GEOLOGIC MAP OF THE

BIG TIMBER 30' x 60' QUADRANGLE

SOUTH-CENTRAL MONTANA

by

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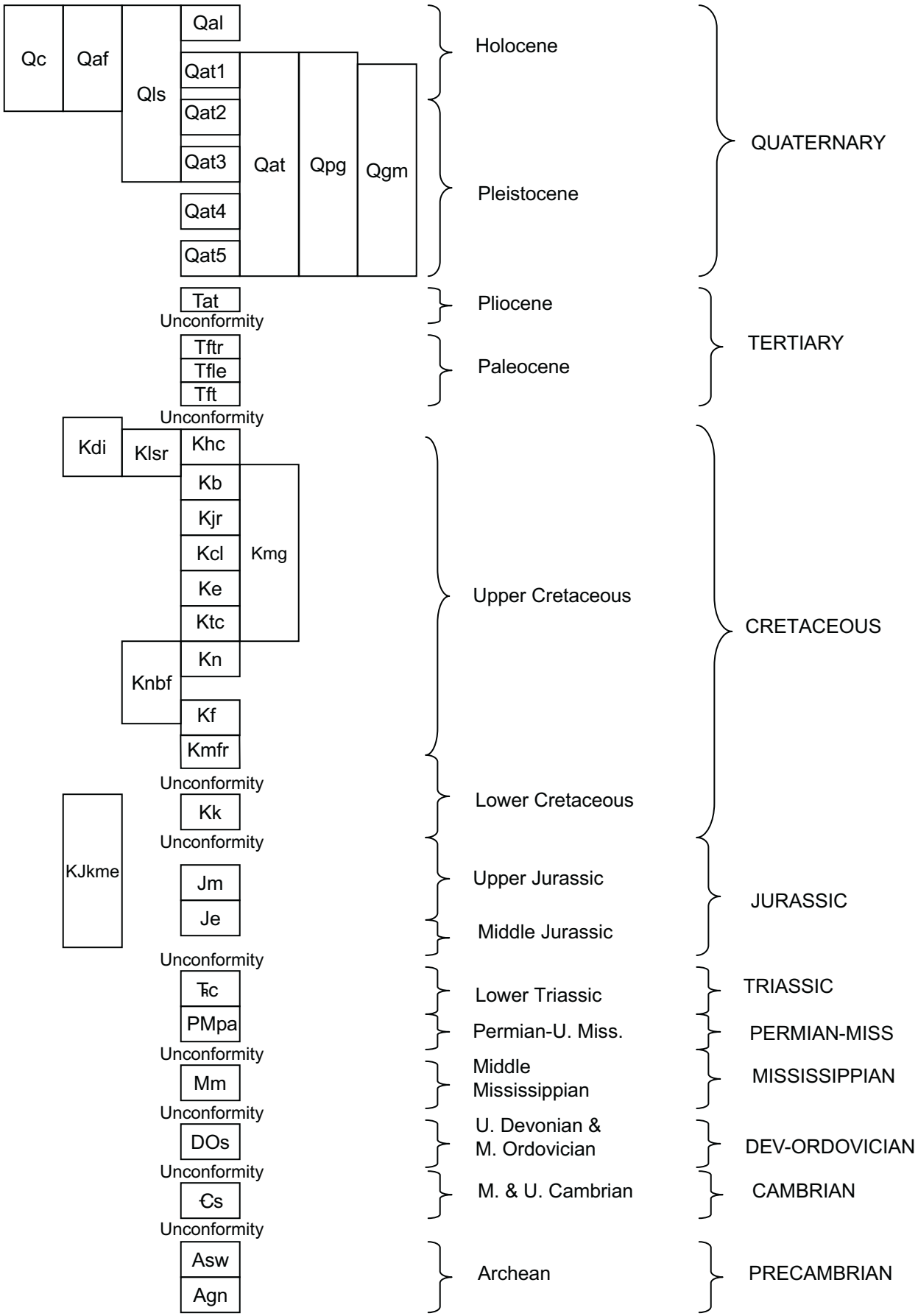
CORRELATION OF MAP UNITS–BIG TIMBER 30´ X 60´ QUADRANGLE



GEOLOGIC MAP OF THE BIG TIMBER 30'X 60' QUADRANGLE
DESCRIPTION OF MAP UNITS

Qal **Alluvium (Holocene)**—Gravel, sand, silt, and clay along active channels of rivers, creeks, and tributaries.

