PRELIMINARY GEOLOGIC MAP OF THE BIG SNOWY MOUNTAINS

30' x 60' QUADRANGLE, CENTRAL MONTANA

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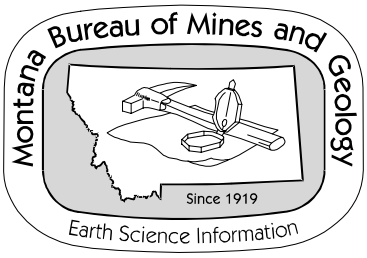

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Introduction

The geology of the Big Snowy Mountains 30' x 60' quadrangle is dominated by the asymmetric Big Snowy Mountains anticlinorium that includes the Little Snowy Mountains at its eastern end. The west area of the map includes the eastern end of the Little Belt Mountains, including the Garneill nose (Vine and Hail, 1950). Exposed strata along the crest of the Big Snowies include argillite and micritic limestone of the Proterozoic Newland Formation and overlying Cambrian, Ordovician, and Devonian carbonates, sandstones, and shales. In the Big Snowies the Lodgepole Formation, lowest part of the Mississippian Madison Group, forms the broad structural roll-over surface with overlying Mission Canyon Formation beds forming the innermost flanking outcrops. In the eastern Little Belts within the map area, the upper Madison Group Mission Canyon Formation forms the roll-over surface, and Lodgepole beds have limited exposure along the anticlinal crest. In the Big Snowies, beds dip gently on the north flank and very steeply on the south flank. In the eastern Little Belts within the map area, beds on the south flank have moderate to high dips, while beds on the north flank dip steeply or are overturned and rotate through a tight syncline before flattening out into broad domes like the Garneill nose. Upper Mississippian and Pennsylvanian strata are exposed on both limbs of both ranges, including the Tyler and Alaska Bench Formations of the Amsden Group, and the Kibby, Otter, and Heath Formations of the underlying Big Snowy Group. These two groups are associated with the mid-Paleozoic central Montana trough depositional setting. In the eastern Big Snowy Mountains and the Little Snowy Mountains, the Bear Gulch Limestone, a restricted marine tongue of Late Mississippian age, is mapped within the Tyler Formation.

The outer southern flanks of both the Big Snowy Mountains and Little Belt Mountains within the map area expose steeply dipping Jurassic and Lower Cretaceous beds. The pre-Jurassic regional erosion surface is well reflected in the wide variability of specific units in contact at this unconformity between underlying Mississippian and overlying Jurassic beds. Southward from the southern flanks of the two mountain ranges, gently dipping Upper Cretaceous strata extend into the Wheatland Syncline. Gravel deposits are extensive in the map area, and are addressed in the following discussion.

Gravel Deposits

Gravel deposits are extensive across the map area and have not been studied in any detail by us or other workers. They are considered predominantly Quaternary (?Pleistocene) in age, based on a tentative interpretation for the age of gravel deposits in the north-adjacent Lewistown quadrangle (Porter and Wilde, 1993, revised 1999). This conclusion, in turn, was based on data of Lindsey (1982) who found 100,000 B.P. travertine fragments in a high-elevation gravel on North Moccasin Mountain. However, some of the gravels could be Tertiary, and are designated on the map as QTab. The gravel deposits slope away from the steeply dipping south flank of the Big Snowies at about 60 feet/mile for more than 10 miles, and form a remarkably uniform surface. Clasts are dominated by carbonate lithologies of the Lower Paleozoic strata exposed in the mountains, particularly the Madison Group limestones.

These gravel deposits are here described as alluvium of dissected braid plains. These deposits appear to be coalesced alluvial braid plain sediments that accumulated on the flanks of mountain ranges during a time of higher rates of erosion/sedimentation and are now being

