PRELIMINARY GEOLOGIC MAP OF THE RED LODGE 30' x 60' QUADRANGLE SOUTH-CENTRAL MONTANA

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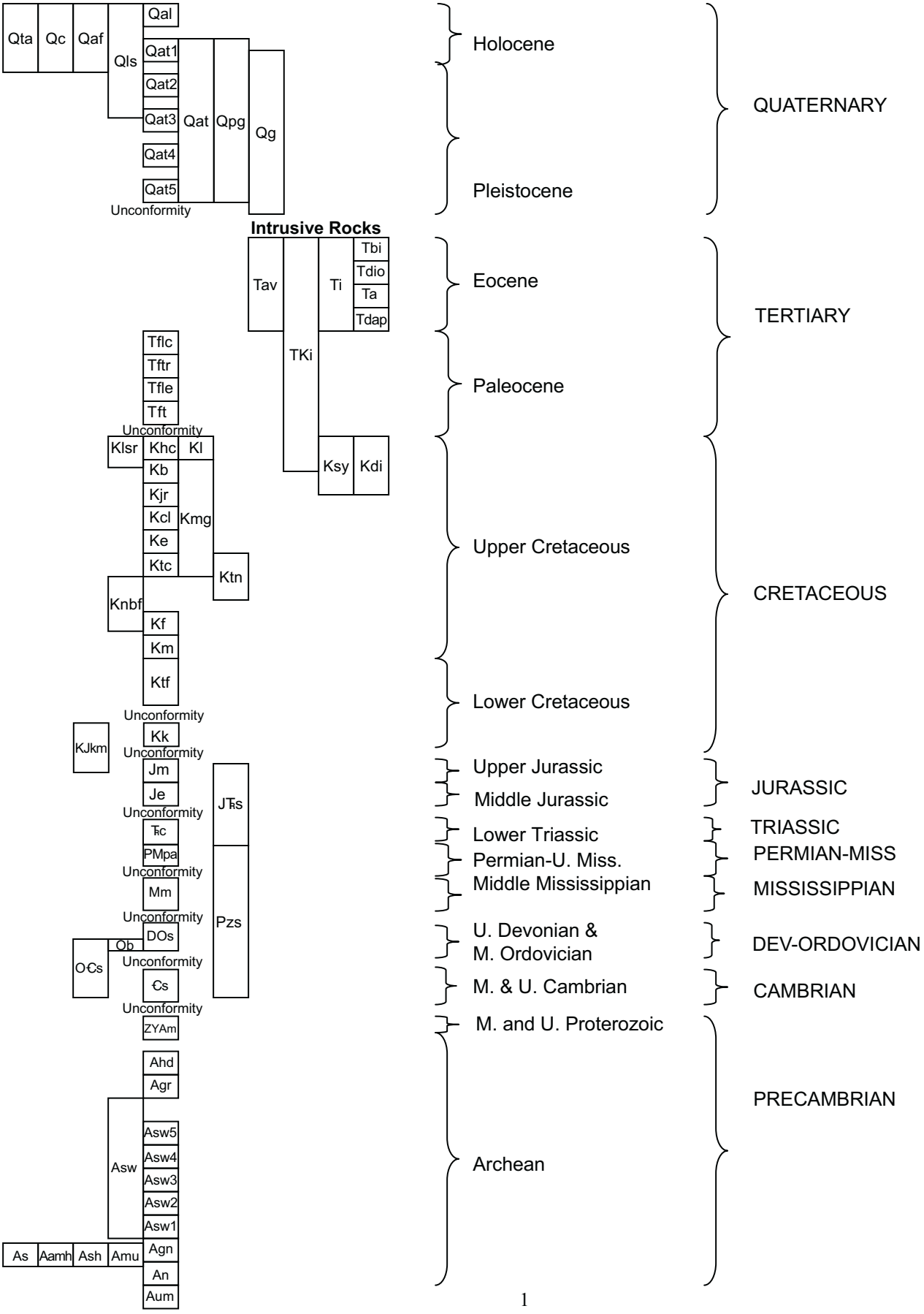
CORRELATION OF MAP UNITS - RED LODGE QUADRANGLE



GEOLOGIC MAP OF THE RED LODGE 30' x 60' QUADRANGLE
DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

af **Artificial fill—**Shown only in dam area of Cooney Reservoir.

