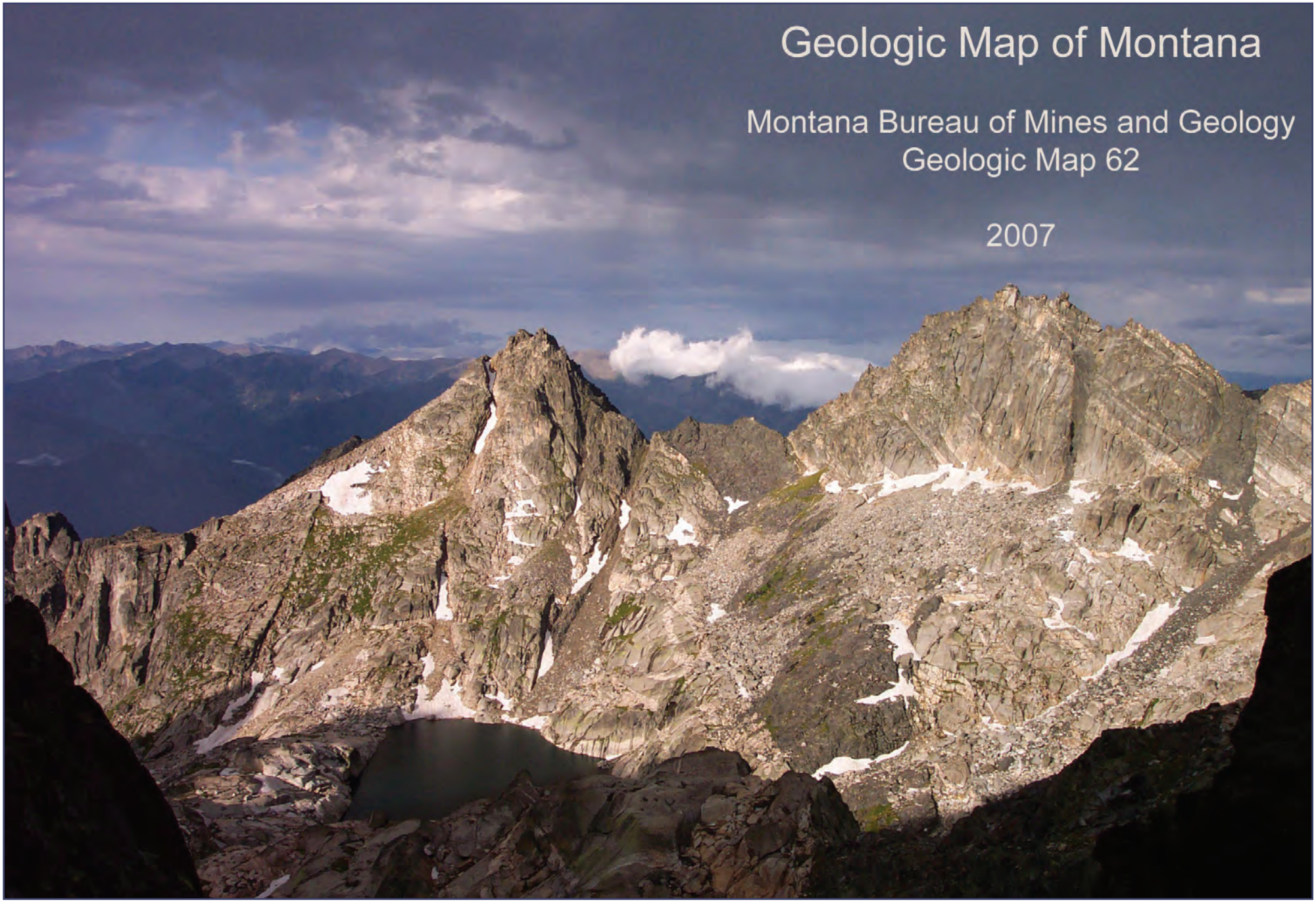
Geologic Map of Montana

Montana Bureau of Mines and Geology
Geologic Map 62

2007



Front Cover: Precambrian Mt. Cowan gneiss underlies these unnamed peaks in the Absaroka Range, Park County.
Photo by Jeff Lonn, Montana Bureau of Mines and Geology.

GEOLOGIC MAP OF MONTANA

Edition 1.0 (2007)

Montana Bureau of Mines and Geology
Geologic Map 62

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INTRODUCTION

The Geologic Map of Montana includes three parts. Plate 1 is the geologic map of the state. Plate 2 provides supporting and complementary information including the correlation chart of surface rocks with generalized lithologic information. The third part is this booklet containing all figures shown on plates 1 and 2, additional figures, the description of map units, list of source maps for plate 1, and references cited for all plates, figures, and text.

The Geologic Map of Montana was compiled from over 100 source maps published between 1982 and 2007 by the Montana Bureau of Mines and Geology (MBMG) and the U.S. Geological Survey (USGS; fig. 9), and from a limited number of unpublished maps. Over 80 of these maps were prepared by the MBMG with support from the STATEMAP component of the USGS Cooperative Geologic Mapping Program. Source maps are listed by quadrangle in the Source Maps for Plate 1 section of this booklet (p. 21). Figure 9 provides the location and name of each quadrangle.

The MBMG is indebted to and gratefully acknowledges the contributions of the many earth scientists who have directly and indirectly contributed to this Geologic Map of Montana. Since the previous Geologic Map of Montana was published (Ross and others, 1955), a wealth of new information and concepts has become available, including a significant amount of new and more detailed geologic mapping throughout the state. Since the middle 1980s, the MBMG has produced quadrangle maps at the 1:100,000, 1:24,000, and intermediate scales. The MBMG's first digital maps were produced in 1996, and since then many earlier geologic quadrangle maps have been brought into digital form.

This edition of the new Geologic Map of Montana (2007, edition 1.0) is provided digitally in PDF format on a CD, or can be obtained from the MBMG as a print-on-demand product. Individual digital layers will not be separately available. The data are compiled at the 1:500,000 scale and are intended for use only at this scale. The map will be updated periodically. Comments can be sent by e-mail to svuke@mtech.edu.

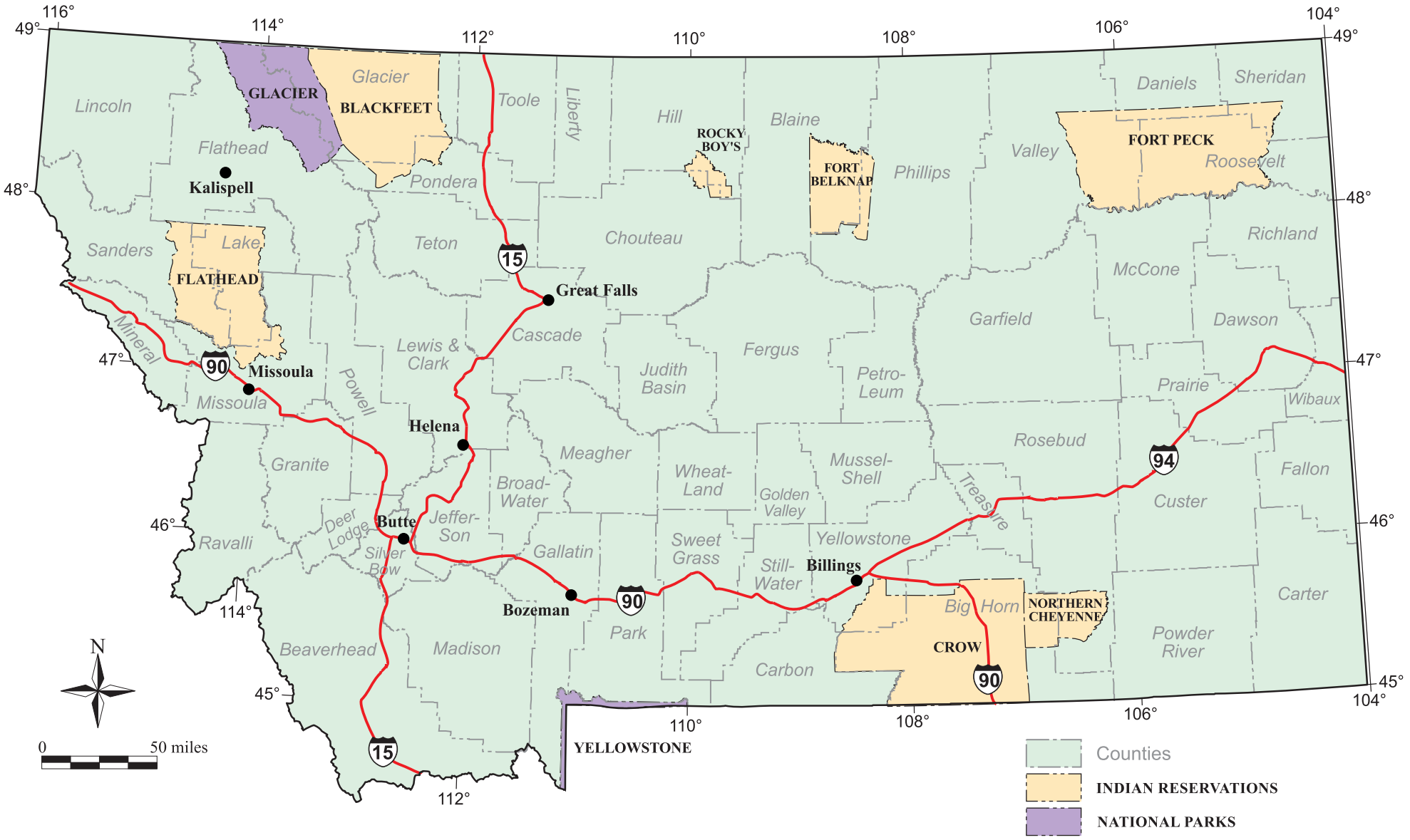
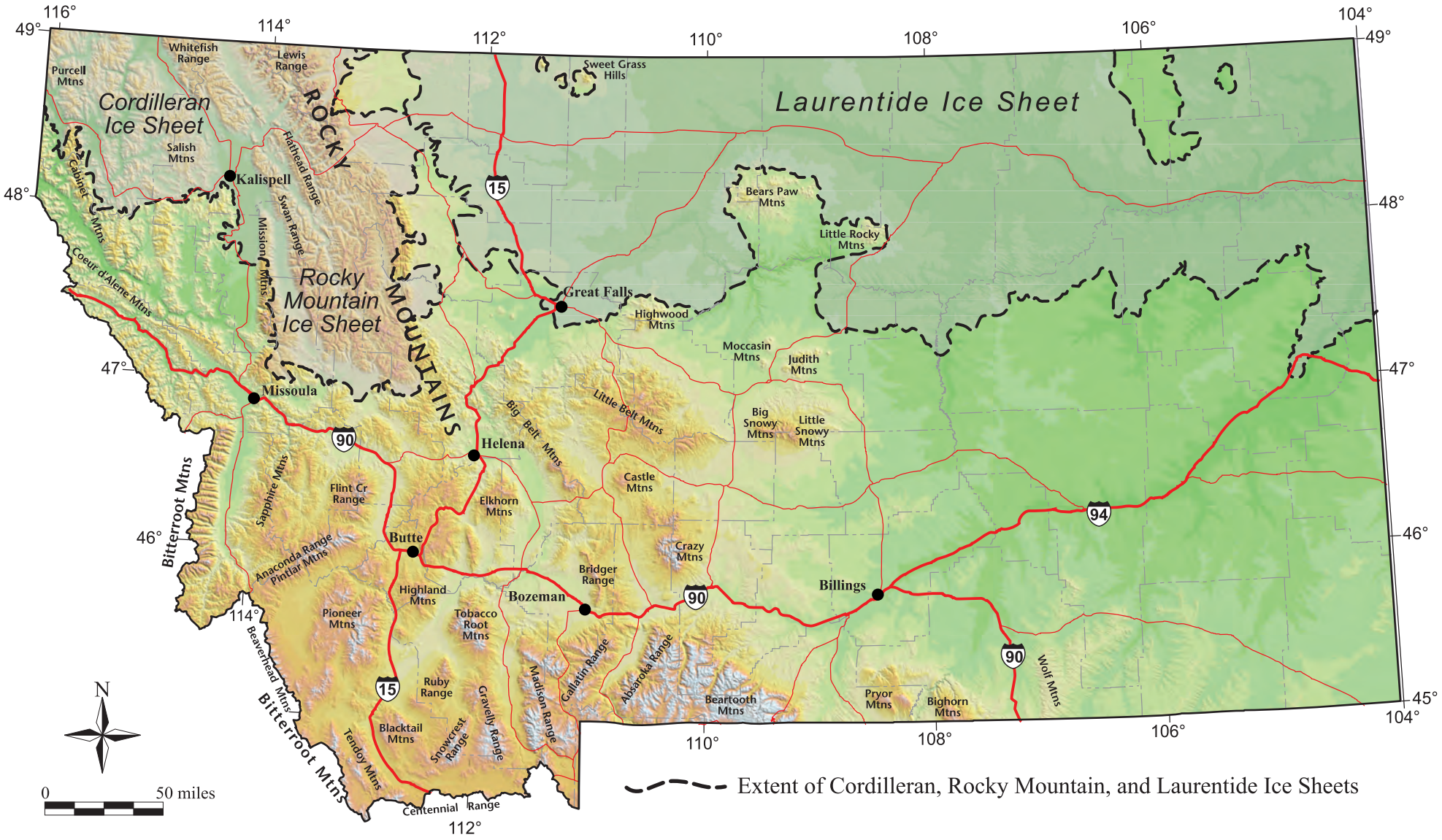


