GEOLOGIC MAP OF THE

CHOTEAU 30′ x 60′ QUADRANGLE

NORTH CENTRAL MONTANA

Compiled and Mapped

By

Richard B. Berg

Montana Bureau of Mines and Geology
Open File Report 571
2008

This map has had preliminary reviews for conformity with technical and editorial standards of the Montana Bureau of Mines and Geology.

Research supported by the U.S. Geological Survey, National Cooperative Geologic Mapping Program under USGS award number 07HQA60080. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

INTRODUCTION

The Choteau 30' x 60' quadrangle includes a large area generally surrounding the city of Choteau that is situated approximately 80 km (50 miles) northwest of Great Falls (figure 1). The geology for the western half of this quadrangle was compiled mainly from Mudge and Earhart (1983) (figure 2). The area to the east is largely new mapping.

The western half of the Choteau 30' x 60' quadrangle is dominated by the Montana Disturbed Belt where sedimentary beds ranging in age from Precambrian through Cretaceous have been thrust eastward along many thrust faults. Twenty four of these faults are shown on the east-west cross section that accompanies this map. In contrast, the Cretaceous formations of the plains east of the Rocky Mountain Front generally show a regional southwest dip of only a few degrees. With the exception of the Virgelle Formation, Cretaceous formations are generally poorly exposed in this area. The Virgelle Formation has eroded to produce mesas that are formed by the erosion-resistant, brown-weathering titaniferous magnetite beds at the upper contact of this formation.

Gravel of Quaternary and probably Tertiary age veneers terraces in this area as well as along the Rocky Mountain Front to both the north and south. Glacial drift deposited by alpine glaciers that moved out onto the plains covers a large area in the southern half of this map. Melting of alpine glaciers produced large outwash deposits - most notably Burton Bench north of Choteau. Glacial drift deposited by the continental ice sheet overlies Cretaceous formations in the eastern part of this quadrangle. Fine-grained sediments that may have been deposited in a glacial lake occupy some of the areas of lower elevation north and east of Choteau. Evidence of reworking of Quaternary alluvium along the Teton River by the 1964 flood is prominent west of Choteau.

