

# **GEOLOGIC MAP OF THE GREAT FALLS NORTH 30' x 60' QUADRANGLE, CENTRAL MONTANA**

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## Revision 9/02

Explanation: Quaternary units and Kootenai Formation

Correlation diagram: made compatible with explanation revisions

Map: Slight adjustments in position of a contact and labels. Mislabeled Quaternary units in southeast corner map corrected.

## Revision 3/03

Reference added

## Revision 9/12

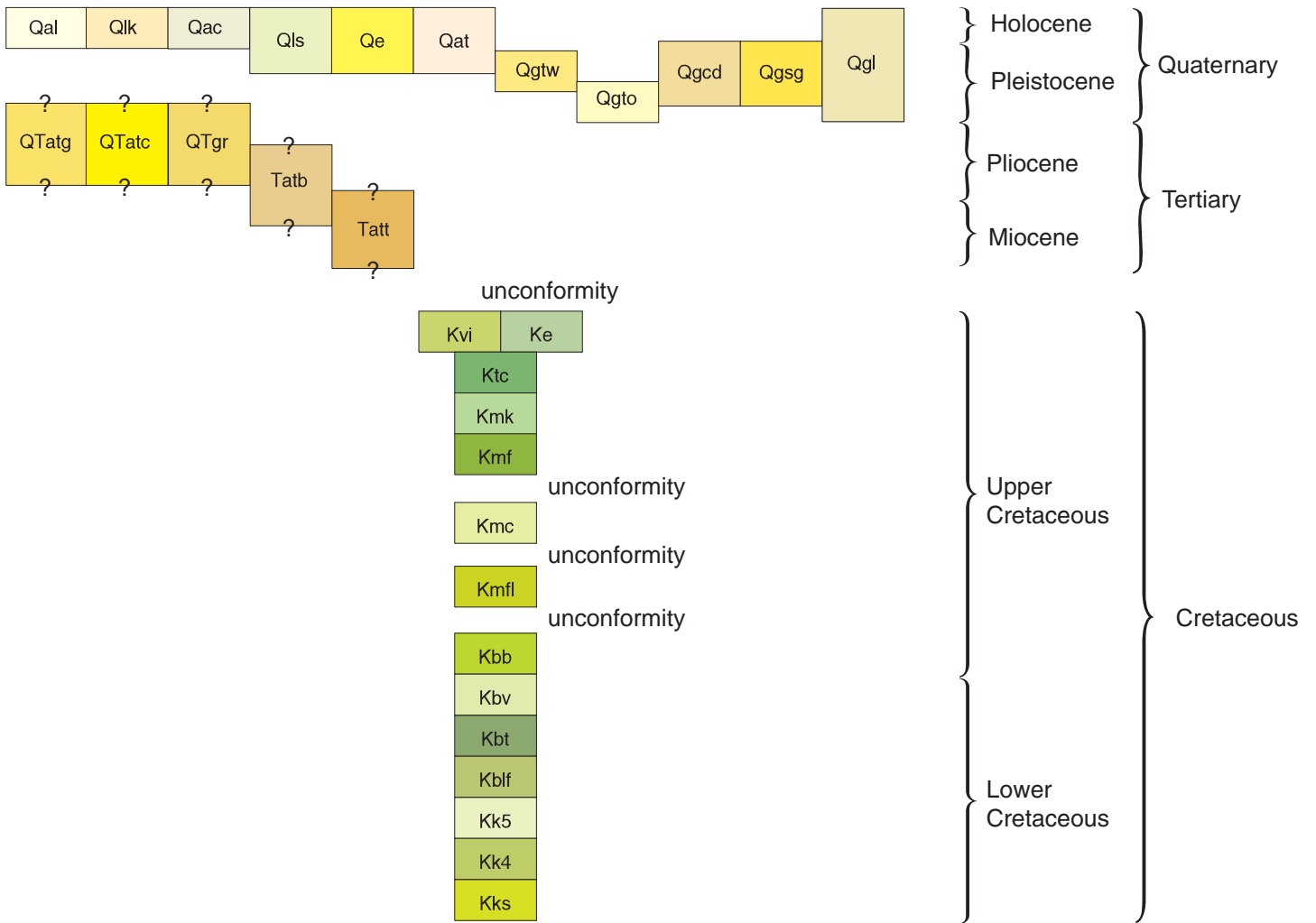
Edge-match with Choteau quadrangle

This report has had preliminary reviews for conformity with Montana Bureau of Mines and Geology's technical and editorial standards.