Figure 1. Cultural features.



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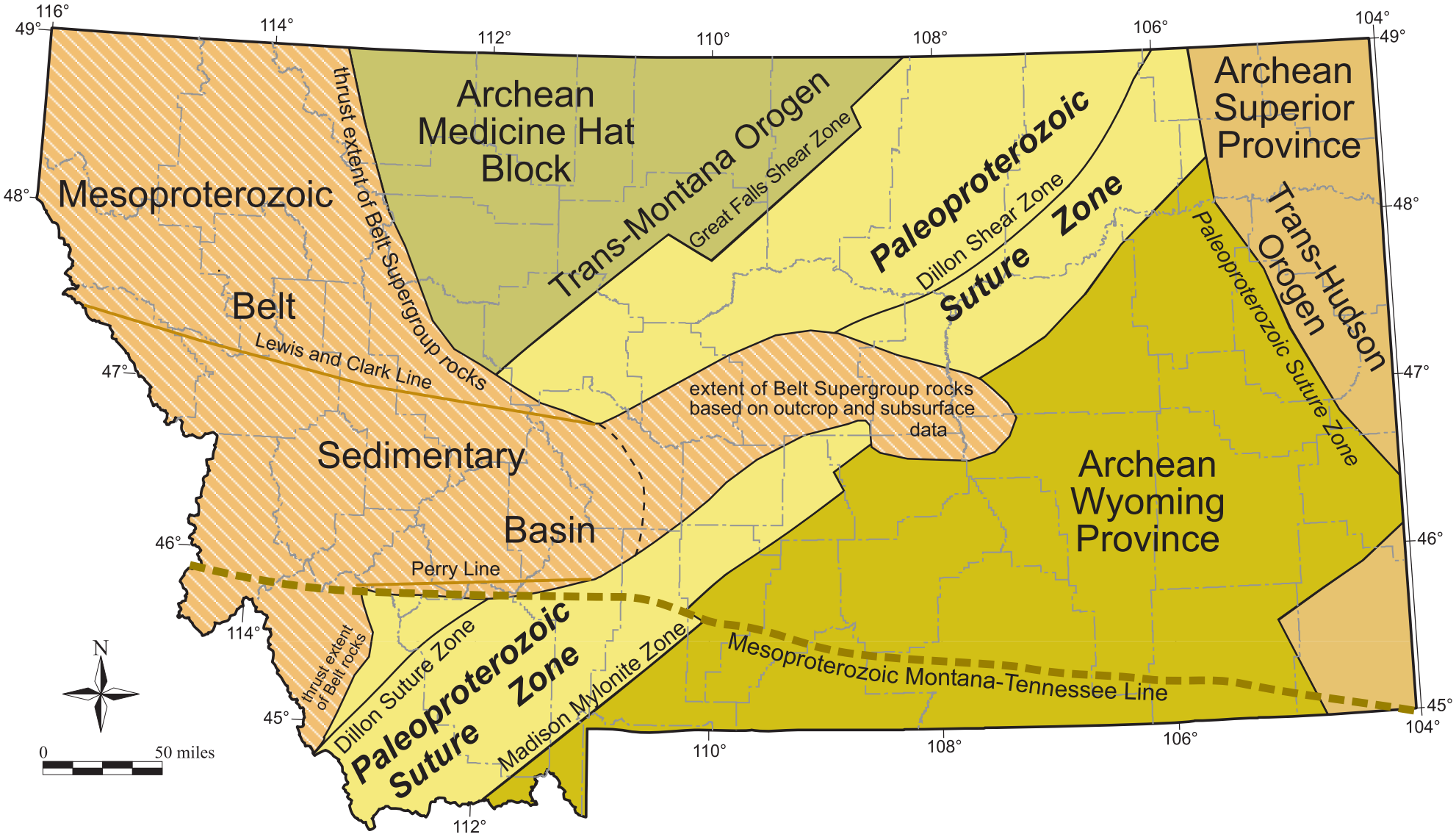


Figure 3. Precambrian provinces. Modified and compiled from Lisenbee and DeWitt (1993), Nelson (1993), Sears (2006), and Sims and others (2004).

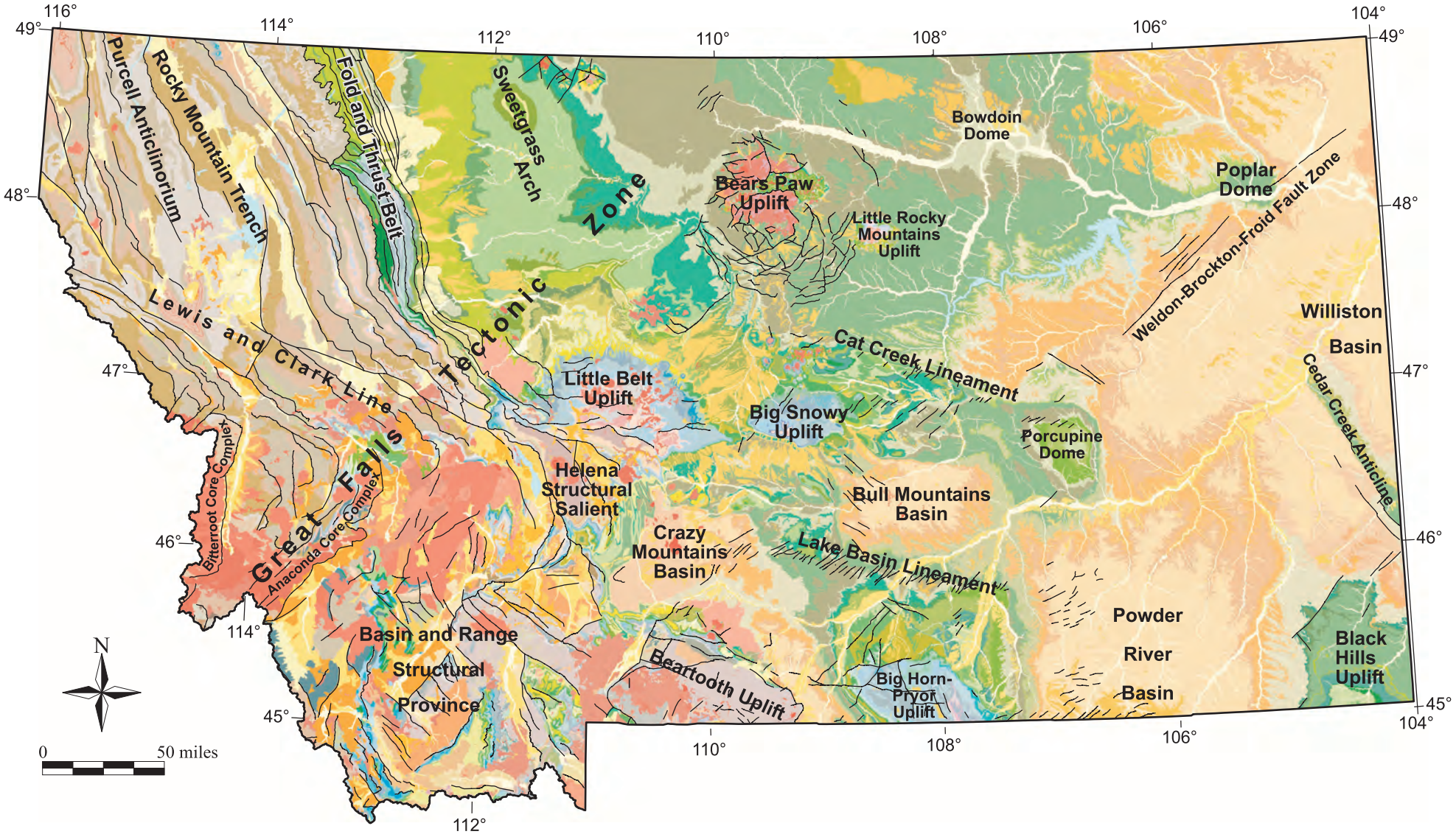


Figure 4. Major tectonic features. Base map and faults from plate 1.