Qal **Alluvium (Holocene)**—Gravel, sand, silt, and clay along active stream channels.

Qpg **Pediment gravel deposits (Holocene and Pleistocene?)**—Angular and Subangular, coarse gravel derived from local bedrock; gravel deposits occur beneath smooth, concave-upward, pediment surfaces sloping away from the Beartooth Mountains. About 10 (3 m) to about 30 ft (9 m) thick.

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 (9 m). Commonly grades into Qal. Locally contains well-rounded cobbles derived from alluvial terrace gravel. May also contain glacial lake deposits behind end moraines.

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 (15 m) at head of fans.

Qta **Talus (Holocene and Pleistocene)—**Angular blocks and clasts of bedrock that accumulate below cliffs and steep slopes along the mountain front.

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 below resistant rocks but can occur where steep slopes and moisture content produce unstable conditions. Large landslides are common in glacial moraines along the mountain front.

Qg **Glacial deposits, undivided (Holocene and Pleistocene)**—Unsorted clay- to boulder-size material transported and deposited by glaciers. Characteristic hummocky surface form. Occur in valleys along the mountain front. 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 about 600 ft (6-185 m) above present altitude of modern streams and rivers. Equivalent to Qat1-Qat5.

Qat1 **Alluvial gravel, terrace level 1 (Holocene)**—Gravel underlying terraces 10 to 20 ft (3-6 m) 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. Ten to 40 ft (3-12 m) thick.

Qat2 **Alluvial gravel, terrace level 2 (Pleistocene)**—Gravel underlying terraces 20 to 40 ft (6-12 m) above Qal. Mostly cobbles and pebbles with minor amounts of sand and silt. Clasts mainly granitic igneous rocks, granitic gneiss, schist, and quartzite, with much less limestone and sandstone. Ten to 40 ft (3-12 m) thick.

Qat3 **Alluvial gravel, terrace level 3 (Pleistocene)**—Gravel underlying terraces 50 to 90 ft (15-27 m) 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. Ten to 30 ft (3-9 m) thick.

Qat4 **Alluvial gravel, terrace level 4 (Pleistocene)**—Gravel underlying terraces 200 to 300 ft (60-90 m) above present altitude of rivers. Cobble- and pebble-size clasts are mainly granite, granitic gneiss, schist, and quartzite. Thickness as much as 20 ft (6 m).

Qat5 **Alluvial gravel, terrace level 5 (Pleistocene)**—Gravel underlying terraces 400 to 600 ft (120-185 m) 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 from a very thin remnant to about 20 ft (6 m).

BEDROCK MAP UNITS

Ti **Intermediate and felsic rocks (Eocene)**—Dikes, sills, and irregular-shaped bodies. Andesite, quartz latite, dacite, and rhyolite; commonly porphyritic (Van Gosen and others, 2000).

Tbi **Breccia pipes, intrusive and/or collapse (Eocene)**—In the Homestake Mine and Alice E Mine areas, north of Cooke City, composed of clasts of Cambrian sedimentary rocks, Precambrian rocks, altered porphyritic intrusive rocks, and volcanic rocks, and intruded by younger dikes of rhyolite and quartz latite. In the Fisher Mountain area (about 2.8 miles north of Cooke City), composed of aphanitic and fine grained porphyritic dacite, rhyolite, quartz latite and felsite breccia; intruded by quartz-rich dacite and porphyritic and aphanitic dikes, and strongly hydrothermally altered (Van Gosen and others, 2000).

Tdap **Dacite porphyry (Eocene)—**Laccoliths, stocks, dikes, and sills in the Lulu Pass and Homestake Mine areas north of Cooke City (Van Gosen and others, 2000).

Tdio **Diorite (Eocene)**—Stock and irregular-shaped intrusive bodies at Scotch Bonnet Mountain, about 3.3 miles north of Cooke City (Van Gosen and others, 2000).

Ta **Andesite and trachyandesite porphyry (Eocene)**—Sills in the Cooke City area (Van Gosen and others, 2000).

Tav **Absaroka Volcanics Supergroup, undivided (Eocene)**— Basaltic, andesitic, and dacitic flows and flow breccias; rhyolitic ash-flow tuff and vitrophyre, tuff breccias, lahars, agglomerates, agglutinates, conglomerate, and minor andesitic and dacitic intrusive bodies (Van Gosen and others, 2000).

