U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

SCIENTIFIC INVESTIGATIONS MAP 2816

GEOLOGIC MAP OF THE HEBGEN LAKE QUADRANGLE, BEAVERHEAD, MADISON, AND GALLATIN COUNTIES, MONTANA, PARK AND TETON COUNTIES, WYOMING, AND CLARK AND FREMONT COUNTIES, IDAHO

By
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Base from U.S. Geological Survey 1993
1927 North American datum
Projection and 10,000-meter grid: Universal Transverse Mercator, zone 12
25,000-foot ticks: Montana coordinate system, south zone, Idaho coordinate system, east zone, and Wyoming coordinate system, west zone

Geology modified from O'Neill and Christiansen (2002)
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SCALE 1:100 000
CONTOUR INTERVAL 50 METERS
SUPPLEMENTARY CONTOUR INTERVAL 25 METERS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

Flood plain deposits (Holocene)—Sand, silt, and clay deposited in broad, open stream valleys and in confined ephemeral stream channels. Maximum thickness unknown

Alluvial and fluvial channel deposits (Holocene)—Sand, silt, clay, and pebble to cobble gravel deposited in narrow stream channels and on broad alluvial slopes at base of low hills and mountain fronts. Locally includes thin colluvial deposits. Generally less than 5 m thick

Colluvium (Holocene)—Unconsolidated deposits of silt, sand, and angular pebbles and cobbles formed by mass movement downslope. Thickness generally less than 2 m

Alluvial and colluvial deposits, undivided (Holocene)

Alluvial fan deposits, undivided (Holocene)—Poorly sorted silty sand and gravel deposited in small alluvial fans along valley margins and around hills and mountains. Maximum thickness unknown

Young alluvial fan deposits (Holocene)—Active, small to large alluvial fans along valley margins

Old alluvial fan deposits (Holocene)—Inactive, generally large alluvial fans, most of which were deposited along east side of Madison Valley; fans are weakly dissected and locally cut by Holocene fault scarps

Eolian deposits (Holocene)—Translucent tan to brown, well-sorted, moderately frosted quartz sand grains; forms sand dune field in northern Centennial Valley. Maximum thickness (dune height) about 10 m

Talus deposits (Holocene)—Unsorted, unstratified angular clasts and slabs as much as 2 m across that accumulate at base of cliffs and very steep slopes

Rock glaciers (Holocene)—Unconsolidated lobate to elongate deposits of coarse gravel and boulders in glacial cirques or at base of cliffs above timberline. Older deposits locally covered by thin soil and vegetation. Thickness generally less than 20 m

Boulder field (Holocene)—Unsorted accumulation of angular boulders on steep slopes

Alluvium of alluvial terrace deposit, undivided (Holocene)—Pebble- to boulder-size gravel and sand on low terraces adjacent to major streams. Maximum exposed thickness about 5 m

Alluvium of younger alluvial terrace deposit (Holocene)—Unconsolidated gravels deposited on lowest terraces of modern streams

Alluvium of older alluvial terrace deposit (Holocene)—Unconsolidated gravels deposited on terraces above lowest terraces in modern stream valleys

Earth flow and landslide deposits (Holocene and Pleistocene)—Coarse, unconsolidated deposits of locally derived, angular pebbles, cobbles, and boulders associated with fine-grained matrix of silt and sand. On south and east sides of Gravelly Range, huge landslides where length and width are measured in kilometers include large toreva blocks of Huckleberry Ridge Tuff (Thr) deposited on unconsolidated sand and silt of the Miocene Sixmile Creek Formation (Tsc); on west side of Gravelly Range, landslides of similar size reflect massive dip-slip slope failure of clay-rich, tuffaceous, weakly indurated Cretaceous formations. Maximum thickness probably near 60 m

Lacustrine deposits (Holocene and Pleistocene)—Light-brown to brown, well-sorted, unconsolidated sand, silt, and clay veneer on undissected surfaces underlain mainly by basin-fill deposits. Marked, in part, by multiple strand lines that outline limit of dwindling glacial lake. Thickness unknown; probably less than 2 m

Glacial outwash deposits (Pleistocene)—Generally poorly sorted, bouldery, layered sand and gravel deposited by glacial meltwater

