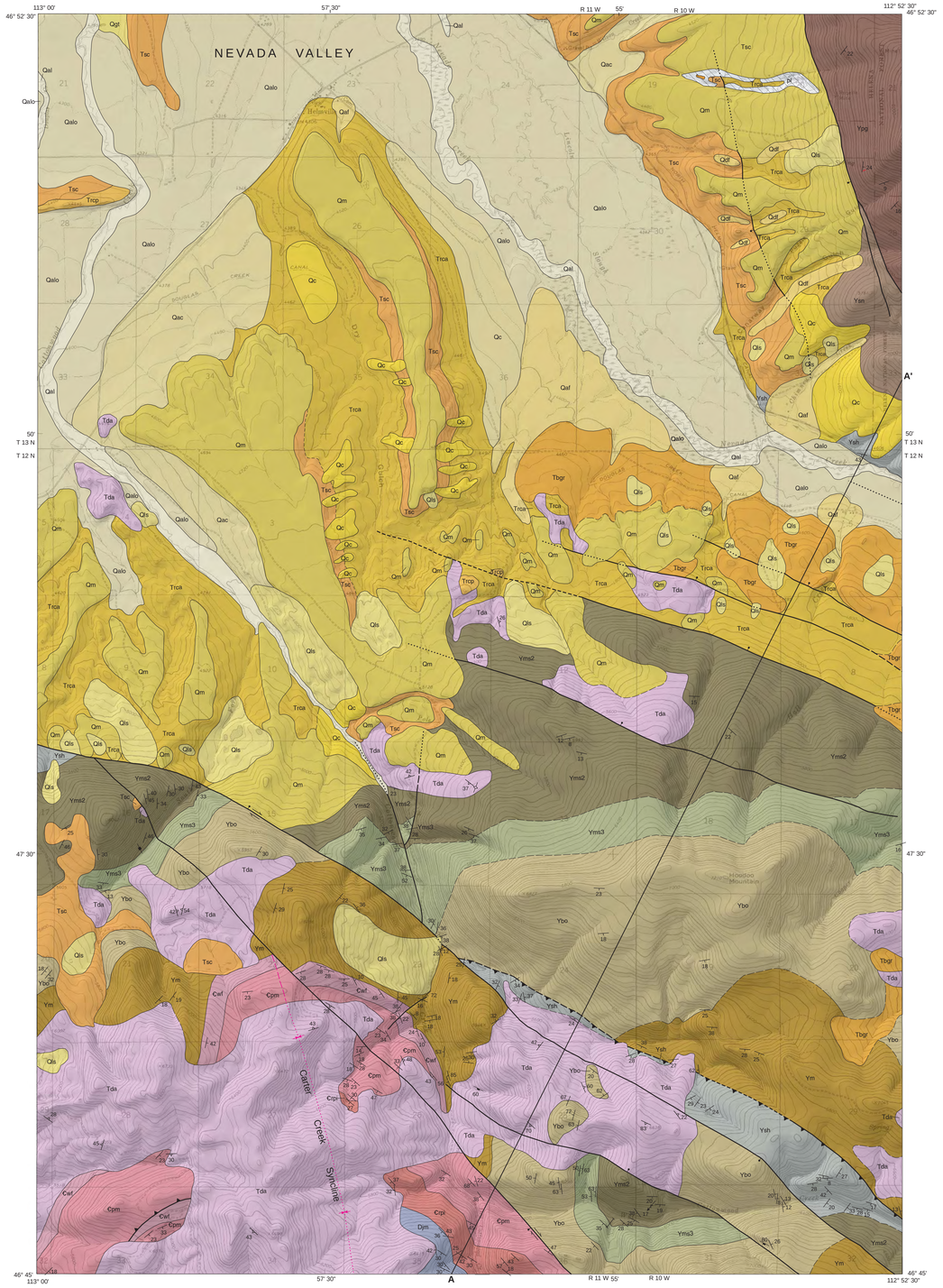


Topographic base from U.S. Geological Survey
Helmville 7.5' topographic quadrangle
Map date: 1968
Projection: UTM zone 12; 1927 NAD
UTM grid declination 12°25' West
1968 Magnetic North Declination 19° East
Contour Interval 40 feet; NGVD of 1929

Shaded relief created from 10 meter digital elevation model from U.S. Geological Survey National Elevation Dataset.

