GEOLOGIC MAP OF THE ROCKY BOY 30' x 60' QUADRANGLE

NORTH-CENTRAL MONTANA

Digital map compilation and mapping of Quaternary deposits
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Original bedrock compilation
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Introduction

This geologic map of the Rocky Boy 30' x 60' quadrangle is intended as a digitally produced reproduction of the 1976 map titled "Geologic and Tectonic Maps of the Bearpaw Mountains Area, North-central Montana" by B. Carter Hearn, Jr., published by the U. S. Geological Survey as Miscellaneous Investigations Map I-919, scale 1:125,000. Dr. Hearn has graciously agreed to be an author on this new version of his earlier map. The I-919 map of the bedrock geology by Hearn (1976) was compiled from original mapping by W. T. Pecora, B. C. Hearn, Jr., D. B. Stewart, J. H. Kerr, R. G. Schmidt, B. Bryant, W. C. Swadley, and others.

Our objective in producing this map is to provide the originally published geologic data in a digital form that is as faithful as possible to the original map, with the following exceptions: (1) two kinds of data have been omitted from this digital version, (a) strike and dip data for volcanic flows, and (b) oil and gas well locations (except that those along cross section X-X' are retained) and producing field areas; (2) new data have been added by R. N. Bergantino for the Quaternary deposits within the quadrangle. Additionally, a few stratigraphic contacts have been adjusted, based upon subsurface data that postdate the original map, and minimal new field data have been added along both the western and eastern map borders in the process of edge-matching with adjacent quadrangles. Cross section X-X' is taken directly from Hearn's (1976) cross section A-D; it has been scaled to fit the present map at the 1:100,000 scale. Figure 2, Correlation Chart of Map Units, is taken substantially from the Hearn (1976) map.

Geologic Setting

The Rocky Boy 30' x 60' quadrangle is located in north-central Montana, between the Milk and the Missouri Rivers (figure 1). The quadrangle is dominated by the Bears Paw Mountains. The southernmost part of the mountains lies within the south-adjacent Winifred 30' x 60' quadrangle (Wilde and Porter, 2002).

The following discussion is taken nearly verbatim from Hearn (1976):

> The area of this map includes the northern and southern volcanic fields, the Bearpaw Mountain arch, and part of the surrounding plains. The arch is a composite anticlinal uplift in the center of the mountains that contains abundant intrusions and exposes sedimentary rocks of Cretaceous, Jurassic, and Mississippian age. Drill-hole data indicate that the plainsward slope of deeper horizons continues beneath the volcanic fields, so that the Bearpaw Mountains uplift is considerably broader than the central arch. Deep drill-hole data also suggest that Precambrian crystalline basement is uplifted as much as 5,000 feet above its regional level 7,000 feet beneath the plains.
>
> The volcanic fields consist of interlayered flows and fragmental volcanic material of middle Eocene age inclined predominantly toward the arch at an average angle of 35 degrees. The youngest volcanics, of local extent, rest unconformably on the older, tilted volcanics. The volcanic fields contain numerous shallow intrusions. Prevolcanic sedimentary formations of Late Cretaceous, Paleocene, and early Eocene age, which have been eroded from the plains, are preserved in down-faulted blocks along the borders of the volcanic fields.
>
> In the plains, gentle regional eastward dip off the Sweetgrass arch to the west exposes Claggett Shale, Judith River Formation, and Bearpaw Shale of Late Cretaceous age successively from west to east. Near the Bearpaw Mountains these formations are disrupted by a network of narrow faulted folds in which beds as old as the base of the Carlile Shale Member [Carlile Formation][...] are exposed and in which down-faulting has preserved rocks as young as the Fort Union Formation.
>
> About 11,500 feet of sedimentary formations were deposited in north-central Montana in

Paleozoic, Mesozoic, and early Cenozoic time. This long interval of sedimentation was followed by intrusive igneous activity and uplift in the Bearpaw [Bears Paw] Mountains area in late early Eocene or in middle Eocene time. Large-scale gravity slides then carried the volcanic deposits and parts of the underlying sedimentary section away from the central uplift. Extensive rifting, tilting, and collapse of the sedimentary and volcanic rocks occurred in the slide sheets. The youngest volcanic rocks, of middle Eocene age, were subsequently deposited on tilted older volcanic rocks. Erosion in post-middle Eocene time removed the distal portions of the volcanic fields, stripped away formations of early Eocene, Paleocene, and Late Cretaceous age in the plains, and produced pediment and terrace deposits of Miocene to Pleistocene age. In Pleistocene time a continental ice sheet advanced from the northwest and covered the western, northern, and eastern sides of the Bearpaw [Bears Paw] Mountains with glacial deposits.