Glacial till and related deposits (Pleistocene)—Poorly sorted, unconsolidated deposits of silt, sand, gravel, and boulders in, commonly adjacent to, and locally at mouths of major alpine valleys. Deposits are both Pinedale and Bull Lake in age; cirque moraines and pretalus ramparts are Holocene in age. Maximum thickness unknown

Pediment deposits (Pleistocene)—Weakly dissected deposits of pebbles and cobbles of generally angular to subrounded, unsorted and unconsolidated sedimentary and crystalline rocks in a fine-grained, pale-yellowish-brown matrix. Deposited on gently dipping surfaces related to development of Madison Valley. Maximum thickness about 5 m

Alluvium of high alluvial terraces (Pleistocene)—Sand and pebble- to boulder-size gravel deposits on terraces along Ruby River that are about 60–100 m above adjacent stream level
Alluvium, undivided (Pleistocene to Miocene)—Isolated sand and pebble- to boulder-size gravel deposits at high elevations in Gravelly and Centennial Ranges
Sand and gravel (Pliocene and Miocene)—Thin alluvial and fluvial sand and pebble-size gravel deposits restricted to abandoned stream valleys in Gravelly Range

IGNEOUS ROCKS

Central Plateau Member of Plateau Rhyolite (Pleistocene)
Upper part—Rhyolitic flows erupted from vents in Yellowstone caldera; flows contain abundant phenocrysts of mainly quartz and sanidine; plagioclase phenocrysts are conspicuous in their absence. Maximum thickness about 300 m
Lower Buffalo Lake flow (informal)—Light-gray, dense, fine-grained to aphanitic rhyolitic ash-flow tuff; angular to rounded phenocrysts of quartz, sanidine, pyroxene, and olivine make up as much as 25 percent of volume of rock
Madison River Basalt (Pleistocene)—Medium- to light-gray, dense basalt; moderately abundant plagioclase phenocrysts and rare olivine phenocrysts; occurs as scattered, thin flows near West Yellowstone
Lava Creek Tuff (Pleistocene)
Upper member—Light-gray, locally pale red, fine-grained to aphanitic, densely welded ash-flow tuff; phenocrysts compose as much as 20 percent of rock. Thickness east of map area ranges from 180 to 300 m
Lower member—Ash-flow tuff lithologically similar to overlying upper member; members are separated by a partially welded tuff locally associated with a sorted and bedded crystal ash several centimeters thick
Mt. Jefferson Rhyolite, Big Bear Lake flow (informal) (Pleistocene)—Light-gray rhyolite flows conformably underlying Lava Creek Tuff; varies in appearance but contains conspicuous phenocrysts of sanidine, quartz, and plagioclase that make up 30–50 percent of volume of rock. Maximum thickness east of map area 450 m
Huckleberry Ridge Tuff, undivided (Pliocene)
Upper member—Pinkish-gray, gray, to brown welded tuff containing abundant phenocrysts of sanidine and quartz (25 and 10 percent, respectively); uppermost part is locally nonwelded and light pink on weathered surfaces, and contains noncompacted pumice fragments
Lower member—Medium- to dark-gray welded tuff containing sparse (less than 5 percent) phenocrysts; base of unit is a vitrophyre overlain by densely welded tuff that becomes only partly welded at top
Volcanic vent (Miocene and Oligocene)—Basaltic scoria, flows, and volcanic ejectamenta in cone-shaped deposit on Lion Mountain
Mafic volcanic rocks (Miocene and Oligocene)—Dark-gray to black, dense, fine-grained flow rock; commonly vesicular or columnar jointed; sparse olivine phenocrysts. Maximum thickness in southern Gravelly Range along West Fork of Madison River is near 120 m. In Eastern Centennial Mountains, divided into two similar mafic flow sequences separated by rhyolitic flows (Tfv). Upper

sequence is sparsely porphyritic basalt to basaltic andesite flows interlayered with thin, discontinuous beds of mudflow breccia. Lower sequence consists of lava flows and flow breccias of dark-gray to brownish-black basalt, basaltic andesite, and gray, brown, and yellowish-brown andesite; mafic flows diminish lowermost in sequence. All rocks are porphyritic; basaltic rocks contain plagioclase and olivine phenocrysts whereas andesite contains sparse to abundant phenocrysts of plagioclase and at least one mafic mineral in a glassy to aphanitic groundmass. Total thickness about 870 m