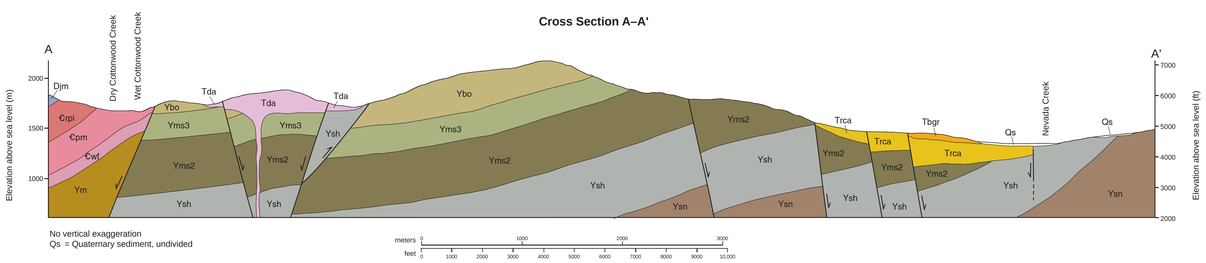
N

SCALE 1:24,000

1 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 0 1 KILOMETER

CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

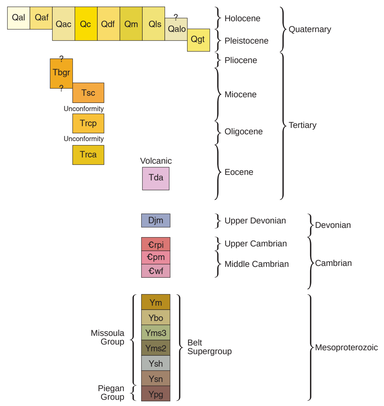
Cross Section A–A'



No vertical exaggeration
Qs = Quaternary sediment, undivided

Maps may be obtained from:
Publications Office
Montana Bureau of Mines and Geology
1300 West Park Street
Butte, Montana 59701-8997
Phone: (406) 496-4174 Fax: (406) 496-4451
http://www.mbmg.mtech.edu

CORRELATION DIAGRAM



MAP SYMBOLS

- Contact: dashed where approximately located
- Fault: dashed where approximately located; dotted where concealed, bar and ball on downthrown side; arrows indicate relative lateral movement
- Reverse or thrust fault: teeth on upthrown block; dashed where approximately located; dotted where concealed
- Plunging syncline axial trace: dashed where approximately located; dotted where concealed
- Strike and dip of inclined beds
- Strike and dip of cleavage
- Strike and dip of vertical cleavage
- Strike and dip of joints
- Strike of vertical joints
- Strike and dip of volcanic foliation
- Strike of vertical volcanic foliation
- Bearing and plunge of bedding/cleavage intersection
- Placer workings

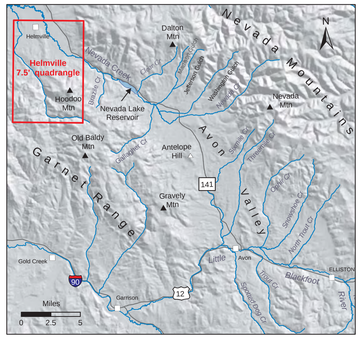


Figure 1. Location map for the Helmvile 7.5' quadrangle.

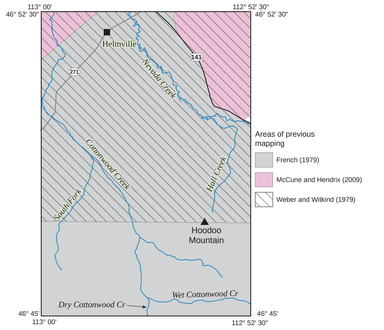


Figure 2. Helmvile 7.5' quadrangle showing areas of previous mapping and primary features.

INTRODUCTION

The Montana Bureau of Mines and Geology (MBMG), in conjunction with the STATEMAP advisory committee, selected the Helmville 7.5' quadrangle for detailed mapping to provide new information on stratigraphy and structure in an area where only reconnaissance mapping existed. This new mapping is part of the MBMG's effort to complete the Elliston 30' x 60' geologic map. The southern half of the Helmville quadrangle is within the eastern Garnet Range; the northern half covers part of the southern Nevada Valley (fig. 1).