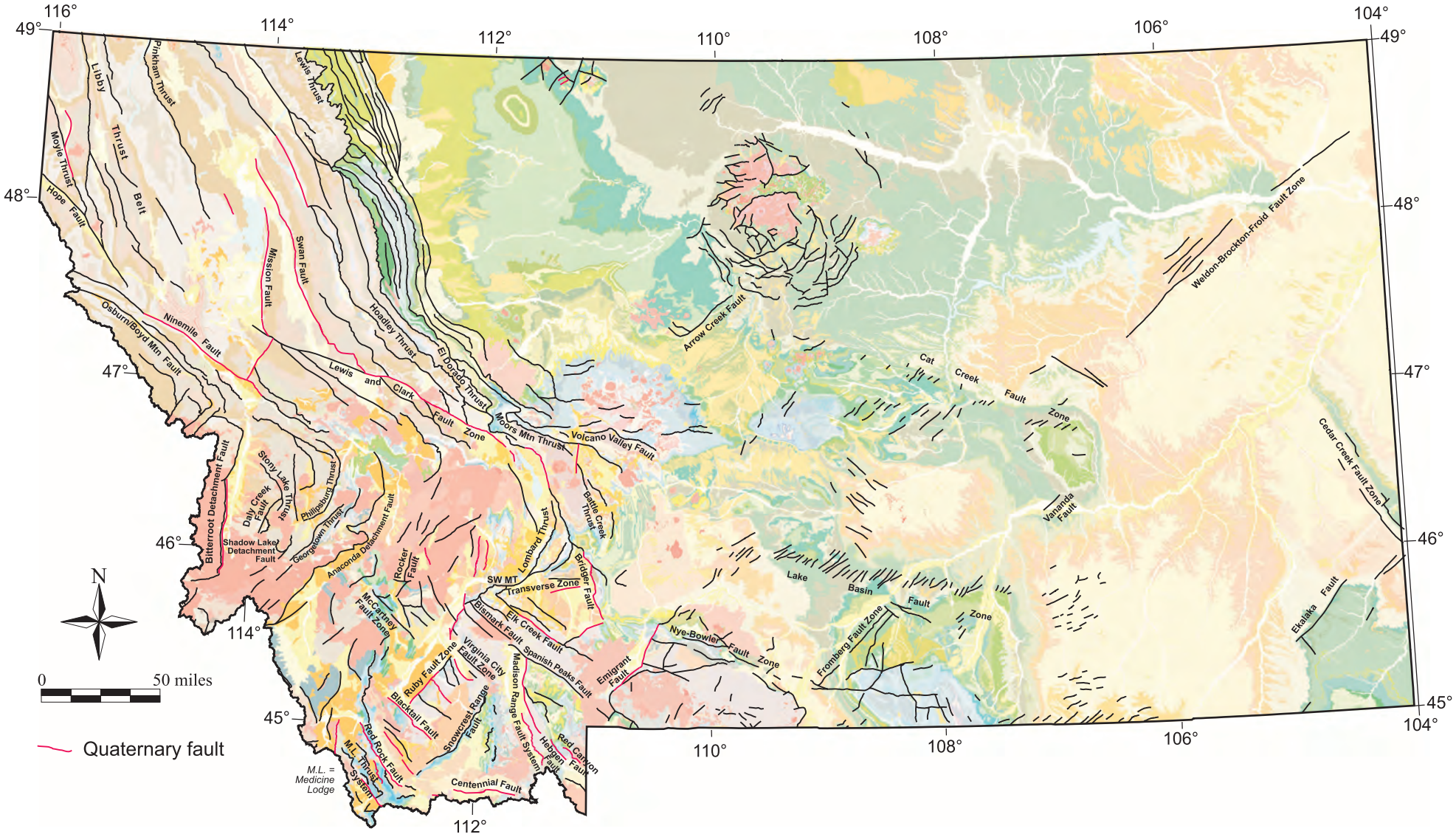
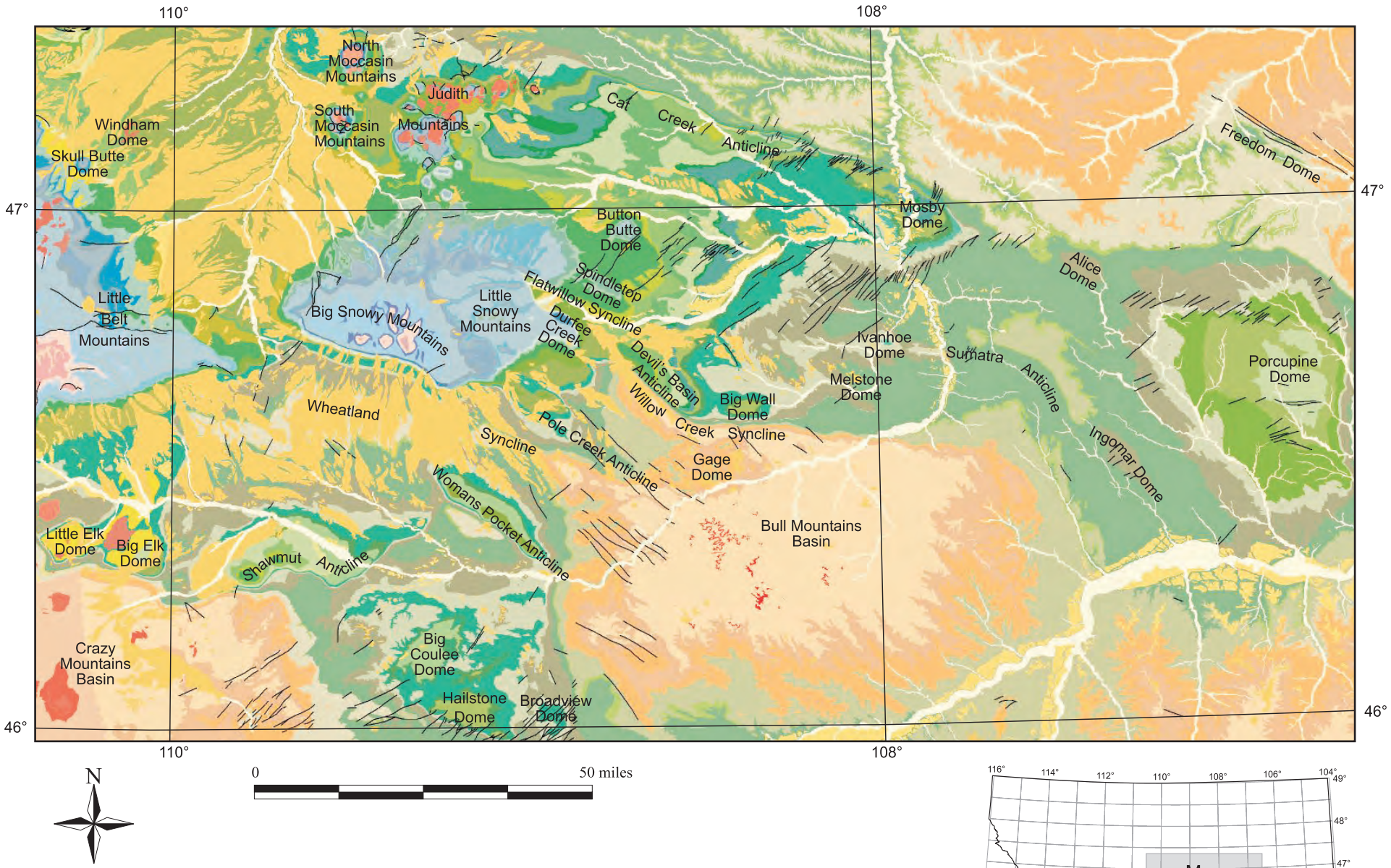


Figure 5. Major faults. Base map from plate 1. Quaternary faults from Stickney and others (2000).



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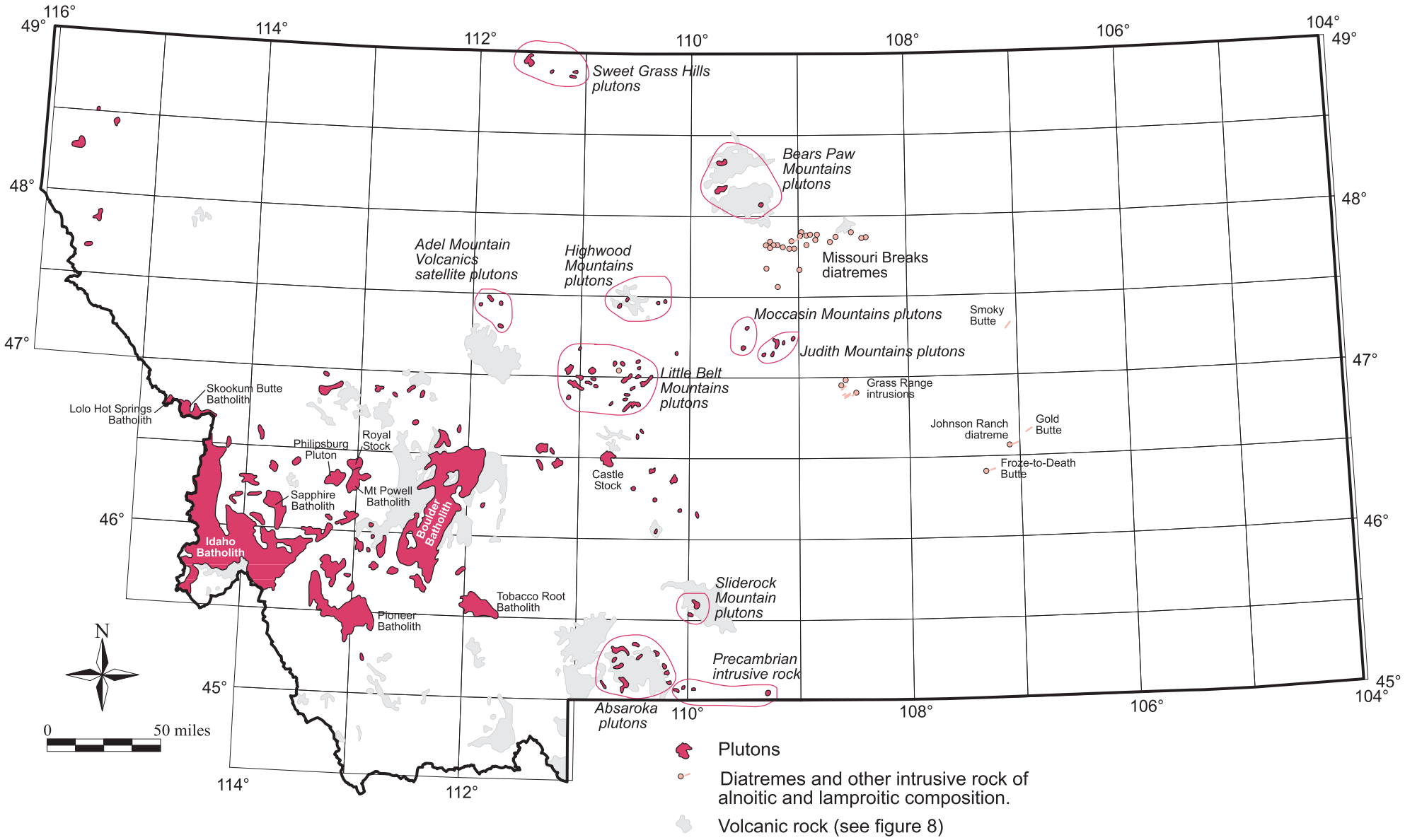

Figure 7. Plutons, diatremes, and other intrusive rock. Compiled from plate 1 and Hearn and others (1989).