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# CORRELATION OF MAP UNITS

Great Falls North 30' x 60' Quadrangle



MAP SOURCES AND INDEX OF 7.5' QUADRANGLES  
GREAT FALLS NORTH 30' x 60' QUADRANGLE

112°	Collins NW	Collins	Dutton NW	Dutton NE	Timber Coulee North	Shannon Bridge	Dent Bridge	Dent Bridge NE	111° 48°
	1	1							
	TL Gap	Collins SE	Dutton	Dutton SE	Timber Coulee South	Sheep Coulee Spring	Antelope Flat	Antelope Lake	
	1	1							
	Cleiv	Green- field	Power	Vaughn NE	Benton Lake West	Benton Lake East	Flick Lake	Floweree	
			4	4	2	2	5	5	
	Fairfield	Fort Shaw	Sun River	Vaughn	Manches- ter	North- west Great Falls	North- east Great Falls	Morony Dam	
			4	4	2	2, 3	3, 5	5	

Numbers above correspond to references below.

1. Chalmers, A.L., 1968, scale 1:62,500
2. Lemke, R.W., 1977, scale 1:62,500.
3. Lemke, R.W., and Maughan E.K, 1977, scale 1:24,000.
4. Maughan, E.K., 1961, scale 1:62,500.
5. Maughan, E.K., and Lemke, R.W., 1991, scale 1:31,680.

DESCRIPTION OF MAP UNITS  
GREAT FALLS NORTH 30' x 60' QUADRANGLE

Note: Thicknesses are given in feet because original field maps were on 7.5' quadrangles with contour intervals in feet. To convert feet to meters (the contour interval unit on this map), multiply feet x 0.3048.

- Qal Flood plain and channel alluvium (Holocene)**—Yellowish-brown to gray gravel, sand, silt, and clay beneath flood plains and in valleys of active streams. Well to poorly stratified; moderately well sorted. Locally includes Mazama ash bed (Lemke, and others, 1975) dated as  $6845 \pm 50$  <sup>14</sup>C yr B.P. (Bacon, 1983). Generally less than 10 ft thick, but may be as thick as 40 ft (Lemke, 1977).
- Qlk Lake deposit (Holocene)**—Grayish-brown, and dark-brown clay, and silt, with lesser amounts of sand and organic material. Thickness not known.
- Qac Sheetwash alluvium, flood-plain and channel alluvium, and colluvium, undivided (Holocene and Pleistocene)**—Yellowish-brown to brownish-gray, poorly sorted to moderately well sorted, locally derived sediment on slopes. Clast size from clay and silt to gravel, depending on source. Locally includes Mazama ash bed (Lemke and others, 1975) dated as  $6845 \pm 50$  <sup>14</sup>C B.P. (Bacon, 1983). Thickness generally less than 20 ft.
- Qls Landslide deposit (Holocene and Pleistocene?)**—Mass-movement deposit of stable or unstable, unsorted mixtures of clay- to boulder-size clasts. Some deposits are rotated or slumped blocks of bedrock and surficial sediment, others are earthflow deposits or mudflow deposits. Thickness generally less than 50 ft.
- Qe Eolian deposit (Holocene and Pleistocene?)**—Pale yellowish-brown, wind-deposited fine-grained sand and silt as much as 10 ft thick in southeastern part of map. Older deposits (Pleistocene) as much as 3 ft thick on Greenfield Bench not mapped.
- Qat Alluvial terrace deposit (Holocene and Pleistocene)**—Missouri River area: Reddish-brown and brown, poorly sorted sand and gravel dominantly of subangular to slabby sandstone and subrounded quartzite, shale, granite, and argillite (Maughan and Lemke, 1991). Sun River, Muddy Creek, and Teton River areas: Oblate, well-rounded cobbles and pebbles of quartzite and argillite and scarce pebbles of limestone and dolomite (Maughan, 1961). Thickness less than 30 ft.
- Qgtw Glacial till, dominantly late Wisconsin (Pleistocene)**—Grayish-brown and gray, unstratified, unsorted, heterogeneous mixture of unconsolidated clay, silt, and sand with matrix-supported granules, pebbles, and lesser amounts of cobbles and boulders. Clasts dominantly granite, gneiss, schist, quartzite, argillite, sandstone, dolomite, and limestone. Older till locally exposed