Felsic volcanic rocks (Miocene and Oligocene)—In Eastern Centennial Mountains, consists of two units. Upper sequence is light-gray, yellowish-gray, and brown porphyritic dacite and rhyodacite flows and flow breccias interlayered with thin, discontinuous beds of mudflow breccia; maximum thickness about 350 m. Lower sequence is light- to brownish-gray mudflow breccia and mudstone containing poorly sorted volcanic rock fragments in an ash-rich matrix; thickness 0–60 m

Mafic intrusive rocks (Miocene and Oligocene)—Large to small plugs and sills of basalt and basaltic andesite in western part of map area; largest plug is Black Butte in Gravelly Range. In eastern part of map area includes sills of dacite porphyry and minor shoshonite

Absaroka Volcanic Supergroup, undivided (Eocene)—In Eastern Centennial Mountains consists of dark-gray to black, fine-grained to aphanitic pyroxene trachyte porphyry; augite, olivine, and andesine phenocrysts common. Correlative volcanic rocks present in Henry Mountains. Thickness unknown

SEDIMENTARY ROCKS

Sixmile Creek Formation (Miocene)—Weakly consolidated, tan to light-orange-brown, laminated, tuffaceous mudstone, siltstone, sandstone, and lithic pebble conglomerate. Maximum exposed section along West Fork of Madison River about 70 m

Renova Formation (Oligocene and Eocene)—Weakly consolidated, cream-colored, tuffaceous mudstone; common calcareous concretions; interlayered with lesser amounts of sandy siltstone and granule-pebble conglomerate. Maximum exposed thickness at Lion Mountain about 260 m

Boulder conglomerate (Paleocene and Upper Cretaceous)—Unconsolidated cobbles and boulders of subrounded metamorphic rock in scattered exposures along crest of Gravelly Range. Maximum preserved thickness about 10 m

Beaverhead Group (Upper Cretaceous)

Limestone and conglomerate—Limestone and limestone conglomerate interbedded with varying amounts of siltstone and sandstone. Best exposures are at Red Hill in Gravelly Range where basal siltstone and limestone conglomerate are interlayered with lenses of well-rounded quartzite gravel in an angular quartz sand matrix; gravel is similar to that of underlying stream gravel deposits (Kbeg) and may have been derived, in part, from these fluvial deposits. Lacustrine limestone is medium to coarse crystalline and light gray, and locally contains abundant snails, stromatolites, and oncolites; also commonly interlayered with coarse-grained sandstone, siltstone, and intraformational limestone rip-up conglomerate. Many of the conglomerate lenses consist of clasts of locally derived Paleozoic rocks upon which these rocks rest; they are confined to paleovalleys that, in Gravelly Range, drained from west to east. Maximum thickness about 20 m

Gravel and sand—Unconsolidated, well-rounded, pebble- to cobble-size stream deposits composed chiefly of quartzite derived from Mesoproterozoic Lemhi Group and Belt Supergroup exposed to the northwest and west of Gravelly Range, beyond borders of Hebgen Lake quadrangle. Thickness about 10 m or less

Sandstone—Poorly exposed, buff to brown silty sandstone interlayered with lenses of well-rounded to subrounded cobbles and boulders of metamorphic rock; present in northern Centennial Valley and southernmost Gravelly Range. Thickness may be as much as 725 m

Everts(?) Formation and Virgelle Sandstone, undivided (Upper Cretaceous)

Everts(?) Formation—Light- to dark-gray, thin- to thick-bedded, fine- to medium-grained, quartz-rich sandstone and interbedded siltstone; includes sparse mudstone, porcellanite, and dark-gray limestone. Lower 60–90 m are thinly interbedded mudstone, siltstone, shale, coal, and minor crossbedded sandstone. About 425 m thick

Virgelle Sandstone—Thin- to thick-bedded, medium- to coarse-grained, crossbedded sandstone forming prominent white-weathering ledges. Thickness ranges from 23 to 50 m

Telegraph Creek Formation (Upper Cretaceous)—Upper half consists of light-brown-weathering mudstone and siltstone; thin interbeds of light-gray sandstone locally contain chert-pebble lags and glauconite. Middle 20 m consists of conspicuous white-weathering, finely laminated tuffaceous siltstone. Lower 75 m consists of slope-forming siltstone and mudstone in upper part that overlies lowermost "salt and pepper," ripple-marked sandstone. Total thickness about 206 m