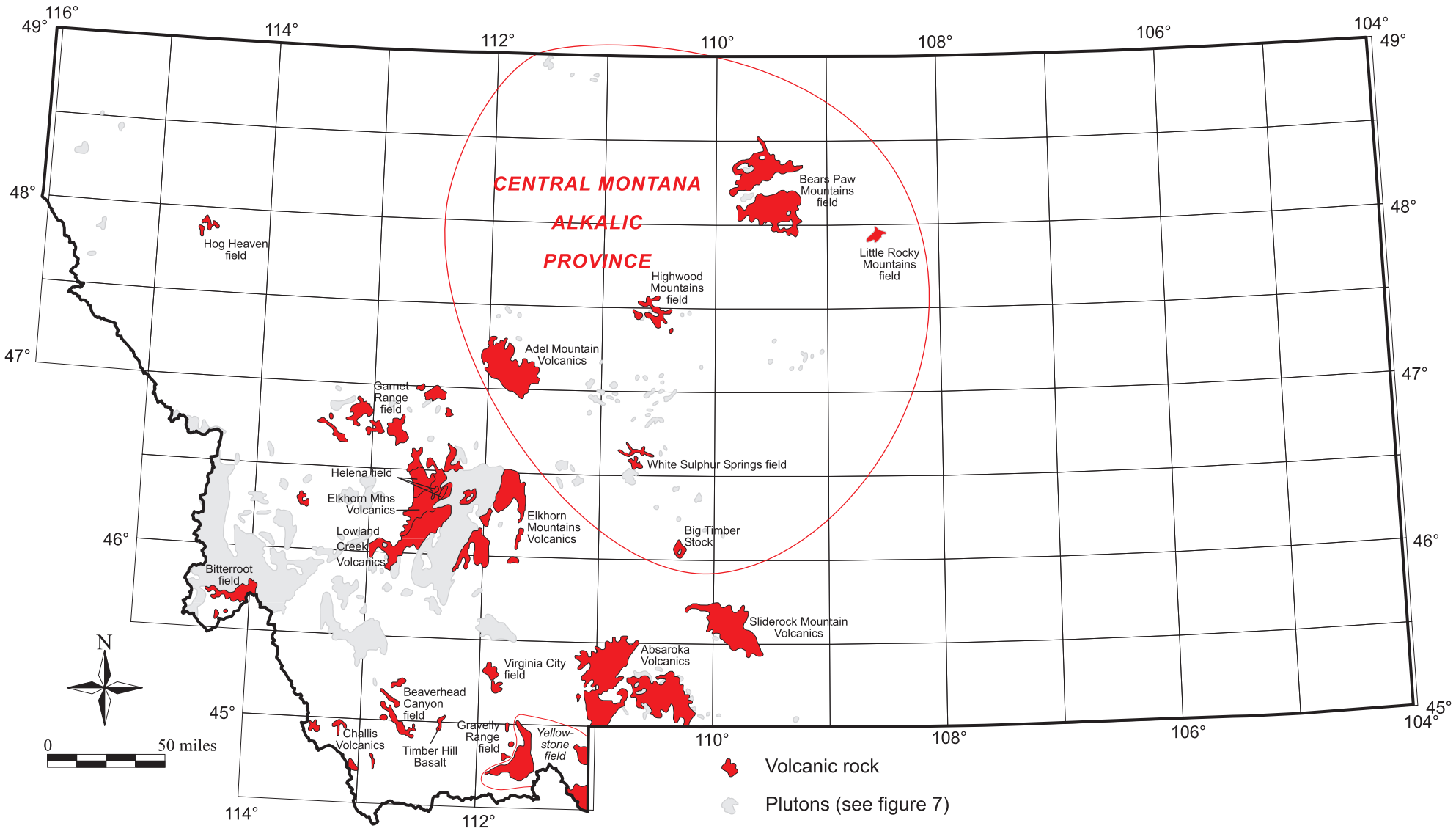

Figure 8. Volcanic rock. Compiled from plate 1.

DESCRIPTIONS OF STRATIGRAPHIC UNITS

Certain surficial deposits such as colluvium and landslide deposits are not shown on the Geologic Map of Montana (plate 1) in order to emphasize the bedrock geology.

Sedimentary

Alluvium (Qal)—Gravel, sand, silt, and clay deposits of stream and river channels, and floodplains.

Alluvial fan deposit (Qaf)—Variable deposits with fan-shaped morphology developed where slope gradient changes abruptly. Shown only where relatively extensive.

Lacustrine deposit (Qlk)—Light brown to brown, well-sorted, unconsolidated, laminated sand, silt, and clay. Lima Reservoir and Red Rocks Lake area, southwestern Montana.

Gravel (Qgr, QTgr)—Variable deposits that range from pebble to boulder size and include sand, silt, and clay. Dominantly alluvial terrace, abandoned channel and floodplain, remnant alluvial fan, and local glacial outwash.

Travertine (Qtr, QTtr)—Qtr (central Montana): white to light grayish pink, typically vuggy and finely crystalline, locally banded limestone. QTtr (southwestern Montana): light gray to white, thick-bedded, vuggy limestone.

Glacial deposit (Qgd)—Dominantly till, outwash, and local glacial lake deposits. Shown only in western and south-central Montana. Laurentide glacial deposits are indicated with a map pattern (legend, plate 1).

Glacial lake deposit (Qgl)—Light brown laminated silt, fine-grained sand, and clay. Shown only in northwestern and central-western Montana.

Tufa (QTtu)—Light yellowish gray to light gray, vuggy, partly thinly laminated, locally tuffaceous or silty limestone. Along Snowcrest Range fault (fig. 5), southwestern Montana.

Sediment (QTs)—Yellowish gray to very pale orange, angular silt and clay-size sediment with lenses of angular and subangular locally derived rock ranging to very large boulder size but generally cobble size and smaller. In some areas granules and pebbles float in the silty matrix. Locally cemented; clasts may be coated with calcium carbonate, especially near the base. Thickness as much as 200 ft.

Basin-fill deposit (QTbf)—Interbedded poorly consolidated to unconsolidated, well-bedded to massive silt, sand, and well-rounded cobbles. Ennis Lake area, southwestern Montana.

Paleosol (QTps)—Light gray to very pale orangish gray calcrete and calcareous silt with scattered small pebbles near the base. Northeastern Montana.

Upper Tertiary sediment or sedimentary rock (Tsu)—Conglomerate, tuffaceous sandstone and siltstone, marlstone, and equivalent sediment and ash beds. Local volcanic flows in southwestern Montana. Includes Sixmile Creek Formation. Dominantly fluvial, alluvial fan, mudflow, and palustrine.

Middle Tertiary sediment or sedimentary rock (Tsm)—Tuffaceous siltstone, sandstone, bentonitic mudstone, conglomerate, limestone, and equivalent sediment and ash beds. Local volcanic flows in southwestern Montana. Includes Renova Formation. Dominantly fluvial, floodplain, palustrine, lacustrine, debris flow, and eolian.

Composite thickness for Tsu and Tsm exceeds 4,880 m (16,010 ft).

Anaconda Formation (included in Tsm)—Light gray, reddish tan, or brownish red, coarse breccia that laterally grades to conglomerate, sandstone, and siltstone. Locally intertongues with Lowland Creek Volcanics. Derived from overlying unmetamorphosed plate of metamorphic core complex. Thickness as much as much as 200 m (656 ft).

Arikaree Formation (Tar)—Greenish gray, fine-grained sandstone with interbedded light gray volcanic ash. Nonmarine to possibly marine-influenced. Thickness as much as 80 m (262 ft).

White River Group (included in Tar)

Brule Formation—Pink, sandy, locally bentonitic claystone with siliceous concretions. Nonmarine. Preserved in local areas below Arikaree Formation. Thickness as much as 10 m (33 ft).

Chadron Formation—Very light gray, fine-grained sandstone. Nonmarine. Preserved locally with Brule Formation. Thickness as much as 30 m (98 ft).

Wasatch Formation (Tw)—*Southeastern Montana:* orangish brown, arkosic sandstone, lenticular conglomerate and siltstone, dark gray carbonaceous shale, coal, and varicolored claystone. *Bears Paw Mountains:* variegated red, pink, lavender, light green, yellow, gray, and very light gray shale, bentonitic claystone, and siltstone; light gray, brown, and green cross-bedded sandstone; and lenses of boulder conglomerate. Syntectonic alluvial fan and alluvial plain. Thickness as much as 120 m (394 ft) in Montana; upper part removed by erosion.

Kishenehn Formation (Tk)—Light to dark bluish gray, locally sandy clay with interbeds of light gray, nodular sandstone, conglomerate, and coal. Dominantly fluvial, palustrine, and lacustrine. Exposed thickness 230 m (755 ft).

Fort Union Formation (TKfu)

Sentinel Butte Member (Tfsb)—Dark gray shale with interbedded lignite and gray sandstone. Nonmarine. Thickness 200 m (656 ft).

Tongue River Member of Fort Union Formation (Tftr)—Yellowish orange sandstone, sandy and silty carbonaceous shale, and coal. Alluvial plain. Thickness as much as 300 m (984 ft).

Linley Member of Fort Union Formation (Tflc)—Reddish to grayish brown conglomerate interbedded with coarse-grained sandstone, siltstone, and mudstone. Alluvial fan deposits derived from Beartooth uplift (fig. 4). Thickness as much as 610 m (2,000 ft).

Ludlow Member of Fort Union Formation (Tfld)—Gray and brown shale, siltstone, silty or bentonitic claystone, sandstone, and coal. Alluvial plain with marine-influenced tongues. Thickness as much as 230 m (755 ft).

Lebo Member of Fort Union Formation (Tfle)—Dark gray carbonaceous shale, bentonitic claystone, sandstone, and coal. Alluvial plain. Thickness as much as 185 m (607 ft).

Ekalaka Member of Fort Union Formation (Tfe)—Yellowish orange or tan, fine- to medium-grained sandstone interbedded with mudstone and thin shale and coal beds. Estuarine. Thickness as much as 55 m (180 ft).

Tullock Member of Fort Union Formation (Tftu)—Yellow sandstone interbedded with subordinate grayish brown and black shale and thin beds of coal. Alluvial plain. Thickness as much as 180 m (590 ft).

Beaverhead Group (TKb)—Reddish gray conglomerate with limestone and quartzite clasts, gray limestone, and grayish brown sandstone. Syntectonic alluvial fan and braided stream. Thickness as much as 3,250 m (10,663 ft).

Willow Creek Formation (TKw)—Reddish gray, olive gray, and purple mudstone, and gray, greenish gray, and yellow sandstone. Alluvial plain. Thickness as much as 330 m (1,083 ft).

St. Mary River Formation (Ksm)—Gray calcareous shale and siltstone with lenticular argillaceous sandstone and thin interbeds of black, nodular limestone. Lagoonal and fluvial. Thickness as much as 300 m (948 ft).

Horsethief Formation (Kh)—Gray to light brown, medium- to coarse-grained, locally titaniferous sandstone with argillaceous sandstone and mudstone near base. Brackish to littoral marine. Thickness as much as 60 m (197 ft).

Two Medicine Formation (Ktm)—Gray and greenish gray volcanic sandstone, siltstone, and mudstone, andesite–pebble conglomerate, and thin beds of very light gray and pink ash-fall tuff. Volcaniclastic facies (**Ktmv**): gray, greenish gray, maroon, and reddish gray volcaniclastic rocks, volcanic flows, and tuff. Fluvial and alluvial plain. Thickness as much as 660 m (2,165 ft).

Virgelle Formation (Kvi)—Light gray, fine- to coarse-grained, locally titaniferous sandstone. Marine shoreface and foreshore. Thickness as much as 90 m (295 ft).

Hell Creek Formation (Khc)—Light gray, bentonitic claystone that alternates with gray to brown sandstone interbedded with carbonaceous shale. Laterally equivalent to Lance Formation. Fluvial and flood plain. Thickness as much as 335 m (1,100 ft).

Lance Formation (Kl)—Orangish brown, coarse- to fine-grained sandstone with subordinate interbeds of shale and mudstone. Laterally equivalent to Hell Creek Formation. Fluvial. Thickness as much as 150 m (492 ft).

Fox Hills Formation (Kfh)—Yellowish orange to gray, fine- to medium-grained, non-calcareous sandstone in upper part, and interbedded sandstone, siltstone, and black shale with calcareous concretion zone in lower part. Marginal marine. Thickness 30–45 m (98–148 ft).

