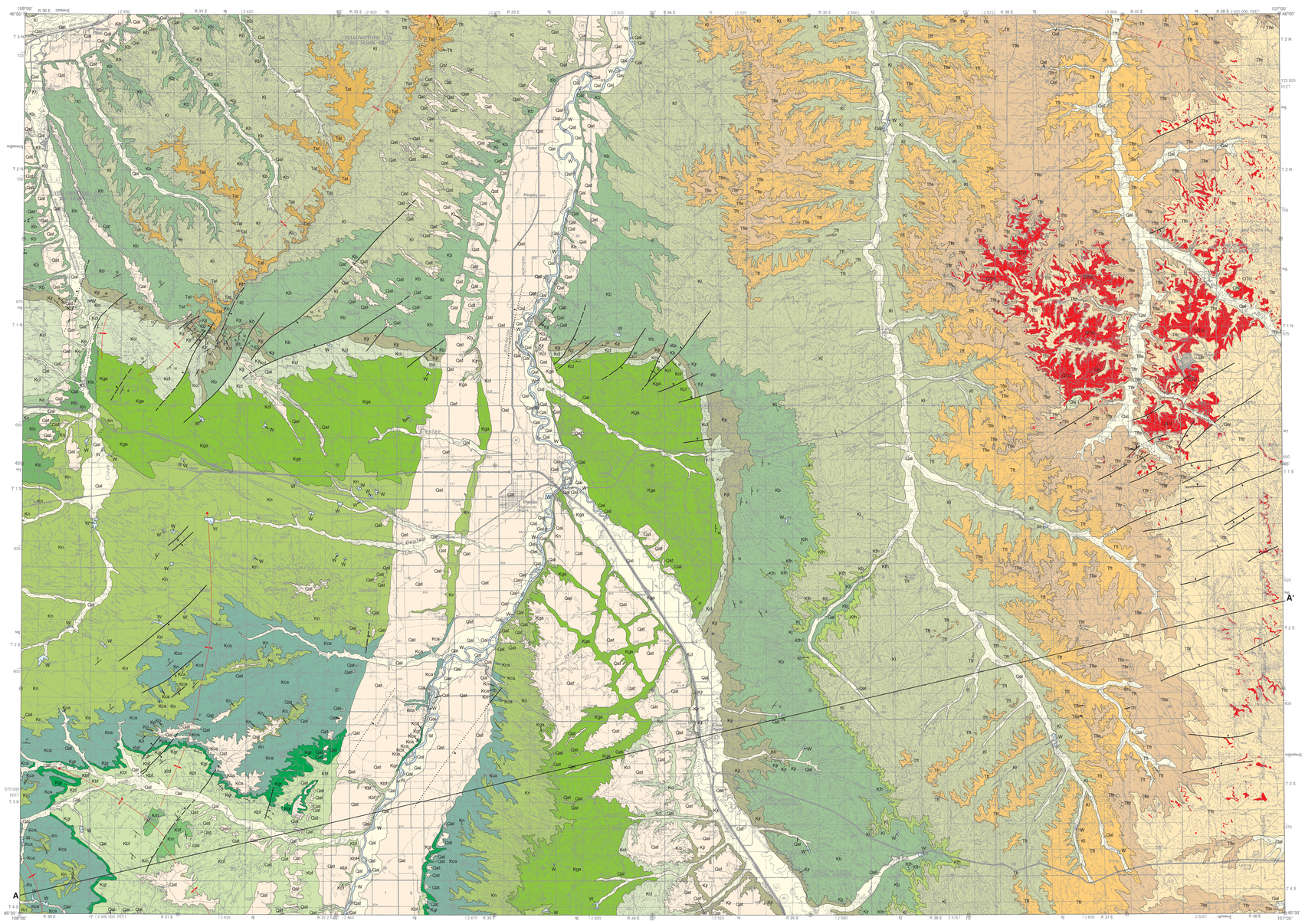
**Prepared in Cooperation with the U.S. Geological Survey and the U.S. Department of Energy National Petroleum Technology Office**