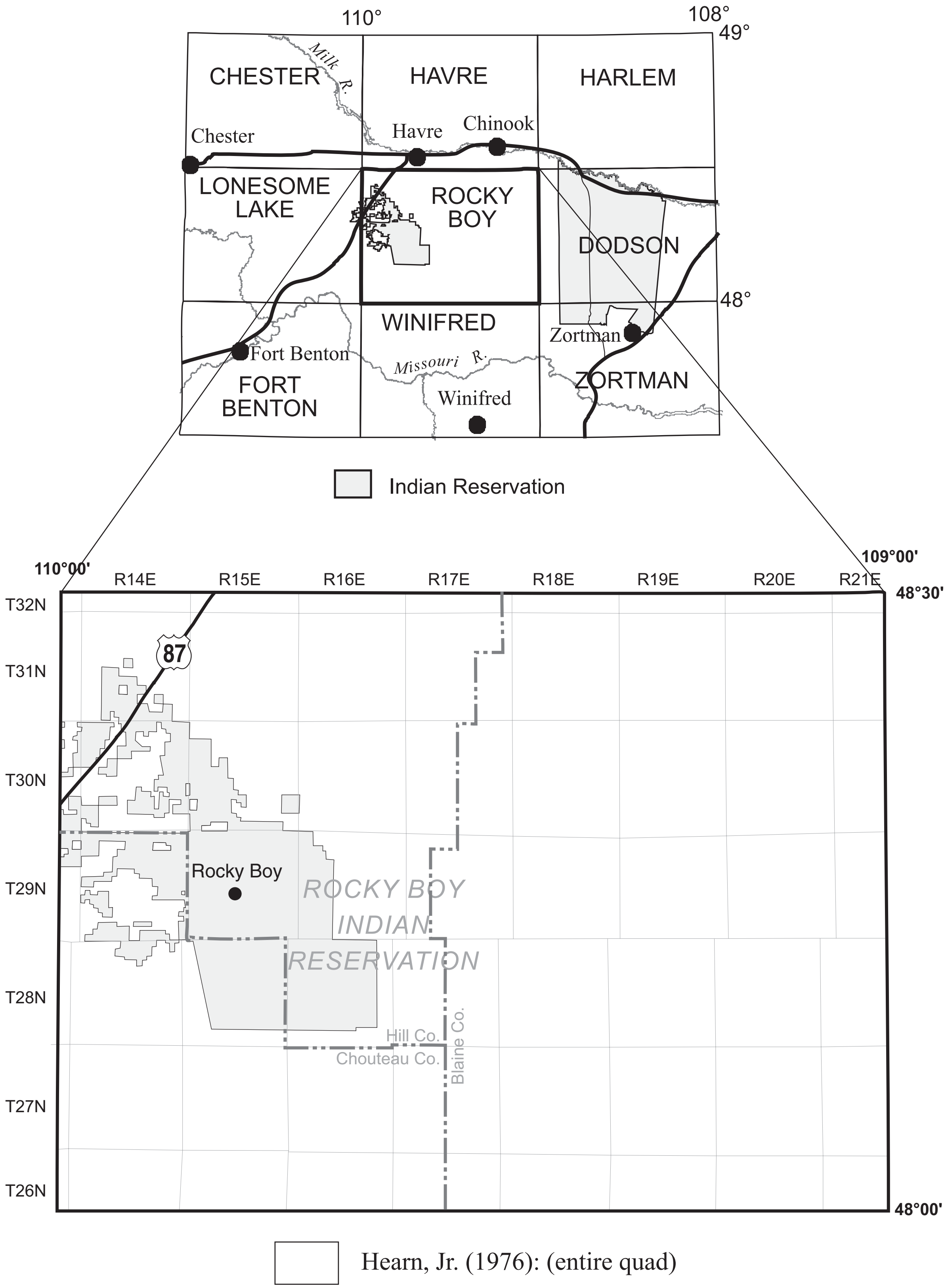


Figure 1. Location map for Rocky Boy 30' x 60' quadrangle. Geologic map based on Hearn, Jr. (1976) (see References). Also shown are locations of adjacent geologic maps published or in progress by MBMG.