Colgate Member (Kfhc)—White to yellowish, fine- to medium-grained, porous sandstone. Brackish to marine shoreline. Only present near Glendive (eastern Montana) and in several other isolated areas. Thickness 0–40 m (130 ft).

Timber Lake Member (Kftt)—Yellowish orange to gray, fine- to medium-grained, noncalcareous, hummocky-bedded sandstone. Thickness 15–22 m (50–72 ft).

Trail City Member (Kftc)—Yellowish orange, wavy-bedded siltstone and black shale with calcareous concretion zone. Thickness 10 m (33 ft).

Pierre Formation (Kp)—Dark gray, partly silty shale with abundant bentonite beds and zones of gray, calcareous concretions. Marine. Thickness as much as 650 m (2,133 ft). Only upper 50 m (164 ft) exposed.

Groat sandstone bed (Kpg)—Gray, ferruginous and glauconitic, fine- to coarse-grained sandstone, siltstone, and sandy to silty gray shale. Offshore marine. Pinches out laterally. Thickness as much as 100 m (328 ft).

Bearpaw Formation (Kb)—Dark gray shale with several zones of calcareous concretions, a basal zone of ferruginous concretions, and numerous thin bentonite beds. Marine. Thickness as much as 300 m (984 ft).

Judith River Formation (Kjr)—Light brown to light gray, fine- to coarse-grained sandstone with interbeds of gray to black carbonaceous shale, silty shale, and thin coal. Local *Parkman Sandstone Member* (lower part of formation): yellowish gray to brownish gray and olive green, fine- to medium-grained, cross-bedded sandstone interbedded with yellowish gray, silty shale. Estuarine, brackish, and nearshore marine. Thickness as much as 305 m (1000 ft).

Claggett Formation (Kcl)—Dark gray to gray shale that weathers brown, with thin, gray sandstone laminae and beds in upper or middle part and calcareous concretions in lower part. Marine. Thickness as much as 170 m (558 ft).

Gammon Formation (Kga)—Dark gray mudstone and shale with numerous red-weathering ferruginous concretions, and thin, fine-grained sandstone or siltstone beds interbedded with shale. Offshore marine. Thickness as much as 260 m (853).

Eagle Formation (Ke)—Gray or grayish brown, thick-bedded sandstone, sandy shale, and thin interbedded coal. Chert-pebble lag deposit common at top of formation. *Virgelle Member* (lower part of formation in parts of central Montana): very light gray, gray, or brown sandstone that coarsens upward. Root zone and thin carbonaceous beds at top of member. Delta, coastal plain, tidal flat, and marine shoreface and foreshore. Thickness as much as 150 m (492 ft).

Telegraph Creek Formation (Ktc)—Thin interbeds of yellowish brown sandstone or siltstone and gray shale. Marine shoreface and offshore. Thickness as much as 200 m (656 ft).

Landslide Creek Formation (Klc)—Dark gray, conglomeratic, feldspathic, lenticular sandstone interbedded with varicolored dark mudstone, claystone, bentonite, and coal. Fluvial. Thickness as much as 610 m (2,000 ft).

Livingston Formation (Klv)—Pale green or gray, volcaniclastic conglomerate and conglomeratic sandstone, dark gray volcanic flows, purple flow breccia, brown and gray tuff, and maroon, green, and gray mudstone and siltstone. Fluvial and alluvial fan. Thickness about 1,000 m (3,280 ft).

Livingston Group

Livingston area

Hoppers Formation (Kho)—Olive gray and yellowish gray, volcaniclastic sandstone, conglomeratic sandstone, and subordinate olive gray mudstone. Channel fill and floodplain. Thickness as much as 765 m (2,510 ft).

Billman Creek Formation (Kbc)—Olive gray, grayish brown, and dusky red tuffaceous claystone interbedded with subordinate grayish yellow sandstone, conglomeratic sandstone, and siltstone beds. Fluvial and lacustrine. May be brackish in part. Thickness as much as 915 m (3,002 ft).

Miner Creek Formation (included in Kmic)—Alternating beds of olive gray tuffaceous siltstone and greenish gray volcaniclastic sandstone, silicified tuff, and bentonite. *Sulphur Flats Member* (lower part of formation): massive, cross-bedded, poorly sorted sandstone. Inland coastal plain. Thickness as much as 410 m (1,345 ft).

Cokedale Formation (included in Kmic)—Olive gray, tuffaceous siltstone, dusky yellowish green and light gray, volcaniclastic-rich sandstone, grayish brown mudstone, water-laid tuff, bentonite, and carbonaceous claystone; coal in lower part. Transitional inland coastal plain to brackish. Thickness as much as 790 m (2,592 ft).

Sedan area

Sedan Formation (Kse)—Varicolored welded tuff and dark brown conglomerate interbedded with sandstone, conglomeratic sandstone, and dark gray or olive gray mudstone. Nonmarine including mudflow, and marginal marine. Thickness 915–1470 m (3,002–4,823 ft).

Maudlow area

Maudlow Formation (Kmau, Kmam, Kmal)—Upper part: light gray, volcanic conglomerate and breccia and olive green or dark yellowish brown volcanic sandstone, conglomeratic sandstone, siltstone and mudstone. Middle part: grayish red and grayish green lava flows, varicolored tuff, and bluish green and dark yellowish brown volcanic breccia, tuffaceous volcanic sandstone, mudstone, and minor conglomerate. Lower part: purple lava flows and gray, brown, green, and purple sandstone, conglomerate, breccia, mudstone, and tuff. Nonmarine. Thickness 1,525–1,675+ m (5,003–5,495+ ft).

Lennep Formation (Kle)—Yellow to gray, fine- to medium-grained sandstone with subordinate interbedded gray shale. Nearshore marine. Thickness as much as 185 m (607 ft).

Everts Formation (Kevt)—Light-colored, fine- to medium-grained, lenticular sandstone and medium to light gray or locally greenish, yellowish, or brownish gray mudstone. Shallow marine and brackish. Thickness as much as 425 m (1,395 ft).

Sphinx Formation (Ksp)—Reddish gray sandstone and conglomerate. Clasts dominantly carbonate and quartzite. Syntectonic alluvial fan. Thickness over 1,000 m (3,281 ft).

Golden Spike Formation (Kgs)—Volcaniclastic sandstone and conglomerate, chert-pebble conglomerate, andesitic lava, andesitic tuff, and limestone. Fluvial, mudflow, and landslide, locally derived from Elkhorn Mountains Volcanics. Thickness as much as 2,700 m (8,858 ft).

Slim Sam Formation (Kss)—Greenish gray, pyroclastic tuff and volcaniclastic-rich sandstone, siltstone, mudstone, and porcellanite. Nonmarine, locally derived from Elkhorn Mountains Volcanics. Thickness as much as 200 m (656 ft).

Niobrara Formation (Kn)—Gray to dark gray shale with numerous thin bentonite beds. Chalky aggregates of coccoliths and rhabdoliths in upper part. *MacGowan Concretionary Bed* (middle part of formation): grayish brown concretionary dolostone and limestone with phosphatic pellets and gray to black chert pebbles. Marine. Lower part noncalcareous. Thickness as much as 9–23 m (30–75 ft).

Carlile Formation (Kca)—Dark to light gray, noncalcareous, partly silty or sandy shale with upper zone of white-weathering, calcareous concretions, middle zone of sandy, orange-weathering, calcareous concretions, and basal zone of ferruginous concretions. Marine. Thickness as much as 195 m (640 ft).

Greenhorn Formation (Kgr)—Gray to light gray calcareous shale and shaly marl with thin beds of limestone. Shale contains white to pink calcareous specks. Marine. Thickness as much as 100 m (30–75 ft).

Belle Fourche Formation (Kbf)—Gray to black shale with ironstone concretions and numerous bentonite beds. *Mosby Sandstone Member* (upper part of formation in north- and east-central Montana): brown sandstone locally with chert pebbles, interbedded with gray shale. *Big Elk Sandstone Member* (lower part of formation in southwest-central Montana): light gray, chert-rich sandstone commonly stained dark red, interbedded with thin, dark gray to black clayey shale. Marine shelf. Thickness as much as 260 m (853 ft).

Mowry Formation (Km)—Light gray to silvery gray, platy to blocky, siliceous shale and subordinate thin-bedded, gray siltstone or very fine-grained sandstone laminae or beds. Fish scales common in central Montana. Ledge-forming, chert-bearing, fine- to medium-grained sandstone at top throughout west-central Montana. Marine. Thickness 240 m (787 ft).

Marias River Formation (Kmr)

Kevin Member (Kmk)—Dark gray shale with calcareous concretions and numerous bentonite beds. Upper part calcareous. *MacGowan Concretionary Bed* (middle part of member): grayish brown concretionary dolostone and limestone with phosphatic pellets, and gray to black chert pebbles. Marine. Thickness as much as 350 m (1,148 ft).

Ferdig Member (included in Kfc)—Gray and dark gray shale with thin siltstone or sandstone beds at the top. Marine. Thickness as much as 125 m (410 ft).

Cone Member (included in Kfc and Kcf)—Calcareous, dark gray shale and thin limestone beds and lenses. Widespread bentonite bed and septarian concretions near base. Shallow marine. Thickness as much as 20 m (66 ft).

Floweree Member (included in Kcf)—Dark gray, noncalcareous shale with interbeds of siltstone. Calcareous concretions and scattered granules of dark gray chert. Shallow marine. Thickness as much as 30 m (98 ft).

Carter Creek Formation (included in Kcc)—Varicolored sandstone, siltstone, and silty mudstone, with subordinate dark shale and lenses of coarse-grained conglomeratic dacitic tuff. Nearshore marine, brackish, and terrestrial. Thickness as much as 2,000 m (6,562 ft).

Jens Formation (included in Kcc)—Dark gray shale, siltstone, siliceous mudstone, volcaniclastic siltstone, and minor fine-grained calcareous sandstone. Marine. Thickness as much as 505 m (1,657 ft).

Coberly Formation (included in Kcc)—Gray limestone and tan, massive sandstone. Intertidal and shallow marine. Thickness as much as 215 m (705 ft).

Cody Formation (Kco)—Gray to dark gray shale with some sandstone beds. *Eldridge Creek Member:* greenish gray, glauconitic, fine-grained sandstone. Marine. Thickness as much as 465 m (1,526 ft).

Frontier Formation (Kf)—*Western Montana:* gray, fine- to medium-grained, locally conglomeratic sandstone with interbeds of dark gray carbonaceous shale. Local conglomerate, porcellanite, and coal. *Central Montana:* dark gray, carbonaceous shale interbedded with siltstone and sandstone, chert-pebble conglomerate, and coal. *Big Elk Sandstone Member:* light gray, chert-rich sandstone commonly stained dark red, interbedded with thin, dark gray to black, clayey shale. *Boulder River Sandstone Member:* gray to greenish gray, very fine-grained to conglomeratic, glauconitic sandstone. Brackish to nonmarine. Thickness exceeds 2,135 m (7,005 ft) in Lima Peaks region, and exceeds 915 m in the Greenhorn, Snowcrest, Gravelly, and Pioneer Mountains of southwestern Montana. Elsewhere thickness as much as 215 m (705 ft).

Muddy Formation (Kmd)—Gray to brown fine- to medium-grained sandstone with interbedded dark gray locally carbonaceous shale. Deltaic, shoreface, and offshore marine. Thickness as much as 50 m (164 ft).

