, brownish-gray concretions 6 in. to 1 foot in diameter and large (as much as four feet in diameter) light-brown to dark yellowish-orange concretions characteristic. "Frontier-like" sandstone present in upper part that is fine- to medium-grained, salt-and-pepper sandstone, and very thin to absent in eastern part of map area and about 1 to 2 feet thick in west. Upper contact marked by abrupt change to very calcareous shale above a very light greenish-gray bentonite bed about two feet thick at the top of the Belle Fourche Shale. Thickness is 350 to 400 feet.

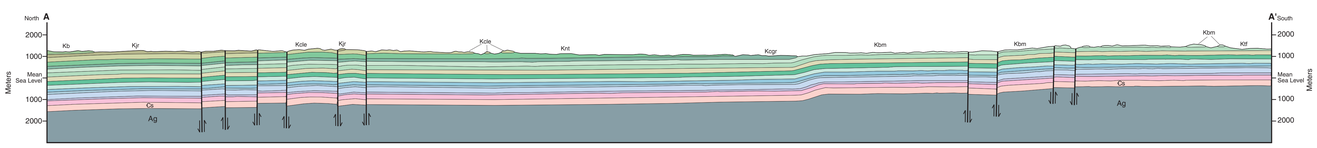
Km **Mowry Shale** (Upper Cretaceous): Interbedded, siliceous, very fine- to fine-grained sandstone, siltstone, and shale. Sandstones and siltstones mostly light-gray to medium-gray, with a silvery sheen. Some sandstone beds in Billings area are highly silicified, very hard quartzite. Shales are fissile, and mainly medium dark-gray. Bentonite beds common, 1 to 4 feet thick, including prominent beds at base and near top. Fish scales on bedding planes of sandstones and siltstones are characteristic of the formation. Thin, coarse lag deposit containing fish bones, fish teeth, and chert pebbles near the middle of the section. Upper contact of Mowry marked by thick bentonite above last fish scale-bearing sandstone. Basal contact placed at change from dark-gray fissile Thermopolis Shale to characteristic silvery sandstone and siltstone of Mowry containing fish scales. Thickness about 250 feet.

Ktf **Thermopolis Shale and Fall River Sandstone Undivided** (Lower Cretaceous): Upper 50 feet shale, dark-gray fissile, with few thin bentonite beds. Interval below this is dark-gray to brownish-gray and olive-gray fissile shale with thin interbeds and laminae of olive-gray and light olive-gray, argillaceous sandstone. Common bentonite beds and zones of iridescent very dusky-purple to grayish-black, ironstone concretions. The Fall River Sandstone at the base of the Thermopolis is an upward coarsening sequence of interbedded medium dark-gray, fissile shale and fine-grained, quartzose, light brownish-gray to moderate yellowish-brown sandstone. Sandstone coarsens and beds thicken slightly up section, commonly rippled, burrowed to bioturbated, and moderately to heavily limonite and hematite stained. Total thickness of the Thermopolis and Fall River Sandstone is about 600 to 650 feet.

Kk **Kootenai Formation** (Lower Cretaceous): Mostly reddish-brown, olive-gray, and dusky-purple mudstones with interbedded, lenticular, fine- to coarse-grained sandstones. Locally thick, lenticular, fluvial, fine-grained sandstone, the Greybull Sandstone, is present at the top. The basal Pryor Conglomerate Member is brown conglomerate and pebbly coarse-grained sandstone and is 20 to 60 feet thick. The total thickness of the Kootenai Formation is 200 to 250 feet.

Adjacent 30' x 60' maps

Harlowton	Roundup	Hysham
Big Timber	Billings	Hardin
Red Lodge	Bridger	Lodge Grass

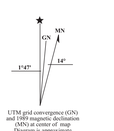


Cross Section A–A'

Scale (Vertical and Horizontal) 1:100,000
Surficial deposits not shown

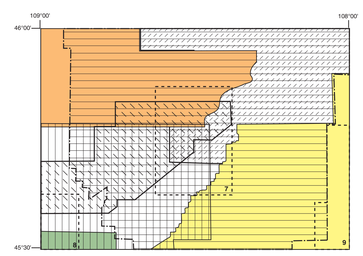
- Kb Bearpaw Shale
- Kjr Judith River Formation
- Kcle Claggett Shale & Eagle Sandstone*
- Knt Niobrara & Telegraph Creek Formations*
- Kcgr Carlile Shale & Greenhorn Formation*
- Kbm Belle Fourche & Mowry Shales*
- Ktf Thermopolis Shale & Fall River Sandstone
- KJkm Kootenai & Morrison Formations*
- Je Ellis Group, undivided
- Tc Chugwater Formation
- Pt Tensleep Sandstone
- PMa Amsden Formation
- Mm Madison Group, undivided
- Dj Jefferson Formation
- Ob Bighorn Dolomite
- Cs Cambrian sedimentary rocks, undivided
- Ag Granitic gneiss, hornblende schist, and biotite schist

* Units combined on cross section only



UTM grid convergence (GN) and 1989 magnetic declination (MN) at center of map
Diagram is approximate

INDEX OF PREVIOUS GEOLOGIC MAPPING



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Geologic Map of the Billings 30' x 60' Quadrangle, Montana

by
David A. Lopez
2000

Maps may be obtained from
Publications Office
Montana Bureau of Mines and Geology
1300 West Park Street, Butte, Montana 59701-8997
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