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GEOLOGIC MAP OF THE ENNIS 30′ × 60′ QUADRANGLE, MADISON AND GALLATIN COUNTIES, MONTANA, AND PARK COUNTY, WYOMING

By
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DESCRIPTION OF MAP UNITS

Qal **Alluvium (Holocene)—**Unconsolidated silt- to boulder-size, moderately sorted to well-sorted sediments in modern flood plains, including overbank deposits. Larger clasts are moderately rounded to well rounded. Maximum thickness greater than 5 m

Qs **Swamp deposits (Holocene)—**Black to dark-brown, organic-rich clay, silt, and sand in grassy or willow-covered, flat outcops. Mostly represents eutrophication of shallow lakes

Qcl **Colluvium and loess (Holocene and upper Pleistocene)—**Unconsolidated to slightly indurated, mostly massive, dark-brown to light-gray-brown deposits that mantle gently to moderately sloping surfaces; sediment types are intermixed by downslope movement. Colluvium contains cobbles and pebbles derived from weathering of bedrock; loess is very fine grained sand, silt, and minor clay. Commonly contains poorly to moderately developed soil profile in upper part. Includes alluvium in small channels and sheetwash on steeper hillsides. Some small areas (as in Tobacco Root Mountains) underlain by till in valleys above about 2,000 m elevation. Unmapped in many areas, particularly where deposit is thin and forms discontinuous veneer. Maximum thickness probably less than 10 m

Qt **Talus deposits (Holocene and upper Pleistocene?)—**Angular and subangular cobbles and boulders at base of steep valley walls or cliffs. Boulders generally as large as 2 m, although in places as large as 10 m. Locally includes minor alluvial deposits and rock-glacier deposits. Maximum thickness greater than 20 m

Ql **Landslide deposits (Holocene and upper Pleistocene)—**Ranges from chaotically oriented debris to almost intact slump blocks of bedrock. About 10 m to greater than 50 m thick

Qr **Rock glacier deposits (Holocene and upper Pleistocene?)—**Hummocky, lobate deposits of angular boulders having a frontal slope near the angle of repose; locally active. In places, grade into and include some talus deposits (unit Qt). About 20 m thick

Qf **Fan deposits (Holocene and upper Pleistocene)—**Moderately well sorted pebble- to boulder-size gravel in fan-shaped deposits at base of mountain fronts. Includes piedmont-slope deposits and debris-flow deposits

Qfc **Fan deposits of the Cedar Creek alluvial fan (Holocene and upper Pleistocene)—**Moderately well sorted cobble and boulder gravel that forms a prominent alluvial fan at mouth of Cedar Creek in Madison Valley. Clasts rounded to sub-rounded. Surface is characterized by braided stream pattern. Locally mantled by loess less than 1 m thick. Fan formed mainly during Pinedale (about 20–14 ka) and Bull Lake (about 140–100 ka) glaciations; deposits of both ages exposed at surface (Ritter and others, 1990); minor proximal fan development during Holocene. Modern channel of Cedar Creek incised about 10 m into fan deposits near mouth of creek, indicating that proximal fan deposits are presently eroding. As much as 150 m thick. Unit shown separately from other fan deposits due to its prominent size and detailed studies (Ritter and others, 1990)

Qti **Till (upper Pleistocene)—**Unsorted, unstratified, unconsolidated, subangular to subrounded boulders in an unsorted matrix as fine as silt. Most till deposited during Pinedale (about 20–14 ka) and Bull Lake (about 140–100 ka) glaciations. Pinedale-age till preserved in hummocky deposits that contain numerous closed depressions and have a thin or non-existent soil profile; deposits of Bull Lake–age till have more rounded topography, are more dissected, and generally exhibit a well-developed soil profile. As much as about 50 m thick

Qd **Diamicton (upper? Pleistocene)—**Unsorted, unstratified, non-consolidated deposit composed of angular to subangular clasts of Archean gneiss as large as 2 m across. Believed to be mostly debris-flow deposits, but may include some till and landslide deposits. Mapped only in Jack Creek area. Maximum thickness greater than 20 m

Qg **Terrace-gravel deposits (upper Pleistocene)—**Moderately sorted, moderately rounded to well-rounded sand and gravel. Underlies about 12 recognized terrace surfaces in Madison Valley. Bearzi (1987) recognized 11 geomorphic surfaces along Jack Creek. In Madison Valley, east of Madison River, includes all but the highest (and oldest) terrace-gravel deposit, which is shown separately (unit Qgc). Man-tled by less than 2 m of loess at most places, although loess on many higher surfaces is thick enough to support cultivation. Mostly less than 10 m thick

Qgc **Terrace-gravel deposits of the Cameron bench (Pleistocene)—**Moderately sorted, moderately rounded to well-rounded sand and gravel underlying topographically highest (and oldest) terrace deposits in Madison Valley. Formed during Bull Lake glaciation (about 140–100 ka) (Schneider and Ritter, 1987). Mantled by less than 2 m of loess in most places

QTbf **Basin-fill deposit (Pleistocene and Pliocene?)—**Interbedded, moderately sorted, poorly consolidated to unconsolidated, well-bedded to massive silt, sand, and well-rounded cobbles that are exposed in slopes adjacent to, and below, terraces in Madison Valley. Exposed basin-fill deposits are interpreted to be no older than Pliocene, although they overlie buried basin-fill deposits, as thick as 4,500 m, that may be as old as Eocene in the Madison Valley (Rasmussen and Fields, 1983)

Tht **Huckleberry Ridge Tuff (Pliocene)—**Light-brown to gray, massive welded tuff that contains sparse phenocrysts of sanidine, quartz, and plagioclase. Matrix is mostly devitrified glass shards, opaque minerals, and aphanitic minerals. Contains sparse pumice fragments. Lithophysae and vesicles not observed in quadrangle. Forms prominent cap to many ridges and buttes. Age of unit is 2.0 Ma, and source is from Yellowstone caldera (Christiansen and Blank, 1972), the northern edge of which is about 30 km south of quadrangle's southeastern corner. Thickness increases to south, and maximum thickness in quadrangle is about 50 m

Tls **Old landslide deposits (Pliocene and Miocene)—**Mapped at several localities in northern Madison River Valley where significant erosion and dissection has transpired since landslide events (Kellogg, 1992, 1993b)