Newcastle Formation (Knc)—Yellowish to reddish sandstone interbedded with subordinate carbonaceous black shale. Nearshore marine to coastal swamp. Thickness as much as 30 m (98 ft).

Thermopolis Formation (Kt)—Dark gray to black shale with subordinate siltstone beds. Middle part of formation contains one or more thin sandstone beds with chert pebble horizons where Muddy Sandstone is not present. Offshore marine. Thickness as much as 305 m (1,000 ft).

Fall River Formation (Kfr)—Gray and brown, fine- to medium-grained, quartzose sandstone with thin interbeds of dark gray shale. Nearshore marine. Thickness as much as 70 m (1,214 ft).

Blackleaf Formation (Kbl)

Bootlegger Member (Kbb)—Dark gray shale interbedded with sandstone, siltstone, and bentonite beds. Marine. Thickness as much as 100 (328 ft) m.

Vaughn Member (Kbv)—Black carbonaceous shale, light gray, greenish to

pinkish bentonitic to tuffaceous siltstone and porcellanite, tuffaceous, arkosic sandstone, thin coal; conglomerate beds in western Montana. Fluvial and coastal delta plain. Thickness as much as 200 m (656 ft).

Taft Hill Member (Kbt)—Black shale, gray bentonitic siltstone, and glauconitic sandstone. Marine. Thickness as much as 180 m (590 ft).

Flood Member (Kblf)—Upper part: medium gray, cliff-forming fine- to medium-grained chert-rich, quartzose sandstone, middle part medium to dark gray shale or gray siltstone; lower part: yellowish brown, gray, or olive gray fine-grained sandstone and siltstone with carbonaceous laminae and thin films of coal and dark gray silty, bentonitic shale. Sandstone beds thin eastward. Quartzose basal sandstone in southwestern Montana. Nearshore marine, tidal flat, and lagoon. Thickness as much as 230 m (755 ft).

Kootenai Formation (Kk, Kku, Kkm, Kkl)—Red, maroon, and olive gray mudstone, tan or gray siltstone, calcareous concretions, limestone beds, and several prominent sandstone beds that include the *Greybull Member* (top of the formation in south-central Montana) and the *Sunburst Member* (middle to lower part of the formation in northwest-central Montana), both dominantly quartzose sandstone. Basal *Cutbank* or *Pryor Conglomerate*. Alluvial plain with local marine influence in the north. Thickness as much as 335 m (1,099 ft).

Mount Pablo Formation (included in KJmpe)—Reddish gray and grayish green mudstone and dark gray shale interbedded with gray limestone and sandstone. Gray basal conglomerate or conglomeratic sandstone. Alluvial plain. Thickness as much as 30 m (98 ft).

Morrison Formation (included in KJme, Jme, and other units)—Green, gray, or red mudstone and marlstone with subordinate limestone and sandstone beds. Upper part Neocomian age in central Montana and contains carbonaceous black shale and coal. Fluvial, paludal, and lacustrine. Thickness as much as 180 m (590 ft).

Ellis Group (Je)

Swift Formation (Jsw)—Orangish brown, glauconitic, flaggy-bedded, commonly fossiliferous, fine-grained sandstone or sandy coquina with subordinate dark gray shale interbeds; chert pebbles common. In west-central and northwestern Montana, a dark gray, noncalcareous, micaceous shale forms the lower part of the formation, commonly with a basal chert-pebble conglomerate or conglomeratic sandstone as much as 3 m (10 ft) thick. Shallow marine. Thickness as much as 70 m (230 ft).

Rierdon Formation (Jr)—Gray, locally fossiliferous limestone that may contain floating grains of quartz sand, interbedded with greenish gray limy shale. Lagoonal and marine shelf. Thickness as much as 105 m (344 ft).

Sawtooth Formation (included in Je)—*Western Montana:* dark gray, platy to shaly, dense limestone with local basal conglomerate. *Central Montana:* upper calcareous siltstone, middle dark gray shale with thin limestone interbeds, and lower fine-grained sandstone. Three local members Bowes, Firemoon, and Tampico, in descending order. *Bowes Member:* dark gray to medium gray, calcareous mudstone, limestone, and quartzose sandstone. *Firemoon Member:* dark to medium gray, limestone and calcareous mudstone. *Tampico Member:* very light gray, well-sorted quartz sandstone and siltstone, and chert-pebble conglomerate. Shallow marine. Thickness as much as 205 m (673 ft).

Piper Formation (Jp)—Upper part: red mudstone and gypsum; middle part: gray shale, limestone, and dolomite; lower part: red mudstone and gypsum. Marine and restricted coastal evaporite basins. Thickness as much as 75 m (246 ft).

Twin Creek Formation (included in Jmet)—Black and gray, calcareous shale and thin-bedded shaly limestone with some beds of yellow sandstone. Marine.

Chugwater Formation (Trc)—Red siltstone, sandstone, and shale with subordinate gypsum and local limestone bed at top. Shallow restricted marine and nonmarine. Thickness as much as 180 m (590 ft).

Thaynes Formation (included in Trtw)—Gray and tan limestone with interbedded siltstone, shale, and tan sandstone. Locally with red shale tongues. Marine. Thickness as much as 290 m (950 ft).

Woodside Formation (included in Trtw)—Maroon and red siltstone, dolomite, and shale. Tidal flat. Thickness as much as 250 m (820 ft).

Dinwoody Formation (Trd)—Interbedded green siltstone, shale, sandstone, and carbonate that grades eastward into red shale, siltstone, and anhydrite. Nearshore and restricted marine. Thickness as much as 330 m (1,083 ft).

Goose Egg Formation (included in TrPcg)—Red shale and sandstone with some interbeds of anhydrite, gypsum, and limestone. Nearshore marine, marine, and restricted marine. Thickness 30 m (98 ft).

Phosphoria Formation (Pp)—Gray and tan dolomite, cherty limestone, bedded chert, siltstone, sandstone, and gray to black phosphatic and dolomitic shale. Marine shelf and offshore marine. Thickness as much as 255 m (837 ft).

Park City Formation (within Ppp)—Gray limestone, tan dolomite, and interbedded sandstone, phosphatic shale, and cherty carbonate. Marine shelf. Thickness as much as 115 m (377 ft).

Shedhorn Formation (Psh)—Orangish brown, very fine- to medium-grained, well-sorted, quartzose sandstone. Nearshore marine shelf. Thickness as much as 70 m (230 ft).

Quadrant Formation (ℙq)—Very light gray, yellowish or pinkish, well-sorted sandstone or quartzite, locally interbedded with subordinate limestone beds. Marine. Generally, thickness as much as 140 m (460 ft), but as much as 800 m (2,625 ft) in southwestern-most Montana.

Tensleep Formation (ℙt)—Very light gray sandstone interbedded with subordinate carbonate, shale, and anhydrite. Cyclical marine, eolian, and sabkha. Thickness about 60 m (197 ft).

Amsden Formation (ℙMa)—Red shale, light gray limestone, and cherty and sandy limestone. Coastal plain or marine. Thickness as much as 180 m (590 ft).

Amsden Group (ℙMam)

Devils Pocket Formation—Red to gray siliceous dolomite, gray, finely crystalline, thin-bedded limestone, and red, gray, or pink, fine- to medium-grained quartz sandstone. May include massive breccia of coarse, cherty dolomite, limestone, red sandstone, shale, and chert. Intertidal to open marine. Thickness 43 m (140 ft) at type section.

Alaska Bench Formation (ℙab, ℙMab)—Gray and bluish gray, hard, fossiliferous limestone with subordinate interbeds of red mudstone. Marine. Thickness as much as 105 (345 ft) m.

Tyler Formation (ℙMt, Mt)—*Cameron Creek Member* (upper part of formation)*:* red, purple, and brown mudstone and siltstone, and quartzose sandstone with subordinate gray shale and limestone. *Bear Gulch Member* (middle part of formation, locally)*:* gray, fossiliferous, platy, argillaceous limestone. *Stonehouse Canyon Member* (lower part of formation): dark gray, carbonaceous mudstone with lenses of sandstone or conglomeratic sandstone. Fluvial and intertidal. Thickness as much as 180 m (590 ft).

Big Snowy Group (Mbs)

Heath Formation (Mh)—Black, fissile, commonly petroliferous shale with subordinate sandstone, gypsum, and coal. Restricted marine to coastal plain. Thickness as much as 150 m (492 ft).

Otter Formation (Mo)—Green, grayish green, gray, and subordinate reddish brown shale interbedded with light brown or gray limestone. Open and semi-restricted marine. Thickness as much as 150 m (492 ft).

Kibbey Formation (Mk)—Red, quartzose sandstone, siltstone, and shale, locally with subordinate thin gypsum beds and limestone bed in middle part. Intertidal and subtidal. Thickness as much as 105 m (345 ft).

Big Snowy Formation (locally included in Mmc)—Olive gray, thick-bedded limestone, yellowish gray siltstone, dark gray shale, and yellowish brown, thin-bedded siltstone and mudstone. Nearshore marine. Thickness 120 m (394 ft).

Snaky Canyon Formation (included in ℙMsb)—Medium gray limestone with yellowish brown chert, interbedded with subordinate thin sandstone beds. Marine. Thickness 245 m (804 ft).

Bluebird Mountain Formation (included in ℙMsb)—Medium gray to brownish gray quartzite interbedded with yellowish brown, very fine-grained sandstone, gray calcareous siltstone, and medium-gray sandy limestone. Marine. Thickness 275 m (902 ft).

Surrett Canyon Formation (included in ℙMbs)—Dark gray, massive limestone with much scattered white bioclastic debris. Marine. Thickness at type section 67 m (220 ft).

Railroad Canyon Formation (included in ℙMbs)—Medium gray and brownish black, phosphatic mudstone, shale, limestone, limestone conglomerate, and medium gray sandstone. Marine. Thickness 260 m (853 ft).

South Creek Formation (included in ℙMbs)—Dark gray, thin-bedded, chert-bearing limestone that alternates with dark gray, argillaceous limestone. Marine. Thickness at type section 91 m (300 ft).

Scott Peak Formation (included in ℙMsrm)—Dark gray, chert-bearing, fine-grained limestone interbedded with subordinate light brown, calcareous, quartzose siltstone to fine sandstone. Marine. Thickness at type section 685 m (2,247 ft).

McGowan Creek Formation (included in ℙMsrm)—Upper part: dark gray and pale yellowish brown, thin-bedded, calcareous siltstone interbedded with dark gray, silty limestone. Lower part: dark gray, carbonaceous, thin-bedded argillite with interbeds of dark gray siltite, medium gray, fine-grained, conglomeratic sandstone and quartzite, and dark gray, silty limestone. Marine. Thickness as much as 61 m (200 ft).

Snowcrest Range Group (ℙMsr)

Conover Ranch Formation—Red siltstone and mudstone with minor silty limestone and sandstone beds. Thickness 35 m (115 ft).

Lombard Formation—Gray, silty limestone with minor black shale. Thickness 120 m (394 ft).

Kibbey Formation—Yellow siltstone, sandstone, and mudstone with minor silty limestone in lower part. Thickness 80 m (262 ft).

Tendoy Group (Mtd)

McKenzie Canyon Formation—Gray, chert-bearing limestone and solution breccia. Marine. Thickness 140 m (460 ft).

Mission Canyon Formation—Light gray, chert-bearing limestone and brown

dolomitic limestone. Shallow marine. Thickness 180 m (590 ft).