Cody Shale (Upper Cretaceous)—Dark-gray, thin-bedded, locally micaceous and silty mudstone; thin interbeds of gray-green siltstone and fine-grained sandstone. About 300 m thick

Frontier Formation (Upper Cretaceous)—Interbedded sandstone, siltstone, mudstone, carbonaceous shale and coal seams, and minor limestone. Sandstone is predominantly medium light gray to yellowish or greenish gray, very fine to medium grained, and commonly calcareous. Coarse-grained varieties include subangular lithic sand grains of chert, feldspar, and biotite; locally conglomeratic, containing well-rounded pebbles of quartzite and chert. Sandstone beds generally less than 1 m, but occur in layered units as much as 7 m thick. Siltstone and mudstone are olive gray and medium to dark gray, bentonitic, and porcellanitic. Limestone is thin bedded to nodular, light to medium gray, and micritic. Thickness ranges from about 870 m directly north of Gravelly Range to 2,100 m near southern part of Gravelly Range, and thins to 120 m in Madison Range

Mowry Shale (Upper Cretaceous)—Upper part is slope-forming, dark-gray mudstone and silty mudstone interbedded with minor siltstone, sandstone, and bentonite with organic-rich shale. Lower part is light-colored pink, gray-green, green, and orange-cream mudstone, bentonitic mudstone, and porcellanite interlayered with welded tuff, mudstone, siltstone, and minor quartz sandstone. Generally poorly exposed because of slumping; in Gravelly Range the Mowry is the site of pronounced landsliding. About 150–180 m thick

Muddy Sandstone (Lower Cretaceous)—Upper part consists of light-gray, thin- to medium-bedded, fine- to coarse-grained quartz sandstone, feldspathic sandstone, and arkose. Middle part is dark-gray, thin-bedded siltstone, sandstone, and shale. Lower part is greenish-gray to tan, fine- to medium-grained sandstone. Middle part thins to the west and is absent in Gravelly Range. Thickness ranges from 0 to about 110 m

Thermopolis Shale (Lower Cretaceous)—Dark-gray to black, fissile, organic-rich shale overlying light- to dark-brown-weathering, thin- to medium-bedded, fine- to medium-grained sandstone. Thickness ranges from about 50 to 75 m

Kootenai Formation (Lower Cretaceous)—Upper 15 m consists of conspicuous, ledge-forming, medium- to thick-bedded, light-gray fresh-water limestone that contains abundant gastropods. Middle part is a slope-forming gray, maroon, yellow, red, and purple mudstone with siltstone, sandstone, and, in its lower part, minor limestone. Lower part is thick-bedded, cherty, crossbedded, quartz-rich sandstone and minor, well-rounded chert-pebble conglomerate. Thickness about 125 m

Morrison Formation (Upper Jurassic) and Ellis Group (Upper and Middle Jurassic), undivided

Morrison Formation (Upper Jurassic)—Interbedded red, green, gray, and yellowish-gray siltstone, mudstone, and shale locally interlayered with thin beds of dense, fine-grained limestone. In Madison Range upper part includes yellowish-tan, medium-bedded sandstone lenses as much as 20 m thick. Generally poorly exposed and forms reddish-colored slopes. Maximum thickness about 100 m

Ellis Group (Upper and Middle Jurassic)

Swift Formation (Upper Jurassic)—Thin- to medium-bedded, medium- to coarse-grained, calcareous, locally chert bearing quartz sandstone; contains abundant ooids and shell fragments. Lowermost part is olive-green shale and claystone. The Swift is the only formation of the Ellis Group exposed in western part of map area. Thickness ranges from about 1 to 30 m

Rierdon Limestone (Middle Jurassic)—Light-gray to pale-brown, thin- to thick-bedded, dense, oolitic limestone; locally contains sparse chert pebbles. Absent in western part of map area. Maximum thickness about 30 m

Sawtooth Formation (Middle Jurassic)—Thin-bedded, light- to dark-gray limestone; local shaly to silty limestone interbeds; locally fossiliferous and oolitic. Absent in western part of map area. Maximum thickness about 55 m

Woodside and Dinwoody Formations, undivided (Lower Triassic)

