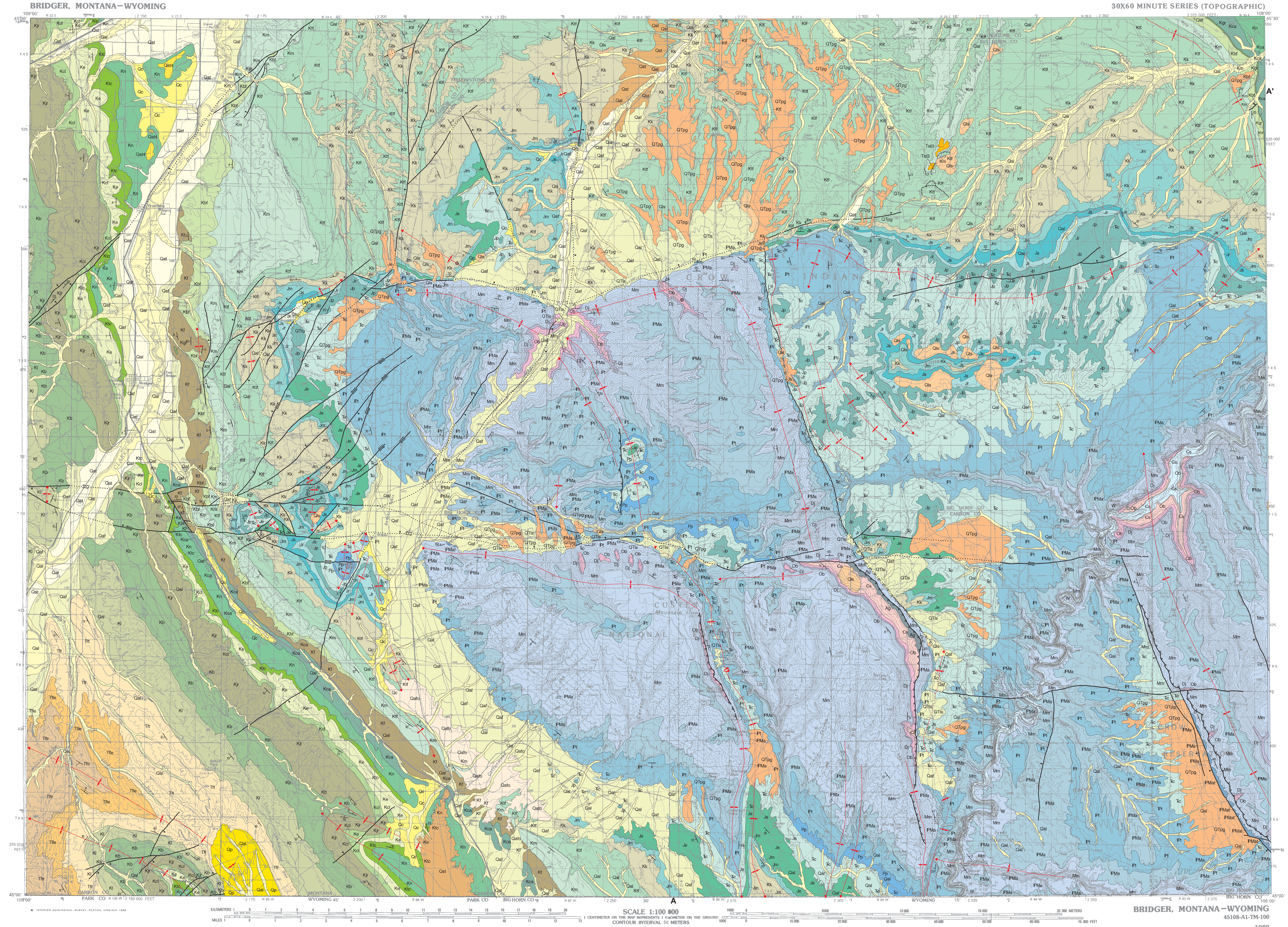
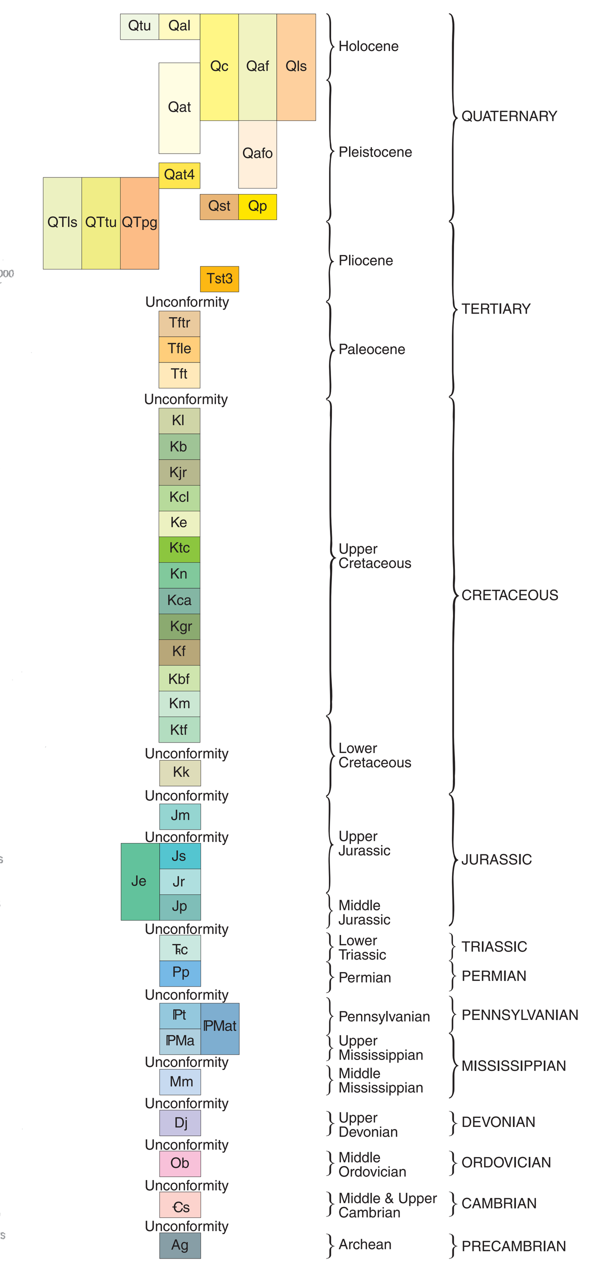
Prepared in Cooperation with the U.S. Geological Survey and the U.S. Department of Energy National Petroleum Technology Office