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

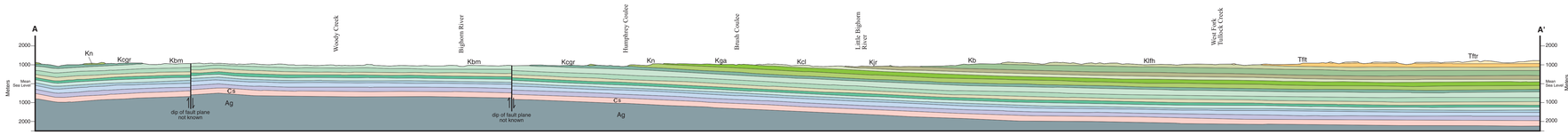



Base from U.S. Geological Survey
Hardin 30'x60' topographic quadrangle
Map date: 1981
Projection: UTM zone 13; 1927 NAD

KILOMETERS 1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
MILES 1 0 1 1 2 3 4 5 6 7 8 9 10 11 12 13

**SCALE 1:100 000**
1 CENTIMETER ON THE MAP REPRESENTS 1 KILOMETER ON THE GROUND
**CONTOUR INTERVAL 20 METERS**

1000 0 5000 10 000 15 000 20 000 METERS
5000 0 10 000 20 000 30 000 40 000 50 000 60 000 70 000 FEET




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

## Cross Section A–A'

| | | | |
|---|---|---|---|
| Tftr | Tongue River Member of Fort Union Formation | Klf | Thermopolis Shale & Fall River Sandstone |
| Tflt | Lebo & Tullock Members of Fort Union Formation | KJkm | Kootenai & Morrison Formations* |
| Klfh | Lance and Fox Hills Formations | Je | Ellis Group |
| Kb | Bearpaw Shale | PPcg | Chugwater & Goose Egg Formations* |
| Kjr | Judith River Formation | PMs | Tensleep & Amsden Formations* |
| Kcl | Claggett Shale | Mm | Madison Group |
| Kga | Gammon Shale | DOJb | Three Forks, Jefferson, and Bighorn Formations* |
| Kn | Niobrara Formation | Cs | Cambrian sedimentary rocks |
| Kcgr | Carlile Shale & Greenhorn Formation* | Ag | Granitic gneiss, hornblende schist, and biotite schist |
| Kbm | Belle Fourche & Mowry Shales* | | * Units combined on cross section only |

# Geologic Map of the Hardin 30' x 60' Quadrangle, Montana

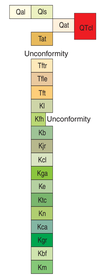
**Compiled and Mapped by**
**Susan M. Vuke, Edith M. Wilde, and Robert N. Bergantino**
**2000 (Revised 2007)**

| Revised | Date |
|---|---|
| map - S M Vuke | 8/07 |

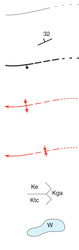
**Adjacent 30' x 60' maps**

| | | |
|---|---|---|
| Roundup | Hysham | Forsyth |
| Billings | Hardin | Lame Deer |
| Bridger | Lodge Grass | Birney |

## CORRELATION OF MAP UNITS




## MAP SYMBOLS




## DESCRIPTION OF MAP UNITS

**Qal** **Alluvium** (Holocene): Gravel, sand, silt, and clay along active channels of rivers, streams, and tributaries; poorly to well stratified, dominantly clast supported; and moderately well sorted. Includes terrace deposits less than six feet above river or stream. Gravel of Big Horn River alluvium mainly pebbles, cobbles, and boulders of limestone and dolomite, andesite and other mafic volcanic rocks, quartzite, granitic rocks, and sandstone and chert, in descending order of abundance (Agard, 1989). Thickness as much as 35 feet.

**Qls** **Landslide deposit** (Holocene): Rock and soil that moved downslope in discrete units through mass-wasting processes that resulted in irregular or hummocky surfaces. Thickness of unit ranges from 100 to 150 feet.

