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

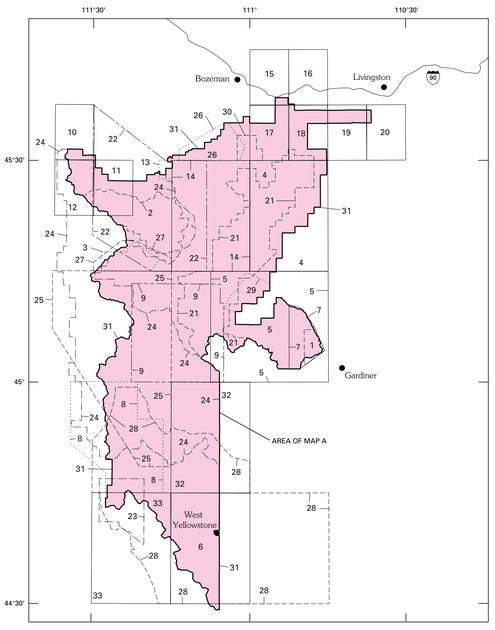
GEOLOGIC INVESTIGATIONS SERIES
I–2584 (SHEET 1 OF 2)

INTRODUCTION

The geology of Gallatin National Forest (GNF) was mapped as part of an evaluation of its mineral resource potential by the U.S. Geological Survey (USGS). Map A, the western part of GNF, south of Interstate Highway 90 (I-90) and west of the Yellowstone River, includes the Gallatin and Madison Ranges and the West Yellowstone area. Map B, the northern part of GNF, north of I-90, includes the Bridger Range and Crazy Mountains. The eastern part of GNF, south of I-90 and east of the Yellowstone River, was examined previously by the USGS as part of the mineral resource potential study of the Absaroka-Beartooth study area and is published separately (Hammarstrom and others, 1993).

The colored maps of this report supersede a black-and-white version (Wilson and Elliott, 1995). Both maps were digitized, compiled, and produced using the USGS software program GSMAP (Selner and Taylor, 1993) and unreleased proprietary updates to it. All original source maps were digitized at their original scales and map projections, then merged into the final digital map formats. After editing, the digital maps were filtered to remove all points not necessary for improving resolution at a scale of 1:126,720 (2 mi per in., the scale used in this report and by the U.S. Forest Service).

Rocks range in age from Archean to Holocene. For purposes of resource assessment (Elliott and others, 1995), many rock units have been combined on these maps. Only brief descriptions of rock units are presented here; the reader is referred to original sources for detailed rock unit descriptions.

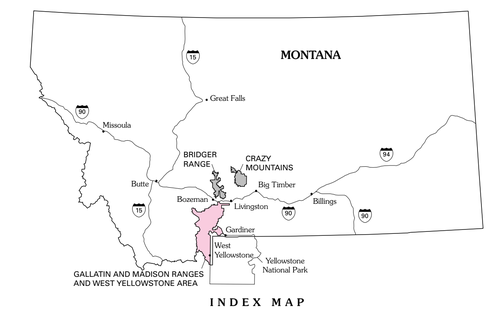


INDEX TO SOURCES OF GEOLOGIC MAPPING

SOURCES OF GEOLOGIC MAPPING

[The following sources were also consulted, but are not shown on the "Index to Sources of Geologic Mapping": Fix (1940), Fraser and others (1969), Freeman and others (1950), Hamilton (1964), Pierce and others (1991), Richards (1957), Roberts (1972), Spencer and Kozak (1975), Swanson (1970), Tilley (1976), Todd (1969), and Tysdal and others (1986)]