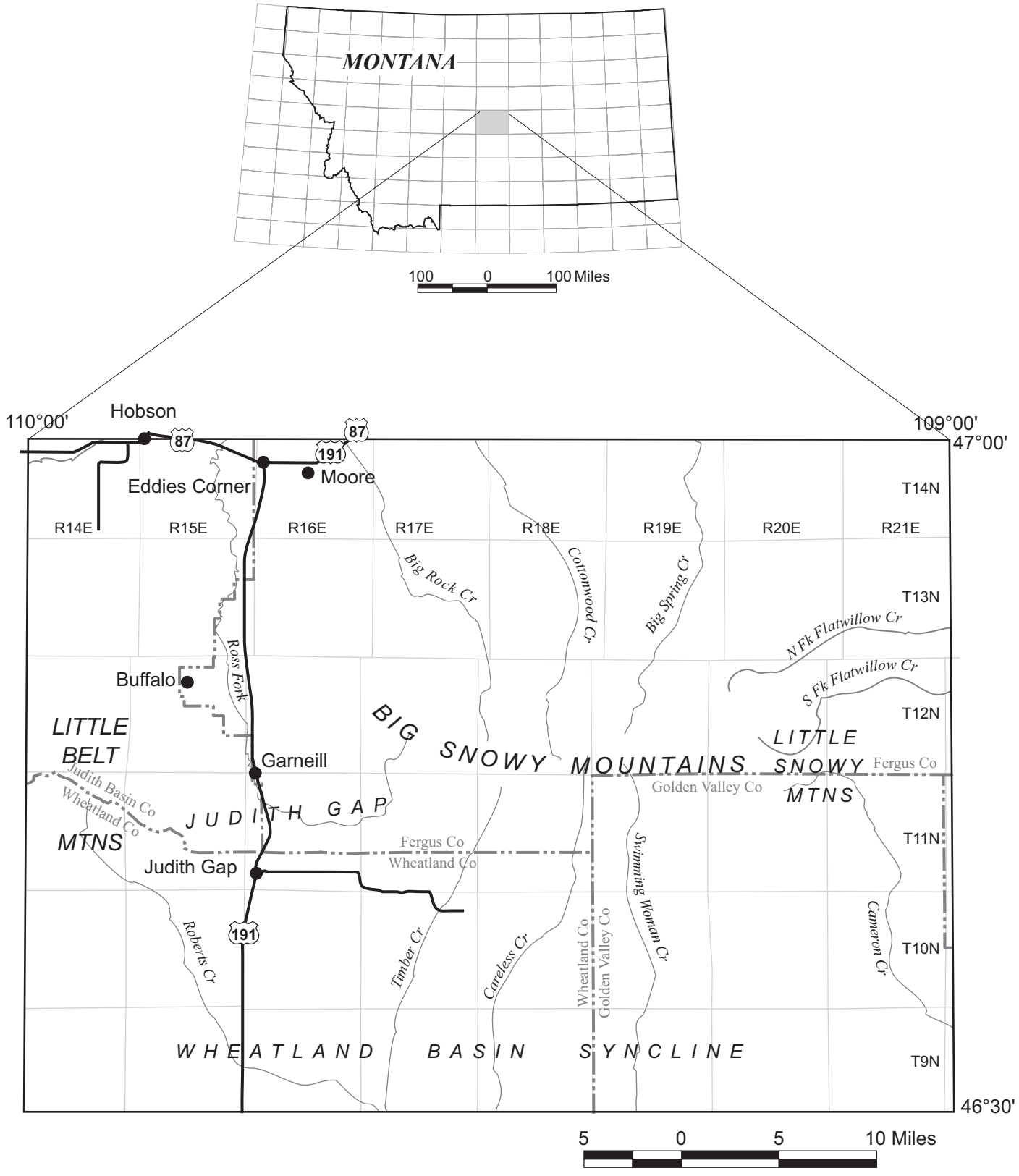


Figure 1. Location of Big Snowy Mountains 30'x60' quadrangle, central Montana.

dissected and redistributed by modern stream processes. They occur at several levels, and are locally cemented. These are not pediment gravels except where they locally form a thin veneer on an exposed pediment surface. They may include deposits now lying on terraces as modern streams incise and redistribute the earlier braid plain sediments. More sedimentologic, provenance, and stratigraphic study is needed for better understanding of these gravel deposits.

Sources of Previous Geologic Mapping in the Quadrangle

This report combines the previous mapping of Reeves (1930), Gardner (1950, 1959b), Vine and Hail (1950), Vine (1956), Lindsey (1980), and Derkey and others (1985) within the map area (Figure 2), and provides extensive new mapping of both the Pennsylvanian-Mississippian and Cretaceous sections. Mapped units have been integrated with recent geologic mapping completed by MBMG in adjacent 1:100,000-scale quadrangles (north-adjacent Lewistown quadrangle: Porter and Wilde, 1993, revised 1999; east-adjacent Musselshell quadrangle: Porter and Wilde, 1999; south-adjacent Harlowton quadrangle: Wilde and Porter, 2001).