**Qat** **Alluvial terrace deposit** (Pleistocene): Gravel, sand, silt, and clay underlying alluvial terrace surfaces adjacent to and higher in elevation than modern streams and rivers; poorly to moderately well stratified and sorted with planar and trough cross-bedding. At least three distinct terrace levels in the map area along the Yellowstone River and its tributary, Fly Creek, range from 8 to 395 feet above the river and creek. Gravel composed of rounded to subrounded clasts of granitic igneous rocks, schist, gneiss, and quartzite, with fewer clasts of limestone and sandstone. Thickness ranges from 3 to 10 feet. At least eight distinct terrace levels are recognized along Big Horn River and Little Big Horn River, ranging from 15 to 560 feet above the rivers. Gravel composed of rounded to subrounded clasts of limestone and dolomite, andesite and other mafic volcanic rocks, quartzite, granitic rocks, and sandstone and chert, in order of descending abundance. Lowest terrace deposit has been dated at about 0.02 Ma and highest at 1.2 Ma (Agard, 1989). Thickness of unit ranges from 15 to 50 feet.

**QTd** **Clinker** (Holocene, Pleistocene, and Pliocene): Red, pink, orange, black, and yellow resistant thermally metamorphosed shale, siltstone, and sandstone of the Fort Union Formation. Bedrock was baked by burning of underlying coal. Locally, baked rock was melted and fused to form buchite, a black, glassy, vesicular or scoriaceous rock. Thickness as much as 150 feet.

**Tat** **Alluvial terrace deposit** (Pliocene): Gravel, sand, silt, and clay underlying alluvial terrace surface on Pine Ridge, about 1,100 feet above the Big Horn River. Poorly to moderately well sorted and stratified with planar and trough cross-bedding. Gravel clasts consist of rounded to subrounded volcanic rocks, crystalline rocks, and quartzite (Agard, 1989). Thickness of unit ranges from 30 to 35 feet.

—FORT UNION FORMATION—

**Tftr** **Tongue River Member** (Paleocene): Yellowish-gray to grayish-yellow, fine- to medium-grained, trough cross-bedded, planar-bedded, or massive sandstone interbedded with much less brownish-gray carbonaceous shale and brownish-gray to yellowish-gray siltstone, and at least 10 significant coal beds ranking from subbituminous C to low in the range of subbituminous B, and are up to 33 feet thick (Robinson and Van Gosen, 1986). Thickness of member exposed in map area 525 feet.

**Tfle** **Lebo Member** (Paleocene): Medium-gray, dark-gray, and olive-gray shale that is commonly smectitic or carbonaceous, and silty shale with thin, interbedded yellowish-gray sandstone and siltstone, and thin coal beds. Thickness of member 130 to 165 feet.

**Tft** **Tullock Member** (Paleocene): Yellowish-gray, fine- to medium-grained trough cross-bedded, planar-bedded or massive sandstone. Interbedded with much less brownish-gray or dark-gray carbonaceous shale. Sandstone beds thinner, and more tabular and persistent than those in underlying Lance Formation. Thickness of member 195 to 230 feet.

**Kl** **Lance Formation** (Upper Cretaceous): Light brownish-gray, fine-grained, cross-bedded, lenticularly bedded or massive sandstone. Interbedded with much less light olive-gray to greenish-gray shale. Contains calcite-cemented concretionary sandstone lenses. Locally contains a white sandstone interbedded with coal at the base. Sandstone beds thicker and more lenticular than those in overlying Tullock Member. Thickness of formation 400 to 500 feet.

**Kfh** **Fox Hills Formation** (Upper Cretaceous): Brownish-gray siltstone and fine-grained, cross-bedded or hummocky-bedded poorly resistant sandstone interbedded with dark-gray shale. Not present in northern part of map area. Thickness of formation 0 to 100 feet.

**Kb** **Bearpaw Shale** (Upper Cretaceous): Dark-gray fissile shale interbedded with thin, brownish-gray siltstone and fine-grained sandstone beds near the top. Contains numerous brown-weathering calcareous concretions throughout, and numerous bentonite beds in the middle, one of which is 20 feet thick. Thickness of formation 800 to 860 feet.

**Kjr** **Judith River Formation** (Upper Cretaceous): Yellowish-gray to brownish-gray and olive-green, fine- to medium-grained cross-bedded sandstone interbedded with lesser amounts of yellowish-gray silty shale. Thickness of formation 230 to 260 feet.

**Kcl** **Claggett Shale** (Upper Cretaceous): Brownish-gray and dark-gray fissile or bentonitic shale. Contains distinctive yellowish-tan or orange septarian concretions, many of which contain marine fossils. Thickness of formation 150 to 200 feet.