Qc **Colluvium (Holocene and Pleistocene)**—Locally derived slope-wash deposits mainly of sand, silt, and clay. Typically thin veneer concealing bedrock, but locally as thick as 30 ft. Commonly grades into Qal. Locally contains well-rounded cobbles derived from alluvial terrace gravel.

Qaf **Alluvial fan deposits (Holocene and Pleistocene)**—Gravel, sand, silt, and clay deposited in fans being formed by modern streams along major valley margins. Display characteristic fan-shaped map pattern and convex upward profile. Typically grade upstream into Qal. Thickness ranges from very thin at toe to as much as 50 ft at head of fans.

Qls **Landslide deposits (Holocene and Pleistocene)**—Unconsolidated mixture of soil and blocks of bedrock transported down steep slopes by mass wasting. Characteristic hummocky surface with concentric swales and ridges near down-slope limits. Common along steep slopes beneath resistant rocks but can occur where slope and moisture content produce unstable conditions.

Qpg **Pediment gravel deposits (Holocene and Pleistocene?)**—Angular and subangular coarse gravel derived from local bedrock; gravel deposits beneath smooth pediment surfaces sloping away from the Crazy Mountains and Beartooth Mountains. About 10 to 30 ft thick.

Qgm **Glacial moraine deposits, undivided (Holocene and Pleistocene)**—Unsorted mixture of clay-to boulder-size material transported and deposited by glaciers. Characteristic hummocky surface form. Occur in valleys near the Beartooth Mountains in the southwest corner of the map area. Clasts are predominantly Archean metamorphic rocks with lesser amounts of quartzite, igneous rocks, dolomite and limestone.

ALLUVIAL TERRACE GRAVELS

Qat **Alluvial gravel undivided (Holocene and Pleistocene?)**—Gravel, sand, silt, and clay underlying terraces about 20 to 600 ft above present altitude of modern streams and rivers. Equivalent to Qat1-Qat5.

Qat1 **Alluvial gravel, terrace level 1 (Holocene and Pleistocene)**—Gravel underlying terraces about 10 to 20 ft above altitude of Qal (present altitude of rivers). Mostly cobbles and pebbles with minor amounts of sand and silt. Clasts are mainly granitic igneous rocks, granitic gneiss, schist, and quartzite, with much less limestone and sandstone. About 10 to 40 ft thick.

Qat2 **Alluvial gravel, terrace level 2 (Pleistocene)**—Gravel underlying terraces about 20 to 40 ft above Qal. Mostly cobbles and pebbles with minor amounts of sand and silt. Clasts are mainly granitic igneous rocks, granitic gneiss, schist, and quartzite, with much less limestone and sandstone. About 10 to 40 ft thick.

Qat3 **Alluvial gravel, terrace level 3 (Pleistocene)**—Gravel underlying terraces about 50 to 90 ft above present altitude of rivers. Mostly cobbles and pebbles and minor amounts of sand and silt. Clasts are mainly granitic igneous rocks,

granitic gneiss, schist, and quartzite, with much less limestone and sandstone. About 10 to 30 ft thick.

Qat4 **Alluvial gravel, terrace level 4 (Pleistocene)**—Gravel underlying terraces about 200 to 300 ft above present altitude of rivers. These terraces locally exhibit a relatively steep gradient toward the Yellowstone River Valley and may actually include several levels of terraces that are difficult to distinguish. Cobble- and pebble-size clasts are mainly granite, granitic gneiss, schist, and quartzite. Thickness as much as 20 ft.

Qat5 **Alluvial gravel, terrace level 5 (Pleistocene)**—Gravel underlying terraces about 400 to 600 ft above present altitude of rivers. Occur mainly as small discontinuous erosional remnants. Cobble- and pebble-size clasts are mainly granite, granitic gneiss, schist, and quartzite. Calcite cement locally present, especially at base. Thickness ranges from a very thin remnant to about 20 ft.

Tat **Alluvial gravel, terrace level 6 (Pliocene?)**—Gravel underlying terrace about 900 ft above present altitude of rivers. Composed mainly of well-rounded cobbles of granitic gneiss, schist, and quartzite. About 30 to 40 ft thick.