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. Arrows along fault trace indicate relative strike-slip displacement. Several faults have been reactivated at different times and show vertical and strike-slip displacements

Reverse fault: Open teeth on upthrown block

Slump block scarp: Hachures indicate direction of block movement

Horizontal beds

Strike and dip of inclined beds

Strike and dip of overturned beds

Anticline: Showing trace of axial plane and direction of plunge; dashed where approximately located, dotted where concealed

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

Overturned syncline: Showing trace of axial plane and direction of dip of bedding; dashed where approximately located, dotted where concealed

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

Water

DESCRIPTION OF MAP UNITS

Qal **Alluvium** (Holocene): Gravel, sand, silt, and clay along active channels of rivers, creeks, and tributaries. Most sediment in tributaries draining areas underlain by Cretaceous sandstone, and shale bedrock is sand, silt, and clay.

Qc **Colluvium** (Holocene and Pleistocene): Locally derived slope-wash deposits mainly of sand, silt, and clay. Usually 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. Thicknesses range from very thin at toes to as much as 50 feet at heads of fans.

Qafo **Older alluvial fan deposits** (Pleistocene?): Deposits similar to Qaf but overlain by Qaf and are erosionally dissected; occur only along the southwest margin of the Pryor Mountains.

Qtu **Calcareous tufa** (Holocene): Very light-gray, vuggy limestone, being deposited by Blue Water Spring in T. 6 S., R. 24 E., sections 4 and 9. Plant material commonly incorporated. Thickness unknown but probably 10 to 20 feet thick.

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. Characteristic hummocky surface with concentric swales and ridges near downslope limits. Can occur where slope and moisture content produce unstable conditions. Many small landslides and some with only minor downslope displacement (Colton, 1995, written communication) are not shown because of bedrock emphasis of this map.