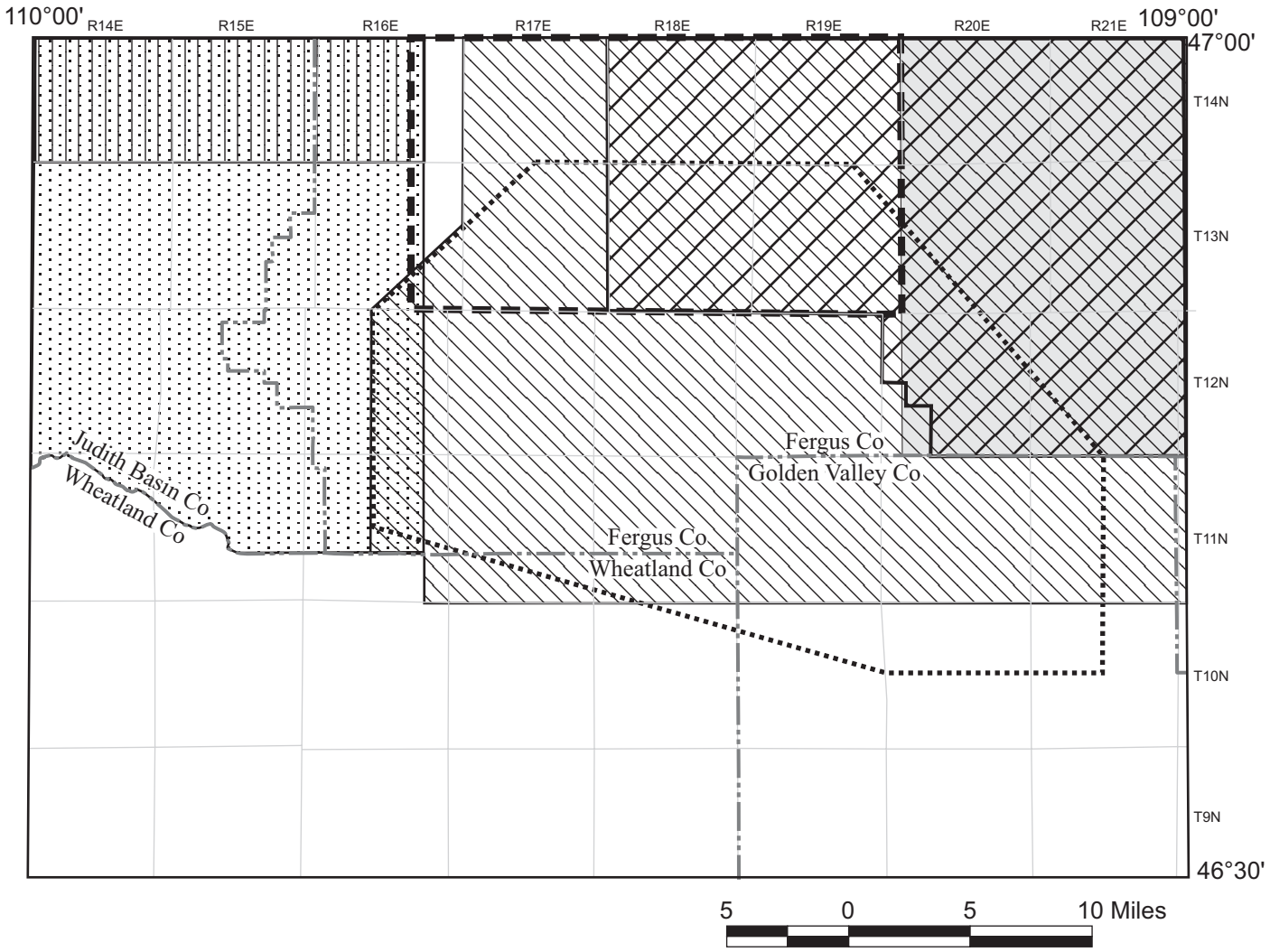


Figure 2. Index of source maps for Big Snowy Mountains 30'x60' quadrangle. For complete references see References section.

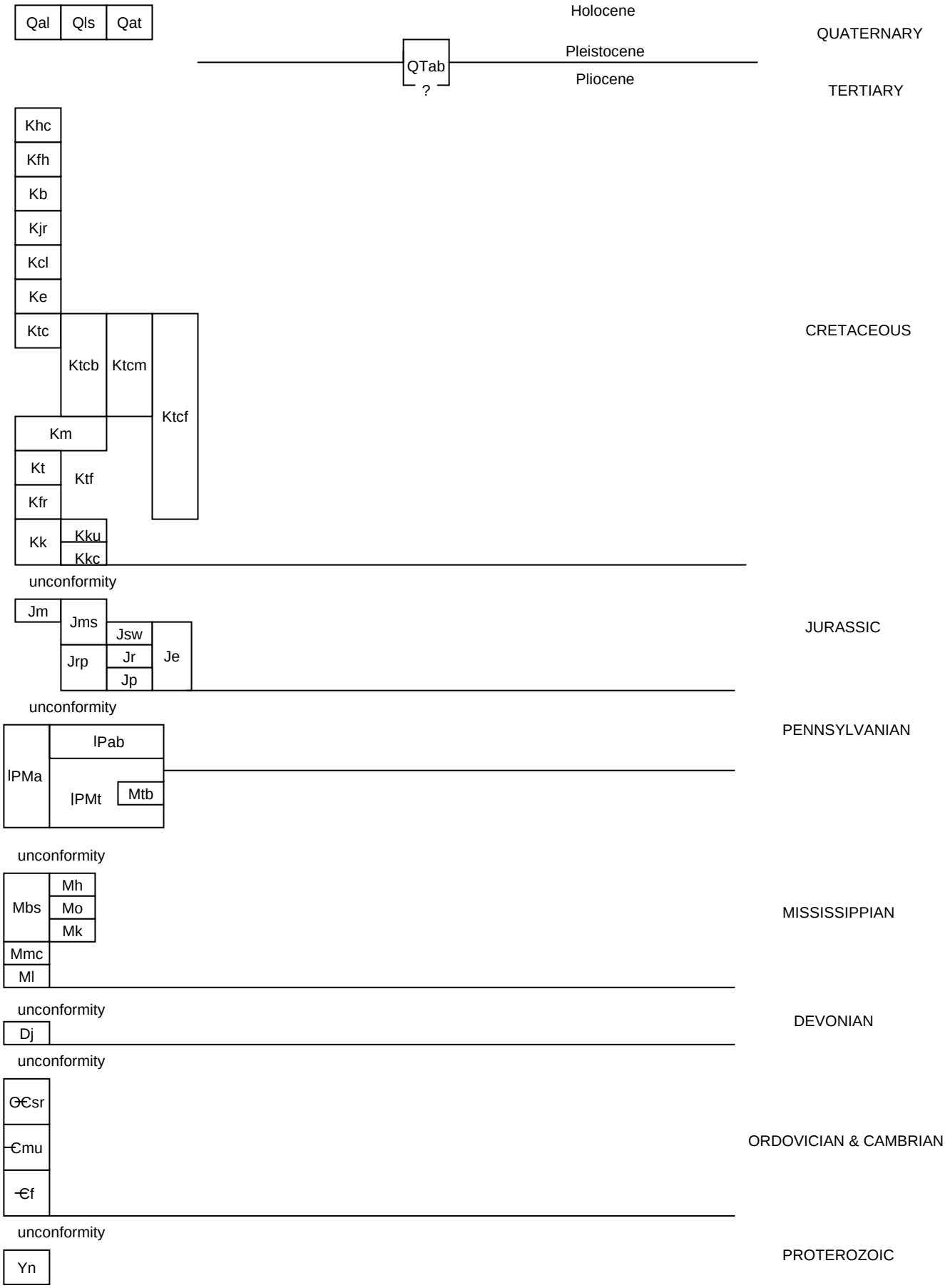


Figure 3. Correlation chart of map units for Big Snowy Mountains 30’ x 60’ quadrangle map.