Middle Canyon Formation—Dark gray, silty limestone with chert beds and nodules. Shallow marine. Thickness at type section 335 m (1,100 ft).

Paine Formation—Dark gray, silty limestone with solution breccia zone. Shallow marine. Thickness 230 m (755 ft).

Madison Group (Mm)

Mission Canyon Formation (Mmc)—Gray, massive limestone with chert beds and nodules, and solution breccia zones. Shallow marine. Thickness as much as 520 m (1,706 ft).

Lodgepole Formation (Ml)—*Woodhurst Member* (upper part of formation): light gray, well-bedded limestone, typically with much dark chert, interbedded with thinner calcareous mudstone beds. *Paine Member* (middle part of formation): dark gray, thin-bedded, silty or fossiliferous limestone. *Cottonwood Canyon Member* (lower part of formation): black shale with basal conglomeratic lag deposit. Shallow marine. Thickness as much as 305 m (1000 ft).

Northwest Montana

Castle Reef Formation (included in Mm)—Medium to light gray, thick-bedded limestone or dolomite. *Sun River Member* (upper part of formation): light gray dolomite with thick fossiliferous lenses. Shallow marine. Thickness as much as 300 m (984 ft).

Allan Mountain Formation (included in Mm)—Dark gray, thinly bedded limestone with thin mudstone and shale partings, and nodular chert. Shallow marine. Thickness as much as 200 m (656 ft).

Three Forks Formation (MDt)—*Sappington Member* (upper part of formation): yellowish orange and yellowish gray siltstone. *Trident Member* (middle part of formation): greenish gray and light olive gray, fossiliferous, calcareous shale that contains interbeds and nodules of fossiliferous, argillaceous limestone. *Logan Gulch Member* (lower part of formation): yellowish gray and grayish red, argillaceous limestone breccia and shale breccia that may include dolomitic siltstone. Marine to restricted marine with evaporite basins. Thickness as much as 185 m (607 ft).

Jefferson Formation (Dj)—*Birdbear Member* (upper part of formation): light to medium gray, sucrosic dolomite. Lower part of formation: grayish black, commonly petroliferous dolomite or limestone that may be interbedded with light gray quartzite. Marine. Thickness as much as 520 m (1,706 ft).

Maywood Formation (included in MDtm)—Thin-bedded dolomitic limestone and dolomite interbedded with calcareous shale. Shallow marine. Thickness as much as 120 m (394 ft).

Palliser Formation (locally included in MDtm)—Gray and greenish gray limestone and dolomitic limestone with locally abundant black chert. Pinkish gray, very thinly laminated, calcareous mudstone at base. Marine. Thickness as much as 300 m (984 ft).

Alexo Formation (locally included in MDtm)—Pale yellowish orange, medium-grained, calcareous siltstone with calcareous mudstone at the base. Shallow marine. Thickness as much as 595 m (1,952 ft).

Fairholme Group (locally included in MDtm)—Brownish black, bioturbated, calcareous mudstone, gray algal limestone and dolomite, and pale yellowish orange, medium-grained, calcareous sandstone at the base. Thickness as much as 550 m (1,805 ft).

Bighorn Formation (Ob)—Yellowish gray to very pale orange crystalline dolomite with local basal sandstone. Marine shelf. Thickness as much as 120 m (394 ft).

Beartooth Butte Formation (included in DOjb and DO$\in$js)—Light gray and grayish red dolomite and limestone breccia and conglomerate, sandy and silty dolomite, and dolomitic siltstone, sandstone, and shale. Isolated outcrops throughout central Montana. Estuarine. Thickness as much as 50 m (164 ft).

Kinnikinic Formation (Ok)—Very light gray, massive quartzite with local lenses of dolomite and dolomitic shale. Marine shelf. Thickness as much as 245 m (804 ft).

Snowy Range Formation ($\in$sr)—*Sage Member* (upper part of formation): gray limestone and grayish green shale interbedded with grayish green flat-pebble conglomerate. *Dry Creek Member* (lower part of formation): greenish gray shale and grayish orange calcareous sandstone. Shallow marine. Thickness as much as 85 m (280 ft).

Red Lion Formation (included in $\in$rf)—Gray limestone with siliceous laminae and black calcareous shale interbedded with thin limestone. Shallow marine. Thickness as much as 115 m (377 ft).

Grove Creek Formation (included in $\in$gf)—Shale, limestone, dolomite, and intraformational limestone-pebble conglomerate. Shallow marine. Average thickness 10 m (35 ft).

Devils Glen Formation (included in $\in$df)—Light gray dolomite with subordinate algal limestone and shale. Shallow marine. Thickness as much as 200 m (656 ft).

Switchback Formation (included in Cdf)—Green and gray, locally calcareous, fissile shale or mudstone, interbedded with thin beds of gray, flaggy limestone or dolomite. Shallow marine. Thickness as much as 95 m (312 ft).

Steamboat Formation (included in Cdf)—Tan, thick-bedded, hard limestone with thin layers of green fissile shale and nodular shaly limestone. Shallow marine. Thickness as much as much as 90 m (295 ft).

Pentagon Formation (included in Cdf)—Black fissile shale and brownish gray, platy limestone beds. Laterally replaced by Pagoda Formation. Shallow marine. Thickness as much as 88 m (289 ft).

Pagoda Formation (included in Cdf)—Green shale interbedded with maroon calcareous mudstone and gray limestone, and lower fissile black shale and thin limestone-pebble conglomerate. Shallow marine. Thickness as much as 120 m (394 ft).

Dearborn Formation (included in Cdf)—Upper brownish gray to gray limestone and lower interbedded green shale, shale-pebble conglomerate, and calcareous sandstone. Shallow marine shelf. Thickness as much as 115 m (377 ft).

Damnation Formation (included in Cdf)—Brownish gray or bluish gray fossiliferous, locally oolitic limestone and subordinate dark gray shale. Shallow marine. Thickness as much as 70 m (230 ft).

Hasmark Formation (included in Crf)—Light gray or bluish gray limestone and dark-gray calcareous shale. Shallow marine. Thickness as much as 560 m (1,823 ft).

Pilgrim Formation (included in Cpif and other units)—Gray, commonly mottled limestone that may contain intraformational limestone conglomerate. Shallow marine. Thickness as much as 180 m (590 ft).

Park Formation (included in Cpif and other units)—Grayish green, fissile, micaceous shale with a few thin beds of calcareous sandstone and thin, gray limestone. Local arkose beds. Offshore marine. Thickness as much as 310 m (1,017 ft).

Meagher Formation (included in Cpif and other units)—Gray to bluish gray limestone and dolomitic limestone, locally mottled and with intraformational conglomerate beds. Shallow marine. Thickness as much as 300 m (984 ft).

Silver Hill Formation (included in Crf)—Brown, green, and very light gray banded calcareous shale interbedded with laminated limestone. Shallow marine. Thickness as much as 120 m (394 ft).

Elko Formation (included in Cdf)—Light brownish gray dolomite and subordinate mudstone. Thickness as mucah as 220 m (722 ft).

Gordon Formation (included in Cdf)—Upper part of formation: dark green to dark brown, fissile shale with thin beds of sandstone and gray, glauconitic limestone. Lower part of formation: ferruginous sandstone, sandy shale, and grayish green shale. Shallow marine. Thickness as much as 90 m (295 ft).

Wolsey Formation (Cw)—Dark green and purplish gray fissile, micaceous shale, thin glauconitic limestone beds and thin, fine-grained sandstone beds. Shallow marine. Thickness as much as 145 m (476 ft).

Flathead Formation (Cf)—Pinkish gray to light gray sandstone or quartzite. Locally very glauconitic, pebbly, arkosic, or iron-stained. Marine shoreface. Thickness as much as 100 m (328 ft).

Quartzite (CYq)—Purple to light gray, fine- to medium-grained massive quartzite that contains sparse floating pebbles of quartz interbedded with and grading downward into fine- to coarse-grained feldspathic quartzite with abundant mud chips, trough and planar crossbeds, and flat laminations.

Metasedimentary rock (Ys) (Beaverhead Mountains, southwestern Montana)—Light gray quartzite with subordinate argillite, siltite, and calc-silicate rocks; unresolved unit that has been variously assigned to Yellowjacket Formation, Lemhi Group, Swauger Formation, or Belt Supergroup. Thickness as much as 2,700 m (8,858 ft).

Belt Supergroup (Yb)

Missoula Group (Ym)

Upper Missoula Group (Ymu)

Pilcher Formation—Light gray and red cross-bedded, feldspathic, fine-grained quartzite.

Garnet Range Formation—Dark green, micaceous, fine-grained quartzite with subordinate argillite interbeds. Thickness as much as 1,200 m (3,937 ft).

McNamara Formation—Dense green and red siltite and argillite in mud-cracked couplets containing diagnostic chert beds and rip-up clasts. Thickness as much as 1,650 m (5,413 ft).

Libby Formation—Light to dark gray and greenish gray siltite and argillite with subordinate quartzite in mud-cracked couplets. Thickness as much as 2,300 m (7,546 ft).

Bonner Formation—Pink, cross-bedded, feldspathic, medium- to coarse-grained quartzite. Thickness as much as 580 m (1,903 ft).

Mount Shields Formation—Upper part: red quartzite, siltite, and argillite in mud-cracked couples and couplets with abundant salt casts. Lower part: light gray, flat-laminated, feldspathic, fine-grained quartzite. Thickness as much as 2,000 m (6,562 ft).

Lower Missoula Group (Yml)

Shepard Formation—Tan-weathering, dolomitic, green siltite and argillite in couplets and microlaminae. In the west formerly considered part of the "upper Wallace." Thickness as much as 1,100 m (3,609 ft).

Snowslip Formation—Green and red siltite and argillite in couplets. Western Snowslip equivalent is black siltite and argillite in couplets and microlaminae, formerly considered part of the "upper Wallace." A new name is under consideration for the western Snowslip equivalent. Thickness as much as 1,200 m (3,937 ft).

Piegan Group (Ypg) ("Middle Belt carbonate")

Wallace Formation (included in Ypg) (Restricted to what was formerly "middle Wallace")—Tan-weathering, dolomitic quartzite and siltite, and black argillite with calcite ribbons (molar tooth structure) in graded pinch-and-swell couples and couplets. Thickness as much as 2,500 m (8,202 ft).

Helena Formation (Yh and included in Ypg)—*Northwestern Montana* (formerly "lower Wallace"): cycles of basal white quartzite or intraclast beds overlain by couplets of green siltite and argillite, capped by dolomite beds. Calcite pods and ribbons (molar tooth structure) common. *West-central Montana:* gray to dark gray limestone and dolomitic limestone with siltite partings. Thickness as much as 2,000 m (6,562).

Ravalli Group (Yr)

Empire Formation (Ye)—Grayish green and pale olive gray argillite and siltite with subordinate thin beds of quartzite and sandy limestone. Thickness as much as 610 m.

Spokane Formation (Ysp)—Red siltite and argillite in mudcracked couplets. Thickness as much as 1,500 m (492 ft).

Grinnell Formation—White, cross-bedded sandstone or quartzite with red to purple siltite and argillite beds. Thickness as much as 1,160 m (3,806 ft).

St. Regis Formation—Green and purplish gray quartzite, siltite, and argillite in mud-cracked couples and couplets. Thickness as much as 900 m (2,953 ft).

Revett Formation—Light gray, cross-bedded, felspathic, fine-grained quartzite. Thickness as much as 900 m (2,953 ft).