Qp **Pediment surface deposits** (Pleistocene): Deposits of sand, silt, and clay mixed with cobble-size clasts of locally derived sandstone on pedimented flat surface immediately east of Elk Basin oil field in the southwestern part of the quadrangle. Pediment surface truncates steeply dipping Fort Union beds. The surface is at the same elevation as the ancestral Shoshone River terrace (Qst) located about six miles to the east and is thought to be similar in age (about 1.4 m.y.).

QTls **Landslide deposits** (Pleistocene and Pliocene?): Unconsolidated mixture of soil and blocks of local bedrock along the flanks of the Pryor Mountains uplift. Much of surface form is obliterated by later erosion.

QTpg **Pediment gravel deposits** (Pleistocene and Pliocene?): Angular and subangular, coarse gravel derived from local bedrock, mostly limestone, forming smooth surfaces sloping away from the Pryor and Big Horn mountains. These deposits are assumed older than Qpg because they are at much higher altitudes and are slightly dissected. Thicknesses 10 to 30 feet.

QTtu **Calcareous tufa** (Pleistocene and Pliocene?): Light-gray and grayish-pink, vuggy, limestone spring deposits with plant material commonly incorporated, occurs only at Blue Water Spring, T. 6 S., R. 24 E., section 9. Inactive deposit about 100 feet higher in altitude than Qtu. Thicknesses 10 to 20 feet.

ALLUVIAL TERRACE GRAVELS

Qat **Alluvial gravels, terrace levels 1-3 undivided** (Holocene and Pleistocene?): Gravel, sand, silt, and clay underlying terraces about 20 to 200 feet above present elevation of modern streams and rivers. Equivalent to Qat1-Qat3, mapped on the Billings quadrangle to the north (Lopez, 1996).

Qat4 **Alluvial gravel, terrace level 4** (Pleistocene): Gravel underlying terraces 200 to 300 feet above present altitude of Yellowstone River. These terraces locally exhibit 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 as much as 20 feet.

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, this terrace, near the Pryor Mountains, is below the level of Pryor Creek. Transported by the 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.

Tst3 **Ancestral Shoshone River(?) gravel, terrace level 3** (Pliocene): Gravel and sand underlying terrace about 200 feet above the upgradient projection of Tst2. (Tst1 and Tst2 are not present on the Bridger quadrangle but are present to the north on the Billings quadrangle [Lopez, 1996]). Gravel consists of rounded and weathered cobbles of limestone, quartzite, sandstone, and about 10% of andesitic volcanic clasts. May represent a period of accelerated down-cutting of Ancestral Shoshone River through the sequence of sedimentary rocks of Paleozoic age in Pryor Gap.

BEDROCK MAP UNITS

—FORT UNION FORMATION—

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 minor thin coal beds. Sandstones ledge forming, commonly support growths of pine trees. Thickness 500 to 700 feet.

Tfle **Lebo Member, Fort Union Formation** (Paleocene): Predominantly dark-gray to olive shale, locally yellowish-gray claystone, thin, interbedded sandstones and siltstone, yellowish-gray. Typically forms smooth grassy slopes below the Tongue River Member. Thickness 200 to 250 feet.

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. About 400 feet thick.

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. Total thickness of the formation is about 350 feet.

Kb **Bearpaw Shale** (Upper Cretaceous): Dark-gray shale, fissile, commonly weathering dark brownish-gray. Brownish-gray calcareous concretions and nodules are common, middle part of formation contains numerous thin mostly greenish-gray bentonite beds; thin, silicified, hematite-stained sandstone beds common near the top. The thickness is 200 to 800 feet, thinning to the west.

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 generally up to 10 feet thick, but 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. Greenish-gray and pale maroon-gray mudstones and easily eroded sandstones occur near the top of the formation. The thickness is variable because of the lenticularity of the sandstones and eastward regional thinning; in this area it is 250 to 350 feet.

Kcl **Claggett Shale** (Upper Cretaceous): Brownish-gray fissile shale with minor interbeds of light brownish-gray very argillaceous sandstone. Also includes thin bentonite beds. Light brownish-gray to light-brown, calcareous concretions common, often 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 ranges from 100 to 300 feet, thinning westward and southward toward the Wyoming border.

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 as much as 15 feet in diameter. As many as four sandstone intervals 10 to 50 feet thick can be present with intervening sandy shales as thick as 50 feet. Coal beds present near the top of the formation were mined in the Fromberg-Bridger area. Thickness ranges from 100 to 350 feet, thinning to the south and west.

