GEOLOGIC MAP OF THE FORT BENTON 30' x 60' QUADRANGLE,

NORTH - CENTRAL MONTANA

by

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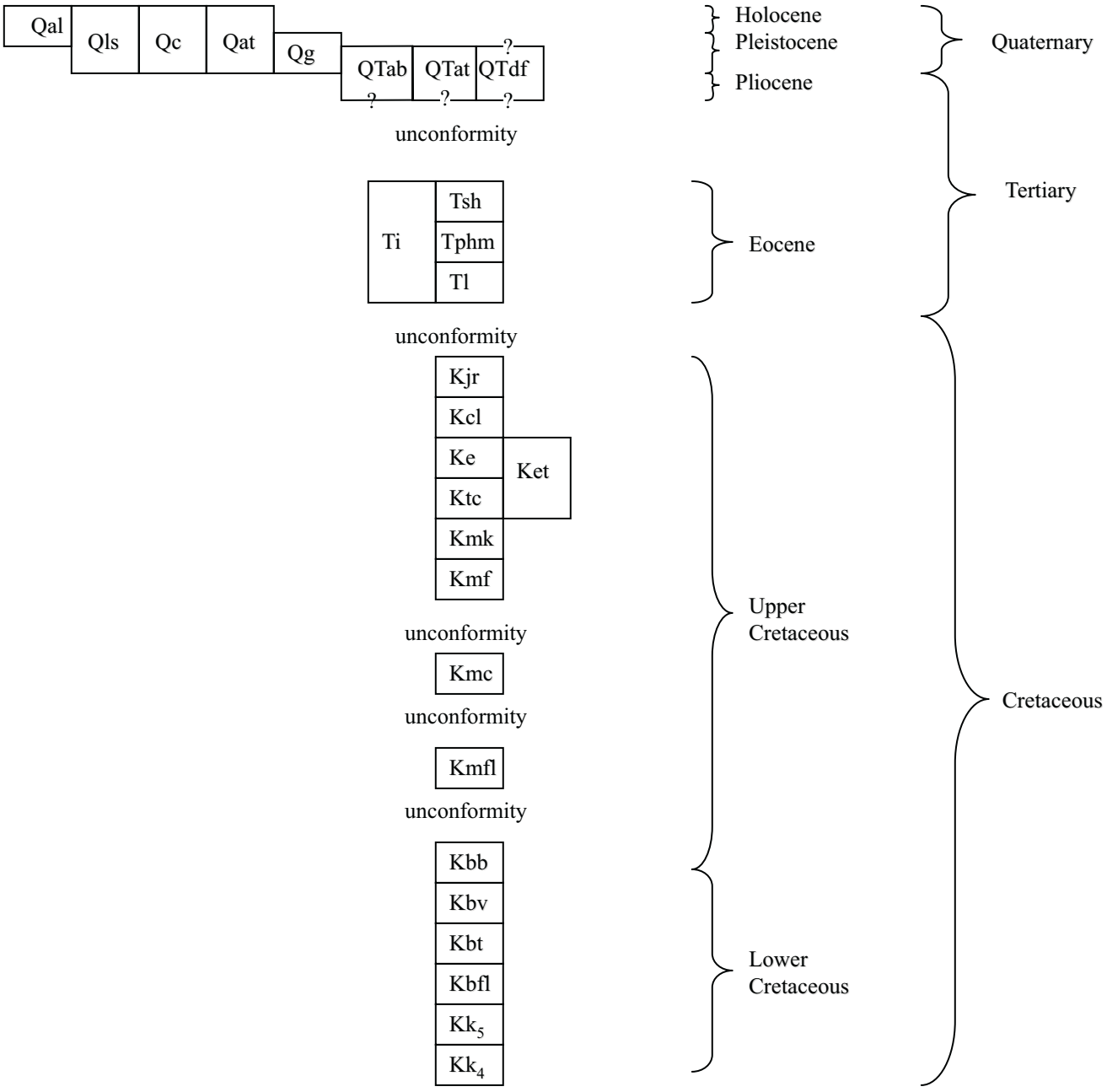
Introduction

