

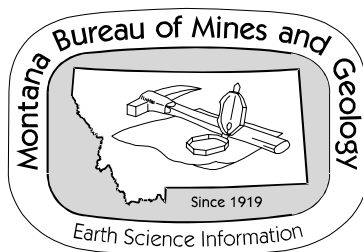
GEOLOGIC MAP OF THE ANGELA 30' x 60' QUADRANGLE

EASTERN MONTANA

Compiled and mapped by
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This report has been reviewed for conformity with Montana Bureau of Mines and Geology's technical and editorial standards.

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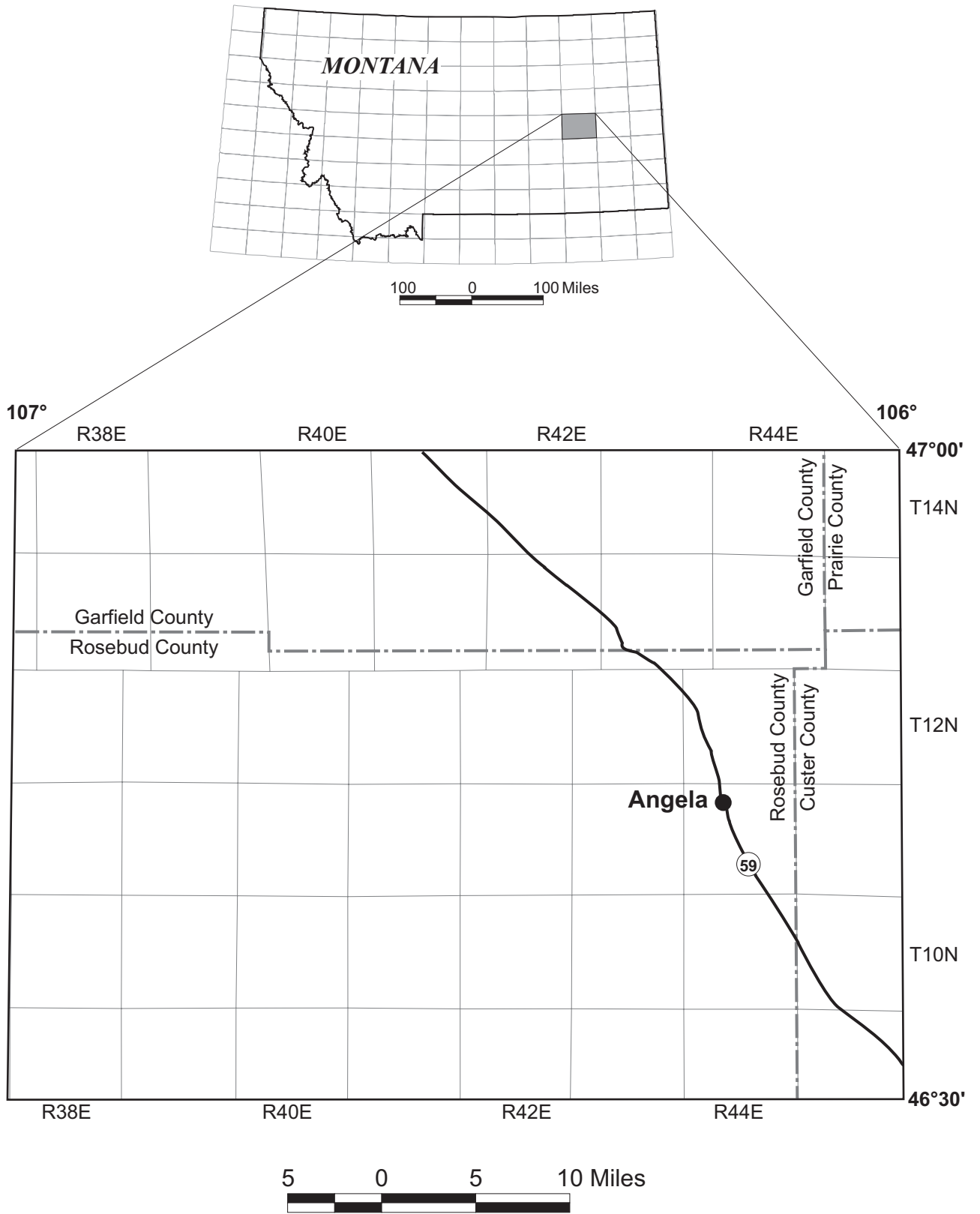
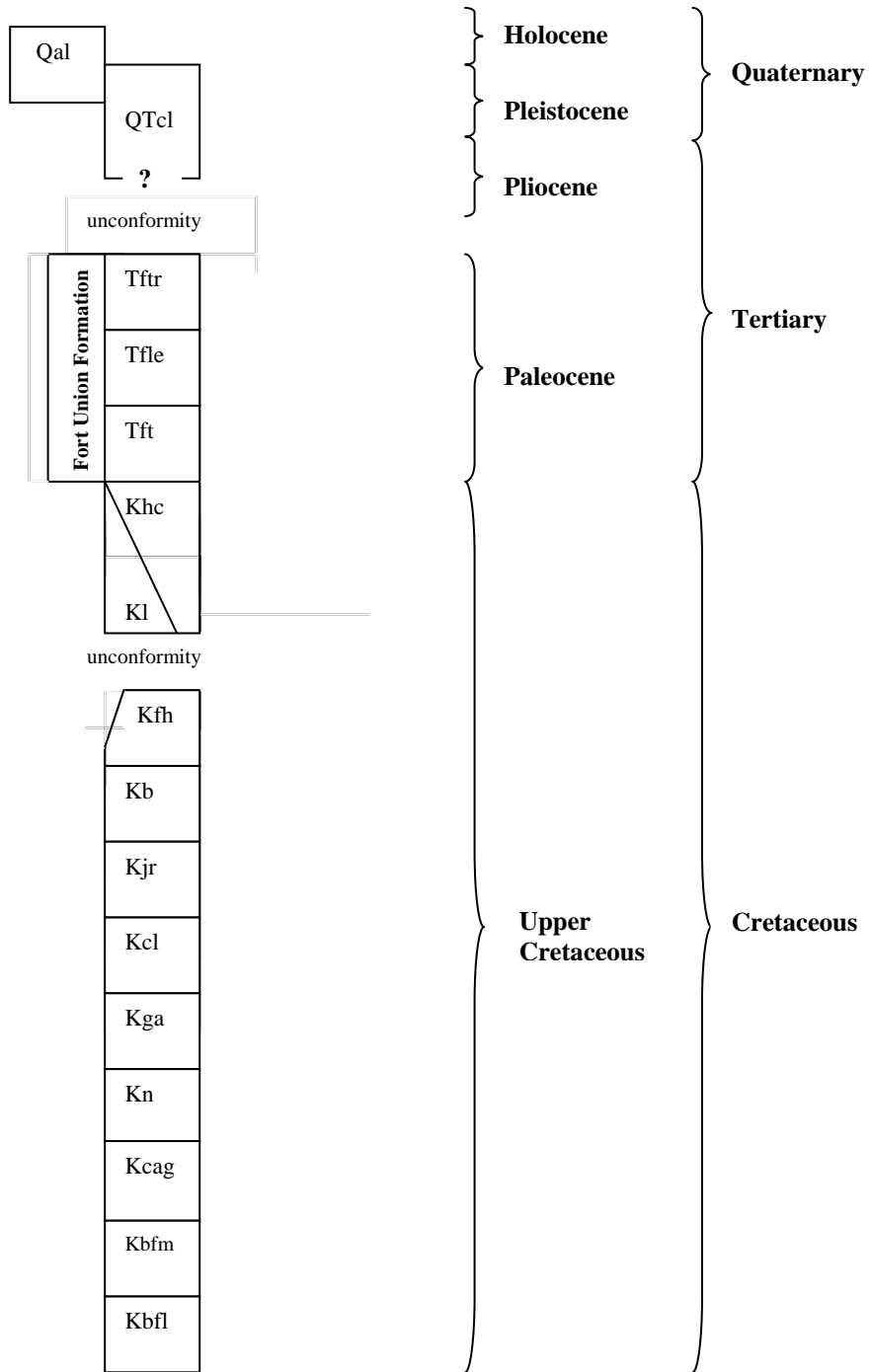


Figure 1. Location of Angela 30'x60' quadrangle, eastern Montana.