Correlation Chart of Map Units
Rocky Boy 30' x 60' Quadrangle

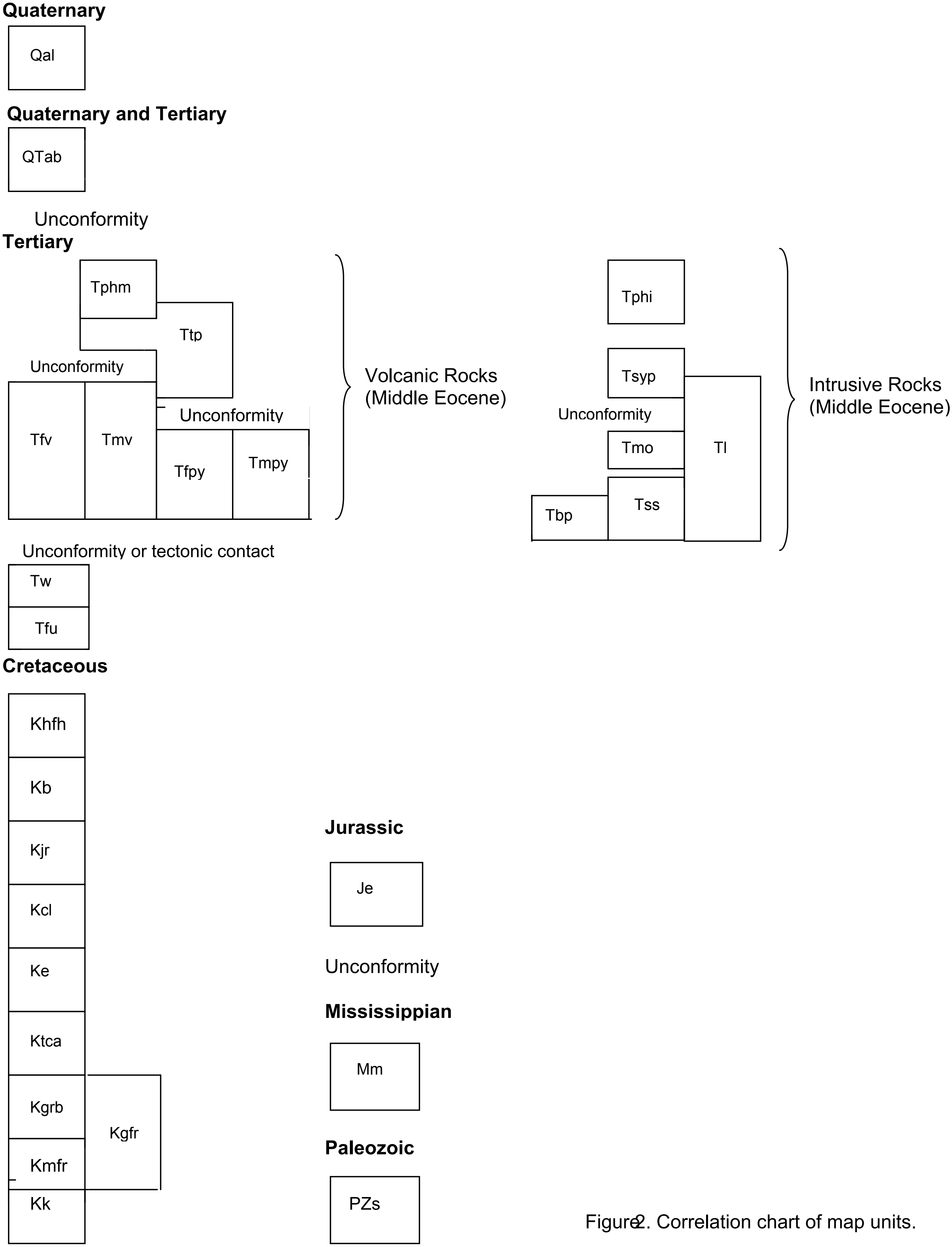


Figure 2. Correlation chart of map units.

Description of Map Units

NOTE: Descriptions of map units are extensively taken from Hearn, Jr. (1976). Original thickness data given in English measurement; conversion of feet to meters in this report: ft/3.28 = [m], assuming ending zeros of feet measurements to be nonsignificant figures

Quaternary

Qal — ALLUVIUM — Deposits of modern streams and associated flood plains; includes colluvium, modern terrace deposits; locally includes some slightly older Holocene terrace alluvium. Equivalent to Qsg unit mapped on east-adjacent Dodson quadrangle (Bergantino, 2001). Thickness not measured.

Quaternary and Tertiary

QTab — ALLUVIUM OF DISSECTED BRAID PLAINS — Described by Knechtel (1959) as "older alluvium of gravel benches", and by Alverson (1965) as "terrace deposits." Following from Knechtel (1959), these deposits may represent remnants of alluvial braid-plain sedimentation across broad surfaces flanking the Bears Paw Mountains and other mountain uplifts of central Montana. Unit mapped only in easternmost part of quadrangle. Thickness not measured.