Published maps shown in the responsibility diagram were incorporated into this map with generally only slight modification. Larsen's 1941 map of igneous rocks in the Highwood Mountains was modified and also adjusted to fit on a topographic base. Reconnaissance mapping of the unmapped part of the Fort Benton quadrangle was accomplished during the summer of 1994 (8 days) and during the summer and fall of 2001 (33 days). Most shonkinite dikes were mapped from aerial photos. Lamprophyre dikes were not recognized on aerial photos because of their relative ease of erosion as compared to shonkinite dikes, and thus are not shown on this map. Field observation suggests that lamprophyre dikes are rare in the Fort Benton 1:100,000 quadrangle.

Much of the quadrangle is covered by glacial till and interglacial deposits, with bedrock exposures confined to the coulees. The Missouri River provides excellent exposures of Cretaceous formations, particularly upstream from Fort Benton. Rapids approximately 6 miles southwest from Fort Benton that presumably limited upstream steamboat travel are caused by the resistant limestone beds in the Cone Member of the Marias River Formation.

Reviews by Karen Porter, Jeff Lonn, and Wayne Van Voast improved the map and text and are appreciated.

CORRELATION DIAGRAM
FORT BENTON 30' x 60' QUADRANGLE



DESCRIPTION OF MAP UNITS
FORT BENTON 30' x 60' QUADRANGLE

Qal **Alluvium of modern channels and flood plains (Holocene)**—Alluvial sand, silt, and clay deposits.

Qls **Landslide deposit (Holocene and Pleistocene)**—Mass-wasting deposit that consists of stable to unstable, unsorted mixtures of clay- to boulder-size material or rotated blocks of bedrock. Includes block-glide masses of of bedrock, slumped blocks of bedrock and surficial sediment, earthflow deposits, and mudflow deposits. Color and lithology reflect parent rock and transported surficial materials.

Qc **Colluvium (Holocene and Pleistocene)**—Locally derived slope-wash deposits of sand, silt, and clay. Commonly grades into Qal.

Qat **Alluvial terrace deposit (Holocene and Pleistocene)—**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). Thickness about 20 ft.

Qg **Glacial deposits, undivided (Pleistocene)**—Unit includes Wisconsin, Illinoian, and two superposed, lithologically similar units of pre-Illinoian till (D. Fulleron, USGS, written communication, 2002); intercalated glacial lake, outwash, and meltwater channel deposits; extensive pre-Illinoian interglacial alluvial deposits (exposed in the Floweree area; Missouri River valley from Carter area northeastward; Dry Fork Coulee, Fort Benton, and Loma areas); and thin pre-glacial alluvial deposits. (D. Fullerton, USGS, written communication, 2002; Fullerton and Colton, 1986).
Till: Pale yellowish-brown, light olive-gray, and brownish-gray, unstratified, unsorted, heterogeneous mixture of clay, silt, and sand with matrix-supported granules and pebbles, and some cobbles and boulders. Clasts composed of granite, gneiss, schist, quartzite, argillite, sandstone, and limestone. Wisconsin till is unconsolidated; Illinoian till is compact, oxidized, and jointed; pre-Illinoian till is extremely hard, overconsolidated, intensely stained, and strongly jointed (Fullerton and Colton, 1986).
Interglacial alluvial deposit: Brownish-gray gravel, sand, and silt. Clasts composed of igneous rocks of the Highwood Mountains and clasts of reworked pre-Illinoian till (R. Colton, USGS, field notes). Thickness as much as about 100 ft (D. Fullerton, written communication, 2002).
Glacial lake deposits: Grayish-brown to pale orange silt interbedded with layers of very fine-grained sand and clay. Deposits are horizontally bedded and laminated. Thickness not known.

QTab **Alluvium of braid plains (Pleistocene and Pliocene?)**— Light-brown to light-gray, crudely to well-stratified, and moderately to well-sorted sand and

gravel that is older than alluvium of modern stream channels (Qal). Occurs as remnants of braided-plain alluvial deposits and dissected deposits of coarse sediment derived from the Highwood Mountains as well as tan quartzite presumably derived from the Belt Supergroup metasedimentary rocks in the Rocky Mountains to the west. Thickness not known.