Woodside Formation (Lower Triassic)—Brick-red to orange-red, thin-bedded siltstone and mudstone interbedded with gypsum and thin, discontinuous limestone beds; uppermost strata are silty and locally crossbedded. Thickness ranges from 0 to about 220 m

Dinwoody Formation (Lower Triassic)—Tan- to pale-brown-weathering, finely laminated, calcareous siltstone in upper part; grades downward into chocolate-brown-weathering gray to tan limestone, silty limestone, and siltstone. Thickness variable, ranging from about 20 to 80 m

Shedhorn Sandstone (Lower Permian)—Uppermost part is medium-bedded, fine- to coarse-grained sandstone; minor chert lenses grade downward into yellowish- to dark-brown, thin-bedded chert with silty, locally phosphatic partings. Lower part is brown to gray, thin- to medium-bedded sandstone that grades downward into yellowish-gray, medium-bedded dolomite and sandy dolomite locally containing abundant chert fragments. Equivalent in part to the Phosphoria Formation. Thickness variable, ranging from about 35 to 70 m

Quadrant Sandstone (Pennsylvanian)—White to tan, medium- to thick-bedded, clean, well-sorted quartz sandstone. Lower part contains thin interbeds of pale-brown dolomite and gray limestone. Thickness 60–100 m

Amsden Formation (Middle Pennsylvanian to Upper Mississippian)—Dark-red, gray-red, and pinkish-red, thin-bedded, calcareous siltstone, silty shale, and shale. Upper part contains interbeds of medium- to coarse-grained calcareous sandstone whereas lower part is interbedded with thin-bedded limestone, limestone-pebble conglomerate, and dolomite. Thickness ranges from about 10 to 50 m

Madison Group, undivided (Upper and Lower Mississippian)—Thickness ranges from about 400 to 700 m

Mission Canyon Limestone (Upper and Lower Mississipian)—Commonly cliff forming, thick-bedded, light-gray-weathering, cherty, fine-grained limestone and minor dolomite. Uppermost few meters of formation contain prominent orangish-gray-weathering solution breccia

Lodgepole Limestone (Lower Mississippian)—Slope- to ledge-forming, thin- to medium-bedded, light-gray, finely crystalline, fossiliferous limestone; brownish-gray silty limestone partings

Three Forks Formation (Lower Mississippian and Upper Devonian)—Consists of three members, from top to bottom: yellowish-tan calcareous siltstone and silty limestone (Sappington Member, maximum thickness 25 m); gray-green, fissile, micaceous shale (Trident Member, maximum thickness 6 m); and yellowish-gray vuggy limestone and dolomite underlain by olive-green micaceous shale (Logan Gulch Member, maximum thickness 12 m)

Jefferson Dolomite (Upper Devonian)—Light-gray, tan, yellowish-brown, and dark-gray, finely crystalline to sucrosic dolomite locally interbedded with 1-m-thick silty, shaly, laminated dolomite. In Madison Range, includes uppermost, massive, ledge-forming dolomite breccia (Birdbear Member). Maximum thickness about 100 m

Bighorn(?) Dolomite (Upper Ordovician) and Snowy Range Formation and Pilgrim Limestone (Upper Cambrian), undivided

Bighorn(?) Dolomite—Light-gray, thin-bedded, dense cryptocrystalline dolomite. About 11 m thick

Snowy Range Formation—Tan, thin-bedded limestone with reddish mottles underlain by greenish, thin-bedded dolomite and dolomitic mudstone that grades downward into red calcareous siltstone and green sandy shale. About 300 m thick

Pilgrim Limestone—Light-gray and yellowish-brown to gray-brown, thin- to medium-bedded, glauconitic dolomitic limestone; mud-chip conglomerate and oolitic beds locally common. Thickness approximately 60 m

Pilgrim Limestone (Upper Cambrian) and Park Shale and Meagher Limestone (Middle Cambrian), undivided