Ts **Limestone, sandstone, conglomerate, and ash deposits (Miocene?)—**White, light gray, and light-brownish-gray, moderately indurated to well-indurated, locally vuggy limestone, limy sandstone, ash-bearing sandstone, pebbly sandstone, and pebble conglomerate. Interlayered ash deposits are common, especially in association with limestone. Limestone may be either lacustrine deposits or carbonate paleosols (Hanneman and others, 1991). Mapped along Madison River, east of Ennis Lake, and in Spanish Creek basin. One maximum $^{40}Ar/^{39}Ar$ age on sanidine from just east of Ennis Lake in Madison Valley (NE¼, Sec. 6, T. 5 S, R. 1 E.), is 16.2±0.19 Ma (K.K. Kellogg and S.S. Harlan, unpub. data, 1990). Deposits in Spanish Creek basin are undated, but probably Miocene. Maximum thickness greater than 1,000 m

Tl **Freshwater limestone (Miocene)—**Light-brownish-gray to yellowish-gray, locally vuggy, well-bedded, fine-grained limestone. Similar to thin limestone beds associated with ash-bearing sediments in unit Ts, although much thicker, so is considered to be Miocene in age; maximum thickness greater than 20 m. Mapped along west side of Madison Valley (Hadley, 1969a,b)

Volcanic rocks of Virginia City volcanic field (Oligocene and Eocene)

Tvd **Diatreme (Oligocene?)—**Probably basaltic, contains fragments of clay and basalt (Wier, 1982). Intrudes both volcanic rocks and Archean gneiss. One oval outcrop mapped, about 200 m in diameter, just south of Virginia City

Tvv **Andesite and basalt flows (Oligocene and Eocene)—**Mostly dense to scoriaceous basalt and andesite flows, volcanic agglomerates, sandy tuff, and interbedded basaltic cinder deposits. Flows are black and dark brown and contain small phenocrysts of calcic plagioclase, olivine, augite, opaque minerals, and, in places, potassium feldspar and biotite (Hadley, 1980). At least one silicic (latitic?) plagioclase-pyrric flow occurs near base of unit, 4 km southeast of Virginia City. Three localities gave the following potassium-argon (K-Ar) dates: (1) 49.3±2.5 and 51.1±1.9 Ma (biotite) and 51.0±3.8 Ma (plagioclase); this flow is just north of Virginia City and overlies Archean basement; (2) 34.4±3.0 Ma (whole rock); and (3) 32.7±1.4 Ma (whole rock) (Marvin and others, 1974). Unit greater than 200 m thick

Tvr **Rhyolite flows (Oligocene or Eocene)—**Dark-gray to black aphanitic rhyolite flows north and northwest of Ennis Lake (Kellogg, 1993b; Vitaliano and Cordua, 1979). Cut by many faults; local steep dips. Correlated with volcanic rocks of Virginia City volcanic field

Tvt **Felsic tuff (Eocene)—**Pale-gray to white rhyolitic air-fall ash, tuffaceous sandstone, and sparse gravel lenses. Poorly exposed in most places and occurs locally at base of sequence of volcanic rocks of Virginia City volcanic field. Large areas mapped by Hadley (1969b) as felsic tuff are underlain mostly by chaotic, locally tuffaceous landslide deposits. Thickness as great as about 40 m

Tg **Volcaniclastic sandstone and gravel deposits (Eocene)—**Coarse-grained, well-bedded, cross-bedded volcaniclastic sandstone, pebbly sandstone, and pebble and cobble conglomerate that in places underlie the rocks of the Virginia City volcanic field (Hadley, 1969b, 1980)

Volcanic rocks of undetermined affinity (Oligocene and (or) Eocene)

Tv **Andesite and basalt flows—**In Madison Valley in southern part of quadrangle (Hadley, 1969b); may be outlier of volcanic rocks of Virginia City volcanic field

Ti **Dacite porphyry sills and stocks (Eocene)—**Light- to medium-gray and brownish-gray, dense, porphyritic dacite. Phenocrysts are euhedral plagioclase, hornblende, and biotite. Petrographically very similar to dacite porphyry of Fan and Lone Mountains, but at least some stocks intrudes Eocene volcanic rocks; other nearby rocks of similar composition intrude Cambrian strata and Archean gneiss. One potassium-argon biotite date of 49.5±1.5 Ma (Chadwick, 1969)

Absaroka Volcanic Supergroup (Eocene)

Tai **Intrusive rocks—**Dark-gray, very fine grained basalt or andesite intrusive breccia containing sparse, small phenocrysts of plagioclase. Forms two small necks in upper Porcupine Creek, east of Gallatin River Valley. Intrudes Eocene volcanic rocks and Archean gneiss. Not included in Absaroka Volcanic Supergroup by Simons and others (1985), but unit probably formed feeder vents for younger rocks of Supergroup

Tam **Mt. Wallace Formation—**Shown where proportion of mostly andesitic and basaltic flows predominate over volcaniclastic rocks, as mapped by the U.S. Geological Survey (1972). Compositions similar to those in Sepulcher Formation, described below. Conformably overlies rocks of Sepulcher Formation

Tas **Sepulcher Formation—**Mafic and intermediate-composition volcaniclastic rocks, flow breccias, and lava flows. Contains sparse beds of light-reddish-brown welded tuffs. Includes Fortress Mountain and Daly Creek Members (Smedes and Prostka, 1972), and Hyalite Peak Volcanics (Chadwick, 1969; Hiza, 1994). Most of unit composed of dark-grayish-brown, laharic breccias, volcaniclastic conglomerate, and light- to medium-gray volcaniclastic sandstone. Both laharic deposits (vent facies) and conglomeratic deposits (alluvial facies) are greater than 100 m thick in places, crudely stratified, and well indurated. Laharic deposits composed of unsorted, angular to subrounded volcanic debris containing clasts as large as 3 m across. Both lahars and conglomerates contain much silicified wood, commonly as large trunks as thick as 3 m, in growth positions.

Lavas are mostly medium-gray to dark-gray, fine-grained to sparsely porphyritic pyroxene or olivine-pyroxene andesite and basalt. Flows having compositions as silicic as latite or trachyandesite occur in upper part of section (as on Steamboat Mountain). Proportion of flows appears to increase upward in section.