GEOLOGIC SUMMARY

The oldest formations exposed in the quadrangle are metasedimentary rocks of the Mesoproterozoic Belt Supergroup. The Belt rocks form a thick (4,650 m /15,250 ft) section of carbonates, quartzites, and argillites mapped as the Piegan Group (Helena and Wallace Formations, undifferentiated) and as the overlying Snowslip, Shepard, Mount Shields (members 2 and 3), Bonner, and McNamara Formations, which are part of the Belt Missoula Group. The Belt rocks are separated from overlying Paleozoic rocks by a low-angle unconformity. The Middle Cambrian Flathead Formation (quartzite) forms the base of the Paleozoic section and is overlain by shales, dolomites, and limestones of the Middle to Upper Cambrian Woolsey, Meagher, Park, Pilgrim, and Red Lion Formations. The youngest Paleozoic rocks mapped are shales, siltstones, and limestones of the Middle and Late Devonian Maywood and Jefferson Formations.

The Mesoproterozoic and Paleozoic rocks are intruded and unconformably overlain by Cenozoic volcanic rocks. The volcanic rocks are predominantly Eocene dacite to trachydacite flows of the eastern Garnet Range volcanic field (Mosolf, 2015). The volcanic rocks are widespread in the southeast corner of the quadrangle and as isolated, small exposures on the flanks of the Garnet Range.

The youngest units mapped are Tertiary and Quaternary valley-fill and surficial deposits. The oldest valley-fill deposits are the Miocene/Oligocene Cabbage Patch member and Climbing Arrow Member of the Renova Formation. The Renova Formation is unconformably overlain by the Miocene Sixmile Creek Formation and local boulder gravel deposits that may be remnants of Pliocene(?)/Miocene alluvial fans. Quaternary surficial deposits are widespread in the Nevada Valley and include alluvium and colluvium along stream drainages, landslides (primarily developed in the Renova Formation), debris flow deposits, gravel mantle deposits, and glacial till.

Structure

The Helmville quadrangle is within the eastern part of the Lewis and Clark Line (LCL)—a major WNW-striking tectonic zone recurrently active since the Proterozoic (Sears and Hendrix, 2004; Wallace and others, 1990; Reynolds, 1979; Billingsley and Locke, 1941). From Late Cretaceous to late Paleocene, the LCL underwent left-lateral transpression associated with crustal shortening (Sears and Hendrix, 2004). In the Helmville area, shortening resulted in folding and thrust faulting of the Mesoproterozoic and Paleozoic rocks. The most prominent fold is the southeast-plunging Carter Creek Syncline. This regional-scale fold extends at least 16 km (10 mi) southeast of the Helmville quadrangle and deforms strata as young as Late Cretaceous (Sears and Hendrix, 2004; Sears and others, 2000). The most prominent thrust fault is the NW-striking, southwest-dipping thrust south of Hoodoo Mountain (fig. 1) that juxtaposes the Shepard Formation against the Bonner and McNamara Formations.

Since the late Eocene, deformation along the LCL has been predominantly right-lateral transtension associated with regional middle Tertiary crustal extension (Stickney, 2015; Sears and Hendrix, 2004). In the Helmville quadrangle, steep, mostly NW-trending, oblique- and normal-slip faults cut and overprint the older transpressive structures. These younger faults cut Eocene volcanic rocks and valley-fill deposits as young as Miocene, suggesting movement on the faults is generally younger than middle Miocene. A review of recent earthquakes (Stickney, 2015) indicates active faults have both strike-slip and oblique-normal motions.

PREVIOUS MAPPING

The entire quadrangle was included on a 1:250,000-scale map by Lewis (1998). Weber and Witkind (1979) completed reconnaissance mapping in the north half of the Helmville quadrangle (fig. 2). McCune and Hendrix (2009) mapped part of the Nevada Valley at 1:24,000 scale. French (1979) mapped the area south of Nevada Creek for a 1:62,500-scale geologic map of the eastern Garnet Range.

DESCRIPTION OF MAP UNITS

Qal **Alluvium (Quaternary: Holocene)**—Gravel, sand, silt, and clay along Nevada, Cottonwood, and Douglas Creeks. Rounded to subrounded quartzite clasts are cobble size and smaller, but include boulders in uppermost deposits along Cottonwood Creek. Thickness probably less than 7 m (20 ft).

Qaf **Alluvial-fan deposit (Quaternary: Holocene)**—Gravel, sand, silt, and clay in deposits with fan-shaped morphology along tributaries of Nevada Creek. Clasts are dominantly cobbles, but may also include boulders and pebbles. Thickness less than 15 m (50 ft).

Qac **Alluvium and colluvium (Quaternary: Holocene)**—Silt, sand, granules, and pebbles deposited on slopes by sheetwash and incorporated with locally derived colluvial gravel from older upslope deposits. Thickness generally less than 15 m (50 ft).