DESCRIPTION OF MAP UNITS

NOTE: Unit thicknesses are given in feet because original field mapping was done on 7.5' topographic quadrangle maps with contour intervals in feet. To convert feet to meters, the contour-interval unit on this map base, multiply feet x 0.3048.

Quaternary

Qal ALLUVIUM OF MODERN STREAM CHANNELS AND FLOOD PLAINS (HOLOCENE) – Gravel, sand, silt, and clay. Clast composition closely reflects Paleozoic sedimentary rock formations exposed on flanks and crest of Big Snowy Mountains; limestone dominates the gravel fraction. Unit locally includes deposits of some low, young terraces. Thickness not measured.

Qls LANDSLIDE DEPOSITS (HOLOCENE) – Large, rotated slide blocks and incoherent mass wasting deposits extensively developed in lower Tyler and Heath Formations on flanks of Big Snowy Mountains and in Cambrian shales along crest of Big Snowy Mountains. Thickness not measured.

Qat ALLUVIAL TERRACE DEPOSITS, UNDIVIDED (HOLOCENE) – Composed of same sediment types as modern stream deposits. Mapped primarily along shallow, broad streams flowing across south flank of Big Snowy Mountains.

Quaternary and Tertiary

QTab ALLUVIUM OF BRAID PLAIN DEPOSITS (QUATERNARY AND ?TERTIARY) – Unconsolidated to locally cemented cobbles in pebble, sand, and clay matrix. Cobbles predominantly light-gray, rounded clasts of Madison Group limestone, commonly coated with powdery white calcium carbonate. Cemented intervals, thin to as much as three feet thick, have iron-rich calcareous matrix commonly weathering reddish to yellow-orange or rusty brown. Unit includes several levels of gravel apparently deposited in broad, coalescing alluvial fans formed on slopes of Big Snowy Mountains and now being incised by modern streams. Unit equivalent to Qab unit mapped on north-adjacent Lewistown quadrangle (Porter and Wilde, 1993; revised 1999) and east-adjacent Musselshell quadrangle (Porter and Wilde, 1999), and to Pediment Deposits (Qp) of Lindsey (1980) mapped south of Big Snowy Mountains. Age of unit is considered to be mostly early Quaternary based on conclusions of Lindsey (1982) for similar gravels flanking the Moccasin Mountains. However, the unit may be partly Tertiary in age. Thickness 6-60 feet (Lindsey, 1980).

Cretaceous

Khc HELL CREEK FORMATION (UPPER CRETACEOUS) – Brown-weathering, calcareous, fine- and medium-grained, cross-stratified sandstone. Interbedded with brown siltstone, and medium- and dark-gray, bentonitic claystones and fissile, dark shale. Exposed

throughout the Wheatland Basin across the distal south flank of the Big Snowy Mountains and southeastern flank of Little Snowy Mountains. Estimated thickness of 900 feet (Lindsey, 1980).

Kfh FOX HILLS FORMATION (UPPER CRETACEOUS) – Poorly resistant, yellowish-white, commonly iron-stained sandstone poorly exposed in southern part of map area. Formation is transitional above Bearpaw Shale and frequently incised by sandstone channels of the overlying Hell Creek Formation. Estimated thickness 124 feet (Lindsey, 1980).

Kb BEARPAW SHALE (UPPER CRETACEOUS) – Medium-gray weathering, fissile, poorly resistant shale with numerous thin, white or yellowish-white bentonite layers common throughout. Large, ovoid, reddish-purple weathering concretions common in lower part; gray weathering, calcareous concretions more common in upper part; both concretion types commonly fossiliferous. Formation generally poorly exposed. Estimated thickness 720 feet (Lindsey, 1980).

Kjr JUDITH RIVER FORMATION (UPPER CRETACEOUS) – Composed of three distinct intervals, although exposures generally poor. Lower unit: yellowish-gray weathering, very fine- or fine-grained, quartzose, massive to poorly bedded, locally cross-stratified, burrowed to bioturbated sandstone. Uppermost beds ferruginous, forming resistant ledges or caps that dominate exposures. Middle unit: green-gray weathering sandstones, siltstones, mudstones, and brown carbonaceous shale; numerous conspicuous rusty-brown to purple-black weathering ironstone concretions; interval very poorly exposed. Upper unit: basal yellow-gray weathering, fine-grained, quartzose sandstone overlain by interbedded sandstone, mudstone, and carbonaceous shale with common small ferruginous concretions. Formation present across distal south flank of Big Snowy Mountains and across wide area of Judith Gap between Big Snowies and Little Belt Mountains. Thickness about 720 feet (Lindsey, 1980).

Kcl CLAGGETT SHALE (UPPER CRETACEOUS) -- Dark-gray, fissile shale commonly weathering to brown; commonly sandy in middle and upper part; thin, laterally persistent sandstone beds observed locally, indicating a transitional contact with overlying Judith River Formation. Characteristic orange-brown weathering, smooth, ovoid, calcareous concretions in upper middle part are as much as 3 feet in diameter, commonly highly fractured with yellow calcite vein filling, and weather into mounds of small orange-brown fragments. Numerous very light gray bentonite layers, 1 to 5 inches thick in lower part of formation are equivalent to the Ardmore Bentonite (Gill and Cobban, 1973). Formation is commonly bare to sparsely vegetated. Thickness about 360 feet (Lindsey, 1980).