Basal Daly Creek Member of Sepulcher Formation commonly mapped on basis of lighter color and preponderance of alluvial-facies material. However, except for a gradual increase upward in percentage of flows, no distinct difference was noted between lower and upper parts of Sepulcher Formation

Tc **Basal conglomerate and siltstone (lower Eocene)—**Cobbles and boulders predominantly of Archean rocks, with subordinate clasts of Paleozoic carbonate and Tertiary volcanic rocks, mapped near Garnet Mountain in northeastern part of quadrangle (McMannis and Chadwick, 1964). Conglomerate is locally overlain by a thin, discontinuous siltstone of late early Eocene age. Not overlain by volcanic rocks in quadrangle, but similar rocks in adjacent areas occur at the base of volcanic sequences of the Absaroka Volcanic Supergroup

TKf **Intrusive felsite (lower Tertiary or Upper Cretaceous)—**Greenish-gray to pinkish-gray, sparsely porphyritic, massive, siliceous dacite or rhyolite. Most phenocrysts consist of as much as 15 percent white, strongly saussuritized plagioclase crystals as long as 3 mm. Rock commonly stained black by manganese oxide. Mainly forms thin sills, dikes, and irregular pods intruding exclusively Archean rocks. Described by Kellogg (1993b). Unit undated, but shares compositional and textural similarities with both Upper Cretaceous dacite porphyry of Fan and Lone Mountains and Eocene rhyolite and rhyodacite plugs near Norris (Kellogg, 1994, 1995), about 10–15 km north of quadrangle

TKg **Gabbro sills (Eocene to Late Cretaceous)—**Black, medium-grained plagioclase-clinopyroxene gabbro that typically weathers into spheroidal blocks. In places completely weathered into grussy orange-brown soil. Several larger sills contain irregular dikes, as wide as 2 m, of fine-grained, pinkish-gray, inequigranular clinopyroxene-biotite syenite, in which the clinopyroxene forms conspicuous rods as long as

1 cm. Syenite, in turn, is intruded by thin aplitic dikes. Unit crops out near Meadow Village at Big Sky and intrudes Upper and Lower Cretaceous rocks

Kd **Dacite porphyry of Fan and Lone Mountains (Late Cretaceous)—** Gray to greenish-gray porphyritic dacite that weathers to a very light gray or tan. Euhedral to subhedral phenocrysts compose 30–50 percent of the rock; phenocrysts are 70–90 percent zoned plagioclase crystals ($An_{25–35}$) as long as 1 cm, trace to 15 percent green hornblende crystals as long as 6 mm, 0–15 percent biotite flakes as long as 3 mm, and 0–10 percent equant quartz crystals as long as 5 mm. Mafic minerals are commonly altered to chlorite and epidote; plagioclase is sericitized. Matrix is very fine grained and dense, and contains about 5 percent opaque minerals. Fine-grained chill zone extends inward several centimeters from contacts. Commonly contains mafic autoliths as large as about 0.5 m. Forms sills, some greater than 80 m thick, in two intrusive centers underlying Fan Mountain and Lone Mountain. The sills are thought to form a "Christmas-tree laccolith" complex underlying both mountains (Swanson, 1950), although Kellogg (1992) found no evidence for a central "trunk." Late Cretaceous beds dip away from the central peaks at both Fan and Lone Mountains. Intrudes rocks that range in age from Middle Cambrian to Late Cretaceous. Where less than about 20 m thick, unit is indicated on map by a single line. Potassium-argon (K-Ar) and $^{40}Ar/^{39}Ar$ ages from hornblende are about 68–69 Ma (Tysdal and others, 1986; K.S. Kellogg and S.S. Harlan, unpub. data, 1994)

Kgd **Granodiorite of Tobacco Root batholith (Late Cretaceous)—**Gray, coarse-grained, inequigranular to porphyritic, massive hornblende-biotite granodiorite, monzogranite, and monzodiorite (classification of Streckeisen, 1976). Typically contains 50 percent normally zoned oligoclase (An_{25}–An_{28}), 15–25 percent green hornblende, 10–20 percent microcline (slight development of braid perthite) commonly as phenocrysts as long as 3 cm, 0–20 percent quartz, 5 percent biotite, 0–1 percent clinopyroxene cores in some hornblende, trace to 3 percent magnetite, and traces of apatite and conspicuous sphene and zircon; hypidiomorphic texture. Includes minor dark-gray hornblende diorite and granodiorite along border and in satellitic stocks east of main batholith. Weathers light gray, in rounded tors or flat grussy outcrops. K-Ar age of batholith is 71–74 Ma (Vitaliano and Cordua, 1979)

Ks **Sphinx Conglomerate (Upper Cretaceous)—**Reddish-orange conglomerate with sandstone matrix cemented by calcite and hematite. Contains well-rounded cobbles and boulders derived from Paleozoic and Mesozoic strata shed from thrust plates to west; represents an unroofing sequence, the clasts generally increasing in age upwards (DeCelles and others, 1987). Lower contact is conformable with underlying Livingston Formation. Well exposed only on Sphinx Mountain and The Helmet. Minimum thickness about 610 m

Kb **Beaverhead Group (Upper Cretaceous)—** Conglomerate and interbedded limestone containing well-rounded clasts of Archean gneiss and Belt Supergroup quartzite. Mapped by Hadley (1969b) in Gravelly Range as two separate units (Sphinx Conglomerate and Tertiary gravel), but both units were reinterpreted on fossil and stratigraphic evidence as Beaverhead Group rocks of Cretaceous age (J.M. O'Neill, oral commun., 1997)

Kl **Livingston Formation, undivided (Upper Cretaceous)—**Livingston Formation exposed on west side of Madison Range, near Sphinx Mountain, and east of Gallatin River, south of the Spanish Peaks fault. Does not crop out west of Madison River valley. Undivided unit shown only in southeastern part of quadrangle. Description after Tysdal (1990)

Klu **Upper member—**Cobble and boulder conglomerate composed of well-rounded volcanic clasts in matrix of coarse-grained volcaniclastic sandstone; upper part is predominantly sandstone. Lower contact is conformable. Thickness as much as 180 m

Klm **Middle member—**Brown, maroon, and gray dacite to basalt flows, autoclastic breccia, tuff breccia, and welded tuff; minor interlayered volcaniclastic sandstone. Lower contact is conformable. Thickness estimated 300–450 m

Kll **Lower member—**Complexly intertonguing units of dark-green to dark-brown, medium- to coarse-grained, locally pebbly volcaniclastic sandstone, olivine basalt, mudflow breccia, volcaniclastic conglomerate, and mudstone. Conformable with underlying Everts(?) Formation. Thickness ranges from about 60 to 210 m)