1 Adams, K.D., and Pierce, K.L., USGS, 1989?, unpublished map compilation, scale 1:62,500.
2 Becraft and others (1966)
3 Bolm (1969)
4 Chadwick (1982)
5 Chadwick, R.A., Montana State University, year unknown, unpublished mapping, approximate scale 1:48,000.
6 Christiansen, R.L., and Blank, H.R., Jr., USGS, 1975, unpublished mapping of West Yellowstone quadrangle, scale 1:62,500.
7 Elliott, J.E., USGS, 1994, unpublished mapping of part of Tom Miner basin area and Yankee Jim Canyon area, scale 1:24,000.
8 Erslev (1981, 1983)
9 Hall (1961)
10 Kellogg (1995)
11 Kellogg, Karl, USGS, 1994, unpublished mapping of Willow Swamp quadrangle, scale 1:24,000.
12 Kellogg (1993)
13 Kellogg, Karl, USGS, 1994, unpublished mapping of part of Beacon Point quadrangle, scale 1:24,000.
14 McMannis and Chadwick (1964)
15 Roberts (1964a)
16 Roberts (1964b)
17 Roberts (1964c)
18 Roberts (1964d)
19 Roberts (1964e)
20 Roberts (1964f)
21 Simons and others (1985)
22 Spencer and Kozak [1973 (1980)]
23 Sumner (1988)
24 Tysdal and Simons (1985)
25 Tysdal (1990)
26 Tysdal (1966)
27 Tysdal, R.G., USGS, 1980–83, unpublished mapping of Big Sky–Lone Mountain area, scale 1:62,500.
27 Wilson, A.B., Hammarstrom, J.M., Van Gosen, B.S., and Elliott, J.E., USGS, 1993, unpublished mapping of Big Sky–Lone Mountain area, scale 1:24,000.
28 U.S. Geological Survey (1964).
29 Van Gosen, B.S., USGS, 1993, unpublished mapping of part of Tom Miner basin area, scale 1:24,000.
30 Weber (1965)
31 Wilson and Elliott (1995)
32 Witkind (1969)
33 Witkind (1972)



INDEX MAP

DESCRIPTION OF MAP UNITS

GALLATIN AND MADISON RANGES AND WEST YELLOWSTONE AREA

Qs **Surficial deposits, undivided (Quaternary)**—Alluvium, colluvium, talus, landslide deposits, rock glaciers, glacial and glaciofluvial deposits, and boulder fields. Only selected major areas, generally exposed for at least 1 mi in a single direction, are shown

Qr **Rhyolite (Pleistocene)**—Rhyolite flows of Madison Plateau, in extreme southern part of map area. Upper part (about 100 ft) is agglomerate consisting of blocks of black obsidian (ranging from granules to large blocks) in a matrix of unconsolidated glass shards. Much of the obsidian is crumbly and spherulitic (1–3 cm in diameter and varicolored). Middle part (several hundred feet) is flow-banded rhyolite. Lower part (30 ft) is perlitic and spherulitic obsidian agglomerate (Hamilton, 1964)

QTf **Felsic volcanic rocks (Pleistocene and Pliocene)**—Includes Plateau Rhyolite [Central Plateau Member (Pleistocene: Christiansen and Blank, 1972)] and Yellowstone Group [including Lava Creek Tuff (Pleistocene: Christiansen and Blank, 1972) and Huckleberry Ridge Tuff (Pliocene: Love, 1989)]. Plateau Rhyolite is light-gray, dense, lithoidal, fine-grained to aphanitic ash-flow tuff. Phenocrysts (1.5 mm in diameter) of quartz, sanidine, pyroxene, fayalite, and sphene form 25 percent of rock (Witkind, 1972). Yellowstone Group is light-brown to gray, thick-bedded, mostly rhyolitic, porphyritic welded tuff and minor flows. Matrix is chiefly devitrified glass shards; phenocrysts of sanidine, quartz, and sparse plagioclase (Tysdal and Simons, 1985; Tysdal, 1990)

Tt **Trachyte, trachybasalt, and basalt (Eocene)**—Basalt porphyry, trachybasalt porphyry, and trachyte porphyry in volcanic flows and breccias; probably correlates with Absaroka Volcanic Supergroup. Mapped south of Hebgen Lake (Christiansen and Blank, 1975)