Ke EAGLE SANDSTONE (UPPER CRETACEOUS) – Yellow-gray weathering, salt-and-pepper, fine- and medium-grained sandstone; commonly soft and poorly resistant but locally cemented and forms low ridges and isolated hoodoos as seen at Castle Rocks on southwest flank of Big Snowy Mountains near center of map area. Iron-rich caps and nodules, and iron-staining common. Beds cross-stratified to planar-bedded. Where exposures are good, two sand bodies were observed, separated by barely exposed finer-grained, swale-forming beds of nonburrowed mudstones and shales, and a few lignite laminae. Lower sandstone contains *Ophiomorpha* and other marine trace fossils.

Thickness about 240 feet (Lindsey, 1980).

Ktc TELEGRAPH CREEK FORMATION (UPPER CRETACEOUS) – Medium-gray weathering, noncalcareous, poorly exposed shale; becomes silty and sandy upward in transition to overlying Eagle Formation; upper contact generally placed at base of lowest prominent Eagle sandstone. Lower beds, where exposed, contain dark-red ironstone concretions. Lower contact with Niobrara never exposed. Unit mapped separately only in southwest corner of map. Thickness not measured but about 150 feet regionally.

Ktcb TELEGRAPH CREEK FORMATION THROUGH BELLE FOURCHE FORMATION, UNDIVIDED (UPPER CRETACEOUS) – Includes approximately 1,200-1,300 feet of poorly exposed to unexposed marine shale and minor sandstone; occasional exposures of characteristic lithologies of the contained formations. See Porter and Wilde (1993a; revised 1999) for full description of these formations. Unit carried throughout map area because of lack of exposures above Mowry Formation to base of Eagle Sandstone.

Ktcm TELEGRAPH CREEK FORMATION THROUGH MARIAS RIVER FORMATION, UNDIVIDED (UPPER CRETACEOUS) – Includes same stratigraphic interval as unit Ktcb. Unit employed in northwest map area to establish continuity with north-adjacent Lewistown quadrangle where the name Marias River Formation is applied to the interval below the Telegraph Creek and above the Mowry west of the Judith Mountains.

Ktcf TELEGRAPH CREEK THROUGH FALL RIVER FORMATIONS (UPPER AND LOWER CRETACEOUS) – Includes approximately 2,000 feet of poorly exposed to unexposed, dominantly marine shale and minor sandstone; occasional outcrops of characteristic lithologies of the contained formations. See Porter and Wilde (1993a; revised 1999) for full description of these formations. Unit carried along southern flank of Big Snowy Mountains where beds, including Mowry Formation, not mappable between Kootenai Formation and base of Eagle Sandstone.

Km MOWRY FORMATION (UPPER CRETACEOUS) – Regionally contains two distinct lithologies: an upper, resistant, gray weathering, cherty and chert-pebble-bearing, medium- and coarse-grained sandstone, and a lower, laminated, dark-gray siltstone and shale interval with numerous thin, white bentonite beds. Only the resistant sandstone is exposed in the map area, forming a low persistent ridge or ledge that often provides the only certain stratigraphic horizon within the approximately 1,900-foot section above the Fall-River/Kootenai beds and below the Eagle Sandstone. Exposed thickness about 50 feet along south flank of Big Snowy Mountains; about 100 feet north of Little Belt Mountains.

Kt THERMOPOLIS SHALE (LOWER CRETACEOUS) -- Composed of dark-gray to black weathering shale, tan-gray weathering sandy shale, olive-tan weathering laminated very fine-grained sandstone, and dark-gray-brown weathering, quartzose, medium-grained sandstone; numerous thin, white bentonite beds throughout. Generally poorly resistant and poorly exposed, occupying grass-covered interval between overlying Mowry Shale and underlying Fall River Sandstone; sandstone-bearing middle part may form low, subparallel scarps or ledges; one or more of these commonly contains chert pebbles. Total formation thickness about 650 feet (Porter and Wilde, 1999).

Ktf THERMOPOLIS FORMATION AND FALL RIVER SANDSTONE, UNDIVIDED (LOWER CRETACEOUS). Approximately 700-750 feet thick.

Kfr FALL RIVER SANDSTONE (LOWER CRETACEOUS) -- Tan-brown weathering, light-gray-tan or buff-tan, predominantly fine-grained quartzose sandstone, commonly brown-speckled on fresh surfaces. Equivalent to First Cat Creek Sandstone of subsurface. Cross-stratified and ripple-laminated in thin to thick beds with numerous very thin, dark shale partings. Interbedded dark, clayey to sandy shale that is laminated to burrowed to bioturbated. Invertebrate tracks and trails on bedding plane surfaces. Excellent exposures occur in sec. 17, T12N, R14E. Lowermost part commonly laminated mudstone, commonly burrowed and often weathering shaly; may be a few inches to several feet or more below good sandstone. Lindsey (1980) reports a formation thickness of about 18 feet on south flank of Big Snowy Mountains, but this section is probably tectonically thinned; regional thickness is around 70-90 feet.

Kk KOOTENAI FORMATION, UNDIVIDED (LOWER CRETACEOUS) -- Fine- to coarse-grained, chert-bearing, salt-and-pepper, feldspathic, commonly cross-stratified sandstone, and dark- to medium-red, gray-green and minor buff-colored silty, blocky weathering shale and mudstone. Basal sandstone, Third Cat Creek Sandstone of subsurface, as much as 100 feet thick. Less resistant overlying mudstones locally form patchy red soil above the basal sandstone. Approximate formation thickness 330 feet (Lindsey, 1980).