Ku **Everts Formation, Virgelle Sandstone, Telegraph Creek Formation, Cody Shale, Frontier Formation, and Mowry Shale, undivided (Upper Cretaceous)—**May locally include Muddy Sandstone and Thermopolis Shale. Mapped in area of Cretaceous outcrops east of Gallatin River

Kev **Everts Formation and Virgelle Sandstone, undivided (Upper Cretaceous)**

Everts Formation—Thin- to medium-bedded, light-gray to dark-gray, poorly to moderately sorted, quartz-rich sandstone; intercalated with thin-bedded, greenish-gray to dark-gray mudstone and siltstone. Contains a few thin beds of dense limestone, porcellanite, and coal. About equal quantities of sandstone and finer grained sedimentary rocks. Does not crop out west of Madison River valley. Conformably overlies Virgelle Sandstone. About 425 m thick

Virgelle Sandstone—Thin- to thick-bedded, medium- to coarse-grained, light-brown to yellowish-brown, trough-crossbedded quartz sandstone that forms prominent white-weathering ledges. Conformably overlies Telegraph Creek Formation. Does not crop out west of Madison Valley. About 25–50 m thick

Ktc **Telegraph Creek Formation (Upper Cretaceous)—**Light-gray to dark-brown, thin-bedded to medium-bedded, feldspathic, calcite-cemented sandstone and interbedded dark-gray siltstone and mudstone. Middle marker sequence is a 20-m-thick white tuffaceous siltstone and sandstone. Contains thin flaggy sandstone beds in lower part. Conformably overlies Cody Shale. Does not crop out west of Madison River valley. Thickness about 200 m

Kc **Cody Shale (Upper Cretaceous)—**Upper part consists of thin-bedded black fissile shale that is interbedded with minor amounts of thin-bedded, brown, commonly bioturbaded calcareous, fine-grained sandstone. Lower part consists of black, fissile shale and minor siltstone that weathers dark gray. Does not crop out west of Madison River valley. Conformably overlies Frontier Formation. Thickness about 300 m

Kf **Frontier Formation (Upper Cretaceous)—**Mostly a sequence of alternating black shale and light-gray to yellowish-tan, thin-bedded to very thick bedded, cross-bedded sandstone. In the Madison Range, sandstone ledges are as thick as 3 m; ratio of sandstone to shale is about 1:3. Shale is locally carbonaceous or coaly. Shale sequences are as thick as about 20 m and commonly contain equally spaced 5- to 10-cm-thick sandstone beds, spaced 15–20 cm apart. Contains several white porcellanite beds; one prominent porcellanite bed in the Madison Range, about 6 m thick, is about 15 m above base of sequence and displays well-developed ball-and-pillow structures. Conformable with underlying Mowry Shale. Formation thickens greatly to the west; thickness in Madison Range about 140–180 m while that in Gravelly Range is greater than 1,500 m

Kmo **Mowry Shale (Upper Cretaceous)—**Mostly brownish-gray and greenish-gray tuffaceous mudstone and shale and, in upper part, contains abundant thin sandstone beds. Lower Vaughn Member consists of conspicuous gray, green, yellow, brown, orange, pink, and cream-colored bentonitic mudstone, porcellanite, siltstone, and minor interbedded quartz sandstone, although strikingly varicolored units are missing in northern Madison Range. Poorly exposed in most places. Unconformable with underlying Muddy Formation. Thickness 90–180 m

Kmt **Muddy Sandstone and Thermopolis Shale, undivided (Lower Cretaceous)**

Muddy Sandstone—Thin- to medium-bedded, medium- to coarse-grained, brown to brownish-gray, poorly to moderately indurated, clayey, ledge-forming salt-and-pepper sandstone; locally contains mud chips as long as 1 cm. In northern Madison Range, formation typically exposed as upper and lower sandstone sequence interrupted by central, poorly exposed shaly sequence. Thickness varies widely; in the northern Madison Range it is about 20–45 m thick; farther south in the Madison Range it is as great as 107 m (Tysdal, 1990); in the Gravelly Range it is about 15 m thick (Hadley, 1969b, 1980)

Thermopolis Shale—Composed of an upper sequence (three-quarters of the total thickness) that is black to dark-gray, locally carbonaceous, fissile shale and poorly indurated, thin-bedded, silty brown sandstone. Lower one-quarter of unit is thin- to medium-bedded, fine-grained, white to tan quartz arenite that contains black shale interbeds; ripple marks and Liesegang bands are common in sandstone beds. Unconformable contact with underlying Kootenai Formation. Thickness throughout quadrangle about 70–80 m

Kk **Kootenai Formation (Lower Cretaceous)—**Upper 10–15 m is medium-bedded light-gray, micritic, oolitic limestone that contains abundant gastropod fossils in uppermost part. Middle part is variegated red, purple, yellow, and gray shale, mudstone, siltstone, sandstone, and locally nodular freshwater limestone. Formation typically weathers to a reddish soil. Lower 10–40 m is medium- to coarse-grained, gray, well-indurated, ledge-forming salt-and-pepper sandstone that contains a basal chert-pebble conglomerate as thick as 1 m. Lower contact is unconformable. Total thickness in the northern Madison Range is about 90 m (Kellogg, 1992, 1993a); in the Gravelly Range it is as thick as 170 m (Hadley, 1980), and in the southeastern part of the map area it as much as about 130 m thick

JŦu **Morrison Formation (Upper Jurassic), Ellis Group (Upper and Middle Jurassic), and Woodside Siltstone and Dinwoody Formation (Lower Triassic), undivided**

Jm **Morrison Formation (Upper Jurassic)—**Upper 20–30 m is mostly black and locally purple shale that contains minor intercalated thin- to medium-bedded, rusty-brown and gray quartz sandstone that is lensoidal in places. Lower, thicker part of the Morrison is composed of thin-bedded, gray, yellow, orange, red, and green shale and siltstone interbedded with lesser amounts of gray quartz arenite and thin-bedded, brown limestone. Uncon-formable with underlying unit. About 75–100 m thick

JŦed **Swift Sandstone, Rierdon Limestone, and Sawtooth Formation of Ellis Group (Upper and Middle Jurassic), Woodside Siltstone (Lower Triassic), and Dinwoody Formation (Lower Triassic), undivided—**In most places this combined unit is poorly exposed. Total thickness about 185 m