BEDROCK MAP UNITS

Tftr **Tongue River Member, Fort Union Formation (Paleocene)**—Gray to grayish-yellow, fine- to medium-grained sandstone, cross-bedded. Interbedded with brownish-gray carbonaceous shale and siltstone and minor thin coal beds. Sandstones ledge forming, commonly support growths of pine trees. A section

about 400 ft thick of this member is present in the map area; top not present in the map area.

Tfle **Lebo Member, Fort Union Formation (Paleocene)**—Predominantly dark-gray to olive shale, locally yellowish-gray claystone; thin, interbedded, yellowish-gray sandstones and siltstone. Typically forms smooth grassy slopes below the Tongue River Member. Thickness 200 to 250 ft.

Tft **Tullock Member, Fort Union Formation (Paleocene)**—Yellowish-gray, fine- to medium-grained, ledge-forming sandstone, cross-bedded in part. Interbedded with gray to greenish-gray claystone, siltstone, and minor carbonaceous shale. Supports growths of pine trees. About 400 to 600 ft thick.

Khc **Hell Creek (Upper Cretaceous)**—Interbedded light-brownish-gray, cliff- and ledge-forming, fine-grained, thin- to thick-bedded sandstone, and gray, pale-greenish-gray and pale-purple-gray mudstones. Sandstone beds support growths of pine trees. Includes basal beds commonly mapped as Lennep Formation that are typical of basal Hell Creek to the east (personal communication, Susan Vuke and Edie Wilde, MBMG). Total thickness of the formation is about 900 to 1,100 ft.

Kdi **Diorite and diorite porphyry (Upper Cretaceous)—**Dark-gray to medium-gray fine-grained diorite and diorite porphyry, phenocrysts of plagioclase, hornblende, pyroxene, and locally biotite. Occurs as stocks in the Sliderock Mountain area and in the core of a dome in the southwest corner of the map area. Also occurs as dikes and smaller stocks of diorite porphyry and andesite porphyry and trachyandesite. In the area of Ellis Mountain includes xenoliths of rocks derived

from the Stillwater Complex. Radiometric age is 74-77 m.y. (du Bray and Harlan, 1993, and du Bray and others, 1994).

Klsr **Sliderock Mountain formation, informal, of Livingston Group (Upper Cretaceous)—** This unit includes all the volcanic rocks erupted from the Sliderock stratovolcano (du Bray and others, 1994). Mostly andesite breccia (lahars) gray, pale purple gray, pale greenish gray. Andesite in clasts is porphyritic with phenocrysts of chalky plagioclase, hornblende, and pyroxene; matrix is similar but lighter in color and slightly finer grained. Very resistant, forming cliffs and very rugged topography especially near the vent zone in Sliderock Mountain area. Near the vent zone, adjacent to stock of Kdi, this unit is intruded by innumerable dikes of andesite porphyry and diorite. In distal areas, as near town of Greycliff, clasts are less angular but otherwise similar to breccias elsewhere. Locally contains minor flows of porphyritic andesite and basaltic andesite, with phenocrysts of plagioclase, hornblende, and pyroxene. Thickness is at least 1,000 ft (du Bray and others, 1994).

Kb **Bearpaw Shale (Upper Cretaceous)**—Dark-gray shale, commonly weathering dark-brownish-gray, fissile, fossiliferous, brownish-gray calcareous concretions and nodules are common. Middle part of formation contains numerous thin, mostly greenish-gray bentonite beds, thin sandstone beds common near the top. The thickness is about 100 to 300 ft, thinning westward.

Kjr **Judith River Formation (Upper Cretaceous)**—Interbedded brownish-gray sandy shale and light-brown to pale-yellowish-brown, argillaceous, very-fine to fine-grained lenticular sandstone in beds up to 10 ft thick. A basal, massive cliff-

forming sandstone is commonly referred to as the Parkman Sandstone and resembles those in the Eagle Sandstone, Sandstones friable to moderately well indurated, cross-bedded, burrowed to bioturbated, and support growths of pine trees. Greenish-gray and pale-maroon-gray mudstones, poor-quality coal, and easily eroded sandstones occur near the top of the formation. The thickness ranges from 700 to 1000 ft

Kcl **Claggett Shale (Upper Cretaceous)**—Brownish-gray, fissile shale with minor interbeds of light-brownish-gray, very argillaceous sandstone. Light-brownish-gray to light-brown, calcareous concretions common, commonly fossiliferous. The upper contact is gradational and conformable, and is placed at the change to ledge-forming sandstones of the Judith River Formation. Thickness of the formation is 100 to 300 ft, thinning westward.