Tv **Volcanic rocks of the Absaroka Volcanic Supergroup, undivided (Eocene)**—Includes Hyalite Peak and Golmeyer Creek Volcanics (Chadwick, 1982). Volcanic flows and breccia, andesite and basalt flows, pyroxene trachyte porphyry, breccia, tuff, conglomerate, sandstone, channel-fill deposits, and minor carbonaceous siltstone. Lava flows mostly gray, fine-grained to sparsely porphyritic andesite and basalt; plagioclase and pyroxene phenocrysts; aphanitic groundmass; some lava more (Simons and others, 1985; Tysdal and Simons, 1985) or less (McMannis and Chadwick, 1964) silicic. Volcanic breccia interlayered with the flows. Some volcanic units contain abundant fossil wood

Ti **Intrusive rocks, undivided (Eocene)**—Dacitic, andesitic, and basaltic dikes, sills, and small stocks. Dacitic rocks show distinct flow structures and are conspicuously porphyritic; contain phenocrysts of plagioclase, hornblende, and biotite; matrix of feldspar microlites and devitrified glass. Andesitic and basaltic rocks contain a few small phenocrysts of plagioclase in pilotaxitic groundmass of andesine(?) microlites and interstitial pyroxene and opaque minerals (Simons and others, 1985)

Tc **Conglomerate (Eocene)**—Poorly indurated conglomerate of cobbles and boulders of Precambrian gneiss, amphibolite, vein quartz, Paleozoic carbonate strata, and volcanic rocks. Contacts not exposed; presumed to be basal unit of Tertiary sequence. Mapped only near Garnet Mountain in northern part of Gallatin Range (McMannis and Chadwick, 1964)

Kda **Dacitic and andesitic intrusive rocks (Upper Cretaceous)**—Gray porphyritic dacite and, locally, andesite sills and dikes; hornblende and plagioclase phenocrysts; fine-grained to aphanitic plagioclase, potassium feldspar, and quartz matrix. Includes dacite porphyry laccolith, more than 1,500 ft thick, along Gallatin River (Witkind, 1969); sills as much as 400 ft thick and dikes 3–50 ft thick (Tysdal and Simons, 1985; Tysdal, 1990). K-Ar and $^{40}Ar/^{39}Ar$ dates on hornblende 68–69 Ma (Tysdal and others, 1986; Tysdal, 1990)

Klv **Livingston Formation (Upper Cretaceous)**—Upper member is volcaniclastic sandstone, mudflow breccia, volcanic conglomerate, and mudstone; middle member is dacite to basalt, autoclastic breccia, tuff breccia, welded tuff, dacite flows, and volcaniclastic sandstone; lower member is intertonguing volcaniclastic sandstone, olivine basalt, mudflow breccia, volcanic conglomerate, and mudstone. Well exposed. Total thickness 1,500–2,500 ft (Roberts, 1972; Tysdal and Simons, 1985; Tysdal, 1990)

Ke **Eagle Sandstone, Virgelle Sandstone, and Everts Formation, undivided (Upper Cretaceous)**—In extreme northeastern part of map area, near Cokedale, Eagle Sandstone is divided into an unnamed upper member and a lower member, the Virgelle Sandstone. Upper part of upper member includes an upper zone of coal beds, carbonaceous siltstone, and sandstone that is underlain by well-bedded to massive, medium- to well-sorted, light-olive-gray quartzose sandstone and siltstone; lower part of upper member contains two units of coal, carbonaceous siltstone, and fine-grained sandstone. Coal zones contain commercial-grade, high-volatile bituminous coal beds, some of coking quality (Roberts, 1972); some beds were extensively mined until the early 1900's. Underlying Virgelle Sandstone is very light gray, well-cemented, massive to crossbedded, fine-grained arkosic sandstone (Roberts, 1972). Total thickness of Eagle Sandstone is 645 ft, including the 110-ft-thick Virgelle Sandstone (Roberts, 1966).