Tflc **Linley Conglomerate, Fort Union Formation (Paleocene?)**—
Unit named by Calvert (1916) after exposures near the community of Linley (Linley no longer exists but was about 1 mile east-southeast of Luther). These rocks occur along the northern mountain front of the Beartooth Uplift (Calvert, 1916; Jobling, 1974; DeCelles and others, 1991) and are considered to be Laramide synorogenic deposits. Similar rocks occur along the eastern front of the Beartooth Uplift (Laramide synorogenic deposits of Flueckinger, 1970, and Beartooth Conglomerate of DeCelles and others, 1991), and are included here with the Linley Conglomerate. Unconformably overlies the Tongue River Member of the Fort Union Formation, but also overlies an erosional unconformity cut into Upper Cretaceous rocks just south of the map area in Wyoming (DeCelles and others, 1991). The unit consists of mainly reddish brown to gray-brown, interbedded conglomerate, coarse-grained sandstone, siltstone, and mudstone; the coarsest facies being generally near the mountain front. Conglomerate cobbles are mostly less than 6 inches in diameter and composed mainly of limestone, andesite porphyry, black chert, metamorphic rocks, and granitic rocks. Paleontologic data indicate the deposits are Paleocene (Flueckinger, 1970; Jobling, 1974; DeCelles and others, 1991). Changes in clast composition in the conglomerates record the unroofing of the Beartooth Uplift, that is, clasts of younger stratigraphic units generally occur near the base and clasts of older rocks occur higher in the section (Flueckinger, 1970; Jobling, 1974; DeCelles and others, 1991). Thickness is about 600 ft (185 m) along the north front (Jobling, 1974). Flueckinger (1970) reports a total thickness of the section along the east front, including exposures in Wyoming, of about 4,200 ft (1,280 m), but exposures on the Red Lodge sheet appear to be about 2,000 ft (610 m) thick. DeCelles and others (1991) report a thickness of more than 2,300 ft (700 m).

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 coal beds. Sandstones ledge forming, commonly support growths of pine trees. Thickness is variable but is as much as 2,800 ft (850 m) (Rawlins, 1986).

Tfle **Lebo Member, Fort Union Formation (Paleocene)**—Predominantly dark-gray to olive shale, and thin, interbedded, yellowish-gray sandstones and siltstone, locally includes yellowish-gray claystone. Typically forms smooth grassy slopes below the Tongue River Member. Thickness 200 to 500 ft (60-150 m).

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. Thickness is variable; from about 400 ft (120 m) to as much as 1,500 ft (460 m) in the Bear Creek area (Rawlins, 1986).

TKi **Intermediate and felsic intrusive rocks (Tertiary or Late Cretaceous)**—Laccoliths, plugs, dikes, sills and irregular-shaped bodies of fine-grained and porphyritic rhyolite, dacite, quartz latite, andesite, and diorite (Van Gosen and others, 2000).

Khc **Hell Creek Formation (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 Edith Wilde, MBMG). Total thickness of the formation is 900 to 1,100 ft (275-335 m).

Kl **Lance Formation (Upper Cretaceous)**—Interbedded light-brownish-gray, cliff- and ledge-forming, fine-grained, thick-bedded to massive sandstone, and medium-gray, fissile shale. Sandstone beds are much thicker and more continuous than sandstone beds in the Hell Creek. Sandstone beds support growths of pine trees. Occurs only in the southeast part of the quadrangle, interfingers and changes facies into Hell Creek lithologies in the Joliet area; Lance is used on the map south of Rock Creek and Hell Creek is used to the north. Total thickness of the formation is about 350 ft (105 m).

Ksy **Syenite (Upper Cretaceous)—**Multiple phases of syenite and monzonite of variable grain sizes and textures, locally altered and mineralized, occurs in a stock near Goose Lake about 7 miles northeast of Cooke City (Van Gosen and others, 2000).

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 (Big Timber 30'X 60' quadrangle, Lopez, 2000) and in the cores of domes in the northwest corner of the map area. Also occurs as dikes and smaller stocks of diorite porphyry and andesite porphyry and trachyandesite. In the Lodgepole intrusive (Brozdowski, 1983), and in the Ellis Mountain area (on the Big Timber quadrangle, Lopez, 2000) includes xenoliths of

rocks derived from the Stillwater Complex. Radiometric age is 74-77 ma (du Bray and Harlan, 1993; du Bray and others, 1994).