Ke **Eagle Sandstone (Upper Cretaceous)**—Light-brownish-gray to very-pale Orange, very fine to fine-grained, cross-bedded sandstone, burrowed to bioturbated in part. Locally contains calcareous, light-brown sandstone concretions up to 15 ft in diameter. Up to four sandstone intervals with interbedded shale. Thickness is about 150 ft.

Ktc **Telegraph Creek Formation (Upper Cretaceous)**—Shale and sandy shale, brownish-gray to medium-dark-gray with thin interbedded sandstone. Dusky-red concretions common near base. Sandstone beds thicker and more abundant upward, grading into Eagle Sandstone. Contact with Eagle is placed at the base of the first cliff-forming sandstone. Maximum thickness about 150 ft.

Kmg **Montana Group, undivided (Upper Cretaceous)—**Includes Bearpaw Shale, Judith River Formation, Claggett Shale, Eagle Sandstone, and Telegraph Creek Formation. Shown only in cross-section.

Kn **Niobrara Shale (Upper Cretaceous)**—Shale, olive-gray and dark-brownish-gray, fissile, and contains abundant thin bentonite beds. Upper half calcareous, containing few very thin bentonite beds, and near top contains thin beds of very calcareous, laminated sandstone, siltstone, and sandy limestone. Commonly contains medium-light-gray to pale-yellowish-brown concretions from few inches to 1 or 2 ft in diameter. *Inoceramus* prisms common. Upper contact placed at change from calcareous shales to non-calcareous shales of Telegraph Creek. Zone of dusky-red concretions in the Telegraph Creek, just above contact, also helps establish its position. Basal contact not exposed, thickness unknown.

Knbf **Niobrara through Belle Fourche Formations, undivided (Upper Cretaceous)**—Units mapped together where poorly exposed and where thermally metamorphosed in area of intrusive rocks. Mostly medium-gray to dark-gray shales, partly calcareous, occurring between the Telegraph Creek and Frontier Formations. On cross-section includes the Frontier Formation. Thickness approximately 1000 ft

Kf **Frontier Formation (Upper Cretaceous)**—Light-brownish-gray, fine-grained thick-bedded to massive, “salt and pepper” sandstone. Contains three sandstone intervals interbedded with dark-gray, fissile shale. Thickness about 350 ft

Kmfr **Mowry Shale through Fall River Sandstone, undivided (Upper Cretaceous)**—Mowry Shale is interbedded, siliceous, very fine- to fine-grained sandstone, siltstone, and shale. Contains several prominent bentonite beds. Sandstones and siltstones mostly light gray to medium gray, with a silvery sheen. Fish scales on bedding planes of sandstones and siltstones are characteristic of the formation. Thermopolis Shale is predominantly dark-gray, fissile shale, bentonitic shale, containing several beds of bentonite. Has hematitic concretionary zone near base. Fall River Sandstone is brownish-gray, thin-bedded, argillaceous, fine-grained, quartz sandstone. Generally poorly exposed in map area; mostly covered by glacial deposits. Total thickness is about 1,300 ft.

Kk **Kootenai Formation (Lower Cretaceous)**—Mostly reddish-brown, olive-gray, and dusky-purple mudstones with interbedded, lenticular, fine- to coarse-grained sandstones. Locally thick, lenticular, fluvial, fine-grained sandstone (Greybull Sandstone) is present at the top. The basal Pryor Conglomerate Member is brown conglomerate and pebbly coarse-grained sandstone, 20 to 60 ft thick. The total thickness of the Kootenai Formation is about 500 ft.