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

Kn **Niobrara Shale** (Upper Cretaceous): Olive-gray and dark brownish-gray, fissile shale with abundant, thin bentonite beds. Upper half calcareous, containing few very thin bentonite beds, and contains thin beds of very calcareous, laminated sandstone, siltstone, and sandy limestone near the top. Concretions medium light-gray to pale yellowish-brown and from a few inches to two feet in diameter commonly present. Inoceramus prisms common. Upper contact placed at change from calcareous shales to non-calcareous shales of Telegraph Creek. Basal contact is placed below ledge-forming zone of closely spaced, fossiliferous gray septarian concretions with veins brown calcite. About 700 feet thick.

Kca **Carlile Shale** (Upper Cretaceous): Dark-gray to dark bluish-gray fissile shale. 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 surface exposures are nearly bare of soil and vegetation. Septarian nodules and concretions common, ranging from light-gray to dark-yellowish-orange. Basal contact placed above last calcareous shale in the underlying Greenhorn Formation. About 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. About 75 feet thick.

Kf **Frontier Formation** (Upper Cretaceous): Light brownish-gray, fine-grained, thick-bedded to massive sandstone. Interbedded with dark-gray, fissile shale. Occurs south of Fromberg. Interfingers with the upper part of the Belle Fourche Shale and thickens to the south; near the Wyoming border, it replaces the entire Belle Fourche section, where it reaches a thickness of about 350 feet.

Kbf **Belle Fourche Shale** (Upper Cretaceous): Shale, dark-gray, fissile, containing several thick bentonite beds in lower part. Thin sandstone bed commonly containing small chert pebbles, and zone of very dusky-purple to glossy grayish-black, ironstone concretions near base. Light-gray, brownish-gray concretions about 6 in. to 1 foot in diameter and large (up to four feet in diameter) light-brown to dark yellowish-orange concretions are characteristic. North of Fromberg, the Frontier is absent, but the zone is represented by a salt-and-pepper sandstone present in the upper part of the Belle Fourche that is fine- to medium-grained. Contact with Greenhorn marked by abrupt change to very calcareous 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 silvery sheen. Locally, some sandstone beds are highly silicified, resulting in 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 the highest fish scale-bearing sandstone. Basal contact placed at change from dark-gray fissile Thermopolis Shale to characteristic silvery sandstone and siltstone of the 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 underlies the Thermopolis Shale and 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 combined is 600 to 700 feet.

Kk **Kootenai Formation** (Lower Cretaceous): Mostly reddish-brown, olive-gray, and dusky-purple bentonitic mudstones with interbedded, lenticular, fine- to coarse-grained sandstones, thin zones of light-gray nodular limestone are common in the upper part. Fossil dinosaur remains present locally. Locally thick, lenticular, fluvial, fine-grained sandstone, the Greybull Sandstone, is present at top. The basal Pryor Conglomerate Member is brown conglomerate and pebbly coarse-grained sandstone, 20 to 60 feet thick. The total thickness of the Kootenai Formation is 200 to 250 feet.

Jm **Morrison Formation** (Upper Jurassic): Variegated, mainly greenish-gray and pale reddish-brown mudstone. Very fine to fine-grained, quartzose, calcareous, cross-bedded sandstones are commonly present at about mid-section, 5 to 10 feet thick but locally can be as much as 30 feet thick. Fossil dinosaur remains common. Upper contact placed at the base of the Pryor Conglomerate. The basal contact is placed at the top of fossiliferous limy sandstone and coquina of the underlying Swift Formation. Thickness is 300 to 350 feet.

Je —**ELLIS GROUP undivided** (Jurassic) —

Js **Swift Formation** (Upper Jurassic): Interbedded medium-gray shale, limestone and limy sandstone, fossiliferous. Brownish-gray, fossiliferous, very sandy limestone occurs at the top of the formation and commonly has brownish-gray coquina at the top. About 100 feet thick.