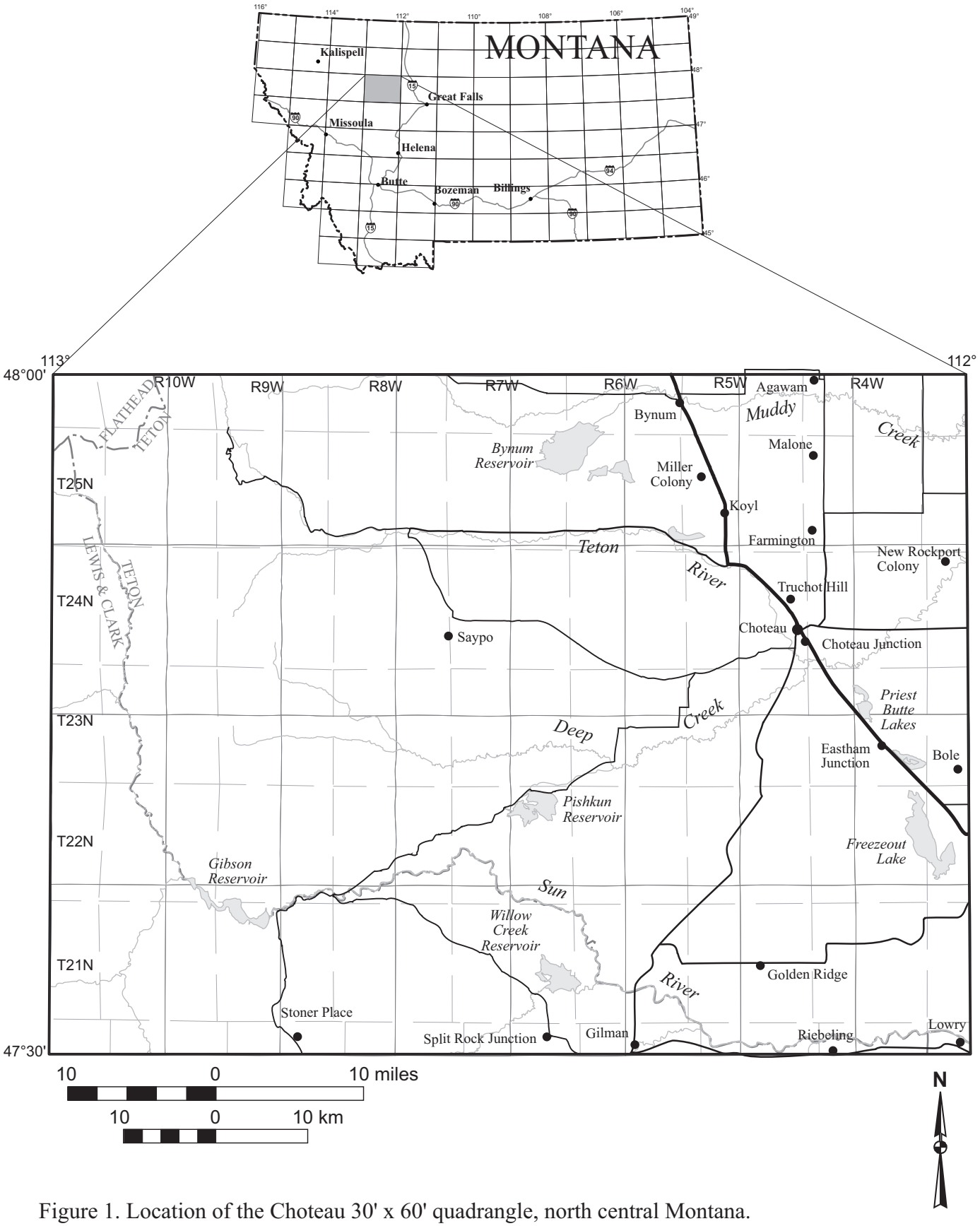


Figure 1. Location of the Choteau 30' x 60' quadrangle, north central Montana.