Jm **Morrison Formation (Upper Jurassic)**— Variegated, mainly greenish-gray and pale-reddish-brown mudstone. Very fine to fine-grained, quartzose, calcareous, cross-bedded sandstones are commonly present at about mid-section, 5 to 10 ft thick, but locally can be as much as 30 ft thick. Fossil dinosaur remains locally present. Upper contact placed at the base of the Pryor Conglomerate. The basal contact is placed at the top of fossiliferous, calcareous

sandstone and coquina of the underlying Swift Formation. Thickness is about 200 ft.

Je **Ellis Group, undivided (Middle and Upper Jurassic)**—Individual formations are not mapped separately; includes the Swift, Rierdon, and Piper Formations. The Swift is interbedded medium gray shale, limestone and calcareous sandstone, fossiliferous. Brownish-gray, fossiliferous, very sandy limestone occurs at the top of the formation, and commonly has brownish-gray coquina at the top. The Rierdon Formation is mostly pale-greenish-gray, very fossiliferous shale with minor interbedded, brownish-gray limestone. Typically poorly exposed, forming smooth slopes littered with fossils, including oysters (*Gryphaea and Ostrea),* belemnites (*Pachyteuthis),* and crinoids fragments (*Pentacrinus).* The Piper is interbedded medium-gray, and pale-reddish-gray, thin-bedded limestone and medium-gray shale. Includes thin interbedded gypsum. Forms ledge below smooth slopes of the Rierdon shales. Thickness of the Ellis Group is about 500 ft.

KJkme **Kootenai Formation, Morrison Formation and Ellis Group, undivided (Lower Cretaceous through Middle Jurassic)—**Shown only in cross-section.

TRC **Chugwater Formation (Lower Triassic)**—Interbedded moderate reddish-brown fine-grained sandstone, siltstone, and mudstone. Maximum thickness is about 100 ft, thinning westward to 0 near the west edge of the quadrangle.

PMpa **Phosphoria, Quadrant, and Amsden Formations, undivided (Permian, Pennsylvanian, and Upper Mississippian)—**Formations not mapped separately because of narrow outcrop width. Phosphoria is light-gray limestone,

sandstone and quartzite, commonly grayish-pink, cherty; thickness is 50 to 75 ft. The Tensleep Sandstone is light-brown to very-pale-orange sandstone, fine-grained, well sorted, well rounded, cross-bedded. Locally contains thin limestone beds, locally cherty near the top, and locally silicified to form quartzite; about 250 ft thick. The Amsden Formation is interbedded grayish-pink to light-red mudstone, limestone, and siltstone. Limestones are commonly cherty. Unconformably overlies karst surface developed on limestone of the Madison Group. Characteristically produces pink stain on underlying cliffs of Madison Group; thickness about 200 ft but locally, tectonically thinned to only a few ft along mountain front. Total thickness of lumped unit is about 500 ft

Mm **Madison Group, undivided (Middle Mississippian)**—Limestone and dolomitic limestone, light-gray to light-brownish-gray. Thick-bedded to massive in the upper part (Mission Canyon Limestone) and thin-bedded to thick-bedded in the lower part (Lodgepole Limestone). Also contains thin, interbedded, gray shales. Fossiliferous and cherty beds are present throughout. Collapse features and caves are common at the upper karst surface. Thickness of the Madison is 800 to 1,000 ft.

DOs **Sedimentary rocks, undivided (Upper Devonian and Ordovician)**—Jefferson Formation (Devonian): Dolomitic limestone, light brownish gray, fetid, poorly exposed, typically occurs as float. Three Forks Formation (Devonian): Mainly yellowish-weathering, argillaceous limestone and medium-gray shale, very poorly exposed. Big Horn Dolomite (Ordovician): Cliff-forming dolomite and dolomitic limestone, very light gray to very pale orange, lower part massive, thin to thick

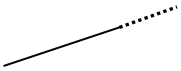
bedded in upper part. Has characteristic pock-marked surface due to differential weathering. Total thickness of unit is about 600 ft

Ꞓs **Cambrian sedimentary rocks, undivided (Middle and Upper Cambrian)**—Light-reddish sandstone and quartzite, greenish-gray shale and sandy shale, gray thin-bedded limestone and greenish-gray flat-pebble limestone conglomerate. Includes the Flathead, Wolsey, Meagher, Park, and Pilgrim Formations. Thickness is 600 to 800 ft.