QTat Alluvium of alluvial terrace deposit (Pleistocene and Pliocene?)— Light-brown to light-gray , unconsolidated, crudely to well-stratified , and moderately to well-sorted sand and gravel in alluvial terraces adjacent to and higher than modern meandering streams. Thickness as much as 40 ft.

QTdf Debris flow deposit (Pleistocene and Pliocene?)—Brownish-gray, dissected, mass-wasting deposits of poorly sorted sediment. Contains abundant angular and subangular, locally derived, matrix-supported clasts ranging from pebbles to boulders; matrix dominately mud. Matrix locally eroded, leaving lag deposit of larger clasts. Thickness ranges from 10 to 50 ft.

Ti Intrusive igneous rocks of unknown composition (Eocene)

Tsh Shonkinite (Eocene)—Dark gray, alkalic igneous rock composed of more than 50 percent mafic minerals, primarily diopsidic augite with some biotite and olivine. Barium sanidine and lesser nepheline make up the felsic component.

Tphm Mafic phonolite (Eocene)—Dark-reddish-brown, dark-gray, and black extrusive rock and associated dikes and sills. Extrusive rocks are primarily flows, but map unit also includes some fragmental rocks. Pyroxene is the most abundant phenocryst, with less abundant pseudoleucite phenocrysts and relatively sparse olivine phenocrysts that typically are altered. Some vesicles are filled with zeolites.

Tl Latite (Eocene)—Pale-reddish-brown, brownish-gray to light-gray and medium gray flows, tuff, breccia, and agglomerate that contain abundant hornblende phenocysts, and less common biotite and small tabular feldspar phenocrysts.

Kjr Judith River Formation (Upper Cretaceous)—Only the lower 100 to 125 ft of the Judith River Formation are present in the extreme northeastern corner of the Fort Benton 1:100,000 quadrangle. In this area the Judith River Formation is mainly buff to gray sandstone (Lindvall, 1962).

Kcl Claggett Formation (Upper Cretaceous)—Chiefly brownish-gray marine shale ranging in thickness from 450 to 500 ft. Upper 150 ft sandy yellowish-gray shale; lower 100 ft brownish-gray shale with several beds of bentonite as much as 18 inches thick. Badland topography is formed on both steep and gentle slopes of the Claggett Formation; slumps and landslides are common on steep slopes (Lindvall, 1962).

Ke **Eagle Formation (Upper Cretaceous)**—Upper and middle members of the Eagle Formation together consist of 125 to 150 ft of alternating beds of gray to buff sandstone, shale, carbonaceous shale, and coal (Lindvall, 1962). Just above the Virgelle Member, beds of maroon, gray, and brown bentonitic shale form barren, rounded hills with scattered reddish-brown ironstone concretions, some with very irregular, hackly surfaces. The Virgelle Member is a hard, massive, white to buff, medium-grained, crossbedded sandstone that contains sandy limonitic concretions and is 80 to 100 ft thick. These sandstone beds form distinctive white, nearly vertical cliffs that are recognizable from miles away (Lindvall, 1962).

Ket **Eagle and Telegraph Creek Formations, undivided (Upper Cretaceous)**—Used in the northeastern corner of the map where the Telegraph Creek Formation was not mapped (Lindvall, 1962). Also used in cross section.

Ktc **Telegraph Creek Formation (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 lineation on sandstone bedding surfaces. Thickness as much as 150 ft., but highly variable.

Kmr **Marias River Formation (Upper Cretaceous)**—Used only in cross section and where bedrock is covered by glacial till.

Kmk **Kevin Member (Upper Cretaceous)**—Upper: Dark-gray shale that contains many beds of yellowish-gray-weathering concretionary limestone. Also yellowish-gray-weathering, thin, shaly beds of very fine-grained sandstone that are interbedded with shale. Middle: Dark-gray shale with numerous beds of reddish-weathering ironstone concretions and concretionary limestone and dolostone. May include one or two beds of granule- and pebble-conglomerate with clasts of polished gray and black chert and olive-gray phosphatic siltstone. Lower: Dark-gray shale banded with numerous thin bentonite beds and gray calcareous limestone concretions. Thickness of member ranges from about 600 to 700 ft.