Qc **Colluvium (Quaternary: Holocene)**—Gravel deposits on slopes derived primarily from immediately upslope mantle (Qm) and Sixmile Creek (Tsc) deposits. Thickness less than 5 m (15 ft).

Qdf **Debris-flow deposit (Quaternary: Pleistocene or Holocene)**—Linear deposits in northeastern part of quadrangle that contain boulder-size blocks of rock derived from upslope. Distribution pattern and large block size suggest debris-flow lag deposits from which most fine-grained matrix was subsequently removed by erosion. Thickness less than 10 m (30 ft).

Qm **Mantle (Quaternary: Holocene and Pleistocene)**—Slope deposits that include sheetwash alluvium, fine-grained colluvium, coarse-grained (pebble, cobble, small boulder) lag from older debris-flow deposits, and regolith. Thickness generally less than 12 m (40 ft).

Qls **Landslide deposit (Quaternary: Holocene or Pleistocene)**—Most landslides developed in bentonitic Climbing Arrow Member of the Renova Formation and display irregular topography, disrupted bedding, displaced associated rock, scarps, seeps, and ponds. Deposits in McNamara and Mount Shields 2 Formations include abundant angular rock fragments. Composition reflects that of parent rock or sediment. Thickness less than 60 m (200 ft).

Qalo **Alluvium, older than Qal (Quaternary: Pleistocene)**—Sand and gravel deposits at higher altitude than, and adjacent to, younger alluvium (Qal) associated with Nevada, Cottonwood, and Douglas Creeks. Clasts generally rounded to subrounded, cobble size and smaller, but boulders also present. Thickness as much as 15 m (50 ft).

Qgt **Glacial deposit (Quaternary: Pleistocene)**—Small deposit in northwestern corner of map of light brown, brown, and reddish brown mixture of granules, pebbles, cobbles, and boulders in a very sandy to silty matrix which locally is clayey and compact. Dominant lithologies are quartzite and argillite. Deposited during Bull Lake glaciation (Weber and Witkind, 1979). Exposed thickness probably less than 12 m (40 ft).

Tbgr **Boulder gravel (Tertiary)**—Dominantly matrix-supported, but locally clast-supported gravel with pebbles to large boulders in a clay/silt/sand matrix. Dominantly Belt Supergroup quartzite with subordinate volcanic clasts that are rounded to subangular. Probably correlates with similar deposits on sides of the Nevada and Avon Valleys. May be considered part of the Sixmile Creek Formation, but distinctive from that described below. Exposed thickness in quadrangle less than 120 m (400 ft).

Tsc **Sixmile Creek Formation (Tertiary: Miocene)**—Yellowish brown tuffaceous siltstone that contains long lenses of angular to subrounded granules to boulders. Clasts are dominantly Belt Supergroup with subordinate amounts of volcanic clasts, and sparse plutonic and spotted hornfels clasts. Several distinctive horizons of matrix-supported well-rounded to subrounded Belt quartzite cobbles to small boulders are also present. Rasmussen (1977) found and identified a Barstovian (Miocene) canine jaw east of Nevada Creek. Several tortoise fossils were found in the same area while mapping the quadrangle. South of Helmville, gravel in the Sixmile Creek Member and coarse-grained gravel in overlying mantle deposits (Qm) obscure any fine-grained deposits. Exposed thickness less than 60 m (200 ft).

Trcp **Renova Formation, Cabbage Patch member (Tertiary: Miocene and/or Oligocene)**—Exposed only on the face of a cuesta on the west side of Cottonwood Creek in the Nevada Valley (northwest part of quadrangle) and in two small exposures south of Helmville. Exposures in the cuesta face were measured by Rasmussen (1977) and include pebbly coarse-grained micaceous arkose with clasts dominantly of plutonic rock, quartz, and chert, and occasional large wood fragments; mudstone with silt-size glass shards that locally contains horizons of fresh-water gastropods; and sandstone lenses. These lithologies are typical of the basal Cabbage Patch member southeast of the Helmville quadrangle. The small exposures south of Helmville consist of light gray recrystallized limestone with occasional faint gastropod outlines, and yellowish brown, silicified limestone. In much of the Helmville quadrangle the Cabbage Patch member is not present between the Sixmile Creek Formation and Climbing Arrow Member of the Renova Formation. Maximum exposed thickness 105 m (350 ft).