beneath this sheet is included in this map unit. Unit also includes glacial lake and fluvial deposits. Thickness of map unit (including older till, glacial lake, and fluvial deposits) as much as about 250 ft.

- Qgto Older glacial till, dominantly Illinoian and pre-Illinoian, undivided (Pleistocene)**—Illinoian till: Grayish-brown and gray, unstratified, unsorted, heterogeneous mixture of compact, locally oxidized, jointed (Fullerton and Colton, 1986; Fullerton, Colton and others, in press) clay, silt, and sand with matrix-supported granules and pebbles, and some angular to rounded erratic cobbles and boulders. Clasts chiefly granite, gneiss, schist, quartzite, argillite, and sandstone. Pre-Illinoian till: Hard, overconsolidated, intensely stained, strongly jointed (Fullerton and Colton, 1986) clay, silt, and sand with matrix-supported granules and pebbles, and some erratic cobbles and boulders. Clasts chiefly granite, gneiss, schist, limestone, dolomite, quartzite, and argillite. Unmapped glacial lake deposits interbedded and intercalated with till are included in map unit. Till in area of Teton Ridge and Bole Bench is interpreted as Illinoian (Fullerton and Colton, 1986, Fig. 2; Fullerton, Colton, and others, in press). Till in Portage area was deposited during late Wisconsin, Illinoian, and pre-Illinoian glaciations. Unit includes thin late Wisconsin till at top, beneath glacial lake deposits, in the area north of the limit of late Wisconsin glaciation. Thickness of unit (including glacial lake and younger till deposits) is 200 ft in the Portage 15' quadrangle (southeastern corner of map) and 110 ft in western part of map.
- Qgcd Glacial meltwater channel deposit (Pleistocene)**—Clay, silt, sand, and pebbly gravel in abandoned meltwater channels, generally covered by younger alluvium and colluvium (Maughan and Lemke, 1991). Maximum thickness not known. May only be a veneer in many places.
- Qgsg Glacial sand and gravel deposit (Pleistocene)**—Kame and alluvial terrace deposit: Dominantly poorly to moderately well-sorted sand and gravel with some cobbles and boulders. Deposited at mouths of ice-marginal glacial meltwater channels. Thickness 5-25 ft. (Maughan and Lemke, 1961). Deltaic deposit: Dominantly moderately to well-sorted, fine to coarse gravel and sand. Deposited where glacial meltwater in channels entered Glacial Lake Great Falls. Thickness 1-49 ft (Maughan and Lemke, 1961).
- Qgl Glacial lake deposit and reworked glacial lake deposit (Holocene and Pleistocene)**—Grayish-brown, yellowish-brown, and pale orange silt interbedded with very fine-grained sand and clay. Lake deposits are horizontally bedded and may be laminated. Unit also contains grayish-orange, yellowish-brown, and pale orange silt and very fine-grained sand of younger alluvial and colluvial deposits reworked from glacial lake deposits, chiefly as sheetwash alluvium, and fine-grained deltaic deposits along Muddy Creek. Most of the unit represents deposits of Glacial Lake Great Falls; in the westernmost part of the map, unit represents deposits of Glacial Lake Choteau. Thickness of as much as 100 ft in Benton Lake area

(Maughan and Lemke, 1991) may represent superposed deposits of different ages including intercalated till.