**Kga** **Gammon Formation** (Upper Cretaceous): Yellowish-brown calcareous siltstone interbedded with yellowish-brown weathering, brownish-gray calcareous silty shale. Contains several yellowish-brown, fine-grained sandstone beds, and a zone of reddish-orange ferruginous concretions in sandy shale. The lateral change from upper Niobrara-Telegraph Creek-Eagle formations to Gammon Formation occurs from west to east in the map area, with the only exposed transitional area in the northwestern part. Thickness of formation 0 to 860 feet.

**Ke** **Eagle Sandstone** (Upper Cretaceous): Light brownish-gray to very pale orange very fine- to fine-grained cross-bedded sandstone. Contains trace fossils. Present only in northwestern part of map area. Thickness of formation 0 to 85 feet.

**Klc** **Telegraph Creek Formation** (Upper Cretaceous): Yellowish-brown shale and silty shale interbedded with yellowish-brown and brownish-gray siltstone and fine-grained sandstone beds that thicken upward. Present only in northwestern part of map. Thickness of formation 0 to 150 feet.

**Kn** **Niobrara Shale** (Upper Cretaceous): Dark brownish-gray fissile shale with abundant, thin bentonite beds and medium light-gray to pale yellowish-brown concretions up to two feet in diameter. Upper half calcareous with thin beds of very calcareous-laminated sandstone, siltstone, and sandy limestone near the top. Contains a nine-foot-thick bed of calcareous shale 75 feet above the base of the formation, and two prominent bentonite beds in the middle of the formation in the area west and southwest of Hardin. Thickness of formation 390 to 410 feet.

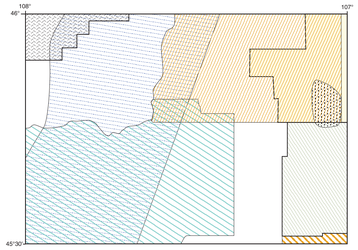
**Kca** **Carlile Shale** (Upper Cretaceous): Very dark-gray to dark bluish-gray fissile shale with dark-gray sandy shale at the base and in the middle. The lower sandy shale contains two bentonite beds 0.6 to 0.9 m (2-3 feet) thick. The upper part contains medium-gray closely spaced calcareous septarian concretions, with thick veins of dark-brown calcite. Thickness of formation 280 to 285 feet.

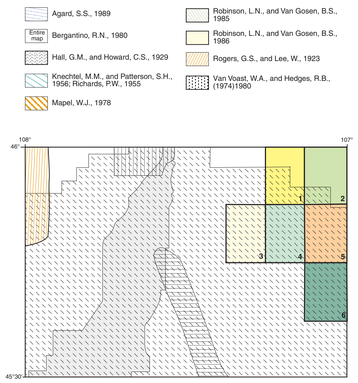
**Kgr** **Greenhorn Formation** (Upper Cretaceous): Dark bluish-gray, calcareous, fossiliferous, poorly resistant shale that weathers very light brownish-gray. Locally contains numerous light-gray calcareous septarian concretions, and a thick zone of bentonitic shale or bentonite at the base. Thickness of formation 115 feet.

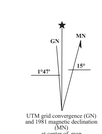
**Kbf** **Belle Fourche Shale** (Upper Cretaceous): Dark-gray fissile shale and sandy shale. Contains ferruginous concretions and a bentonite bed that is six feet thick in lower part; the Soap Creek bentonite bed in the middle that is 3 to 29 feet thick; and a bentonite bed that is 6.5 feet thick, and light-gray and brownish-gray calcareous concretions in the upper part. Thickness of formation 470 to 480 feet.

**Km** **Mowry Shale** (Upper Cretaceous): Light-gray to medium-gray siliceous, very fine- to fine-grained sandstone and siltstone, with silvery sheen interbedded with medium dark-gray fissile shale. Contains abundant fish scales on bedding surfaces. Thickness exposed in map area 160 feet at Woody Creek Dome.

## INDEX OF PREVIOUS GEOLOGIC MAPPING




UTM grid convergence (GN) and 1981 magnetic declination (MN) at center of map
Diagram is approximate

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 or (406) 496-4174
Fax: (406) 496-4451
http://www.mbmg.mtech.edu

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