Kku UPPER MEMBER, INFORMAL, OF KOOTENAI FORMATION – Interval contains all red beds and sandstones above the basal Cutbank Sandstone Member. Red beds are thin, predominantly brick-red to maroon with some medium- and light-green intervals. A middle sandstone horizon (Second Cat Creek Sandstone of subsurface) is present almost everywhere, recording a widespread channeling event within the low-energy red-bed deposits. An upper sandstone horizon occurs locally, approximately defining the top of the formation. Sandstones typically have a salt-and-pepper appearance, are quartzose, chert-bearing, and cross-stratified. Upper contact of Kootenai is sharp beneath overlying dark, locally burrowed mudstones of marine origin in basal Fall River Sandstone. Thickness ranges from 200 to 300 feet, generally thicker where underlying basal Cutbank Sandstone member is thinner.

Kkc CUTBANK SANDSTONE MEMBER OF KOOTENAI FORMATION – Basal, most resistant, and best exposed member of Kootenai; commonly forms cliff faces. Cross-bedded, moderately well sorted, quartzose sandstone. Lowermost part contains predominantly coarse-grained sand and is commonly conglomeratic with locally abundant black and gray chert granules and pebbles. Third Cat Creek Sandstone of subsurface usage. As much as 100 feet thick, though often thinner.

Jurassic

Jm MORRISON FORMATION (UPPER JURASSIC) -- Variegated mudstones, thin, gray limestones, and orange-brown sandstones. Four discrete intervals, from base to top, not all present at every locality: (1) dull-red and buff mudstones capped by an orange-brown weathering, slabby, very fine- to fine-grained, quartzose sandstone; (2) light-gray weathering shale and thin, highly fractured limestone beds; (3) dull-red and green variegated mudstone interval with two prominent cross-stratified, quartzose sandstones; sandstones orange-brown weathering and more resistant at top, but light-yellow-white and rusty-speckled below; (4) medium-gray carbonaceous shale, siltstone, thin quartzose sandstone lenses with coaly fragments, and local coal beds. Coal beds well developed on northeast flank of Big Snowies, associated with the Lewistown Coal Field. Total formation thickness variable – Lindsey (1980) reported 40-70 m (120-210 ft); Porter and Wilde (1999; revised 2005) report an unmeasured estimate of 60 to 80 feet in east-adjacent Musselshell quadrangle.

Jms MORRISON FORMATION AND SWIFT SANDSTONE, UNDIVIDED (UPPER AND MIDDLE JURASSIC) -- Formations combined in mapping on north flank of Little Belt Mountains.

Je ELLIS GROUP (MIDDLE JURASSIC)

Jsw SWIFT SANDSTONE -- Brown weathering, gray, fine- to coarse-grained, glauconitic and calcareous sandstone; cross-stratified and ripple-laminated with numerous clay partings; interbedded with thin-bedded to lenticular mudstones. Basal few feet of sandstone commonly coarse-grained and conglomeratic, containing chert pebbles, mudstone clasts, and abundant broken shell material, particularly of oysters. Commonly, oyster fragments weather out on slopes. Sandstone commonly forms resistant ridge or ledge. In Little Belt Mountains within map area and on western end of Big Snowy Mountains, Swift rests unconformably on Amsden Group; eastward across Big and Little Snowies, Swift rests on either Piper or Rierdon Formation. Thickness about 100 feet (Lindsey, 1980).

Jr RIERDON FORMATION -- Pale-yellow weathering, highly calcareous shale and thin-bedded, light-gray weathering, limestones; locally very fossiliferous, dominated by oysters, *Gryphea* sp. brachiopods, and locally, belemnites; whole and fragmented fossils litter some exposures. Formation mostly poorly exposed, forming soft soils. Thickness of 0-90 feet reported by Lindsey (1980).

Jp PIPER FORMATION -- Dull-red, yellow, and buff mudstone, brittle, white limestone, massive white gypsum, and brown weathering quartzose, shelly sandstones and grainstones, locally conglomeratic. Local section highly variable, reflecting both depositional facies changes and topography of pre-Jurassic erosion surface. Overall, limestone and gypsum occur in lower part of formation, with sandstones in upper part. Thickness 0-140 feet (Lindsey, 1980).

Jrp RIERDON AND PIPER FORMATIONS, UNDIVIDED (JURASSIC)

Pennsylvanian and Mississippian

lPMa AMSDEN GROUP (PENNSYLVANIAN AND MISSISSIPPIAN)

NOTE: The Pennsylvanian-Mississippian boundary is within the upper Tyler Formation in the Big Snowy Mountains area (Dutro and others, 1984, p. 423; Wardlaw (1985); Wardlaw, Bruce, written comm., 1997).

lPab ALASKA BENCH FORMATION (PENNSYLVANIAN) -- White to light-lavender and pink weathering, light-gray, well-bedded, micritic limestone, locally dolomitic, commonly red-stained. Beds dense, brittle, and commonly finely laminated suggesting algal origin. Limestones interbedded with red and maroon mudstones.

lPMt TYLER FORMATION, UNDIVIDED (PENNSYLVANIAN AND MISSISSIPPIAN) -- Mapped where laterally restricted Bear Gulch Limestone middle member is absent. Lower and upper informal members of the Tyler are easily distinguished only by stratigraphic position below and above the laterally restricted but easily recognized Bear Gulch Limestone middle member. Because the Pennsylvanian-Mississippian boundary is within the upper Tyler in the Big Snowy Mountains area (see note above), where the Mississippian Bear Gulch Limestone middle member is present, underlying sandstones and red beds are assigned a Mississippian age and overlying sandstones and red beds are assigned a Pennsylvanian-Mississippian age. Where the Bear Gulch Limestone is absent, the whole Tyler Formation is assigned a Pennsylvanian-Mississippian age in this map area.