**QTatg Alluvial terrace deposit of Greenfield Bench (Pleistocene and/or Pliocene)—**

Brown, clast-supported, moderately well sorted, poorly stratified conglomerate or gravel. Clasts dominantly oblate cobbles, but range from granules to small boulders of quartzite and argillite, cemented by or coated with secondary calcium carbonate. Underlies three distinct alluvial terraces of Greenfield Bench. Thickness 15-20 ft.

**QTatc Alluvial terrace deposit of Cordova area (Pleistocene and/or Pliocene)—**

Light-gray, clast-supported, moderately well sorted, poorly stratified conglomerate or gravel. Clasts about 70 percent quartzite and argillite, and about 30 percent light-gray limestone, cemented by or coated with secondary calcium carbonate. The high relative abundance of limestone clasts distinguishes this deposit from QTatg. Thickness 10-15 ft.

**QTgr Gravel deposit (Pleistocene and/or Pliocene)—**

Poorly to moderately well sorted sand and gravel, dominantly argillite and quartzite cobbles with rare granitic pebbles. Generally 5 to 15 ft thick, but locally as much as 39 ft thick in the Portage area (Maughan and Lemke, 1991), and 70 ft thick in the Teton River area.

**Tatb Alluvial terrace deposit of Bole Bench (Pliocene?)—**Light-brown, poorly stratified to non-stratified conglomerate or gravel with 95 percent quartzite and argillite, and about 5 percent limestone pebbles cemented by or coated with secondary calcium carbonate. Thickness 10-15 ft.

**Tatt Alluvial braid plain deposit of Teton Ridge (Pliocene and Miocene?)—**Brown, poorly stratified to non-stratified conglomerate or gravel deposit. Oblate, well-rounded, pebbles, and lesser amounts of cobbles, chiefly of yellowish-brown, light-gray, black, red, and pink quartzite; maroon and greenish-brown argillite; and relatively scarce limestone cemented by or coated with secondary calcium carbonate. Deposit discontinuous from the west edge of Teton Ridge to the east-southeast for about forty miles. Age estimate based on Pliocene and Miocene fossils in extension of deposit to west (Chalmers, 1968, p. 17). Thickness 30 ft.

**Ke Eagle Formation (Upper Cretaceous)—**Yellowish-brown, thick, relatively resistant sandstone underlain by yellowish-gray, thin-bedded platy sandstone, interbedded with medium-gray shale. Only lower part of formation exposed in map area. Exposed thickness 250 ft.

**Kvi Virgelle Formation (Upper Cretaceous)—**Yellowish-gray very fine- to medium-grained, thinly bedded, cross-bedded sandstone. Only lower part of formation exposed in map area. Exposed thickness 100 ft.