Klsr **Sliderock Mountain formation, informal, of Livingston Group (Upper Cretaceous)**—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 in the northwest part of the quadrangle, which is near the vent zone in Sliderock Mountain area (on Big Timber 30'X 60' quadrangle, Lopez, 2000). In distal areas, as near town of Fishtail, contains interbeds of andesitic conglomerate and coarse-grained sandstone, and clasts are less angular. Locally contains minor flows of porphyritic andesite and basaltic andesite, with phenocrysts of plagioclase, hornblende, and pyroxene. Thickness is at least 1,000 ft (305 m) (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 100 to 300 ft (30-90 m), 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 as much as 10 ft (3 m) 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 from 700 to 1,000 ft (215-305 m).

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 overlying Judith River Formation. Thickness of the formation is 100 to 300 ft (30-90 m), decreasing 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 as much as 15 ft (5 m) in diameter. Usually two or more sandstone intervals with interbedded shale. Contains at least one coal bed west of the town

of Bridger, about 4 miles east of the quandrangle, and north of Nye. Thickness is about 150 ft (45 m).

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 (45 m).

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

Ktn **Telegraph Creek and Niobrara Formations, undivided (Upper Cretaceous)**

Knbf **Niobrara through Belle Fourche Formations, undivided (Upper Cretaceous)**—Lumped unit used on cross-section where it includes the Frontier Formation. Mostly medium-gray to dark-gray shales, partly calcareous, occurring between the Telegraph Creek and Mowry Shale. Thickness is approximately 1,000 ft (305 m).

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. Full interval not exposed on the Red Lodge quadrangle. Total thickness about 350 ft (106 m) on the Livingston quadrangle to the west (Berg and others, 2000).

Km **Mowry Shale (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. Thickness about 300 ft (90 m).

Ktf **Thermopolis Shale and Fall River Sandstone, undivided (Lower Cretaceous)**— 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. About 1,000 ft (305 m) thick.

Ktk **Thermopolis, Fall River, and Kootenai Formations, undivided**

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 to gray conglomerate and pebbly coarse-grained sandstone, 20 to 60 ft (6-18 m) thick. Thickness of the Kootenai Formation is about 500 ft (150 m).

KJkm Kootenai and Morrison Formations, undivided (Lower Cretaceous and Upper Jurassic)

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 (1-3 m) thick, but locally can be as much as 30 ft (9 m) 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 (60 m).

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 crinoid 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 (46 m).

TRc **Chugwater Formation (Lower Triassic)**—Interbedded moderate reddish-brown fine-grained sandstone, siltstone, and mudstone. Maximum thickness is about 100 ft (30 m), thinning westward to 0 near the west edge of the quadrangle.

JTRs **Sedimentary rocks, undivided (Jurassic and Triassic)**—Includes Morrison Formation, Ellis Group, and Chugwater Formation.

Pz s **Paleozoic sedimentary rocks, undivided (Permian through Cambrian).**

PMpa Phosphoria, Tensleep, 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 (15-23 m). 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 (75 m) 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 (60 m) but locally, tectonically thinned

to only a few ft along mountain front. Total thickness of lumped unit is about 500 ft (150 m).

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 (240-305 m).

DOs **Sedimentary rocks, undivided (Upper Devonian and Ordovician)**— Includes Jefferson and Three Forks Formations, and Big Horn Dolomite. The Jefferson is dolomitic limestone, light brownish gray, fetid, poorly exposed, typically occurs as float. The Three Forks is mainly yellowish-weathering, argillaceous limestone and medium-gray shale, very poorly exposed. The Big Horn Dolomite is 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 this interval is about 600 ft (185 m).

OЄs **Sedimentary rocks, undivided (Ordovician and Cambrian)**

Ob **Bighorn Dolomite (Middle 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. Thickness about 400 ft (120 m).

Єs **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 (180-245 m).