lPMtu UPPER MEMBER, INFORMAL, OF TYLER FORMATION (PENNSYLVANIAN AND MISSISSIPPIAN) -- Contains yellow-gray, quartzose, fine- and medium-grained, thin- to thick-bedded sandstones, commonly red- or brown-stained and interbedded with red, gray, and black mudstones and shale. Equivalent to Cameron Creek Member of Maughan and Roberts (1967); these authors report thicknesses of 222 and 83 feet at reference sections in this quadrangle area.

Mtb BEAR GULCH LIMESTONE (UPPER MISSISSIPPIAN), MIDDLE MEMBER OF TYLER FORMATION -- Alternating finely laminated, evenly bedded, micritic, silty limestone beds and calcareous siltstones and claystones. Limestones resistant, medium-gray, weathering to light-gray and tannish-gray; siltstone-claystone beds slightly darker and form poorly resistant, recessive intervals between limestone beds. Even stratification is characteristic. Locally, unit contains abundant fish and invertebrate fossils of a Late Mississippian restricted marine environment (Lund and others, 1993). Exposed along Bear and Rose Creeks in northeast corner of map area. Unit not present in surface exposures farther west in Big Snowy Mountains or in Little Belt Mountains but does extend southeastward in the subsurface.

Mtl LOWER MEMBER, INFORMAL, OF TYLER FORMATION (MISSISSIPPIAN) – Red bed and sandstone lithologies very similar to informal upper member. The two members are separately mapped here only where the Bear Gulch Limestone, middle member of the Tyler, is present. Equivalent to Stonehouse Canyon Member of Maughan and Roberts (1967). Thickness highly variable in the region owing to deposition of lower Tyler on erosional surface of underlying Heath Formation. Maughan and Roberts (1967) report 288 and 101 feet at reference sections in this quadrangle area.

Mbs BIG SNOWY GROUP, UNDIVIDED (MISSISSIPPIAN) – Includes Kibbey, Otter, and Heath Formations, in ascending order, that are combined where dips are steep or exposures are poor.

Mh HEATH FORMATION -- Dark-gray, light-gray, and sometimes whitish-weathering, black, petroliferous limestone and interbedded black, fissile shale. Shales locally silty and commonly calcareous. Gypsum and gypsiferous beds occur locally as do thin coals. Thickness of formation variable throughout central Montana owing to pre-Jurassic erosion; Maughan and Roberts (1967) report thicknesses ranging from less than 100 to more than 500 feet thick in the Big Snowy Mountains, owing at least in part to the regional erosion surface developed on the top of the formation. Maughan (1989) indicates a zero edge of the Heath at about the western edge of this quadrangle, but extensive Heath outcrops occur west of the map area. Westernmost exposure of Heath within this quadrangle is at mouth of Sawmill Canyon along south flank of Little Belt Mountains.

Mo OTTER FORMATION -- Tan, gray-green, and some vivid green, blocky, commonly calcareous shales, and thin-bedded, light-gray to white, brittle, micritic limestones; limestones locally oolitic and/or fossiliferous to coquinoid with brachiopods and crinoid columnals. Thickness of formation highly variable owing to pre-Jurassic erosion; 290 and 374 feet measured by Maughan and Roberts (1967) at two reference sections in eastern Big Snowy Mountains.

Mk KIBBEY FORMATION -- Deep-red, calcareous mudstones and siltstones, and red-stained, white to gray, fine-grained, well-sorted, quartzose sandstone. Poorly exposed in quadrangle; mapped primarily based on reddish soil color in expected stratigraphic position. No massive evaporite is observed in this formation in the quadrangle. However, evaporite is present on Durfee Creek Dome on the east-adjacent Musselshell quadrangle (Porter and Wilde, 1999), where it is assigned to the Kibbey rather than assigning it as a remnant of the Charles Formation that overlies the Mission Canyon Formation in the Williston basin to the east. Thickness variable; 190 and 220 feet measured by Maughan and Roberts (1967) at two reference sections in eastern Big Snowy Mountains.

MADISON GROUP, UNDIVIDED (MISSISSIPPIAN) -- Light-gray weathering, medium-gray, massive to bedded, cliff-forming limestone. Mapped where component formations not

readily distinguished.

Mmc MISSION CANYON FORMATION (UPPER AND LOWER MISSISSIPPIAN) – Medium- to light-gray weathering, cliff-forming, massively bedded, extensively solution-brecciated limestone, poorly fossiliferous and containing well developed small to large vugs and small caves often containing a *terra rosa* mudstone that stains underlying beds on cliff-faces. No occurrence of overlying Charles Formation gypsum observed on outcrop in Big Snowy Mountains, though it is well known southeastward in the subsurface. Thickness about 700 feet (Lindsey, 1980).

Ml LODGEPOLE FORMATION (LOWER MISSISSIPPIAN) – Medium-gray weathering, resistant, thin- to medium-bedded micritic, locally very fossiliferous limestone and dolomite. Beds commonly show ripple lamination, burrowing, and small solution breccias. Lower part contains darker-gray beds with fetid odor and abundant, brown weathering chert lenses and nodules replacing limestone. Massive bioherms, recrystallized to pinkish, coarse-grained to vuggy, dolomitic limestone, locally present in lowermost part of formation, especially well exposed in Swimming Woman and Half Moon Canyons on south flank of Big Snowy Mountains (Cotter, 1965; Smith and Custer, 1987). Thickness about 1,000 feet (Lindsey, 1980).