Tertiary

Volcanic rocks (Middle Eocene)

Tphm — MAFIC PHONOLITE, ANALCIME-RICH — (from Hearn, 1976) Occurs as flows, flow breccias, agglomerate, and thin plant-bearing, water-laid volcanic sediments; red, green, and gray; phenocrysts of analcime, augite, biotite, and rare sanidine; occurs only in southwestern Bears Paw Mountains where it forms topographic highs; rests unconformably on older volcanic rocks, but lower part may be interlayered with porphyritic analcime trachyte. Fossil plants indicate middle Eocene age. Maximum thickness about 1,500 ft [460 m] on Mt. Bearpaw.

Ttp — TRACHYTE PORPHYRY, ANALCIME-RICH — (from Hearn, 1976) Occurs as flows and flow breccias; greenish gray to light gray; phenocrysts of analcime and sanidine; pronounced trachytic texture of sanidine in groundmass; youngest felsic volcanic rock, in part unconformable over older volcanic rocks and in part interlayered with the uppermost older mafic and felsic volcanic flows; extrusive equivalent of porphyritic potassic syenite (Tsyp). Maximum thickness about 1,500 ft [460 m].

Tfv FELSIC VOLCANIC FLOW ROCKS, UNDIVIDED (MIDDLE EOCENE) — (from Hearn, 1976) Flows and flow breccias of porphyritic latite and quartz latite; light-gray, gray, and brown; green celadonitic alteration is common; phenocrysts of potassium feldspar, plagioclase, augite, hornblende, and biotite; quartz in groundmass only; interlayered with mafic and felsic pyroclastic rocks and mafic flows; as mapped includes some felsic pyroclastic rocks; extrusive equivalent of porphyritic latite (Tl). Maximum thickness about 5,000 ft [1,500 m].

Tfpy FELSIC PYROCLASTIC ROCKS (MIDDLE EOCENE) — (from Hearn, 1976) Agglomerate, tuff-breccia, lapilli tuff, tuff, water-laid volcanic sediments, and coarse mudflow deposits; contains more than 50 percent fragments of felsic volcanic rocks; inclusions of biotite pyroxenite and Precambrian basement rocks locally abundant; commonly forms lowermost volcanic unit, particularly in northwestern part of Bears Paw Mountains; in part deposited in local early collapse basins; fossil plants and fish indicate middle Eocene age. Maximum thickness about 3,000 ft [900 m].

Tmv MAFIC VOLCANIC ROCKS (MIDDLE EOCENE) — (from Hearn, 1976) Flows and flow breccias of phonolite and mafic phonolite; brown, red, and purple; phenocrysts of olivine, augite, biotite, analcime, and rare leucite in groundmass of augite, potassium feldspar, and analcime; natrolite, analcime, and calcite are common alteration products; interlayered with felsic flows and felsic and mafic pyroclastic rocks; as mapped includes some mafic pyroclastic rocks; extrusive equivalent of shonkinite and syenite (Tss), and possibly of monzonite (Tmo). Maximum thickness about 5,000 ft [1,500 m].

Tmpy MAFIC PYROCLASTIC ROCKS — (from Hearn, 1976) Agglomerate, tuff-breccia, lapilli tuff, tuff, water-laid volcanic sediments and mudflow deposits; contains more than 50 percent fragments of mafic volcanic rocks; inclusions of biotite pyroxenite and Precambrian basement rocks locally abundant; commonly forms lowermost volcanic unit, particularly in southeastern part of Bears Paw Mountains; in part deposited in local early collapse basins; fossil plants and fish indicate middle Eocene age. Maximum thickness about 3,000 ft [900 m].

Intrusive rocks (Middle Eocene)

Tphi MAFIC PHONOLITE, ANALCIME-RICH — (from Hearn, 1976) Occurs as dikes and plugs; gray to greenish gray; fine grained, porphyritic; phenocrysts of analcime, augite, biotite, and rare sanidine; occurs only in western Bears Paw Mountains; youngest intrusive rock; intrudes part of extrusive equivalent (mafic phonolite,Tphm).