Swift Sandstone—Brown, medium- to coarse-grained glauconitic sandstone, locally containing abundant chert pebbles, and minor olive-green shale; glauconite commonly weathered to orange limonitic clots. More calcareous in eastern part of map area (Tysdal, 1990). Unconformably overlies Rierdon Limestone. Less than 12 m thick

Rierdon Limestone—Thin- to thick-bedded, yellowish-gray to brownish-gray, fine-grained, oolitic limestone; contains a few limy siltstone interbeds. Bivalves *Camptonectes* sp. and *Gryphaea* sp. locally abundant. Forms prominent cliffs near Shell

Creek in western Madison Range. Thickness about 8–30 m

Sawtooth Formation—Interbedded limestone and shale; weathers yellowish brown and is very poorly exposed. Sawtooth unconformably overlies Dinwoody Formation. Thickness 25–55 m

Woodside Siltstone—Brick-red to orange-red, thin-bedded siltstone and mudstone, interbedded with gypsum and scattered thin beds of gray limestone. Mostly poorly exposed, although forms prominent red soil. Thickness increases markedly to southeast; nonexistent north of Porcupine Creek in Gallatin Range (Simons and others, 1985) and only a "feather edge" may exist in the northernmost Gravelly Range (Hadley, 1980). Unit previously mapped as Chugwater Formation in southeastern part of quadrangle (Simons and others, 1985). Thickness 0 to about 220 m (Tysdal, 1990)

Dinwoody Formation—Brown silty sandstone, siltstone, and thin-bedded, brown limestone. Small brachiopods locally abundant. Weathers light yellowish brown and is poorly exposed. Dinwoody unconformably overlies Shedhorn Sandstone. Thickness ranges between about 20 and 80 m

Pmu **Shedhorn Sandstone (Lower Permian), Quadrant Sandstone (Pennsylvanian), and Amsden Group (Lower Pennsylvanian and Upper Mississippian), undivided—**Mapped in Garnet Mountain quadrangle by McMannis and Chadwick (1964), who used the term "Phosphoria Formation" instead of "Shedhorn Sandstone." Units described below

Ps **Shedhorn Sandstone (Lower Permian)—**Mostly medium- to massive-bedded, gray, fine- to coarse-grained, very well indurated quartz-rich sandstone that contains white cherty stringers and nodules. Thin, shaly phosphorite beds in middle of formation are rarely exposed. Dolomitic near base. In Gravelly Range, chert is locally massive and filled with voids, so that chert outcrops commonly have a rubbly appearance. Conformably overlies Quadrant Sandstone. Formation about 35–70 m thick, though is about 50 m thick in northern Madison Range

PMqa **Quadrant Sandstone (Pennsylvanian), Amsden Group (Lower Pennsylvanian and Upper Mississippian), and Snowcrest Range Group (Upper Mississippian), undivided**

Quadrant Sandstone—Medium- to thick-bedded, white to yellowish-tan, well-sorted, fine- to medium-grained, dolomite-cemented quartz arenite; cross-beds common. Lower half and at least upper 15 m of formation contain a few medium-bedded, light-yellowish-tan dolostone beds. Crops out prominently. Conformable contact with underlying Amsden Group. Thickness about 75 m

Amsden Group—Varies widely, both in stratigraphy and thickness. In central and southern Madison Range, and in Gravelly Range east of Greenhorn thrust, unit consists of about 12–50 m of brick-red, reddish-brown, and pink calcareous siltstone, silty shale, shale, sandstone, and light-gray limestone and yellowish-gray dolomite. Along western Madison Range, upper part contains medium- to thin-bedded, gray to grayish-tan dolostone, locally quartzitic, that grades downward into gray limestone beds (correlated by Kellogg, 1992, with Middle and Lower Pennsylvanian Devils Pocket Formation and Alaska Bench Limestone of Wardlaw and Pecora, 1985); this sequence overlies maroon siltstone and shale that contain a few thin beds of gray limestone and dolostone (correlated with Lower Pennsylvanian Tyler Formation of Wardlaw and Pecora, 1985). Total thickness of Amsden Group in western Madison Range is 88 m

Snowcrest Range Group—Mapped only in western Madison Range (Kellogg, 1992), although rocks of the group may have been either unrecognized elsewhere or placed in Amsden Group. Upper 57 m of Snowcrest Range Group (Upper

Mississippian Lombard Limestone) is mostly thin- to medium-bedded, gray limestone that becomes more dolomitic and shaly toward base. The Lombard overlies Kibbey Sandstone, which consists of about 75 m of thin- to medium-bedded, yellowish-gray to maroon, friable dolomitic sandstone, sandy dolostone, and siltstone

Mbs **Big Snowy Group (Upper Mississippian)—**Mapped only west of Greenhorn thrust in Gravelly Range (Hadley, 1969b, 1980); upper, thicker part consists of thin- to thick-bedded, pale olive gray, locally very fossiliferous limestone and minor dark-greenish or olive-gray mudstone and shale. Lower 60 m or so consists of red and greenish-gray shale and calcareous sandstone and minor greenish-gray cherty limestone; sandstone and red color increase downward in sequence. Detailed description of Big Snowy Group is given by Hadley (1980). Total thickness 135–275 m

Mm **Madison Group, undivided (Upper and Lower Mississippian)**

Mmc **Mission Canyon Limestone (Upper and Lower Mississippian)—**Medium- to massive-bedded, light-gray, gray, and brownish-gray, medium-crystalline limestone and minor dolostone. Weathers light gray. Chert stringers and nodules are common; locally fossiliferous; solution breccias in uppermost part. Prominent ridge-forming unit. Conformable with underlying Lodgepole Limestone. Thickness about 240 m

Ml **Lodgepole Limestone (Lower Mississippian)—**Thin- to medium-bedded, gray to brownish-gray, finely crystalline limestone that commonly grades into silty limestone interbeds several centimeters thick. Locally cherty; upper half is profusely fossiliferous. Conformable with underlying Three Forks Formation (erroneously described as unconformable above the Three Forks in Kellogg, 1992, 1993a). Thickness about 180 m

MDtj **Three Forks Formation (Lower Mississippian and Upper Devonian) and Jefferson Formation (Upper Devonian), undivided**

Three Forks Formation—Mostly thin-bedded, yellowish-orange to yellowish-tan siltstone and silty limestone containing a few thin interbeds of brick-red-weathering siltstone. Weathers light yellowish tan. Contains a medium-gray, irregularly bedded, approximately 12-m-thick, rough-weathering limestone about 25 m above base of unit (Logan Gulch Member). Formation poorly exposed; forms slopes and swales. Unconformably overlies Jefferson Formation. Thickness 40–60 m