CORRELATION DIAGRAM
ANGELA 30' x 60' QUADRANGLE



**GEOLOGIC MAP SOURCES AND INDEX OF 7.5' QUADRANGLES
ANGELA 30' x 60' QUADRANGLE**

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Entire Map

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ANGELA 30'x 60' QUADRANGLE
EXPLANATION

- Qal Alluvium (Holocene)**—Light-brown and gray gravel, sand, silt, and clay deposited in stream and river channels and on flood plains. Clasts are well rounded to sub-rounded. Deposits are poorly to well stratified. Thickness probably less than 15 ft.
- QTcl Clinker (Holocene, Pleistocene, and Pliocene?)**— Red, pink, orange, black, and yellow, very resistant metamorphosed sandstone, siltstone, and shale of the Fort Union Formation. Bedrock was baked by natural burning of underlying coal, and collapsed into voids created by burning. Best-developed clinker from the Big Dirty coal bed at the base of the Lebo Member of the Fort Union Formation. Thickness from several inches to as much as 50 ft.
- Fort Union Formation (Paleocene)**
- Tftr Tongue River Member**—Yellow, orange, or tan, fine- to medium-grained sandstone with thinner interbeds of yellowish-brown, orange, or tan siltstone, light-colored mudstone and clay, brownish-gray carbonaceous shale, and coal. Clay dominantly nonswelling. A basal lithofacies, shown with a green hachured pattern on the eastern part of the map, is more prominent to the east of the map area. It consists of orange silty limestone beds associated with light-colored to white siltstone and mudstone beds. Silcrete beds locally in this unit east of the map area. The relatively resistant orange, silty limestone beds form flat-topped caprocks that result in a characteristic topography. Upper part of member was removed by erosion in map area. Exposed thickness of member as much as about 400 ft.
- Tfle Lebo Member**—Gray, greenish-gray, smectitic shale and mudstone that contains lenses and interbeds of gray and yellow, very fine to medium-grained, poorly resistant sandstone. The Big Dirty coal bed and associated dark-gray or grayish-brown carbonaceous shales are at or near the base of the member. Thickness of member about 225 ft.
- Tft Tullock Member**—Light-yellow and light-brown, planar-bedded very fine to medium-grained sandstone and subordinate gray shale with thin beds of dark-brown to black carbonaceous shale and coal. Thickness of member about 150 ft.
- Khc Hell Creek Formation (Upper Cretaceous)**—Dominantly gray, grayish-brown, and dusky-yellow, fine- to medium-grained, locally cross-bedded, locally calcium carbonate-cemented sandstone with subordinant orangish-brown sandstone, smectitic, silty, greenish-brown or gray shale and mudstone, and a few thin beds of carbonaceous shale. Brown calcium carbonate-cemented concretions with round, irregular, or cylindrical shapes are typical in the fine-grained sandstone. Ferruginous clay pebbles are present locally. Thickness 175–275 ft.
- Kl Lance Formation (Upper Cretaceous)**—Light-orange or light-tan, fine- to coarse-grained, massive to cross-bedded sandstone in lenses and channels interbedded with

light-gray or greenish-yellow sandy shale. Calcium carbonate-cemented concretions occur locally in fine-grained sandstone. Thickness 0–100 ft.