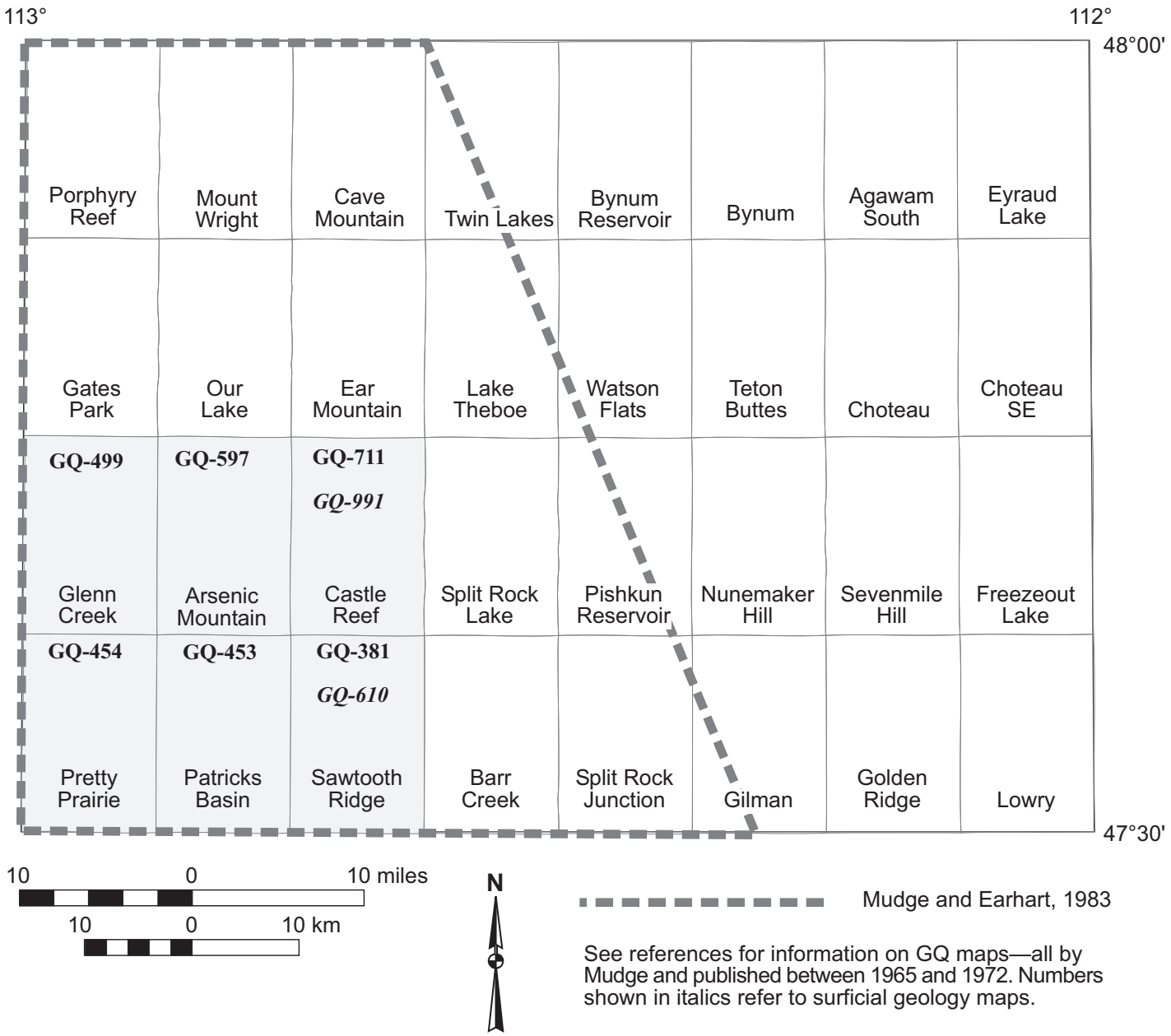
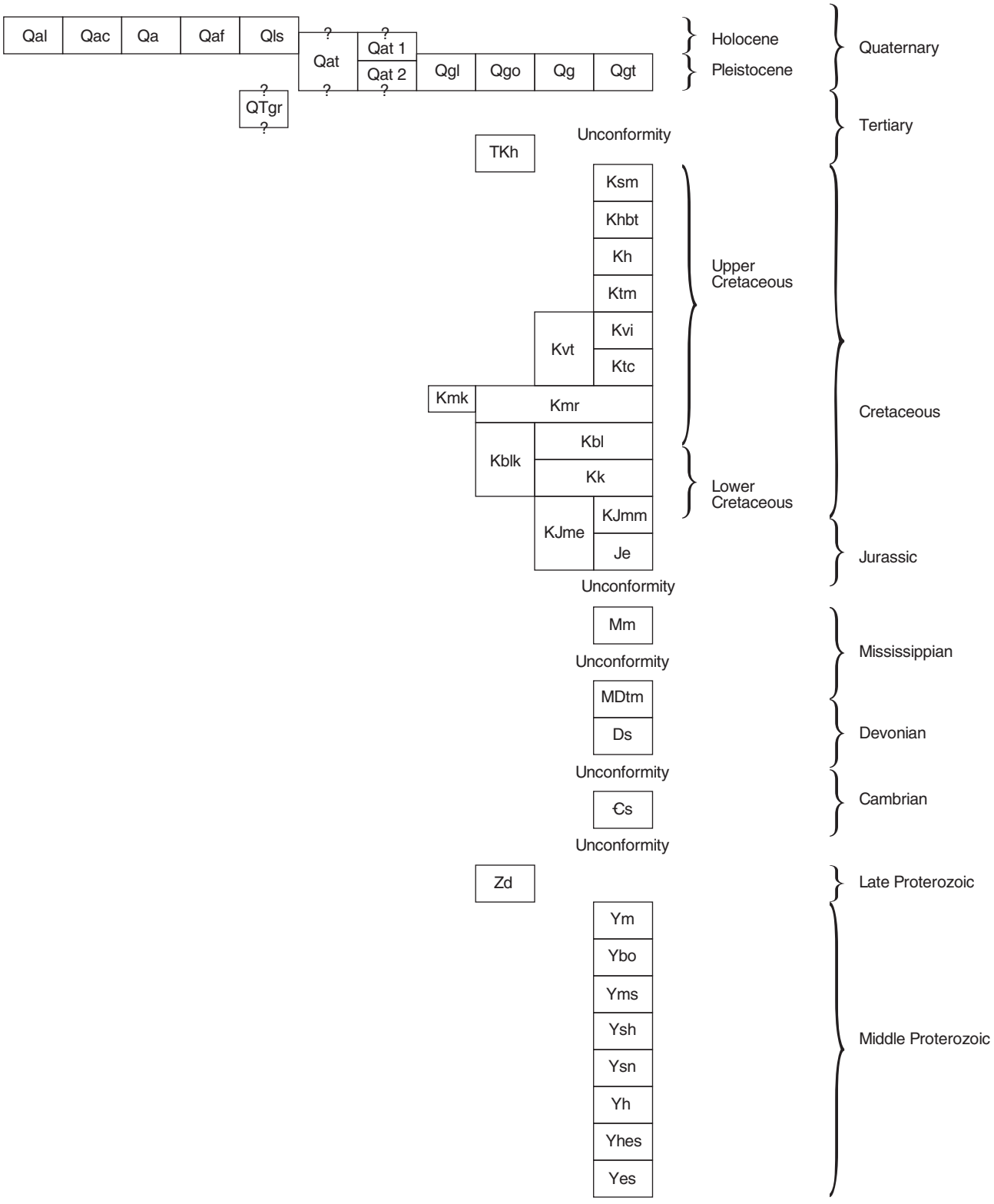


Figure 2. Geologic maps used in compilation of the Choteau 1:100,000 scale quadrangle.