Jefferson Formation—Thin- to thick-bedded, black, brown, dark-gray, and light-gray, petroliferous, medium-crystalline to coarsely crystalline dolostone; colors vary considerably over short stratigraphic intervals. Weathers mostly brown, and outcrops are typically knobby and irregular; forms conspicuous brown hoodoos. At least upper 15 m is thick- to massive-bedded, gray dolostone solution breccia (Birdbear Member). Unconformably overlies Bighorn Dolomite (?) in northern Madison Range. Thickness about 110 m

O€rm **Bighorn Dolostone(?) (Ordovician), Red Lion Formation (Upper Cambrian), Pilgrim Dolostone (Upper Cambrian), and Park Shale (Middle Cambrian), undivided**

Bighorn Dolostone(?)—Medium-gray, sugary dolostone in 0.2- to 1.0-m-thick beds; weathers very light gray. Tentatively placed in Bighorn Dolomite by Hanson (1952) along ridge in NE¼, sec. 22 and NW¼, sec. 23, T. 5 S., R. 1 E. in northwestern Madison Range; not recognized south of this location. Unconformably overlies Red Lion Formation. Thickness about 3 m at location noted above

Red Lion Formation—Thin-bedded, medium-gray to tan, siliceous dolostone containing conspicuous orange-tan to reddish-tan, cherty stringers as thick as 2 cm; lower 7 m contains intraformational clasts as large as 5 mm. Along west side of Gallatin

Range, contains a lower greenish-gray, locally quartzitic shale sequence as thick as 10 m (Dry Creek Shale Member) (McMannis and Chadwick, 1964). Unconformably overlies Pilgrim Formation. Thickness about 40–60 m

Pilgrim Dolostone—Gray, light-gray, and brownish-gray, medium- to massive-bedded, locally oolitic, medium-crystalline dolostone. Weathers light gray and contains irregularly shaped darker gray mottles. Conformably overlies Park Shale. Forms conspicuous crags. Thicknesses about 30 m in northern Madison Range (Kellogg, 1992), about 60 m in the south-central part of the quadrangle (Tysdal, 1990); as much as 120 m in the Gravelly Range, although is missing along east side of range (Hadley, 1969b), and as much as 75 m in the northern Gallatin Range (McMannis and Chadwick, 1964)

Park Shale—Greenish-gray to tan, fissile shale. Poorly exposed, slope-forming unit conformably overlies Meagher Limestone. Thickness about 30–50 m in Madison Range and Gravelly Range, although is missing along eastern side of Gravelly Range (Hadley, 1969b); thickness 50–75 m in northern Gallatin Range (McMannis and Chadwick, 1964)

Ꞓu **Red Lion Formation and Pilgrim Dolostone, undivided (Upper Cambrian)—**Mapped east of Gallatin River and north of Spanish Peaks fault (McMannis and Chadwick, 1964)

Ꞓrp **Red Lion Formation (Upper Cambrian), Pilgrim Dolostone (Upper Cambrian), and Park Shale (Middle Cambrian), undivided—**Mapped south of Cedar Creek and east of Madison Valley (Tysdal, 1990; Kellogg, 1992)

Ꞓmi **Park Shale, Meagher Limestone, Wolsey Formation, and Flathead Sandstone, undivided (Middle Cambrian)—**Mapped east of Gallatin River and north of Spanish Peaks fault (McMannis and Chadwick, 1964)

Ꞓm **Meagher Limestone (Middle Cambrian)—**Thin- to massive-bedded, light-gray to brownish-gray, finely crystalline limestone. Locally oolitic, especially in upper part. Upper 30 m is thin-bedded, gray limestone that contains conspicuous orange mottles; upper few meters contains fissile gray-green shale. Middle 50 m is medium- to massive-bedded limestone, locally mottled tan, and containing small silicic limestone stringers. Lower 30 m is thin- to medium-bedded, tan-mottled, gray limestone that contains a few intercalated micaceous shale beds in lower part. Forms cliffs. Conformably overlies Wolsey Shale. About 100–150 m thick in Madison Range (Tysdal, 1990; Kellogg, 1992), 100–110 m thick in Gravelly Range (Hadley, 1980), but only about 50 m thick in northern Gallatin Range (McMannis and Chadwick, 1964)

Ꞓwf **Wolsey Shale and Flathead Sandstone, undivided (Middle Cambrian)**

Wolsey Shale—Mostly thin-bedded, greenish-gray, olive-drab, gray, and grayish-brown micaceous sandstone, siltstone, and shale. Sandstone beds are wavy and bioturbated, contain green and gray- and green-mottled shale interbeds, and generally weather brown; animal trails are common; locally glauconitic. Near middle of unit is a 10- to 15-m-thick section of thin-bedded, dark-gray, brown-weathering argillaceous limestone interbedded with lesser amount of sandstone and shale. Upper 5 m is interbedded wavy-laminated, thin-bedded, gray limestone and gray, micaceous siltstone. Conformable with underlying Flathead Sandstone. Forms slopes and swales. Thickness 30–65 m

Flathead Sandstone—Thin- to medium-bedded, medium-to coarse-grained, reddish-brown, tan, and purplish-tan, quartz-rich, feldspathic sandstone; locally weathers to rusty red. Two thin zones of fine-grained, micaceous, greenish-gray argillaceous sandstone near top of formation. Basal part of formation contains rounded pebbles of metamorphic rock. Unconformably overlies Archean crystalline rock. Thickness variable, from 15 to 75 m

Ᵽdi **Diabase dike (Proterozoic)—**Black to dark-greenish-gray, fine- to medium-grained, equigranular, well-indurated diabase in steep, northwest-striking dikes as wide as 30 m (most are considerably thinner). Contains about 30–50 percent euhedral labradorite, 30–60 percent augite, 0–30 percent hornblende (inverted from augite), 0–10 percent potassium feldspar, 5–8 percent opaque minerals, 1–3 percent apatite, 0–5 percent biotite, 0–3 percent quartz, and from trace to 1 percent epidote. Emplaced during two periods: about 1,455 Ma and 750–780 Ma (Harlan and others, 1990)

LOW-GRADE METAMORPHIC AND INTRUSIVE ROCKS OF THE RUBY CREEK AREA, EASTERN GRAVELLY RANGE (PROTEROZOIC OR ARCHEAN)