Park Shale (Middle Cambrian)—Greenish-gray to reddish-gray, fissile, locally waxy looking shale interbedded with minor limestone, limestone-pebble conglomerate, and oolitic limestone. Poorly exposed everywhere and perhaps

locally missing in Gravelly Range. Locally included with the underlying Meagher Limestone where too thin to show on map. Thickness 0–30 m
Meagher Limestone (Middle Cambrian)—Light-gray to brownish-gray, thin- to medium-bedded, finely crystalline limestone; thin partings of calcareous shale in upper and lower parts; characteristically contains irregular orange-yellow silty mottles; locally interbedded with centimeter-thick oolitic limestone. Basal few meters of formation in Gravelly Range, where it directly overlies Paleoproterozoic metasedimentary rocks, are characterized by calcareous-cemented lag gravel deposits. In Gravelly Range, locally includes thin, unmapped deposits of the Wolsey Shale and Flathead Sandstone. Maximum thickness about 150 m
Wolsey Shale and Flathead Sandstone, undivided (Middle Cambrian)
Wolsey Shale (Middle Cambrian)—Gray-green to dark-gray, fissile, micaceous shale interbedded with minor, thin limestone beds similar to mottled limestone of the overlying Meagher Limestone as well as thin, glauconitic, quartzose sandstone similar to the underlying Flathead Sandstone. Locally missing in Gravelly and Centennial Ranges. Thickness 0–60 m
Flathead Sandstone (Middle Cambrian)—White, tan, to reddish-brown, hematitic, thin- to medium-bedded, fine- to medium-grained quartz to feldspathic sandstone; interlayered with greenish shale in upper part; glauconitic locally. Where unmapped in Centennial and Gravelly Ranges, formation may be missing or so thin that it is included in the overlying Meagher Limestone. Thickness 0–30 m

LATE PALEOPROTEROZOIC ROCKS

[Late Paleoproterozoic tectonites, metasedimentary rocks, and associated igneous rocks. Relative ages as listed, youngest to oldest. All except mylonite (Xmy) exposed only in Gravelly Range. Rocks have been divided into 12 metasedimentary members (Xpm through Xq4) that have been intruded by gabbro sills and small plugs and, in the north, a granitic stock. The weakly metamorphosed rocks are interpreted to represent a sequence of late Paleoproterozoic clastic foreland basin deposits (O'Neill, 1999) consisting mainly of sandstone and shale; sedimentary iron-formation occurs in middle of sequence and is a marker horizon throughout Gravelly Range. Gabbroic intrusive rocks are weakly tectonized and are associated with contact metamorphic aureoles marked by porphyroblasts of andalusite or staurolite, or both, in pelitic rocks around their perimeters. Mylonitization of rocks occurred about 1.8 Ga, coeval with mylonitic rocks to the east in Madison Range]
Mylonite
Granite
Gabbro, chloritized
Gabbro
Quartzite member 4
Phyllite member 3
Phyllite member 2
Quartzite member 3
Knotted mica schist
Iron-formation

Phyllite member 1
Quartzite member 2
Quartz-mica schist
Quartzite member 1
Quartz-feldspar-biotite gneiss
Pegmatite and metasedimentary rocks, undivided

EARLY PALEOPROTEROZOIC(?) AND LATE ARCHEAN SUPRACRUSTAL METASEDIMENTARY AND META-IGNEOUS ROCKS

[Amphibolite-grade metasedimentary rocks are strongly deformed and show abundant evidence of internal thickening and thinning; original thickness of metamorphic units is not known. These supracrustal rocks, called the Cherry Creek Metamorphic Suite for exposures in Gravelly Range along Cherry Creek directly north of map area (Heinrich, 1960), have traditionally been accepted as being Late Archean in age. Erslev and Sutter (1990) obtained latest Archean (2.53 Ga) cooling ages from gneissic rocks interlayered with metasedimentary rocks directly west of Henrys Lake; however, it is not clear how the gneissic rocks are related to the enclosing metasedimentary rocks. Given the strongly folded and thrust-faulted nature of these rocks, the likely imbricate stacking of Archean crustal rocks with overlying, younger supracrustal rocks in a fold-and-thrust belt, and the fact that supracrustal rocks are virtually unknown from Archean basement rocks of North America, we tentatively suggest the possibility of an early Paleoproterozoic age for these metasedimentary rocks]