Correlation Chart for Choteau 30' x 60' quadrangle



DESCRIPTIONS OF MAP UNITS
CHOTEAU 30´ x 60´ QUADRANGLE

Qal – Alluvium of modern channels and flood plains – Fluvial deposits of locally derived silt, sand, pebbles, and cobbles.

Qac – Alluvium and colluvium, undivided – Shown for the Pine Butte Swamp area south of the Teton River and along the north side of the Sun River where alluvium cannot be distinguished from colluvium, and areas near Choteau.

Qa – Rockfall avalanche deposit – Heterogeneous mixture of angular fragments of carbonate rocks that range from silt to boulders as much as 3 m (10 ft) across. As much as 60 m (300 ft) thick (Mudge, 1967b).

Qaf – Alluvial fan deposit – Developed on the Kevin Member of the Marias River Formation below exposures of the Virgelle and Telegraph Creek formations south of Bynum.

Qls – Landslide deposits – Developed on clayey beds in the Two Medicine Formation and the Kevin Member of the Marias River Formation. The recent landslide in the Kevin Member of the Marias River Formation along the Teton River south of the New Rockport Colony occurred on January 2, 1967.

Qat – Alluvium of alluvial terrace – Includes all alluvial terrace deposits that are not designated as Qat 1 or Qat 2 along the Teton River.

Qat 1 – Alluvium of youngest alluvial terrace – Terraces developed north of the Teton River that can best be seen along U.S. Highway 89, 6 km (3.5 miles) northwest of Choteau where the highway climbs above the present Teton River flood plain. The youngest terrace lies approximately 3 m (10 ft) above the present Teton River flood plain.

Qat 2 – Alluvium of second youngest alluvial terrace – This terrace lies approximately 3 to 4.5 m (10 to15 ft) above Qat 1.

Qgl – Glacial lake deposit – These sediments consist of brown to black silt and clay beds. Chalmers (1968) provides a detailed stratigraphic section of these lake deposits and discusses the probability that they were deposited in a glacial lake.

Qgo – Glacial outwash deposit – Forms extensive gravel plains at elevations lower than QTgr. Gravel consists almost exclusively of limestone clasts derived from exposures in the Rocky Mountain Front. The largest of these deposits is Burton Bench that was deposited when meltwater flowed through Ralston Gap south of Bynum. Farther north meltwater flowed along the valley now occupied by

Muddy Creek and formed the outwash deposit at the northern boundary of this map. Remnants of outwash deposits form prominent flat surfaces in the area between Willow Creek and Deep Creek.

Qg – Glacial deposit, undivided – Glacial drift in the mountainous western part of this area.

Qgt – Glacial till – Includes both glacial till near the Rocky Mountain Front along the Teton River that was deposited by mountain glaciers, and that in the northeastern part of the map area deposited by the continental ice sheet. The extent of the till deposited by the continental ice sheet is recognized not only by its hummocky topography, but also by the occurrence of pebbles, cobbles, and boulders of granitic igneous rocks and metamorphic rocks. Where glacial till overlies the Kevin Shale along the Teton River south of the New Rockport Colony, the upper meter of the Kevin Shale is deformed and mixed with glacial erratics.

QTgr – Gravel – Remnants of older gravel on terraces in the area west of Bynum Reservoir and around Choteau characterized by abundant gray limestone presumably eroded from the exposures of limestone of the Madison Group along the Rocky Mountain Front. An estimated 5 percent or less of the clasts are immature sandstone, perhaps derived from Cretaceous formations exposed to the west. Abundance of pink and white quartzite clasts increases to the south and they are inferred to have been derived from quartzite in the Belt Supergroup that is exposed in the Sun River Valley west of the Rocky Mountain Front. QTgr along the Sun River west of Augusta consists mainly of similar quartzite clasts. This gravel also contains rare clasts of a fine-grained porphyritic igneous rock, presumably trachyandesite, also derived from exposures in the Sun River Valley west of the Rocky Mountain Front.