Tsyp SYENITE PORPHYRY, POTASSIUM-RICH — (from Hearn, 1976) Occurs as dikes, sills, plugs, and stocks; light gray to green; fine to coarse grained; as mapped includes a wide variety of subsilicic-alkalic rocks (pseudoleucite-sodalite tinguaite, nepheline tinguaite, aegirine-nepheline syenite, all restricted to the central and western Bears Paw Mountains) and silicic-alkalic rocks (porphyritic syenite, the only variety of this rock type in the eastern Bears Paw Mountains); fine-grained varieties commonly have phenocrysts of tabular zoned potassium feldspar, and aegirine, with or without psuedoleucite, nepheline, and sodalite, in a fine-grained green or gray groundmass; rock type associated with most sulfide deposits; plug in Rocky Boy stock contains carbonatite vein-dikes; cut by mafic analcime phonolite in western Bears Paw Mountains; in eastern Bears Paw Mountains, generally the youngest rock type with exception of one dike of porphyritic latite.

Tl LATITE, PORPHYRITIC — (from Hearn,1976) Occurs as dikes, sills, laccoliths and stocks; light gray to brown; fine grained, felsic, porphyritic; most contains less than 20 percent mafic minerals; phenocrysts of augite ubiquitous; phenocrysts of potassium feldspar, plagioclase, biotite, and hornblende in varying amounts characterize separate varieties; groundmass of feldspar, augite, and quartz; may represent several episodes of intrusion, and postdates most but not all shonkinite-syenite intrusions.

Tmo MONZONITE — (from Hearn, 1976) Occurs as dikes, sills, plugs, and stocks; light to dark gray; fine to medium grained, locally porphyritic; predominantly mafic; felsic varieties rare; contains potassium feldspar and plagioclase in varying ratio, augite, and subordinate olivine, biotite, and hornblende; lacks quartz, feldspathoidal varieties rare; occurs only in western half of Bears Paw Mountains; postdates most porphyritic latite and shonkinite intrusions, and is cut by porphyritic potassic syenite; fine-grained dikes not mapped separately from porphyritic latite.

Tpb PYROXENITE, BIOTITE-RICH — (from Hearn, 1976) Occurs as small stocks; dark green to black; coarse grained; contains augite and biotite in ratios from 10:1 to 1:1, less than 10 percent total of apatite, potassium feldspar, plagioclase, olivine, and sulfides; transitional to mafic varieties of shonkinite; occurs only in Rocky Boy stock in western Bears Paw Mountains where it is the earliest intrusion; similar biotite pyroxenites with less apatite occur as inclusions in other igneous rocks.

Tss SHONKINITE AND SYENITE — (from Hearn, 1976) Occurs as dikes, sills, laccoliths, plugs, and stocks; gray to black; fine to coarse grained, porphyritic and equigranular; mafic mineral content of shonkinite more than 40 percent, mafic syenite 20 to 40 percent, and syenite less than 20 percent; includes subsilicic-alkalic and silicic-alkalic varieties; contains augite, biotite, and dominantly potassic feldspar, with or without olivine, plagioclase, nepheline, pseudoleucite, apatite, and analcime or interstitial quartz; many varieties weather to biotite-rich soil with no outcrop; represents several episodes of intrusion, and is the earliest intrusive rock in the eastern Bears Paw Mountains.

Sedimentary Rocks (Lower Eocene through Paleocene)

Tw WASATCH FORMATION (LOWER EOCENE) — (modified from Hearn, 1976) Variegated red, pink, lavender, light-green, yellow-gray, and white shale, bentonitic claystone, and siltstone with small calcareous concretions; interbedded light-gray, brown and green, fine- to coarse-grained, cross-bedded sandstones with lenses of boulder conglomerate in upper part of formation containing clasts derived from mountain uplifts to the west or southwest including argillite and quartzite from Proterozic Belt Supergroup rocks, porphyritic igneous rocks, and limestone and dolomite; clasts locally crushed, fractured, and recemented; nonmarine; fossil plants and vertebrates indicate early Eocene age; top of formation missing due to pre-volcanic erosion or tectonic disruption or both. Maximum measured thickness 800 ft [240 m]; original maximum thickness probably exceeded 1,000 ft [300 m].

Tfu FORT UNION FORMATION, UNDIVIDED (PALEOCENE) — (modified from Hearn, 1976) Light-brown to light-yellow, thin-bedded to thick-bedded or massive sandstone with brown sandstone concretions; interbedded with light-colored to greenish siltstone, claystone, and shale; contains carbonaceous shale and coal, locally mined; nonmarine; fossil plants and vertebrates indicate Paleocene age. Maximum thickness about 1,300 ft [400 m].