Granodioritic gneiss—Foliated granodiorite as intrusive sills that locally show crosscutting relationships and chilled margins. Rock is equigranular and composed of plagioclase, quartz, microcline, hornblende, and biotite
Amphibolite—In Madison Range, amphibolite dikes and sills range from infolded, disjointed units to tabular sheets with sharp, planar contacts; mapped units were probably originally gabbroic intrusive rock. In eastern Centennial Range and Horn Mountains, amphibolite is green to greenish brown, schistose to massive, generally fine grained, and locally porphyroblastic; actinolite makes up as much as 50–90 percent of rock
Marble—Massive, light-gray to cream-colored dolomitic marble interlayered with thin quartzite bands; schistosity defined by aligned chlorite and phlogopite, and flattened dolomite grains. In thin section, dolomite dominates the marble; calcite is associated with quartzite layers only; quartz is present generally as granular bands within marble
Quartzite—Light-green, poorly banded quartzite; interfingers with adjacent rock units; quartzite has been completely recrystallized and does not show clastic textures or graded bedding
Mica schist—Interlayered rusty-yellow-weathering, quartz-rich muscovite schist and thin quartzite; locally contains abundant magnetite, chlorite, biotite, and poikiloblastic garnet
Chlorite-biotite schist—Well-banded chlorite-biotite schist and gneiss containing variable amounts of quartz and epidote; interlayered with green phyllonite, chloritic schist with quartz augen, and granulated amphibolite

Biotite schist and gneiss—Compositional layering of biotite-rich metamorphic rocks is defined by relative proportions of quartz, biotite, garnet, and muscovite. Beds, 1–3 m thick, of biotite-rich metasandstone with well-preserved clastic textures separated by thinner beds of metapelite are common. Biotite schist also interlayered with marble (XWm) and associated with chlorite-biotite schist (XWcs) and well-banded quartzite similar to banded cherts associated with minor, unmapped iron-formation

MIDDLE ARCHEAN ROCKS

[Middle Archean amphibolite- to granulite-grade metamorphic tectonites and associated igneous rocks; relative ages uncertain. Middle Archean (>3.1 Ga) age has been confirmed by U-Pb zircon ages from crystalline rocks collected from southern Madison Range (Shuster and others, 1987)]

Ultramafic rock—Pods and lenses of hornblende-rich rock consisting mainly of, from rim to core, hornblende and biotite, actinolite and biotite, chlorite, talc and carbonate, anthophyllite, and serpentine

Granite and granitic gneiss—Pink, foliated granitic rocks having weakly to strongly discordant contacts with adjacent rocks. Rock composition and texture variable, ranging from medium grained and equigranular with faint layering defined by aligned biotite, to highly folded and contorted leucogranite enclosing granodioritic xenoliths, to mafic folded granite and granite gneiss. Northernmost exposures of granitic gneiss in Madison Range contain conspicuous elongate feldspar augen

Quartz-feldspar-biotite gneiss and migmatite—Weakly foliated granitic gneiss; locally strongly deformed. Commonly cut by veins of equigranular granite and pegmatite. Similar in texture to granitic gneiss (Vg) but less mafic and generally concordant

Quartz-feldspar-biotite gneiss and pegmatite—Well-foliated, fine- to medium-grained granitic gneiss cut by abundant, coarse-grained quartz-feldspar pegmatite. Intruded by adjacent granite (Xgr)

Dioritic gneiss—White- and green-spotted, well-foliated plagioclase-hornblende-quartz rock as thin sills and small stocks. Sills typically consist of 60–80 percent plagioclase and hornblende, and minor quartz; stocks are more felsic and include biotite and as much as 30 percent quartz

Tonalitic gneiss—Tonalitic migmatite gneiss and tonalitic biotite gneiss; highly variable both texturally and compositionally; gneiss includes amphibolitic migmatite breccia, leucotonalite gneiss, and dark-gray tonalitic biotite gneiss with moderate migmatite banding. Locally, tonalite gneiss is interlayered with a mixed gneiss composed of green quartzite, biotite-garnet gneiss, amphibolite and garnet amphibolite, and gedrite-cordierite-bearing gneiss. All tonalitic rocks consist of essential plagioclase, quartz, hornblende, and biotite with a granoblastic texture. Also included with these rocks is migmatitic granite gneiss characterized by granite leucosomes containing abundant microcline between thin layers enriched in plagioclase, biotite, and, locally, hornblende

Contact—Dashed where approximately located; dotted where concealed

Normal fault—Dashed where approximately located; dotted where concealed

Thrust fault—Dashed where approximately located; dotted where concealed
Anticline—Dotted where concealed
Overturned anticline
Syncline—Dotted where concealed
Overturned syncline
Monocline

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