[Metamorphic grade of rocks in this area is as low as chlorite facies (quartz-albite-epidote-biotite subfacies of Turner and Verhoogen, 1960), but increases in grade southward to almandine-amphibolite facies. The Ruby Creek assemblage is bounded on the north by a north-dipping thrust, which places marble in the hanging wall above the lower grade rocks of the Ruby Creek area. The age of the assemblage is unknown, but may be as young as Proterozoic (J.M. O'Neill, oral commun., 1995). The geology for this area is modified from Vargo (1990) and Hadley (1969a,b)]

ᵽAmd **Metadiorite—**Mapped by Hadley (1969a,b) but not described in detail

ᵽAss **Epidote-actinolite metasediment—**Green, metamorphosed, fine-grained clastic sedimentary rocks, locally showing good cross-bedding and graded beds. Contains quartz, plagioclase, actinolite, and epidote. Weathers to blocky outcrops

ᵽAbs **Biotite-chlorite schist—**Dark-brownish-gray to black, well-foliated schist containing quartz, plagioclase, biotite, chlorite, magnetite, and muscovite; porphyroblasts of plagioclase abundant

ᵽAph **Phyllite—**Greenish-gray, greenish-red, gray-red, and dark-gray phyllite containing quartz, biotite, chlorite, muscovite, hematite, magnetite, and rare garnet. Contains thin layers of micaceous and actinolite-bearing quartzite and lenticular amphibolite bodies (not shown)

ᵽAms **Mylonitic schist—**Well-foliated chlorite-actinolite schist that contains abundant shear-bounded bodies of metagabbro, metadiorite, and amphibolite. Interpreted as sheared amphibolite (J.M. O'Neill, oral commun., 1995) and may be approximately equivalent to biotite-chlorite schist (unit ᵽAbs). Includes a thin staurolite-sillimanite mylonite that bounds southern contact of unit

ᵽAbg **Biotite gneiss, quartzite, and hornblende gneiss—**Approximately as mapped by Hadley (1969b); part of quartz-feldspar gneiss and pegmatite unit of Vargo (1990)

ᵽAgg **Granite, migmatite, pegmatite, and granitic orthogneiss—**Approximately as mapped by Hadley (1969b), who did not describe unit in detail. Not known if unit is intrusive into adjacent units or forms older basement

ᵽAif **Iron-formation—**Alternating layers, typically 2–10 cm thick, of reddish-brown to black magnetite-quartz and quartzite. Contains minor hydrobiotite and magnetite locally oxidized to hematite and goethite. Layers are commonly tightly folded

META-IGNEOUS ROCKS (ARCHEAN)

[Igneous rock names follow Streckeisen, 1976)]

Agp **Granite porphyry of Hell Roaring Creek—**Pink, coarse-grained, massive to slightly foliated biotite monzogranite porphyry. Contains about 20 percent conspicuous euhedral to subhedral potassium-feldspar phenocrysts as long as 1.5 cm; matrix contains about 30 percent quartz, 35 percent plagioclase, 15 percent potassium feldspar, and about 20 percent biotite. Locally sheared, forming well-developed pinkish-gray augen gneiss, as on Indian Ridge in the Spanish Peaks

Agg **Granitic orthogneiss—**Light-gray to light pinkish gray, generally tan-weathering, medium-grained, hypidiomorphic, weakly to moderately foliated orthogneiss generally ranging in composition from tonalite to monzogranite. Mafic mineral almost exclusively biotite (trace to 15 percent); may contain as much as 5 percent almandine and, rarely, 5 percent hornblende, 2 percent augite, and 2 percent muscovite; also contains traces of zircon, epidote, allanite, and opaque minerals. One unusual occurrence is a pluton near Summit Lake in the Spanish Peaks; the pluton is a discordant body composed of massive to weakly foliated, very light gray biotite tonalite

Amb **Metabasite—**Black (commonly speckled with white feldspar and pink garnet), fine-grained, equigranular, granoblastic, weakly foliated to massive hornblende-augite-almandine metabasite. Composition variable; contains 15–45 percent plagioclase (mostly andesine), 10–60 percent yellowish-green to brown hornblende, 2–20 percent augite, 0–20 percent almandine, 0–5 percent reddish-brown biotite, 1–3 percent opaque minerals, and trace of apatite. In some places relict porphyritic texture is preserved as white clusters of fine-grained plagioclase crystals as long as 1 cm. Mostly occurs as sills as wide as about 40 m concordant to foliation; in some places sills show pinch-and-swell structure and boudinage. Commonly enveloped in medium-grained amphibolite margin as wide as 10 m, indicating post-emplacement metasomatism at amphibolite grade. Equivalent to orthoamphibolite of Vitaliano and Cordua (1979) in Tobacco Root Mountains.

Ags **Hornblende-biotite granodiorite orthogneiss of Summit Lake—**Light- to medium-gray, medium-grained, hypidiomorphic, poorly to well foliated hornblende-biotite granodiorite orthogneiss. Contains 30–40 percent plagioclase, 10–20 percent potassium-feldspar, 15–25 percent quartz, 10–20 percent hornblende, and about 10 percent biotite. Most rock is highly strained, forming well developed foliation; in such places, mafic minerals are concentrated in ribbony layers 2–5 mm thick. Contains numerous, thin (3–10 mm) feldspar-quartz migmatitic layers. Cut by at least three periods of sill and dike intrusion; sills and dikes locally so closely spaced that they form an agmatite. Cut by granitic orthogneiss of Summit Lake pluton

Aum **Meta-ultramafic rocks—**Black to dark-greenish-gray, fine- to medium-grained, well-foliated to massive, variably serpentinized ultramafic rocks of wide-ranging composition; includes olivine websterite, lherzolite, and olivine clinopyroxenite. Accessory minerals include olive-green spinel, magnetite, and apatite. Commonly contains secondary amphibole (anthophyllite or actinolite) serpentine, talc, dolomite, magnesite, and (or) mica. Occurs in lenses, pods, and small irregularly shaped masses, rarely more than 10 m in diameter. Probably tectonically incorporated into country rock

GNEISSIC ROCKS OF UNKNOWN ORIGIN (ARCHEAN)

Aqf **Quartzofeldspathic gneiss—**Mapped where rocks are heterogeneous, generally layered, light- to medium-gray microcline-plagioclase-quartz-biotite gneiss. Commonly migmatitic and blastomylonitic. Some areas not mapped in detail, such as south of Sphinx Mountain in Madison Range and east of Gallatin River in Gallatin Range, which may contain many of the other gneissic rock units