In Madison Range only the Virgelle Sandstone is mapped and overlying strata are assigned to the Everts Formation rather than the Eagle Sandstone (Tysdal and Simons, 1985; Tysdal, 1990). Upper 1,000–1,200 ft of Everts Formation is gray, fine- to medium-grained quartz-rich sandstone and interbedded siltstone; contains mudstone, porcellanite, and finely crystalline limestone beds; lower 200–300 ft is thin interbeds of mudstone, siltstone, shale, coal, and minor sandstone, and a few beds of several-feet-thick, light-gray, fine- to medium-grained, crossbedded sandstone. Virgelle Sandstone is thin- to thick-bedded, medium- to coarse-grained, crossbedded quartz sandstone that forms prominent white-weathering ledges; thickness 75–165 ft (Tysdal, 1990)

Ku **Upper Cretaceous sedimentary rocks, undivided**—In descending order, includes Eagle Sandstone, Telegraph Creek Formation, Cody Shale, Frontier Formation, and Mowry Shale. Includes Eagle Sandstone **(Ke)** along northwest corner of Yellowstone National Park; see description of unit **Ke**. Telegraph Creek Formation is predominantly siltstone and thin-bedded, moderately well sorted sandstone cemented with calcite and containing calcareous concretions; weathers distinctive yellowish gray (Roberts, 1972). In Madison Range, upper part of Telegraph Creek Formation is light-brown-weathering mudstone and siltstone, with minor sandstone and glauconite in some beds; middle part has white-weathering tuffaceous siltstone marker; lower part is siltstone and mudstone overlying ledge-forming, gray, "salt-and-pepper" sandstone (Tysdal and Simons, 1985). About 675 ft thick in Madison Range (Tysdal and Simons, 1985). Cody Shale is mudstone and thin interbeds of gray-green siltstone and minor fine-grained sandstone; about 1,000 ft thick (Tysdal and Simons, 1985). Frontier Formation is gray sandstone interlayered with darker gray siltstone and mudstone in northern part of map area; gray-green glauconitic sandstone, siltstone, and mudstone with zones of coaly shale, pale-green tuff, and porcellanite in southern part; total thickness about 400 ft (Tysdal and Simons, 1985). Mowry Shale is included only along Gallatin River in central part of map area; elsewhere, Mowry Shale is included with undivided Upper and Lower Cretaceous sedimentary rocks (**Kul**). Upper part of Mowry Shale is slope-forming, gray mudstone; lower part is pastel-colored mudstone, porcellanite, welded tuff, siltstone, and sandstone; total thickness about 700–900 ft (Tysdal and Simons, 1985)

Kul **Upper and Lower Cretaceous sedimentary rocks, undivided**—In descending order, includes Mowry Shale (Upper Cretaceous) and Muddy Sandstone, Thermopolis Shale, and Kootenai Formation (Lower Cretaceous). Includes Mowry Shale except along Gallatin River in central part of map area where Mowry is included with undivided Upper Cretaceous sedimentary rocks unit (**Ku**); see unit **Ku** for description of Mowry Shale. Upper part of Muddy Sandstone is gray to tan sandstone and arkosic sandstone; middle part is dark-gray siltstone, fine-grained sandstone, and shale; lower part is poorly sorted, ledge-forming, crossbedded sandstone; total thickness about 125–350 ft (Tysdal and Simons, 1985). Upper part of Thermopolis Shale is dark-gray, locally carbonaceous, fissile shale; lower part is brown, rusty-weathering sandstone with crossbeds and ripple marks; total thickness 200–250 ft (Tysdal and Simons, 1985). Upper part of Kootenai Formation is nonmarine gastropod limestone; middle part is variegated red-yellow-gray mudstone, siltstone, and minor sandstone and limestone; lower part is ledge-forming, cherty, quartzose sandstone and conglomeratic sandstone; total thickness about 350–500 ft (Tysdal and Simons, 1985)