- Ktc Telegraph Creek Formation (Upper Cretaceous)**—Yellowish-gray very fine- to fine-grained calcareous sandstone interbedded with yellowish-gray- weathering silty mudstone and light- to dark-gray-weathering fissile shale. Some trace fossils or parting lamination on sandstone bedding surfaces. Thickness 150 ft.
- Kmr Marias River Formation (Upper Cretaceous)**—Position beneath surficial cover indicated by unit symbol in parentheses.
- Kmk Kevin Member (Upper Cretaceous)**—Upper: Dark-gray shale that contains many beds of yellowish-gray-weathering concretionary limestone and yellowish-gray-weathering, thin, shaly beds of very fine-grained sandstone interbedded with shale. Middle: Dark-gray shale with numerous beds of reddish-weathering ironstone concretions and concretionary limestone and dolostone. May include a bed of granule- and pebble- conglomerate with clasts of polished gray and black chert and olive-gray phosphatic siltstone. Lower: Dark-gray shale with numerous thin bentonite beds and gray calcareous limestone concretions. Thickness ranges from about 600 to 700 ft.
- Kmf Ferdig Member (Upper Cretaceous)**—Upper: Dark-gray hard shale that contains a few thin beds of gray limestone concretions and hackly gray concretionary limestone. Middle: Brownish-gray, very fine-grained wavy- or lenticular-bedded relatively resistant sandstone or siltstone with numerous trace fossils on bedding surfaces, underlain by bluish-gray shale littered with numerous flakes of iron-stained siltstone. Lower: Dark-bluish- gray shale that contains a few fine-grained sandstone stringers and rusty- brown to grayish-red and very dusky red ferruginous dolostone and limestone concretions that break into chips that litter the shale surfaces. Thickness 100-200 ft.
- Kmc Cone Member (Upper Cretaceous)**—Upper: Very dark gray calcareous shale with abundant tiny white specks interbedded with medium-gray, thin, silty, irregularly bedded crystalline limestone that weathers brownish-gray. Middle: Dark-gray argillaceous, shaly, platy limestone that weathers orangish-brown. Lower: Dark-gray calcareous or non-calcareous shale that contains a widespread yellowish-gray bentonite bed, underlain by dark-gray, calcareous shale that contains a widespread zone of dark-gray septarian limestone concretions that weather light bluish-gray. Basal brownish-orange limonitic siltstone may contain fish teeth and bones. Type section in map area on hill where Cone Triangulation Station is located (Sec. 13, T 22 N, R 1 W). Thickness 50-60 ft.
- Kmfl Floweree Member (Upper Cretaceous)**—Dark gray and dark bluish-gray, non-calcareous shale, and medium-gray silty shale with thin beds of fine- grained sandstone and siltstone with sparse light-yellowish-brown- weathering calcareous concretions and gray sandy calcareous septarian concretions. Thickness ranges from 10 to 35 ft.

- Kbl Blackleaf Formation (Upper and Lower Cretaceous)**—Position beneath surficial cover indicated by unit symbol in parentheses.
- Kbb Bootlegger Member (Upper Cretaceous)**—Upper: Medium gray, relatively well cemented thin beds of sandstone and siltstone interbedded with dark-gray silty shale and several yellowish-gray bentonite beds. Some sandstone beds have abundant fish scales on bedding planes. In many places a coarse-grained, well cemented sandstone, or pebble conglomerate with gray black-coated chert pebbles occurs at top and contains fish scales and brown fish bones in many places. Middle: Dominantly dark-gray shale with some thin beds of fine-grained, medium-gray sandstone and yellowish-gray bentonite. Basal: Two light-gray, fine- to medium-grained sandstone units separated by dark-gray, silty shale. Composite type section in map area in T 21 and 22 N, R 3E and R 4 E; named for Bootlegger Trail north of Great Falls. Thickness 150-330 ft (thickens eastward at the expense of the Vaughn Member).
- Kbv Vaughn Member (Upper and Lower Cretaceous)**—Light- to dark-gray, greenish-gray, olive-green, greenish-yellow, pink, or brown, very bentonitic claystone interbedded with thinner lenticular gray to green bentonitic siltstone and sandstone that may be tuffaceous or porcellanitic. Some beds contain abundant small crystals of orange-red clinoptilolite that imparts a pinkish color to the outcrops. Black carbonaceous shale beds that may contain coal are at the top of the member, and a pale-yellowish-green, medium-grained arkosic sandstone is at the base. Type section in map area in T 21 N, R 2 E near the town of Vaughn (Cobban and others 1976). Thickness 52–86 ft.
- Kbt Taft Hill Member (Lower Cretaceous)**—Upper: Light-olive-gray bentonitic siltstone, light-gray bentonitic shale, and light gray bentonite beds. Middle: Olive-green, fine- to medium-grained, glauconitic sandstone. Lower: Dominantly dark-gray poorly to moderately fissile shale with subordinate olive-gray siltstone and fine-grained sandstone, and a few thin bentonite beds. Type section in map area at Taft Hill (T 20 N, R 1 E and R 2 E) (Cobban and others, 1976). Thickness of member 242–249 ft.
- Kblf Flood Member (Lower Cretaceous)**—Upper: Dominantly yellowish-gray, fine-grained relatively resistant sandstone and siltstone with some granule conglomerate, coarse sandstone, dark-gray carbonaceous shale, and a zone of large, resistant, calcareous sandstone concretions. Middle: Medium-dark-gray shale. Lower: Olive-gray shale, siltstone, and sandstone with numerous trace fossils. Dominantly sandstone to the west, and shale to the east. Thickness of member about 140 ft.
- Kk Kootenai Formation (Lower Cretaceous)**—Position beneath surficial cover indicated by unit symbol in parentheses.