Agn **Garnetiferous gneiss of the Tobacco Root Mountains—**Includes biotite-garnet schist, sillimanite-garnet schist, garnetiferous quartzite, quartzite, highly garnetiferous quartzofeldspathic gneiss, corundum gneiss, gedrite schist, cummingtonite schist, and garnetiferous amphibolite (Vitaliano and Cordua, 1979). May represent refractory component (“restite”) remaining after removal of partial melts

Aam **Hornblende-plagioclase gneiss and amphibolite—**Most is gray to black, medium-grained, hypidiomorphic equigranular, moderately foliated to well-foliated hornblende-plagioclase gneiss and amphibolite; contains as much as 5 percent quartz and traces of zircon, opaque minerals, and apatite; locally garnetiferous. Plagioclase is typically An_{30} and weathers white. Commonly contains white, migmatitic leucosomes of anorthosite as thick as 10 cm. Similar unit in Tobacco Root Mountains interpreted to be either metamorphosed, clay-rich dolomite or mafic-extrusive rock (Vitaliano and Cordua, 1979). Amphibolite envelopes around some metabasite intrusive bodies indicate at least some amphibolite was derived from intrusive rocks. Unit may include minor amounts of other Archean units

Abs **Biotite schist—**Black, dark-gray, and gray, fine- to medium-grained biotite-plagioclase-quartz, ±hornblende, ±microcline schist. Interpreted to be sheared mafic rock that equilibrated at lower amphibolite facies; not studied in detail. Crops out in Gallatin Canyon–Hell Roaring Lake (Spanish Peaks) area

Agd **Gedrite and cummingtonite gneiss—**Cummingtonite gneiss is light gray, medium grained, strongly lineated, and vitreous. Contains as much as 90 percent cummingtonite, and variable amounts of quartz, almandine, muscovite, rutile, and opaque minerals. Grades into metaquartzite. Gedrite gneiss is brown to grayish-brown, moderately well foliated gneiss that contains as much as 70 percent clove-brown gedrite, in addition to quartz, plagioclase, ±sillimanite, ±biotite, ±cordierite, and traces of magnetite and rutile. Both rock types occur as small lenses and concordant layers in other Archean rocks

Abh **Biotite-hornblende gneiss of Beartrap Canyon—**White, light-gray, dark-gray, and black, medium-grained, well-foliated and well-layered gneiss. Leucosomes contain plagioclase, quartz, biotite, ± potassium feldspar, ± garnet, and a trace of opaque minerals. Melasomes contain biotite, hornblende, plagioclase, quartz, ± garnet, and trace of opaque minerals. Contains rare quartzite layers and sillimanite-bearing gneiss. Commonly migmatitic. Layers are typically 1–20 cm thick. Injected by numerous sills of metabasite. Crops out extensively in Bear Trap Canyon of Madison River. Similar rocks, also mapped as unit Abh, occur at several other less extensive localities

HIGH-GRADE TECTONITES (ARCHEAN)

At **Mylonite of the Crooked Creek shear zone—**Light- to medium-gray, mottled mylonite that has a well-developed L-S tectonite fabric and a fine-grained recrystallized (granoblastic) texture. Composition variable, ranging from that of quartzofeldspathic gneiss to amphibolite. The mylonite equilibrated at near-peak (lower granulite) metamorphic conditions and forms anastomosing, concordant zones in northern Madison Range (Kellogg, 1993a; Kellogg and Mogk, 1991). Margins of unit are concordant with, and grade, into relatively unmylonitized gneiss

METASEDIMENTARY ROCKS (ARCHEAN)

Aag **Aluminous gneiss and schist—**Gray to dark-brownish-gray, medium-grained, inequigranular, generally well foliated, commonly micaceous gneiss and schist containing aluminosilicate (mostly sillimanite and rarer kyanite). Unit contains 5–90 percent anhedral quartz having undulatory extinction, 0–30 percent microcline, 0–35 percent plagioclase, 0–30 percent almandine, 0–20 percent muscovite, trace to 15 percent sillimanite or kyanite, 0–10 percent reddish-brown biotite, 0–2 percent opaque minerals, including graphite, and trace of zircon. Commonly rich in quartz and locally grades into quartzite. Several kyanite prospects are on east side of Gravelly Range, in sec. 6, T. 8 S., R. 1 W. (Nordstrom, 1947)

Abm **Biotite-muscovite gneiss—**Light- to medium-gray, medium-grained, poorly foliated to well-foliated quartz-feldspar gneiss that contains abundant thin schistose layers containing both biotite and muscovite. Aluminosilicate-bearing lenses are common, and one prominent 20-

to 50-m-thick schistose horizon contains as much as 50 percent coarse-grained biotite, about 20 percent quartz, 0–10 percent gedrite, 5 percent plagioclase, 5 percent sillimanite, 3 percent kyanite (as large blue blades), 3 percent garnet, and 3 percent muscovite. Mapped on north side of Hell Roaring Creek valley in Spanish Peaks

Aq **Quartzite—**White, medium- to course-grained, inequigranular, moderately foliated to massive quartzite; locally bright green where trace amounts of chromium-bearing mica (fuchsite) are present. In most places unit is composed entirely of anhedral quartz grains having undulatory extinction, but locally contains as much as 30 percent microcline, 20 percent muscovite, 15 percent sillimanite, 10 percent cummingtonite, 8 percent almandine, 2 percent actinolite, and trace of zircon and opaque minerals. Commonly forms prominent ridges, especially in northwestern part of Madison Range, where core of a plunging, nearly isoclinal antiform is composed almost entirely of quartzite. Unit is interlayered in most places with mafic amphibolite

Ama **Marble—**White, coarse-grained, massive to moderately well foliated dolomitic marble that contains as much as 3 percent quartz grains. Weathers orange-brown. Locally hydrothermally altered to commercial deposits of talc on east side of Gravelly Range. A few thin layers of calcitic marble, containing as much as 30 percent serpentine, mapped in northern part of Madison Range. Extensive, commercially exploited talc deposits occur in hydrothermally altered zones in large marble body on eastern side of Gravelly Range

Aif **Iron-formation—**Magnetite-bearing schist and gneiss, gruernite-magnetite schist, and garnet-quartz rock. Mapped in Tobacco Root Mountains (Vitaliano and Cordua, 1979)

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