ZYAm **Mafic dikes and sills (Middle and Late Proterozoic, and Archean)—**Includes dikes, sills, stocks, and irregular-shaped bodies of alkali-olivine dolerite, metadolerite, metagabbro, and quartz dolerite (Van Gosen and others, 2000). Ages of dikes are in three sets: 2.5-2.8 b.y., about 1.37 b.y., and about 740 ma (Muller and others, 1985).

Ahd **Hornblende quartz diorite (Archean)**—Small bodies associated with quartz monzonite (Agr) south of the Stillwater Complex (Van Gosen and others, 2000).

Agr **Granitic intrusive rocks (Archean)**—Stocks and irregular bodies of fine-, medium-, and coarse-grained quartz monzonite and aplite south of the eastern exposures of the Stillwater Complex. Occur in intrusive contact with the Stillwater complex (Van Gosen and others, 2000).

Asw Stillwater Complex, undivided (Archean)—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 (6,700 m). Only units 1-5 are exposed on Red Lodge quadrangle.

Asw5 Lower Mixed, Middle Gabbro, and Middle Mixed Zones (Archean)

Asw4 Lower Anorthosite Zone (Archean)

Asw3 Norite and Lower Gabbro Zones (Archean)

Asw2 Bronzitite Zone (Archean)

Asw1 Peridotite Zone (Archean)

Agn Gneissic rocks (Archean)–-Predominantly granitic gneiss and migmatite; commonly consists of alternating bands of more felsic and more mafic gneiss; contains inclusions of metasedimentary rocks (granitic gneiss of Van Gosen and others, 2000).

An Metanorite and metagabbro (Archean)—Stock-like mass composed of metanorite and metagabbro. Occurs in southeastern part of map area (Van Gosen and others, 2000).

Aum Ultramafic rocks, undivided (Archean)—Irregular-shaped bodies and lenses of olivine-bearing rocks and serpentinite in the southeast part of the map area (Van Gosen and others, 2000).

As Biotite schist (Archean)–-Biotite schist that includes minor quartzite, iron formation and amphibolite (Van Gosen and others, 2000).

Aamh Amphibolite and hornblende gneiss (Archean)–-Mostly tabular and lenticular bodies enclosed in granitic gneiss and migmatite (Van Gosen and others, 2000).

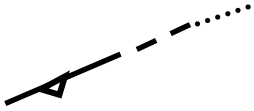
Ash Schist and hornfels (Archean)—Metasedimentary rocks consisting predominantly of schist and hornfels and minor quartzite, amphibolite, and iron-formation; contact metamorphosed to hornblende-hornfels and pyroxene hornfels facies at and near the base of the Stillwater Complex (Van Gosen and others, 2000).

Amt Metamorphic rocks, undivided (Archean)—Amphibolite, micaceous quartzite, and gneiss. Also includes some small bodies of chromite-bearing serpentinite. Occurs only in southeastern part of map area (Van Gosen and others, 2000).

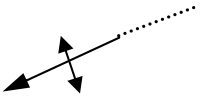
MAP SYMBOLS

Contact—Dotted where concealed.

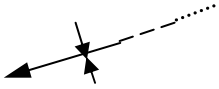
Fault—Dashed where approximately located, dotted where concealed, queried where uncertain. Bar and ball on down-thrown side.



Reverse Fault—Dashed where approximately located, dotted where concealed. Teeth on upper plate or upthrown block.



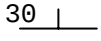
Anticline—Showing trace of axial plane and direction of plunge; dotted where concealed.



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

Detachment Fault—Trace of surface of tectonic denudation of Heart Mountain detachment, present only in the southwest corner of the quadrangle; teeth indicate upper or over-riding plate.

Dike
(red)



Strike and Dip of Beds

Overturned Beds

SOURCES OF GEOLOGIC MAPPING

(see index map on p.14 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. Calvert, W. R., 1916, Geology of the upper Stillwater basin, Stillwater and Carbon Counties, Montana: U. S. Geological Survey Bulletin 641-G, p. 199-214; plate 1, scale 1:145,000.

3. duBray, 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.