**KK<sub>5</sub>**      **Fifth member (informal)**—Red-weathering mudstone that contains lenses and beds of brownish-gray and greenish-gray, cross-bedded, micaceous sandstone, and light gray nodular limestone concretions. Lower part contains a dark-gray shale and lignite bed with a significant pre-angiosperm flora (LaPasha and Miller, 1984, 1984; Miller and LaPasha, 1984). Thickness of member about 230 ft.

**Kk<sub>4</sub>**      **Fourth member (informal)**—Upper: Brownish-gray limestone and interbedded shale. Limestone contains ostracods and brackish water dinoflagellates (Burden, 1984). Lower: Dusky red to pale reddish-brown-weathering, fine- to medium-grained, platy, thin- to medium-bedded sandstone interbedded with very dark reddish-brown mudstone that contains brackish water dinoflagellates (Burden, 1984). Large channels cut through this unit. Channel fill ranges from mudstone to interbedded sandstone and mudstone, to sandstone (Hopkins, 1985). Channel unit: An interval of very large channels is exposed in the Ryan and Morony Dam areas overlying or cutting through the Sunburst Sandstone and and locally resting on the Cutbank Sandstone (Hopkins, 1985; Schwartz, personal communication, 2002). Channel fill fine- to coarse-grained, biotitic, lithic sandstone with steep forsets and sparse associated coal stringers. Thickness of member as much as 200 ft.

**Kks**      **Sunburst Sandstone**—Light yellowish-brown, well sorted, well cemented, resistant quartz sandstone with interspersed limonite specks. Sedimentary structures include cross bedding, and ripple lamination. Invertebrate trace fossils locally abundant near or at the top. Thickness 50 ft.

**Second member (informal)**—Dark gray mudstone (exposed at Ryan Dam on the Missouri River) that grades downward into red mudstone. Too thin and poorly exposed to show at map scale. Walker (1973) interpreted the dark gray mudstone at Ryan Dam as Morrison Formation, but Schwartz (personal communication, 2002) determined that it is part of the Second member of the Kootenai Formation as mapped in adjacent quads (Vuke, 2000; Vuke and others, 2002).

**Cutbank Sandstone**—Moderately well sorted, coarse- to fine-grained sandstone with interspersed black, dark- and light-gray chert clasts. Incompletely exposed near Ryan and Morony Dams. Too thin to show at map scale.

MAP SYMBOLS  
GREAT FALLS NORTH 30'x 60' QUADRANGLE



**(Kmr)**

**Contact**—Dashed where approximately located, dotted where concealed. (Dotted contacts shown for formations, but not members.)

**Concealed bedrock unit**—Symbol shown for formations, but not members: (Ke) Eagle Formation, (Ktc) Telegraph Creek Formation, (Kmr) Marias River Formation, (Kbl) Blackleaf Formation, and (Kk) Kootenai Formation.



(red)

**Dike**—Shonkinite dike segments in southwestern part of map are northernmost exposed igneous rocks associated with Adel Mountain Volcanics to south.

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