J'ku **Jurassic and Triassic sedimentary rocks, undivided**—In descending order, includes Morrison Formation (Upper Jurassic); Ellis Group (Upper and Middle Jurassic); Chugwater Formation (Triassic); and Thaynes(?) Formation, Woodside Siltstone, and Dinwoody Formation (Lower Triassic). Morrison Formation is varicolored nonmarine claystone and mudstone; about 225–400 ft thick (Simons and others, 1985; Tysdal and Simons, 1985). Ellis Group comprises Swift, Rierdon, and Sawtooth Formations. Swift Formation is cream-colored to brown to gray, oolitic, shelly, cherty, calcareous and glauconitic sandstone, sandy limestone, and chert-pebble conglomerate; Rierdon Formation is gray-brown oolitic limestone, fossiliferous gray shale, and argillaceous limestone; Sawtooth Formation (lithic equivalent to Piper Formation of central Montana) is gray, fine-grained, fossiliferous limestone, argillaceous limestone, shale, and varicolored siltstone. Ellis Group is about 80–300 ft thick (Simons and others, 1985; Tysdal, 1985). Chugwater Formation is poorly exposed red siltstone, shale, and fine-grained sandstone; few thin gypsum beds; about 500 ft thick (Simons and others, 1985). Thaynes(?) Formation is gray-orange, thin-bedded, calcareous siltstone and gray-green clay shale; local ledge former; only 0–10 ft thick (Tysdal and Simons, 1985). Woodside Siltstone is red, thin-bedded siltstone and mudstone interbedded with gypsum and thin gray limestone beds; thickness varies from 0 to 725 ft (Tysdal and Simons, 1985). Dinwoody Formation is brown to yellow-gray, chocolate-brown-weathering, thin-bedded limestone, silty limestone, and calcareous siltstone; about 70–265 ft thick (Simons and others, 1985; Tysdal and Simons, 1985)

PMu **Permian, Pennsylvanian, and Mississippian sedimentary rocks, undivided**—In descending order, includes Shedhorn Sandstone (Permian), Quadrant Sandstone (Pennsylvanian), and Amsden Formation (Lower Pennsylvanian and Upper Mississippian). Sandstone, siltstone, mudstone, shale, chert, limestone, and dolomite. Refer to units **Ps** and **IPMu** for descriptions of formations

Ps **Shedhorn Sandstone (Permian)**—Lateral equivalent to the Phosphoria Formation to the west and south (McKelvey and others, 1959). Mostly brown to gray, locally conglomeratic sandstone containing abundant grains, nodules, and layers of chert and pellets of phosphorite (Simons and others, 1985). From top to bottom: interlayered chert beds and common vertical cylindrical burrows; dark-colored, gray to brown, thin-bedded chert with siltstone partings over phosphatic mudstone and limestone; brown to dark-gray, well-cemented sandstone with interbeds of chert and limestone; and yellow-gray dolomite with abundant chert fragments and a few interbeds of dark-brown sandstone. Thickness 115–225 ft (Tysdal and Simons, 1985; Tysdal, 1990)

IPMu **Quadrant Sandstone (Pennsylvanian) and Amsden Formation (Lower Pennsylvanian and Upper Mississippian), undivided**—Quadrant Sandstone is white to tan, bedded, clean, well-sorted quartz sandstone with silica or calcite cement. Interbeds of yellow-brown dolomite and gray limestone in lower part. Thickness about 200–315 ft (Tysdal, 1990). Underlying Amsden Formation is red to pink, calcareous siltstone to shale. Upper part of formation contains calcareous sandstone cemented with iron oxides; middle and lower parts contain limestone, limestone-pebble conglomerate, and dolomite. Thickness 40–160 ft (Tysdal, 1990)