TKh – Hypabyssal intrusive or flows – Trachyandesite (Paleocene or upper Cretaceous) – Sills, dark grayish brown, aphanitic groundmass of feldspar with phenocrysts of plagioclase, potassium feldspar, pyroxene, and quartz (Mudge, 1972a).

Ksm – St. Mary River Formation – Upper part light to dark red, purplish red, brown, gray, greenish gray mudstone and sandstone, with some beds of volcanic sandstone and conglomerate. A thin bed of white ash-fall tuff occurs near the middle part. Weathers to badland topography. Maximum thickness is 800 m (2,600 ft) (Mudge and others, 1982).

Khbt – Horsethief Formation and Bearpaw–Horsethief transition unit – The Horsethief Formation is mostly gray to gray brown , fine to medium-grained, crossbedded sandstone. The upper 6 to 12 m (20 to 40 ft) commonly contains lentils of titaniferous magnetite. The Bearpaw – Horsethief transition unit of Cobban (1955) beneath the Horsethief consists of dark gray to gray mudstone interbedded with light to medium gray mudstone and fine- to medium-grained sandstone (Mudge and others, 1982).

Kh – Horsethief Sandstone – Gray to gray brown, fine- to medium-grained marine sandstone, commonly crossbedded. Titaniferous magnetite sandstone locally present in the upper 5 to 11 m (18 to 36 ft) Maximum thickness of the formation is 45 m (150 ft) (Mudge and Earhart, 1983).

Ktm – Two Medicine Formation – Generally poorly exposed with some areas of badlands topography. Gray green and gray mudstone with minor sandstone in upper and middle parts with gray green, olive drab, and gray sandstone and mudstone in lower part. Upper and middle parts locally contain reddish gray, red brown, and purple interbeds of mudstone. Thickness is about 680 m (2,200 ft) (Mudge and others,1982). Also contains rare lenticular massive sandstone beds up to 1 m (3 ft) thick and some bentonite beds 0.3 to 1 m (1 to 3 ft) thick.

Kvi – Virgelle Formation – The Virgelle Formation forms mesas and buttes surrounded by spectacular sandstone cliffs where the erosion-resistant titaniferous magnetite sandstone bed at the top of this formation protects underlying more easily eroded sandstone. The Virgelle Formation is easily recognizable from a distance by the brown-weathering titaniferous magnetite beds above sandstone that appear white from a distance. Brown-weathering sandstone concretions are prominent just below the uppermost titaniferous magnetite sandstone beds. The sandstone is calcite cemented with prominent crossbeds and some ripple marks. Sandstone color on a weathered surface ranges from dark yellowish brown (10YR 4/2) to yellowish gray (5Y 7/2). Thickness is estimated to range between 29 and 35 m (95 and 115 ft). *Note: A detailed report on the mineralogy of the titaniferous beds in the Virgelle Formation is planned for publication in 2009 by the Montana Bureau of Mines and Geology.*

Kvt – Virgelle and Telegraph Creek Formations, undivided

Ktc – Telegraph Creek Formation – The Telegraph Creek Formation forms sparsely vegetated, relatively gentle slopes below the cliffs of the Virgelle Formation and above the grass-covered gentle topography of the Kevin Member of the Marias River Formation. Telegraph Creek Formation consists of interbedded sandstone and mudstone with the sandstone beds becoming more massive and abundant in the upper part. Black chert, feldspar, and quartz are the major detrital constituents of the calcite-cemented sandstone bed in which individual

calcite grains that surround many detrital grains range up to 2 mm across and are recognized by the reflection of sunlight from cleavage planes. Crossbedding and oscillation ripple marks occur in sandstone locally irregularly interlayered with siltstone that weathers to form an irregular hummocky surface. Color of the sandstone on a weathered surface is olive gray (5Y 4/1) and thickness of this formation is approximately 40 m (130 ft).

Kmr – Marias River Formation – Mainly dark gray marine mudstone that ranges from 370 to 400 m (1,200 to 1,300 ft) thick (Mudge and Earhart, 1983).

Kmk – Kevin Member of the Marias River Formation – The Kevin Member is the uppermost member of the Marias River Formation and is poorly exposed in the Choteau area. Mainly dark gray shale beds with lesser gray-weathering concretionary limestone, very fine grained sandstone, reddish-weathering ironstone concretions and numerous thin bentonite beds in the lower part. Color of weathered exposures of the Kevin Member is dark yellowish brown (10YR 4/2). Thickness ranges from 180 to 215 m (600 to 700 ft) (Vuke and others 2002).