Asw **Stillwater Complex, undivided (Archean)**—Shown only in cross section. Layered ultramafic and mafic rocks from peridotites and pyroxenites at the base (ultramafic series) to gabbros and anorthosite in the upper part (banded series). Maximum exposed thickness in Beartooth Mountains is about 22,000 ft Shown only in cross-section; presence in the subsurface predicted by geophysical data (Kleinkopf, 1985) and by xenoliths in the Lodgepole intrusive (Brozdowski, 1983) and previously unreported xenoliths in the Sliderock Mountain area.

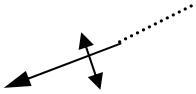
Agn **Granitic gneiss, schist and other metamorphic rocks, undivided (Archean)**—Shown only in cross-section.

MAP SYMBOLS



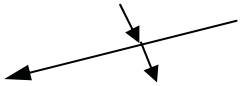
Contact--Dotted where concealed.

Fault--Dashed where approximately located, dotted where concealed, queried where uncertain. Bar and ball on down-thrown side.



Anticline--Showing trace of axial plane and direction of plunge; dotted where concealed.

Syncline--Showing trace of axial plane and direction of plunge; dashed where approximately located, dotted where concealed.



Monocline--Showing trace of axial plane.

Dikes

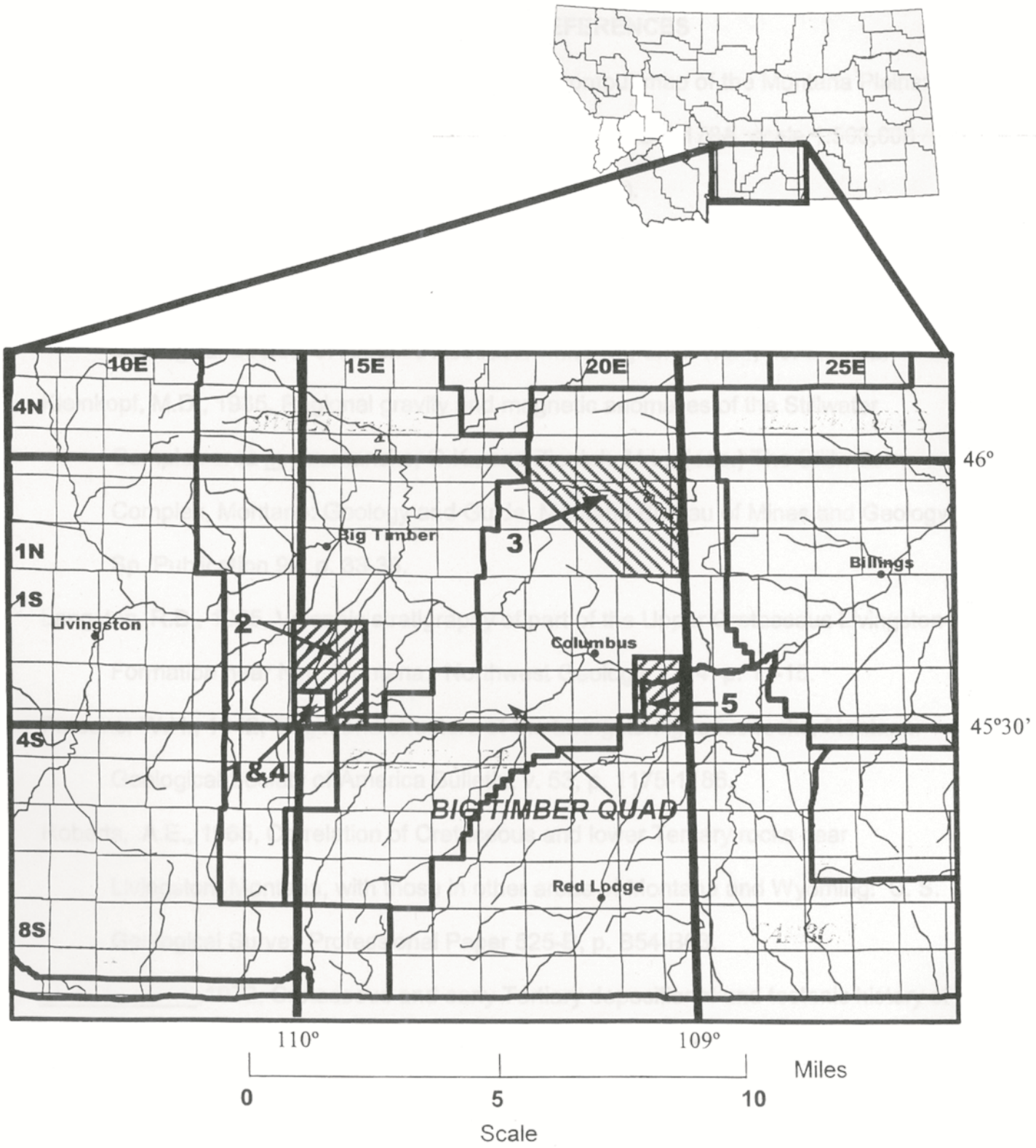
Strike and Dip of Beds

Overturned Beds

SOURCES OF GEOLOGIC MAPPING

(see index map for locations of maps)

1. Brozdowski, R.A., 1983, Geologic setting and xenoliths of the Lodgepole intrusive area: implications for the northern extent of the Stillwater Complex, Montana: Philadelphia, Pa., Temple University, M.A. thesis, 203 p; plate 1, scale 1:24,000.
2. Du Bray, E.A., Elliott, J.E., Van Gosen, B.S., LaRock, E.J., and West, A.W., 1994, Reconnaissance geologic map of the Sliderock Mountain area, Sweet Grass and Stillwater Counties, Montana: U.S. Geological Survey Miscellaneous Field Studies Map MF-2259, scale 1:50,000.
3. Hancock, E.T., 1919, Geology and oil and gas prospects of the Lake Basin Field, Montana: U.S. Geological Survey Bulletin 691, p.101-147; plate 16, scale 1:125,000.
4. Vhay, J.S., 1934, The geology of part of the Beartooth Mountain front near, Nye, Montana: Princeton, N.J., Princeton University, Ph.D. thesis 111 p.; plate 1 scale 1:31,680.