Mm **Madison Group (Mississippian)**—Includes Mission Canyon Limestone and underlying Lodgepole Limestone. Mission Canyon Limestone is buff to brown, gray-weathering, bedded, finely crystalline limestone and minor dolomite with some oolitic, bioclastic, and crossbedded layers. Orange solution breccia in upper part. Persistent cliff former. Lodgepole Limestone is more fossiliferous and contains partings of calcareous silty limestone; chert nodules and stringers in lower beds. Total thickness about 1,300–1,450 ft (Tydsal, 1990; Tysdal and Simons, 1985; Simons and others, 1985)

MDt **Three Forks Formation (Lower Mississippian and Upper Devonian) and Jefferson and Maywood Formations (Upper Devonian), undivided**—At top of unit, Three Forks Formation includes, in descending order, Sappington, Trident, and Logan Gulch Members. Sappington Member is gray to yellow, calcareous siltstone, siltstone, and sandstone; only uppermost part is Lower Mississippian in age. Trident Member is gray to yellow dolomite, dolomitic shale, and some limestone. Logan Gulch Member is red, orange, or yellow carbonate-shale breccia. Total thickness 100–250 ft (Simons and others, 1985; Tysdal, 1990; Tysdal and Simons, 1985). Jefferson Formation includes Birdbear Member and underlying Lower Member. Birdbear Member is brown, coarse-grained, ledge-forming dolomite. Lower Member is brown-gray, fine-grained (sucrosic) dolomitic limestone and limestone; dolomite is fetid and has petroliferous odor. Total thickness about 300–450 ft (Simons and others, 1985; Tysdal, 1990; Tysdal and Simons, 1985). Locally in northern part of map area, Maywood Formation is at base of unit; pale-brown-gray, silty, sandy, and pebbly dolomite overlying yellow, dolomitic, sandy, and conglomeratic siltstone on a regolith (or breccia) base; about 34 ft thick (McMannis and Chadwick, 1964; Roberts, 1964f)

O€u **Ordovician and Cambrian sedimentary rocks, undivided**—In descending order, includes Bighorn(?) Dolomite (Ordovician); Snowy Range Formation (and laterally equivalent Red Lion Formation) and Pilgrim Limestone (Upper Cambrian); and Park Shale, Meagher Limestone, Wolsey Shale, and Flathead Sandstone (Middle Cambrian). Bighorn(?) Dolomite is light-gray, dense cryptocrystalline dolomite; about 35 ft thick (Tysdal, 1990). Snowy Range Formation, which includes Grove Creek Limestone, Sage Limestone, and Dry Creek Shale Members, is tan, thin-bedded limestone with irregular-shaped red mottles and interbedded red silty mudstone underlain by green, thin-bedded dolomite and dolomitic mudstone with green clay-shale partings in the upper part and red calcareous siltstone and green sandy clay shale in the lower part; thickness about 300 ft (Tysdal, 1990). Pilgrim Limestone is brown, nodular limestone and dolomitic limestone with partings of dolomitic siltstone and silty dolomite. Limestone is glauconitic and mottled. Mud-pebble conglomerate and oolite beds are common. About 200 ft thick (Tysdal, 1990). Park Shale is gray-green, chippy shale and a few interbeds of limestone, limestone pebble conglomerate, and oolitic limestone. Fossil fragments, burrows, and trace fossils ("worm trails") are common. Thickness about 100 ft (Tysdal, 1990). Meagher Limestone (pronounced "mar") is finely crystalline limestone with irregular-shaped, yellow-orange siltstone mottles. Upper part contains thin partings of calcareous siltstone or green clay shale; lower part contains mottled gray oolitic limestone and gray, finely crystalline limestone. About 500 ft thick (Tysdal, 1990). Wolsey Shale is gray-green, fissile, micaceous clay shale; 65–200 ft thick (Tysdal, 1990). Flathead Sandstone is white, tan, and red-brown, hematitic quartz sandstone, locally glauconitic. Crossbeds, ripple marks, and worm trails are common. Thickness 10–100 ft (Tysdal, 1990)