Cretaceous

Khfh HELL CREEK FORMATION AND FOX HILLS SANDSTONE, UNDIVIDED (UPPER CRETACEOUS) — (modified from Hearn, 1976) Combined thickness 480 to 600 ft [146 to 597 m]. Includes, in descending order: Hell Creek Formation composed of interbedded gray to light-brown, locally massive sandstone with brown sandstone concretions, and white to light-colored to drab siltstone, claystone and shale locally calcareous with abundant small calcareous concretions; brownish-gray carbonaceous bentonitic claystone also interbedded; persistent beds of carbonaceous shale and lenticular coal near base of formation, locally mined; nonmarine; rare fossil plants and vertebrates indicate latest Cretaceous age; thickness 420 to 500 ft [130 to 150 m]; Fox Hills Formation composed of light-yellowish-gray, light-brown, and yellow, thin-bedded to massive sandstone, commonly concretionary; minor interbeds of brown and gray siltstone and shale; locally contains diagnostic marine fossils. Thickness 60 to 100 ft [20 to 30 m].

Kb BEARPAW SHALE (UPPER CRETACEOUS) — (modified from Hearn,

1976) Medium-gray, fissile shale and silty shale weathering to steel gray or rarely brownish-gray; light-gray to cream-colored bentonite beds prominent in lower one-third; numerous horizons of ovoid, gray, massive or septarian, commonly fossiliferous, limestone concretions; also several horizons of reddish-brown iron-manganese-rich claystone concretions; diagnostic species of *Baculites* define 5 faunal zones; upper 70 to 200 ft [20 to 60 m] are brown to brownish gray, thin-bedded sandstone, siltstone, and dark shale, transitional into overlying Fox Hills Sandstone; bentonite beds in lower one-third allow good subsurface correlation of resistivity well logs, but general absence of bentonites and occurrence of tectonic disruption make well-log correlation of upper two-thirds less reliable. Total thickness approximately 1,000 to 1,200 ft [300 to 370 m], but uncertain because of lack of complete undisturbed section.

Kjr JUDITH RIVER FORMATION (UPPER CRETACEOUS) — (modified from Hearn, 1976) Light-brown to yellow sandstone, locally gas-bearing, siltstone, and white, yellow, greenish, and light-gray claystone and shale; near top commonly are one or more horizons of oyster-shell coquina in dark shale, and several carbonaceous shales and thin coals that have been locally mined; locally, uppermost beds are white, clay-rich marine sandstone; locally, lowermost sandstone is burrowed by marine organisms (Parkman Sandstone of subsurface usage); vertebrate fossils locally common; on resistivity well logs correlation of nonmarine sandstones is uncertain because of lateral lensing, but correlation of basal marine sandstone is reliable over 5 to 10 miles [8 to 15 km] of distance. Thickness 540 to 670 ft [160 to 200 m].

Kcl CLAGGETT SHALE (UPPER CRETACEOUS) — (modified from Hearn, 1976) Dark gray or grayish brown on fresh surfaces, commonly weathered to soft brown; blocky to fissile; characteristic dull-orange-weathering, smooth, ovoid, calcareous concretions in middle and upper part of unit; concretions commonly contain yellow calcite vein filling and are commonly highly fractured, forming mounds of small, sharp-edged orange-brown fragments; numerous grayish white bentonite layers (1 to 5 inches thick [2.5 to 12.5 cm]) in lower 80 ft [20 m] of unit; upper 30 to 200 ft [10 to 60 m] contain laterally persistent sandstone beds forming transitional base with overlying Judith River Formation and are locally gas-bearing; resistivity logs 1 to 3 miles [2 to 5 km] apart are nearly identical, and many markers can be correlated in wells 10 to 20 miles [15 to 30 km] apart; total thickness 400 to 680 ft [120 to 200 m].

Ke EAGLE SANDSTONE (UPPER CRETACEOUS) — (modified from Hearn, 1976) Light-brown to white sandstone with interbedded gray shale, siltstone, and carbonaceous mudstone and shale; contains as many as 3 massive sandstones, some or all of which may be gas-bearing; lowest sandstone (Virgelle Sandstone) is 70 to 170 ft [20 to 50 m] thick in southwest part of map area; upper 20 to 130 ft [6 to 40 m] are alternating thin glauconitic sandstone, chert-pebble conglomerate, siltstone, and shale; sandstone units and shaly interbeds can be carried laterally in subsurface with electric well logs over distances of 5 to 10 miles [8 to 15 km]. Total thickness 140 to 300 ft [40 to 90 m].