5. Wanek, A. A., 1963, Geologic map of the Rapids Quadrangle, Carbon and Stillwater Counties, Montana: U. S. Geological Survey Mineral Investigations Field Studies Map MF-270, scale 1:24,000.



Index Map of Big Timber Quadrangle
and Sources of Geologic Mapping

OTHER GEOLOGIC REFERENCES

Dobbin, C.E., and Erdman, C.E., 1955, Structure contour map of the Montana Plains: U.S.Geological Survey Oil and Gas Investigations OM-178A, scale 1:500,000 (used for location of trace of Reed Point Syncline).

Du Bray, E.A., and Harlan, S.S., 1993, Geology and preliminary $^{40}Ar/^{39}Ar$ geochronology of the Sliderock Mountain volcano, south-central Montana: Geological Society of America Abstracts with Programs, v. 25, no. 5, p. 32.

Kleinkopf, M.D., 1985, Regional gravity and magnetic anomalies of the Stillwater Complex area *in* Czamanske, G.K., and Zientek, M.L., (eds.) The Stillwater Complex, Montana: Geology and Guide, Montana Bureau of Mines and Geology Sp. Publication 92, p. 33-38.

Langston, R.B., 1985, Volcanic stratigraphy of part of the Upper Cretaceous Livingston Formation near Nye, Montana: Northwest Geology, v. 14, p. 11-15.

Parsons, W.H., 1942, Origin and structure of the Livingston igneous rocks, Montana: Geological Society of America Bulletin, v. 53, p. 1175-1186.

Roberts, A.E., 1965, Correlation of Cretaceous and lower Tertiary rocks near Livingston, Montana, with those in other areas of Montana and Wyoming: U. S. Geological Survey Professional Paper 525-B, p. B54-B63.

_____,1972, Cretaceous and early Tertiary depositional and tectonic history of the Livingston area, Montana: U. S. Geological Survey Professional Paper 526-C, 120 p.

Rouse, J.T., Hess, H.H., Foote, Freeman, Vhay, J.S., and Wilson, K.P., 1937, Petrology, structure, and relation to tectonics of porphyry intrusions in the Beartooth Mountains, Montana: Journal of Geology, v. 45, no. 7, p. 717-740.

Weed, W.H., 1893, The Laramie and the overlying Livingston Formation in Montana: U.S. Geological Survey Bulletin 105, 68 p.