Kbl – Blackleaf Formation – Gray marine mudstone and interbedded sandstone, thickness from 200 to 260 m (660 to 850 ft) (Mudge and Earhart, 1983).

Kblk – Blackleaf and Kootenai Formations, undivided

Kk – Kootenai Formation – Nonmarine, gray-green and maroon mudstone with numerous lenticular, poorly sorted, greenish gray sandstone beds, locally crossbedded with lenticular basal conglomerates. Thickness from 200 m (650 ft) to more than 300 m (1,000 ft) (Mudge, 1972; Mudge and Earhart, 1983).

KJme – Mount Pablo Formation, Morrison Formation and Ellis Group, undivided – The Mount Pablo Formation (formerly referred to as the western facies of the Morrison Formation; Mudge and others, 1982) consists of limestone, mudstone, sandstone, and conglomerate with a maximum thickness of 90 m (300 ft) The Morrison Formation is mainly grayish-green, tuffaceous siltstone with interbedded sandstone and limestone with a maximum thickness of 30 m (100 ft) (Mudge, 1972; Mudge and Earhart, 1983).

KJmm – Mount Pablo Formation and Morrison Formation, undivided

Je – Ellis Group, undivided – Composed of three formations in descending order: Swift, Rierdon, and Sawtooth. The Swift Formation consists of sandstone and shale. The upper part of the Rierdon Formation consists of calcareous gray-brown siltstone and claystones; the lower part is dark gray laminated shale and claystone. The Sawtooth Formation consists of two members in the northern part of the area. The upper member is siltstone and the lower member consists of dark gray shale with some siltstone, sandstone, and a few limestone beds.

Thickness of the Ellis Group is approximately 85 m (280 ft) in the Sun River (Mudge and Earhart, 1983).

Mm – Madison Group, undivided – Mainly limestone and dolomite ranging through calcitic dolomite and dolomitic limestone with chert and minor calcareous shale, thickness 275 to 550 m (900 to 1,800 ft) (Mudge, 1972).

MDtm – Three Forks Formation, Jefferson Dolomite, and Maywood Formation – The Three Forks Formation is generally an evaporite-solution breccia that consists of angular fragments mostly less than 1 m (3 ft) across of pale, yellowish-brown dolomite and dolomitic limestone and ranges in thickness from (50 to 200 ft); the Jefferson Formation consists mainly of limestone and dolomite and thickness ranges from 190 to 240 m (620 to 800 ft); the Maywood Formation consists of thinly bedded, somewhat fossiliferous, limestone and dolomitic limestone with greenish gray mudstone with thickness from 15 to 85 m (50 to 280 ft) (Mudge, 1972).

Ds – Upper and Middle Devonian sedimentary rocks, undivided – Consists in descending order of the Three Forks Formation, Jefferson Formation and Maywood Formation.

Ꞓs – Upper and Middle Cambrian sedimentary rocks, undivided – Includes, in descending order, Devils Glen Dolomite, Switchback Shale, and Steamboat Limestone. The Devils Glen Dolomite is thick bedded, light gray dolomite, about 100 m (330 ft) thick in the Sun River Canyon; the Switchback Shale is mostly non-calcareous, greenish gray, thinly laminated, clayey shale with thin interbeds of dolomite, limestone, sandstone, and conglomerate, about 80 m (270 ft) thick in this area; the Steamboat Limestone consists of alternating sequences of limestone and dolomite, and calcareous shales; 66 to 80 m (217 to 266 ft) thick (Mudge, 1972).

Zd – Diorite sills and dikes – Mostly diorite and quartz diorite, locally minor diorite-gabbro and monzonite (Mudge and others, 1982).

Ym – McNamara Formation – Upper part mostly thin beds of reddish brown quartzite and minor amounts of interbedded greenish gray siltite. Fine-grained micaceous quartzites contain crossbeds and ripple marks. Lower part mostly grayish green siltite with some thin beds of argillite and quartzite and locally some reddish gray siltite. Ripple marks, minute crossbeds, load casts, thin beds of glauconitic quartzite, and lenses of vuggy, reddish chalcedony common. Some vugs filled with barite. Locally thin beds of greenish gray and reddish brown quartzite. Thickens from 640 m (2,100 ft) southwest of this map area to 1650 m (5,400 ft) northwest of this map area. (Mudge and Earhart, 1983).