Ktca TELEGRAPH CREEK FORMATION THROUGH CARLILE FORMATION (UPPER CRETACEOUS) — (modified from Hearn, 1976) Total thickness 750 to 870 ft [230 to 260 m]; major gravity-slide planes are near base and near a bentonite bed about 550 ft [170 m] above base. Includes, in descending order: Telegraph Creek Formation, composed of alternating thin-bedded sandstone, siltstone, and shale weathering gray to brownish gray, with increasing sandstone upward in transition to overlying Eagle Sandstone; locally massive sandstone up to 50 ft [15 m] thick may be gas-bearing; thickness varies from 0 to 170 ft [0 to 50 m]; Niobrara Formation and Carlile Formation together composed of dark-gray to brownish-gray marine shale with minor siltstone, and bentonite beds, septarian calcareous claystone concretions, and concretionary limestone lenses; lower 100 to 200 ft [30 to 60 m] (Carlile Formation) are black shale with distinctive rusty-weathering iron-rich claystone concretions; resistivity logs 1 to 3 miles [2 to 5 km] apart are nearly identical, and many markers can be correlated in wells 10 to 20 miles [15 to 30 km] apart; thickness 610 to 850 ft [190 to 260 m].

Kgfr GREENHORN FORMATION THROUGH FALL RIVER FORMATION (UPPER AND LOWER CRETACEOUS) — (from Hearn, 1976) On cross section A-D only.

Kgrb GREENHORN FORMATION AND BELLE FOURCHE SHALE (UPPER CRETACEOUS) — (modified from Hearn, 1976) Total thickness 170 to 290 ft [50 to 90 m]. Includes, in descending order: Greenhorn Formation composed of gray, sandy, thin-bedded limestone, calcareous and noncalcareous siltstone, dark shale, and bentonite; marine fossils abundant; thickness 10 to 50 ft [3 to 15 m]; Belle Fourche Shale, composed of black shale, minor gray sandstone and siltstone, bentonite; distinctive sandstone bed about 100 ft [30 m] above base contains black chert grit; iron-manganese claystone concretions near base; resistivity logs 1 to 3 miles [2 to 5 km] apart are nearly identical, and many markers can be correlated in wells 10 to 20 miles [15 to 30 km] apart; thickness 140 to 270 ft [40 to 80 m].

Kmfr MOWRY FORMATION THROUGH FALL RIVER FORMATION (UPPER AND LOWER CRETACEOUS) — (modified from Hearn, 1976) Total thickness 740 to 800 ft [230 to 240 m]. Includes, in descending order: Mowry Shale, composed of light-silvery bluish-gray-weathering, siliceous shale with prominent bentonite beds near top, and locally abundant fish scales; thickness 60 to 110 ft [20 to 35 m]; Thermopolis Formation, equivalent to combined Shell Creek, Cyprian (Newcastle/Muddy), and Skull Creek intervals recognized to south and east (Porter and Wilde, 2001; Bergantino, 2001; Alverson, 1965; Knechtel, 1959); composed of gray to black shale with common drab to rusty iron-rich concretionary claystone nodules and lenses throughout, and abundant thin beds of sandstone and siltstone in middle part; thickness 270 to 360 ft [80 to 110 m]; Fall River Sandstone (First Cat Creek Sandstone), composed, in upper part, of 40 to 70 ft [12 to 21 m] of light-yellowish-brown-weathering quartzose, extensively burrowed sandstone with prominent chert-pebble conglomerate, and, in lower part, of 300 to 430 ft [90 to 130 m] of black shale with minor thin sandstone and siltstone beds, and phosphatic nodules in lower 30 ft [9 m]. Resistivity logs 1 to 3 miles [2 to 5 km] apart are nearly identical, and many markers can be correlated in wells 10 to 20 miles [15 to 30 km] apart.

Kk KOOTENAI FORMATION (LOWER CRETACEOUS) — (modified from Hearn, 1976) Nonmarine sandstone and mudstone; upper half is variegated dark-red, purple, green, and brown mudstone and siltstone locally interbedded with light-gray to light-brown sandstone; lower half is massive light-gray to light-brown, cross-bedded, chert-bearing "salt-and-pepper" sandstone with interbedded, light-colored siltstone and variegated mudstone; prominent massive, cross-bedded, coarse-grained sandstone at base (Third Cat Creek Sandstone) is locally conglomeratic, containing cobbles and pebbles of quartzite, chert, silicified limestone, and vein quartz. Total thickness 290 to 400 ft [90 to 120 m].