Kmf **Ferdig Member (Upper Cretaceous)**—Upper: Dark-gray hard shale that contains sparse 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-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. Thickness 50-60 ft.

Kmfl **Floweree Member (Upper Cretaceous)**—Dark-gray and dark-bluish-gray, noncalcareous 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 and local layers of chert granules and small pebbles. Type section is in map area in Black Coulee, Sec. 17, T23N, R6E (Cobban and others, 1976). Thickness ranges from 20 to 65 ft.

Kbl **Blackleaf Formation (Upper and Lower Cretaceous)—**Used only in cross section and where bedrock is covered by glacial deposits.

Kbb **Bootlegger Member (Cretaceous)**—Upper: Medium-gray, relatively well-cemented, thinly bedded sandstone and siltstone 10 to 40 ft thick, separated by 50 to 100 ft of dark-gray silty shale that contains 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 that locally contains fish scales and brown fish bones. 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. Thickness 350 ft.

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 not contain coal are at the top of the member, and a pale-yellowish-green, medium-grained arkosic sandstone is at the base. Thickness 150 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. Thickness of member 245 ft.

Kblf **Flood Member (Lower Cretaceous)**—Black to dark-gray fissile shale that contains pods and lenses of bioturbated sandstone at its base. Lacks two prominent sandstone beds that are present west of the quadrangle. Thickness 100 ft.

Kk **Kootenai Formation (Lower Cretaceous)** - Used only in cross section and where bedrock is covered by glacial deposits.

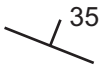
KK_5 **Fifth member (informal)—**Red-weathering mudstone that contains lenses and beds of brownish-gray and greenish-gray, cross bedded, micaceous sandstone, and light gray nodular limestone concretions. Lower part contains a dark-gray shale and lignite bed. Thickness about 200 ft.

Kk_4 **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. Base of member not exposed in map area. Exposed thickness 50 ft.

Map Symbols

Contact - Dotted where inferred beneath glacial deposits and alluvium. Note that contacts of members are not projected beneath surficial deposits; only formation contacts are projected.

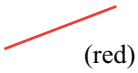
Fault, high-angle normal or reverse - Dotted where inferred beneath glacial deposits or alluvium. Ball and bar on downthrown side.



Strike and dip of bedding - Number indicates dip.

Horizontal bedding

Anticline - Showing trace of axial plane and direction of plunge. Plunge arrow omitted where plunge direction not known.



(red)

Dike - Generally nearly vertical and shonkinitic in composition.

(purple)

Sill or laccolith - Generally shonkinitic in composition. Shown as line where too thin to show as colored area on map. .

(Kmr)

Concealed bedrock unit - Symbol shown for formations, but not for members: (Kmr) Marias River Formation, (Kbl) Blackleaf Formation, (Kk) Kootenai Formation.

PUBLISHED GEOLOGIC MAPS AND INDEX OF 7.5' QUADRANGLES
FORT BENTON 30' x 60' QUADRANGLE

111º 110º 48º

Apple School	Carter NE	Fort Benton NW	Loma West	Loma East	Strana-han	Big Bend School 3	Pilot Rock 3
Carter	Tunis	Fort Benton	O'Hanlon Coulee	Rocky Lake	Strana-han SE	Eagle Buttes SW 3	Eagle Buttes 3
Lander Crossing 1	Rice Reservoir	Shonkin NW	Shonkin	Montague 2	Geraldine NE	Damnel Reservoir	Square Butte NE
Waltham 1	Highwood 1	Big Sag 2	Carter Mountain 2	Lepleys Creek 2	Geraldine 2	Square Butte 2	Square Butte SE

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3. Lindvall, R.M., 1962, Geology of the Eagle Buttes quadrangle, Choteau County, Montana: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-349, scale 1:62,500.

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