Jr **Rierdon Formation** (Upper Jurassic): Mostly pale greenish-gray very fossiliferous shale with minor interbeddded brownish gray limestone. Typically poorly exposed, forming smooth slopes littered with fossils, including oysters (*Gryphaea* and *Ostrea*), belemnites (*Pachyteuthis*), and crinoids fragments (*Pentacrinus*). A laminated sandstone about mid-section, 10 to 20 feet thick, containing fish fossils, is present locally at the southern end of the Pryor Mountains. The Rierdon is about 150 feet thick.

Jp **Piper Formation** (Middle Jurassic): Interbedded medium gray, and pale reddish-gray, thin-bedded limestone and medium-gray shale. Includes thin, interbedded gypsum. Forms ledge below smooth slopes of the Rierdon shales. Thickness 75 to 150 feet.

Ꞧc **Chugwater Formation** (Lower Triassic): Interbedded moderate reddish-brown, fine-grained sandstone, siltstone, and mudstone. Thin light-gray limestone bed is present near the top, and gypsum beds are common in lower part; locally gypsum thickens to about 10 feet. Typically, strike valleys develop at the base of the Chugwater above resistant rocks of the Phosphoria and Tensleep formations. Thickness is 450 to 600 feet.

Pp **Phosphoria Formation** (Permian): Light-gray limestone, sandstone and quartzite, commonly grayish-pink, cherty. Locally a reddish-brown variety of chert, known as Dry Head Agate, has been mined and collected for lapidary purposes. Phosphoria is a very thin remnant, mapped separately where scale allows, but otherwise included with the Tensleep Formation. Thickness 10 to 50 feet.

IPt **Tensleep Sandstone** (Pennsylvanian): Very 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 200 feet thick.

IPMa **Amsden Formation** (Lower Pennsylvanian and Upper Mississippian): 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 ranges from 140 to 300 feet; locally, tectonically thinned to only a few feet along the margins of Pryor Mountains uplift.

IPMat **Amsden Formation and Tensleep Sandstone undivided (**Pennsylvanian and Upper Mississippian): Units mapped together where Amsden has been tectonically thinned as described above.

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 (Campbell, 1978) are common at the upper karst surface. Collapse features often contain pale-red breccia and host low-grade uranium deposits. The upper massive beds of very pure limestone are quarried in the southwest part of the Pryor Mountains for industrial uses and lime production. Thickness of the Madison is 800 to 1,000 feet.

Dj **Jefferson Formation** (Upper Devonian): Dolomitic limestone, light brownish-gray, fetid, poorly exposed, typically occurs as float above Bighorn Dolomite. In other areas of Montana, the Jefferson is overlain by the Three Forks Formation, which is absent in the Pryor Mountains (Sandberg, 1961, 1965). In Punch Bowl Creek on the east side of the Pryor Mountains, a thin section of Beartooth Butte Formation (Lower Devonian), which consists of pale reddish-brown siltstone and limestone and dolomite conglomerate and breccia, is present below the Jefferson (Blackstone, 1975). The Beartooth Butte Formation is mapped with the Jefferson. Total thickness of the Jefferson is about 250 feet.

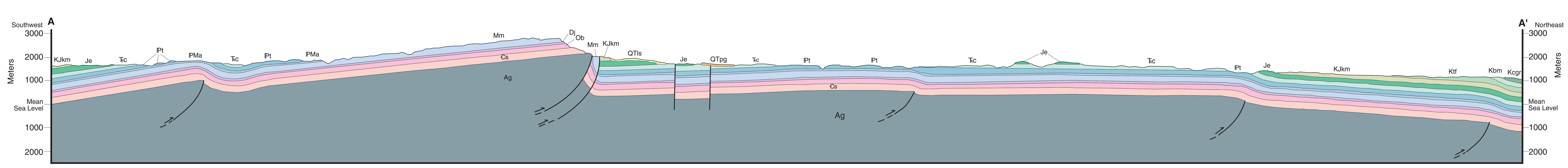
Ob **Bighorn Dolomite** (Middle Ordovician): Dolomite and dolomitic limestone, very light-gray to very pale-orange, lower part massive, thin to thick bedded in upper part. Has characteristic pock-marked surface due to differential weathering. Forms cliffs in lower reaches of deep canyons. About 500 feet thick.