Devonian

Dj JEFFERSON FORMATION (UPPER AND MIDDLE DEVONIAN) – Dark-gray to brown-gray and tan weathering, coarsely crystalline dolomite in alternating beds as much as 6 feet thick that locally give a banded appearance. Beds massive to faintly laminated, locally fetid on fresh surfaces. Common small vugs filled with white crystalline calcite. Locally in lowermost part of formation, thicker tan weathering dolomite beds may be assignable to the Maywood Formation. Conodonts in lowermost beds indicate a Middle or Late Devonian age (Lindsey, 1980). Thickness 100 to 160 feet (Lindsey, 1980).

NOTE on Beartooth Butte Formation in Big Snowy Mountains: Sandberg (1961) described a sequence of red beds of Lower Devonian age along upper Half Moon Creek in the Big Snowies that he tentatively assigned to the Beartooth Butte Formation, the northernmost extension of that formation into Montana from its type locality in northern Wyoming. Although Lindsey (1980) did not mention this possible assignment, and states that upper Snowy Range Formation beds contain Lower Ordovician fossils (not Lower Devonian), his description of these upper Snowy Range beds closely parallels Sandberg's (1961) description of the Beartooth Butte Formation beds on Half Moon Creek.

Ordovician and Cambrian

O€sr SNOWY RANGE FORMATION – Tan weathering, slabby, gray, burrowed limestone beds and interbedded variegated, red weathering, burrowed shale. Upper 30 feet predominantly variegated red and green shale and limestone

forming cliffs. Limestone beds in upper part characteristically contain prominent intraformational limestone pebble conglomerate interbedded with variegated red and green limey shales (These are the beds tentatively assigned to the Beartooth Butte Formation by Sandberg (1961). See note above). Limestone beds in lower part well laminated, not generally pebble-bearing. Trilobite fragments common throughout formation. Based on lithology and stratigraphic position, Lindsey (1980) extended the Snowy Range Formation name from southwest Montana, where the formation is entirely Cambrian in age, into central Montana where he found that it also includes Lower Ordovician strata. Thickness 240 to 360 feet (Lindsey, 1980).

Cmu MIDDLE AND UPPER CAMBRIAN SEDIMENTARY ROCKS, UNDIVIDED; INCLUDES UPPER BEDS OF SNOWY RANGE FORMATION AND PILGRIM, PARK, MEAGHER, AND WOLSEY FORMATIONS – Formations locally recognized along crest of Big Snowy Mountains but exposures are too limited and poor to map separately. Lithologies include limestone pebble conglomerate and gray shale, and green-gray shales in lower part of interval above Flathead Formation. Dark shale and limestone at top of interval belongs to Dry Creek Member of overlying Snowy Range Formation. Thickness of total interval approximately 700 feet (Lindsey, 1980).

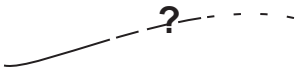
Cf FLATHEAD FORMATION – Reddish-brown-stained, quartzose, quartz-pebble sandstone, locally cross-bedded. Outcrops limited to headwaters of Swimming Woman and Careless Creeks on crest of range (Fig. 1). Thickness about 120 feet (Lindsey, 1980).

Proterozoic

Yn NEWLAND FORMATION – Platy, tan-brown weathering, gray, calcareous, thin-bedded argillite and gray, micritic, finely laminated limestone beds. Argillites and carbonates show characteristic uniform bedding and laminations. Formation crops out only along Swimming Woman Creek at crest of Big Snowy Mountains. Exposed section about 300 feet thick; base not exposed (Lindsey, 1980).

GEOLOGIC MAP SYMBOLS

Big Snowy Mountains 30’ x 60’ Quadrangle

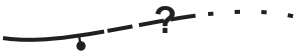


Contact; dashed where approximately located, dotted where concealed, queried where uncertain.

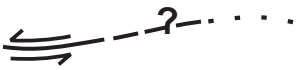
Strike and dip orientation of inclined beds; numbers, where present, indicate degree of dip.

Orientation of vertical bedding.

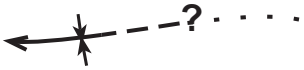
Strike and dip orientation of overturned beds; numbers, when present, indicate degree of dip.



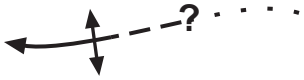
Normal or reverse fault; dashed where approximately located, dotted where concealed, queried where uncertain. Ball and bar on downthrown side.



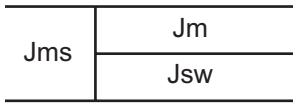
Strike-slip fault; dashed where approximately located, dotted where concealed, queried where uncertain. Arrows indicate direction of relative lateral movement.



Axial trace of syncline; dashed where approximately located, dotted where concealed, queried where uncertain. Plunge of axis shown by arrow head.



Axial trace of anticline; dashed where approximately located, dotted where concealed, queried where uncertain. Plunge of axis shown by solid arrow head.



Indicates a change in map units, based on combining units in areas where beds dip steeply or where exposures do not allow more detailed mapping.

SELECTED REFERENCES

Big Snowy Mountains 30' x 60' Quadrangle

The following reference list is limited to those references that contain geologic maps, theses, and/or measured sections that were consulted in the field work and preparation of this map.

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