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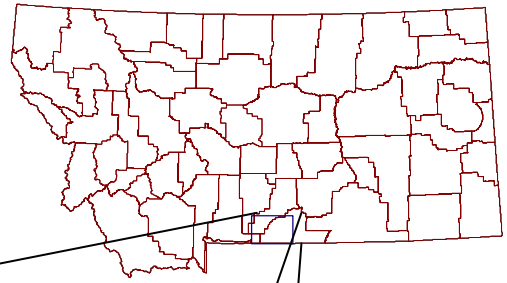
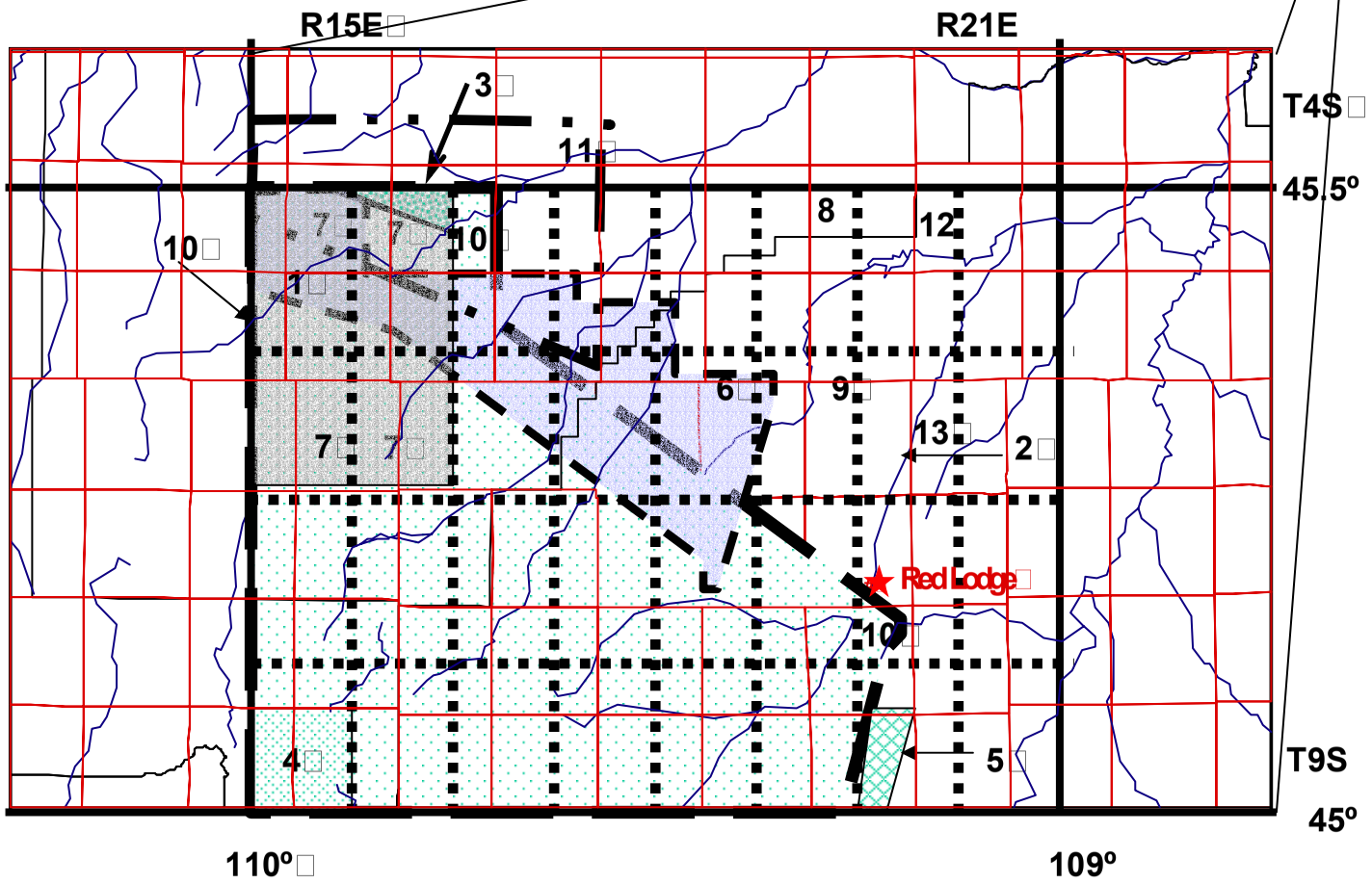
Index map showing sources of geologic mapping in the Red Lodge 30' X 60' Quadrangle. Index numbers correspond to numbers in list of references that follows.





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