Ybo – Bonner Formation – Mostly pink, pale red, and pinkish gray, poorly sorted quartzite. Consists of fine- to medium-grained quartz with minor amounts of

feldspar, and some fragments of red argillite. Many beds cross-laminated; contains ripple marks and forms resistant hillside ledges and smooth rounded knobs. Thickness from 235 to 245 m (770 to 800 ft) (Mudge and Earhart, 1983).

Yms – Mount Shields Formation – Mostly bright reddish-brown, thinly laminated, micaceous siltite, argillite, and thin- to thick-bedded quartzite. Grayish green siltite unit with local, interbedded, dark gray fissile argillite widespread in upper part of formation. Fine - to medium - grained quartzite beds more common in the lower and middle parts of formation. Cross-lamination, ripple marks, mud-crack fillings, and mud chips common. Lower part contains light gray beds of stromatolitic and oolitic limestone in eastern outcrops. Thickness ranges from 520 to 775 m (1,700 to 2,500 ft) (Mudge and Earhart, 1983).

Ysh – Shepard Formation – Mostly greenish gray, locally maroon in lower part, very thinly bedded, micaceous, dolomitic siltite with some silty limestone and argillite, weathers grayish yellow. Thin glauconitic quartzite lentils widespread in upper part of the formation and also ripple marks, minute cross-lamination, load casts, and mud cracks. An edgewise conglomerate occurs near the base of the formation in eastern outcrops. Thickness ranges from 69 to 245 m (225 to 800 ft) in eastern outcrops (Mudge and Earhart, 1983).

Ysn – Snowslip Formation – Pale red to reddish brown and greenish gray beds of argillite, siltite, and some thin beds of very fine to fine-grained quartzite. Thin beds of stromatolitic and oolitic limestone, and local flat pebble conglomerates occur at various horizons. Crossbedding, minute laminae, ripple marks, and mud cracks common. Thickness ranges from 90 m (300 ft) to as much as 213 m (700 ft) in the area shown on this map (Mudge and Earhart, 1983).

Yhes – Helena, Empire, and Spokane Formations, undivided

Yh – Helena Formation – Mainly thin- to thick-bedded limestone, dolomite, and calcitic dolomite with some interbeds of dolomitic siltite and argillite. Gray to dark gray siltites mostly in upper and lower parts. Light to medium gray carbonate beds weather yellowish gray to grayish orange. Beds as much as 2 m (6 ft) thick in the upper part contain stromatolites, oolites, or edgewise conglomerates. Molar-tooth structures that differentially weather to form crenulated patterns are common. Thickness ranges from 174 to 2,000 m (570 to 6,500 ft) over a large area including exposures in this map area (Mudge and Earhart, 1983).

Yes – Empire, and Spokane Formations, undivided

Empire Formation – Greenish gray, olive green, pale green, and yellow green argillite and siltite; lesser grayish red, purplish red, and lavender argillite and

siltite, light green and white quartzite, and gray tan-weathered limestone; very thin bedded. Upper part: interbedded green and greenish gray, tan-weathered, calcareous argillite and siltite and gray to blue gray, tan-weathered argillaceous limestone. Thickness 243 to 300 meters (800 to 1000 ft) (Schmidt and Strong, 1972).

Spokane Formation – Grayish red argillite and siltite, weathered red and purplish red. Lesser light greenish gray argillite and siltite, gray and grayish red quartzite and gray brown weathered limestone; very thin bedded with ripple marks and mud-crack casts on bedding surfaces. Upper part: interbedded red, reddish purple and lavender argillite and siltite and greenish gray light green and yellow green argillite and siltite. Thickness 914 meters (3000 ft) (Schmidt and Strong, 1972).

Geologic Maps Used in Compilation

Mudge, M.R., 1965, Bedrock geologic map of the Sawtooth Ridge quadrangle, Teton, and Lewis and Clark Counties, Montana: U.S. Geological Survey Map GQ-381, scale 1:24,000.

Mudge, M.R., 1966a, Geologic map of the Patricks Basin quadrangle, Teton and Lewis and Clark Counties, Montana: U.S. Geological Survey Map GQ-453, scale 1:24,000.

Mudge, M.R., 1966b, Geologic map of the Pretty Prairie quadrangle, Lewis and Clark County, Montana: U.S. Geological Survey Map GQ-454, scale 1:24,000.