- Kfh Fox Hills Formation (Upper Cretaceous)**—Light-brown or light-yellowish-gray, thin- to thick-bedded, micaceous, fine- to medium-grained sandstone with ferruginous concretions in the upper part and thin-bedded siltstone and silty shale in the lower part. Thickness 10–25 ft.
- Kb Bearpaw Shale (Upper Cretaceous)**—Dark-gray and dark-brownish-gray, bentonitic, fissile shale, and mudstone, with numerous thin bentonite beds and zones of calcareous and less common ferruginous concretions. Several intervals contain fossiliferous gray limestone concretions (Gill and others, 1972). Thickness 800–1000 ft.
- Kjr Judith River Formation (Upper Cretaceous)**—Upper: Very fossiliferous, light-brown, to light-gray, thin- to thick-bedded, fine- to medium-grained, cross-bedded sandstone that weathers tan, gray, and brown and contains lenses of resistant calcium carbonate-cemented sandstone. Lower: Interbedded gray to tan micaceous, noncalcareous, locally cross-bedded sandstone and olive-gray shale and silty shale. Local invertebrate fossil zones and trace fossils including *Ophiomorpha*. Local gray limestone concretions and brown ferruginous limestone concretions. Thin layer of black phosphate nodules and rounded bone fragments at base (Gill and others, 1972). Thickness 250–400 ft.
- Kcl Claggett Shale (Upper Cretaceous)**—Dark-gray, thinly bedded, poorly resistant and poorly exposed shale with calcareous concretions, numerous bentonite beds and some thin, lenticular, fine-grained sandstone beds. Shale bedding planes and fracture surfaces coated with jarosite and limonite. Numerous closely spaced dark-gray, brown-weathering, septarian limestone concretions, about 5 ft in diameter near top. Ardmore bentonite (Gill and others, 1972) near the base. Thickness 200–225 ft.
- Kga Gammon Shale (Upper Cretaceous)**—Light-gray noncalcareous shale, silty shale, and lesser siltstone and fine-grained sandstone lenses, with thin beds of calcareous concretions, ferruginous concretions, and bentonite scattered throughout the formation. Sandstone and shale more abundant near the top of the formation. Thickness 750 ft (Rice, 1976, Sheet 2, well log KB2813).
- Kn Niobrara Shale (Upper Cretaceous)**—Upper: Interbedded dominantly calcareous and subordinately noncalcareous, poorly resistant, fissile, dark-gray shale, that contains siltstone beds, thin bentonite beds, and gray or orangish-brown calcareous or ferruginous concretions. Lower: Noncalcareous, poorly resistant, fissile, dark-gray shale with a few thin bentonite beds. Thickness 250 ft (Rice, 1976, Sheet 2, well log KB2813).
- Kcag Carlile and Greenhorn Formations, undivided (Upper Cretaceous)**
Carlile—*Description modified from Wilde and Porter, 2000.* Light-bluish-gray-weathering, micaceous, very evenly laminated and bedded siltstone, interbedded

with very dark gray shale. Siltstones generally calcareous with shiny dark-red coating on bedding-plane surfaces from concentration of mica and iron oxide. Beds commonly burrowed.

Greenhorn Formation—*Description modified from Rice, 1984.* Dark-gray, calcareous shale that weathers very light gray. A thin, persistent bed of gray septarian limestone concretions occurs at the top of the formation, and a widespread bentonite bed about 1 m thick occurs one meter above its base.

Combined thickness of Carlile and Greenhorn Formations 420 ft (Rice, 1976, Sheet 2, well log KB2813).

Kbfm Belle Fourche Formation, Mosby Sandstone Member (Upper Cretaceous)—

Description modified from Rice, 1984. Light-gray to yellowish-gray, fine-grained, locally calcareous sandstone interbedded with noncalcareous shale. Sandstone sedimentary structures include hummocky crossbeds, parallel lamination, ripple cross-lamination including climbing-ripple cross-lamination, ripple marks, and shale intercalations. Thickness 50 ft (Rice, 1976, Sheet 2, well log KB2813).

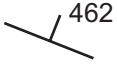
Kbfl Belle Fourche Formation, lower member (informal)(Upper Cretaceous)—

Description modified from Rice, 1984. Dark-gray, noncalcareous, silty to sandy shale that is partly bentonitic. Lower part of formation not exposed in map area. Exposed thickness about 75 ft. Total thickness 500 ft (Rice, 1976, Sheet 2, well log KB2813).

ANGELA 30'x 60' QUADRANGLE
MAP SYMBOLS



Contact—Dotted where concealed.



Strike and dip of bedding—Number indicates degree of dip.



Anticline—Showing trace of axial plane.



Syncline—Showing trace of axial plane.



Fault—Ball and bar on downthrown side.



Paleosol unit—Zone of thin orange limestone beds, light-colored beds, and paleosol beds in the basal part of the Tongue River Member.



Dike—Light- to dark-greenish-brown ultramafic lamprophyre (Doden, 1997)..

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