MzPzu **Mesozoic and Paleozoic sedimentary rocks, undivided**—Limestone, dolomite, chert, shale, siltstone, and sandstone. Mapped only at east edge of northern part of map area (Chadwick, 1982)

mi **Mafic intrusive rocks, undivided (Proterozoic and Archean?)**—Diabase and amphibolite dikes and sills. Diabase sills form cliffs. Northwest-trending diabase dikes in Spanish Peaks area are Proterozoic (K.S. Kellogg, USGS, written commun., June 21, 1996). Plagioclase phenocrysts in a matrix of augite, smaller plagioclase laths, and magnetite. Secondary alteration around associated calcite-quartz veins that commonly contain malachite (Becraft and others, 1966; Erslev, 1981, 1983)

Au **Ultramafic rocks (Archean)**—Serpentinized ultramafic rocks exposed as pods and lenses; generally surrounded by reaction zones (Erslev, 1983)

Am **Metamorphic rocks (Archean)**—Gneiss, schist (biotite, chlorite-hornblende), quartzite, pegmatite, amphibolite, mafic intrusive (diabase and gabbro) rocks, and minor ultramafic rocks. Includes granitic rocks in Mulherin (also known as Mol Heron) Creek area, east-central part of map area

Ad **Dolomitic marble (Archean)**—Coarsely crystalline dolomite with crenulated quartz veins. Locally contains tremolite (Witkind, 1969, 1972)

At **Tremolite marble (Archean)**—Marble composed almost entirely of bladed tremolite crystals. Light gray to gray; extremely resistant; forms topographic ridges. Technically a calc-silicate; tremolite marble terminology from Witkind (1969). Mapped only in southeastern part of map area

Contact—Dashed where approximately located

Normal fault—Dashed where approximately located; dotted where concealed. Ball and bar on downthrown side where direction of movement is known. Opposed arrows indicate sense of lateral displacement where known

Thrust fault—Dotted where concealed. Sawteeth on upper plate

Overturned thrust fault—Sawteeth in direction of dip; base of sawteeth on side of tectonically higher plate. Shown in extreme northeastern part of map area

Madison mylonite zone—Dotted where concealed

Folds—Dashed where approximately located; dotted where concealed. Showing trace of axial plane, direction of dip of limbs, and direction of plunge of axis

Anticline

Overturned anticline

Syncline

Overturned syncline

Monocline—Arrow points in direction of dip of beds. Only shown once in unit Mm in north-central part of map area

Base from U.S. Geological Survey, 1:100,000, Ashton, Ennis, 1989; Bozeman, Gardiner, Livingston, 1992; Hebgen Lake, 1993.
1927 North American Datum. Projection: Universal Transverse Mercator, zone 12.

Geology compiled by Anna B. Wilson and James E. Elliott. See "Index to Sources of Geologic Mapping."
Digital geology by Anna B. Wilson
Editing and digital cartography by Alessandro J. Donatich
Color design by Patricia L. Wilber and Anna B. Wilson
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MAP A. WESTERN PART OF GALLATIN NATIONAL FOREST (GALLATIN AND MADISON RANGES AND WEST YELLOWSTONE AREA)

SCALE 1:126 720

2 1 0 2 4 6 8 10 MILES
2 1 0 2 4 6 8 10 12 14 KILOMETERS

CONTOUR INTERVAL 50 METERS
(Except Ashton quadrangle, contour interval 20 meters)
SUPPLEMENTARY CONTOUR INTERVAL 25 METERS IN HEBGEN LAKE QUADRANGLE
NATIONAL GEODETIC VERTICAL DATUM OF 1929

GEOLOGIC MAPS OF WESTERN AND NORTHERN PARTS OF GALLATIN NATIONAL FOREST, SOUTH-CENTRAL MONTANA

Compiled by
Anna B. Wilson and James E. Elliott

1997

USGS science for a changing world

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