Mudge, M.R., 1966c, Geologic map of the Glenn Creek quadrangle, Lewis and Clark, and Teton Counties, Montana: U.S. Geological Survey Map GQ-499, scale 1:24,000.

Mudge, M.R., 1967a, Geologic map of the Arsenic Peak quadrangle, Teton, and Lewis and Clark Counties, Montana: U.S. Geological Survey Map GQ-597, scale 1:24,000.

Mudge, M.R., 1967b, Surficial geologic map of the Sawtooth Ridge quadrangle, Teton, and Lewis and Clark Counties, Montana: U.S. Geological Survey Map GQ-610, scale 1:24,000.

Mudge, M.R., 1968, Bedrock geologic map of the Castle Reef quadrangle, Teton, and Lewis and Clark Counties, Montana: U.S. Geological Survey Map GQ-711, scale 1:24,000.

Mudge, M.R., 1972, Surficial geologic map of the Castle Reef quadrangle, Teton, and Lewis and Clark Counties, Montana: U.S. Geological Survey Map GQ-991, scale 1:24,000.

Mudge, M.R., and Earhart, R.L., 1983, Bedrock geologic map of part of the northern Disturbed Belt, Lewis and Clark, Teton, Pondera, Glacier, Flathead, Cascade, and Powell Counties, Montana: U.S. Geological Survey Miscellaneous Investigations Series Map I-1375, map scale 1:125,000.

Other Sources of Information and Selected References Related to the Geology of this Area

Chalmers, A.L., 1968, Quaternary glacial geology and geomorphology of the Teton drainage area, Teton County, Montana: Bozeman, Montana State University, M.S. thesis, 83 p., scale 1:62,500.

Cobban, W.A., 1955, Cretaceous rocks of northwestern Montana, *in* Lewis, P.J., ed., Billings Geological Society Guidebook, 6th Annual Field Conference, p. 107–119.

Houston, R.S., and Murphy, J.F., 1977, Depositional environment of Upper Cretaceous black sandstones of the western Interior: U.S. Geological Survey Professional Paper 994–A, 29 p.

Gavin, W.M.B., 1986, A paleoenvironmental reconstruction of the Cretaceous Willow Creek anticline north central Montana: Bozeman, Montana State University, M.S. thesis, 148 p., map scale 1:5,000.

Lorenz, J.C., 1981, Sedimentary and tectonic history of the Two Medicine Formation, Late Cretaceous (Campanian), northwestern Montana: Princeton, N.J., Princeton University, Ph.D. dissertation, 225 p.

Mudge, M.R., 1972, Pre-Quaternary rocks in the Sun River Canyon area, northwestern Montana: U.S. Geological Survey Professional Paper 663–A, 142 p.

Mudge, M.R., 1972, Structural geology of the Sun River Canyon and adjacent areas, northwestern Montana: U.S. Geological Survey Professional Paper 663-B, 52 p.

Mudge, M.L., and Earhart, R.L., 1980, The Lewis thrust fault and related structures in the disturbed belt, northwestern Montana: U.S. Geological Survey Professional Paper 1174.

Mudge, M.R., Earhart, R.L., Whipple, J.W., and Harrison, J.E., 1982, Geologic and structure map of the Choteau 1^{o} x 2^{o} quadrangle, western Montana: U.S. Geological Survey Miscellaneous Investigations Series Map I-1375, scale 1:250,000.

Patton, T.W., 1991, Geology and hydrology of the Burton Bench and Teton Valley aquifers: Montana Bureau of Mines and Geology Open-File Report MBMG 238, 155 p., scale 1:100,000.

Stebinger, E., 1914, Titaniferous magnetite beds on the Blackfeet Indian Reservation, Montana: U.S. Geological Survey Bulletin 540-H, p. 329-337.

Vonhoff, J.A., 1969, Tertiary gravels and sands in the Canadian Great Plains: Saskatoon, University of Saskatchewan, Ph.D. dissertation, 278 p., map scale 1:250,000. (all in Canada)

Vuke, S.M., Colton, R.B., and Fullerton, D.S., 2002, Geologic map of the Great Falls North 30'x 60' quadrangle, central Montana: Montana Bureau of Mines and Geology Open-File Report MBMG 459, 14 p. text, map scale 1:100,000.

Wimmler, N.L., 1946, Exploration of Choteau titaniferous magnetite deposit, Teton County, Montana: U.S. Bureau of Mines Report of Investigations 3981, 12 p.