Ꞓs **Cambrian Sedimentary rocks undivided** (Middle and Upper Cambrian): Light-red sandstone and quartzite, greenish-gray shale and sandy shale, gray thin-bedded limestone and greenish-gray flat-pebble limestone conglomerate. Includes the Flathead Quartzite, Gros Ventre Formation, and Gallatin Limestone of Wyoming terminology or Flathead, Wolsey, Meagher, Park, and Pilgrim of Montana terminology. Thickness is 700 to 800 feet.

Ag **Granitic gneiss and schist** (Archean): Pale to moderate red gneissic granite, medium dark-gray quartzo-feldspathic gneiss, biotite-hornblende schist, quartzite, and aplite and mafic dikes. Locally cut by quartz veins.

Cross Section A–A'

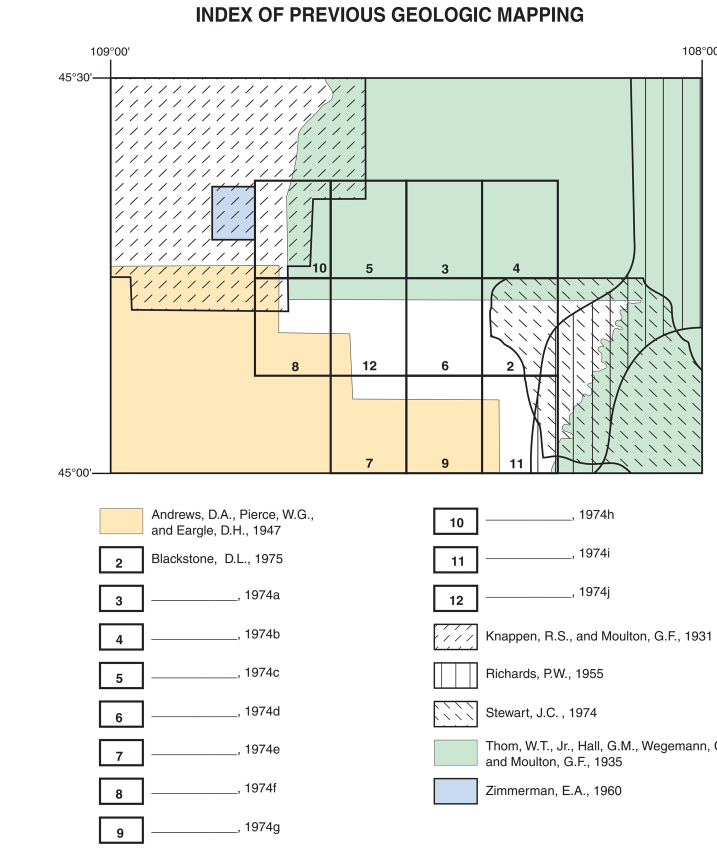
Scale (Vertical and Horizontal) 1:100,000
Thin surficial deposits not shown



- QTls Landslide deposit
- QTpg Pediment gravel
- Kcgr Carlile Shale & Greenhorn Formation*
- Kbm Belle Fourche & Mowry Shales*
- Ktf Thermopolis Shale & Fall River Sandstone
- KJkm Kootenai & Morrison Formations*
- Je Ellis Group, undivided
- Ꞧc Chugwater Formation
- IPt Tensleep Sandstone
- IPMa Amsden Formation
- Mm Madison Group, undivided
- Dj Jefferson Formation
- Ob Bighorn Dolomite
- Ꞓs Cambrian sedimentary rocks, undivided
- Ag Granitic gneiss, hornblende schist, and biotite schist

* Units combined on cross section only

INDEX OF PREVIOUS GEOLOGIC MAPPING



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Geologic Map of the Bridger 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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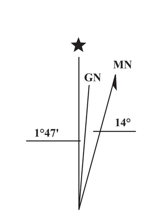
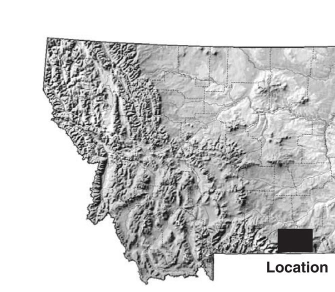


UTM grid convergence (GN) and 1989 magnetic declination (MN) at center of map
Diagram is approximate



Adjacent 30' x 60' maps

Big Timber	Billings	Hardin
Red Lodge	Bridger	Lodge Grass
Cody	Powell	Burgess Junction