Burke Formation—Gray or purple quartzite, siltite, and argillite in mud-cracked couples and couplets. Thickness as much as 1,000 m (3,281 ft).

Lower Belt

Prichard Formation—Thickness as much as 5,000 m (16,404 ft).

Upper Prichard Formation (Ypu)—Black and gray, pyritic siltite and argillite in planar couplets.

Lower Prichard Formation (Ypl)—Dark and light gray, pyrite- and pyrrhotite-rich siltite and argillite in planar couplets with subordinate gray, flat-laminated, fine-grained quartzite.

Appekunny Formation (included in Yaw)—Gray and greenish gray argillite interbedded with light gray quartzite. Thickness as much as 1,700 m (5,577 ft).

Altyn Formation (included in Yaw)—White to light gray dolomite interbedded with dolomitic sandstone and cross-bedded sandstone. Thickness as much as 800 m (2,625 ft).

Waterton Formation (included in Yaw)—Gray to tan dolomite and dark gray limestone with chert nodules and minor dolomitic siltite and sandstone. Thickness 200 m (656 ft).

LaHood Formation (Yla)—Dark gray, dark brown, reddish brown, coarse, arkosic conglomerate locally with very large clasts derived from crystalline metamorphic rocks. Grades from mega-clast conglomerate to shale or argillite over short distances. Thickness as much as 3,000 m (9,842 ft).

Greyson Formation (Yg, Ygu, Ygm, Ygl)—Greenish gray siltite and dark gray argillite with interbedded bands of light brown, sandy argillite and feldspathic quartzite. Thickness as much as 915 m (3,000 ft)

Newland Formation (Yn)—Dark bluish gray limestone. Thickness as much as 2,000 m (6,562 ft).

Moose Formation (included in Ynla)—Silty argillite and siltite. Thickness as much as 90 m (295 ft).

Table Mountain Formation (included in Ynla)—Very light gray quartzite and argillaceous quartzite. Thickness as much as 530 m (1,740 ft).

Chamberlain Formation (Ych)—Dark gray argillite. Thickness as much as 700 m (2,297 ft).

Neihart Formation (Yne)—Very light gray and pinkish gray, coarse-grained, well-sorted quartzite with subordinate interbedded dark green, micaceous argillite in upper part. Thickness 215 m (705 ft).

Igneous

Map units designated only by rock composition names are not further described.

Plateau Rhyolite (Qpr)

Central Plateau Member—Upper part: rhyolitic flows with abundant phenocrysts dominantly of quartz and sanidine, and lacking plagioclase. Lower part: light gray, dense, fine-grained to aphanitic rhyolitic ash-flow tuff, with angular to rounded phenocrysts of quartz, sanidine, pyroxene, and olivine that make up as much as 25 percent of rock volume.

Yellowstone Group

Lava Creek Tuff (Qlc)—Brown, gray, and purple, welded, devitrified ash tuff with quartz, sanidine, and sodic plagioclase phenocrysts.

Huckleberry Ridge Tuff (Thr)—Upper part: pinkish gray, gray, or brown welded or unwelded tuff that contains abundant phenocrysts of sanidine and quartz, and uncompacted pumice fragments at the top.

Absaroka Volcanics Supergroup (Tav)—Calc-alkalic andesite and dacite extrusive rock with lesser amounts of potassic, alkalic, and mafic lava; minor amounts of rhyodacitic ash-flow tuff associated with mafic lava; and dark gray, very fine-grained basalt or andesite intrusive breccia.

Challis Volcanics (included in Tv)—Basaltic andesite, andesite, quartz latite, latite, rhyodacite, and rhyolite flows, and tuff, most of which is nonporphyritic and commonly spherulitic; glassy to devitrified. Subordinate water-laid tuff.

Lowland Creek Volcanics (Tlc)—Quartz latite flows, quartz latite welded tuff and tuff breccia, and basal conglomerate with tuffaceous debris that increases upward.

Elkhorn Mountains Volcanics (Kem)—Light gray to dark gray, grayish red, greenish gray, and brown mostly andesitic to latitic welded tuff and tuff breccia, tuff, lapilli tuff, lava flows, flow breccia, and related hypabyssal intrusive rock. Subordinate quartz latitic welded tuff and basalt flows.

Adel Mountain Volcanics (Kam)—Gray, light brownish gray, and dark gray trachyandesite and trachybasalt flows; dark red, purplish red, and dark grayish green volcanic breccia containing angular clasts of trachybasalt and trachyandesite in matrix of coarse tuff; and dark gray, dark grayish red, brownish gray, and dark grayish green porphyritic shonkinite intrusive rock with augite phenocrysts.

Sliderock Mountain volcanics (Klsr)—Gray, pale purplish gray, and pale greenish gray andesite lahar breccia with interbeds of andesitic conglomerate and coarse-grained sandstone. Subordinate flows of porphyritic andesite and basaltic andesite containing plagioclase, hornblende, and pyroxene phenocrysts.

Purcell Lava (Ypl)—Black to blackish green alkaline basalt flows.

Pinto Diorite (Xpd)—Mottled gray to greenish gray massive, locally gneissic, medium- to coarse-grained diorite.

Stillwater complex (Asw)—Layered ultramafic and mafic rocks from peridotite and pyroxenite at the base (ultramafic series) to gabbro and anorthosite in the upper part (banded series). Maximum exposed thickness in the Beartooth Mountains is about 6,700 m (22,000 ft).

Metamorphic

Map units are designated by rock composition names and are not further described.

Sources: Balster (1971)
Source maps (fig. 9)
U.S. Geological Survey GEOLEX (http://ngmdb.usgs.gov/Geolex/geolex_home.html, accessed February 2007).

SOURCE MAPS FOR PLATE 1

The Geologic Map of Montana (plate 1) was compiled primarily from maps of 30' x 60' and 1º x 2º quadrangle maps prepared by the Montana Bureau of Mines and Geology and the U.S. Geological Survey (fig. 9). These quadrangle map sources were supplemented by larger-scale geologic maps (fig. 9) and some unpublished maps.

Source maps for the Geologic Map of Montana are listed by 30' x 60' quadrangle first, followed by the 1° x 2° quadrangles. The first reference listed under each quadrangle, in **bold type**, is the primary source for that quadrangle. Each primary source is followed by its respective source maps, which may include maps published before and after the previous Geologic Map of Montana (Ross and others, 1955). The primary source maps contain a significant amount of new field mapping and reflect new stratigraphic and structural concepts. Maps produced by the Montana Bureau of Mines and Geology since 1994 have been supported in part by the STATEMAP component of the National Cooperative Geologic Mapping Program of the U.S. Geological Survey.

Where we have used additional maps in a quadrangle as source maps, these are listed under **Additional source map(s) for plate 1**. Other maps in the quadrangle area, not directly used as source maps, are listed under **Other map(s)**.

Users of this Geologic Map of Montana are referred to the primary source map for each 30' x 60' or 1° x 2° quadrangle for more detailed geologic data and for complete references. These primary source maps provide significantly more detail than the 1:500,000-scale Geologic Map of Montana. Each primary source map can be viewed at http://www.mbmg.mtech.edu/stmap.htm.

30' x 60' Quadrangles

Alzada

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Ellis, M.S., and Colton, R.B., 1994, Geologic map of the Powder River Basin and surrounding area, Wyoming, Montana, South Dakota, North Dakota, and Nebraska: U.S. Geological Survey Miscellaneous Investigations Map I-2298, scale 1:500,000.

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Stoner, J.D., and Lewis, B.D., 1980, Hydrogeology of the Fort Union coal region, eastern Montana: U.S. Geological Survey Miscellaneous Investigations Map I-1236, scale 1:500,000.

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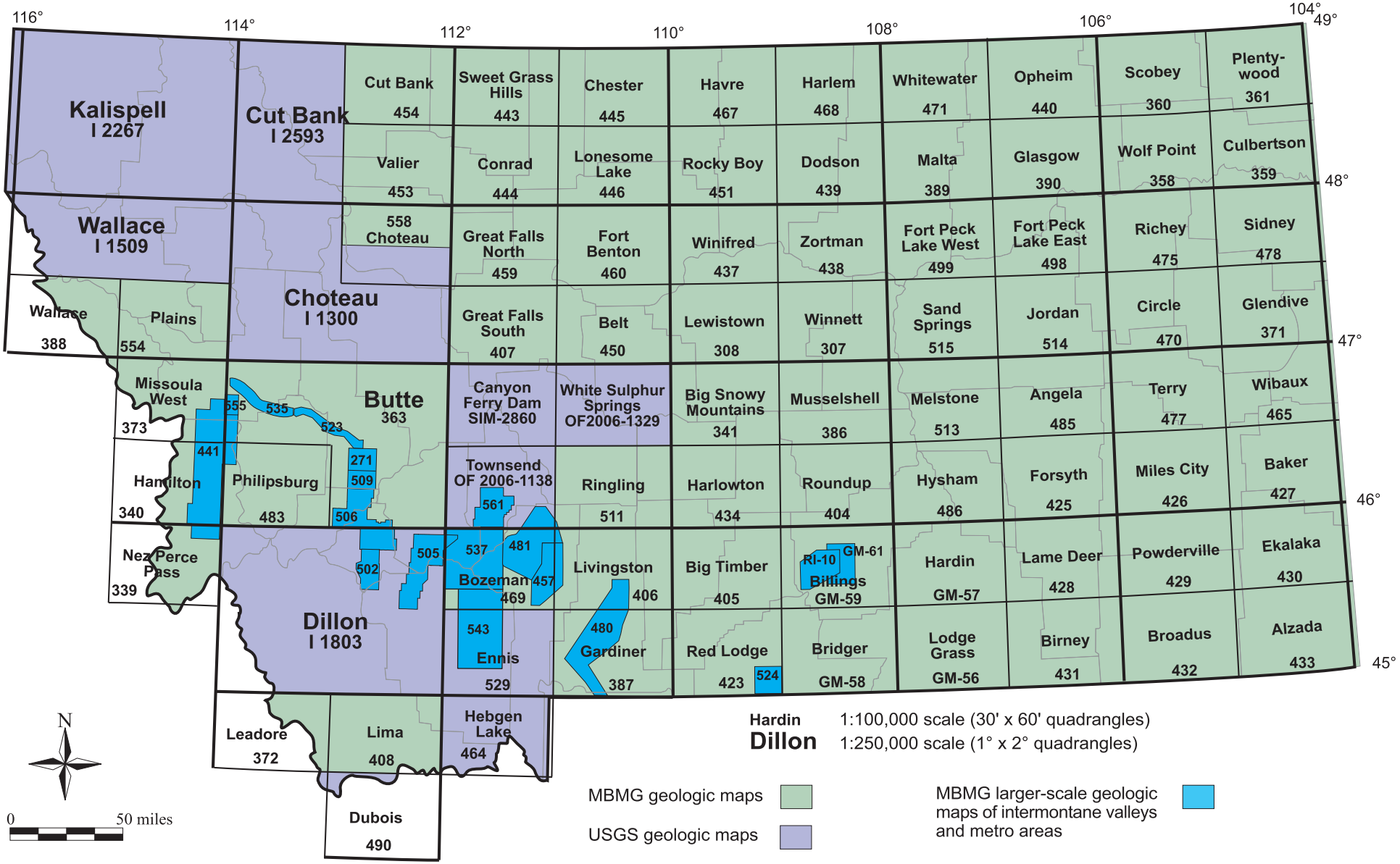

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