Jurassic

Je ELLIS GROUP (UPPER AND MIDDLE JURASSIC) — (extensively modified from Hearn, 1976) Total thickness 280 to 550 ft [85 to 170 m]. Includes, in descending order: Swift Formation, composed of light-brown, massive to thin-bedded marine sandstone, brown siltstone, and dark-gray shale; common brown-weathering concretionary limestone lenses; uppermost 20 to 40 ft [6 to 12 m] may be Morrison Formation equivalent (Hearn, 1976); thickness 70 to 230 ft [21 to 70 m]; Rierdon Formation, composed of massive to thin-bedded, light-gray limestone, and light-gray- to yellowish-gray-weathering, thin-bedded argillaceous limestone and calcareous shale; thickness 70 to 190 ft [20 to 60 m]; Sawtooth Formation, composed of (a) upper, Bowes Member (after Nordquist, 1955), interbedded thin- to medium-bedded, medium-gray, quartz-sandy limestone, oolitic limestone, cross-bedded bioclastic limestone, and calcareous sandstone; minor thin beds of light-gray, mud-cracked limestone, and some wavy-bedded algal limestone; about 27 ft [8 m] thick (Porter, 1996); (b) middle, Firemoon Member (after Nordquist, 1955), massive medium-gray-weathering, dark-gray fossiliferous limestone; and (c) lower, Tampico Member (after Nordquist, 1955), white-weathering, calcareous, quartzose sandstone, siltstone, and shale, with small white quartz pebbles locally. Bowes and Firemoon Members contain oil in Bowes Field in northern part of map area. Sawtooth Member is stratigraphically equivalent to redbeds and limestones of Piper Formation farther south and east in central Montana and Willison basin (Porter, 1996, p. 7); Porter (1998) concludes that the term Sawtooth is preferable in north-central Montana because of lithologic similarities with the type sections of the Sawtooth in western Montana (Cobban, 1945). Hearn (1976) reports that the Piper [Sawtooth] Formation thins southward and eastward, and gives a total thickness of 0 to 260 ft [0 to 80 m].

Mississippian

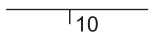
Mm MADISON GROUP, UNDIVIDED (UPPER MISSISSIPPIAN) — (modified from Hearn, 1976) Includes, in descending order: Mission Canyon Limestone and Lodgepole Limestone, mapped together; exposures limited to uppermost 200 ft [60 m] of Mission Canyon Limestone composed of massive, light-gray to dark-gray limestone with abundant lenses and nodules of gray chert; crinoidal and coralline fossils abundant. Total thickness of 650 to 1,050 ft [200 to 320 m], based on subsurface data; thickness variability reflects regional pre-Middle Jurassic erosion.

Paleozoic (on cross sections only)

PZs PALEOZOIC SEDIMENTARY ROCKS, UNDIVIDED (UPPER MISSISSIPPIAN THROUGH CAMBRIAN) — On cross section only (from Hearn, Jr., 1976). Includes, in descending order: Mission Canyon and Lodgepole Formations of Madison Group (Mississippian), Three Forks Shale, Jefferson Limestone and Maywood Formation (Devonian), Bighorn Dolomite (Ordovician), Emerson Formation and Flathead Sandstone (Cambrian). Total thickness of 3,000 to 3,400 ft [910 to 1,040 m].

Map Symbols

Contact; dashed where approximate or inferred; dotted where concealed



Strike and dip of bedding; degrees of dip indicated


Strike of vertical beds


Horizontal bedding


Anticlinal fold shown by trace of axial plane; dotted where concealed; arrow indicates direction of plunge where known

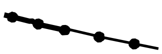

Synclinal fold shown by trace of axial plane; dotted where concealed; arrow indicates direction of plunge where known

Fault, normal; dashed where approximate or inferred; dotted where concealed


Fault, reverse or thrust; dashed where approximate or inferred; dotted where concealed; teeth on upper plate


Approximate limit of undifferentiated glacial deposits; hachures toward glacial deposits (blue line on map)

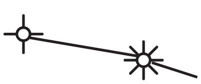
Dikes, sills:


Mafic analcime-rich phonolite dikes (red line on map)


Potassium-rich syenite porphyry dikes and sills (red line on map)


Shonkinite and syenite dikes and sills (red line on map)


Porphyritic latite dikes and sills (blue line on map)


Line of cross section X-X'; line passes through or close to locations of petroleum wells, indicated by  (dry hole) or  (gas well)

References

Primary Geologic Map Source for Rocky Boy Quadrangle

Hearn, B.C., Jr., 1976, Geologic and tectonic maps of the Bearpaw Mountains area, north-central Montana: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-919, scale 1:125,000.

Additional References

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