Trca **Renova Formation, Climbing Arrow Member (Tertiary: Eocene)**—Gray, reddish brown, or olive brown bentonitic mudstone that displays "popcorn weathering" and desiccation cracks in associated dry soil; dark gray or dark olive fissile shale that is locally lignitic; fossiliferous paper shale; and pebbly beds in a sand and granule matrix—typically iron-oxide stained. Northeast of Nevada Creek, a sandstone with white chert matrix is present at several locations. Unit is prone to landslide development, especially southwest of Cottonwood Creek in the west-central part of the quadrangle. Equivalent to Douglas Creek beds of Konizeski (1961, 1965).

Tda **Dacite (Tertiary: Eocene)**—Gray and dark gray weathering, aphanitic to slightly porphyritic, dacite to trachydacite lava flows. Autobrecciated flow bottoms are overlain by massive, coherent flow interiors; zones of vesiculation are rarely preserved. Lava flows commonly exhibit distinctive flow banding and form flaggy, angular talus, often with red iron staining on parting surfaces. Aphanitic lavas exhibit a strong trachytic texture consisting mainly of plagioclase microlites, but also include pyroxene, magnetite, and volcanic glass. Slightly porphyritic flows exhibit a similar trachytic texture and groundmass mineralogy, but contain subhedral to euhedral phenocrysts of plagioclase, hornblende, and some biotite.

Djm **Jefferson and Maywood Formations, undivided (Middle and Upper Devonian)**
Jefferson Formation—Gray to black, thin- to thick-bedded, coarsely crystalline dolomite and limestone, strong petroliferous fetid odor on fresh surfaces. Some beds contain brachiopod, gastropod, bryozoan, and other unidentified fossil fragments. Exposed thickness about 170 m (560 ft).
Maywood Formation—Thin-bedded, gray, reddish gray, grayish green, and yellow dolomitic shale and siltstone, silty dolomite, and minor gray limestone. Exposed thickness about 10 m (30 ft).

Crpi **Red Lion and Pilgrim Formations, undivided (Upper and Middle Cambrian)**
Red Lion Formation—Upper part is light to dark gray, micritic limestone with interbedded, thin and discontinuous, siliceous layers. The siliceous layers stand in relief on weathered surfaces, imparting a wavy, ribbon-like appearance to the bedding. Flat-pebble intraclast conglomerate is relatively common. Lower part is red, reddish brown, and yellowish brown siltstone and shale with local calcareous cement and common trace fossils. Weathered float often has distinct grayish red and pale red liesegang banding.
Pilgrim Formation—Light to medium gray, massive to thinly laminated, thin- to very thick-bedded, finely crystalline and microcrystalline dolomite with rare oncolites and chert. Weathers very light gray with a gritty, typically faintly laminated surface. Combined thickness of the Red Lion and Pilgrim Formations in the map area is about 275 m (900 ft).

Cpm **Park and Meagher Formations, undivided (Middle Cambrian)**
Park Formation—Interbedded grayish green fissile shale, calcareous siltstone, very fine-grained sandstone, and gray limestone and dolomite. Siltstone and sandstone beds weather dark yellowish orange with occasional small (<5 cm) black brachiopods. Poorly exposed. Thickness approximately 80 m (260 ft).
Meagher Formation—Gray to dark gray, thin- to thick-bedded micrite and biomicrite containing distinctive thin interbeds of uneven and discontinuous, pale yellowish and orange weathering, siliceous and argillaceous dolomite. Thickness 180 m (590 ft).

Cwf **Wolsey and Flathead Formations, undivided (Middle Cambrian)**
Wolsey Formation—Greenish gray, micaceous shale and glauconitic siltstone interbedded with thin beds of gray limestone near the top, and glauconitic quartzite, grayish red siltstone, and fine-grained sandstone near the base. Thickness about 90 m (300 ft).
Flathead Formation—Gray to purple, thin- to thick-bedded, fine- to medium-grained, crossbedded quartz arenite. Contains common, well-rounded, coarse quartz grains and occasional pebbles. Dark red, hematite-stained sandstone beds common near base of formation. Thickness about 30 m (100 ft).

Ym **McNamara Formation (Mesoproterozoic)**—Couplets and microcouplets of variegated red and green fine-grained quartzite, siltite, and waxy argillite containing diagnostic red or green chert beds and chert rip-up clasts. Mudcracks and mud rip-up clasts common. Top part is light gray, thick-bedded, fine- to medium-grained, crossbedded quartzite with abundant red mud rip-up clasts, uncommon red chert rip-up clasts, and abundant thin, red, mudcracked argillite interbeds. Exposed thickness about 670 m (2,200 ft).

Ybo **Bonner Formation (Mesoproterozoic)**—Pink to red, medium- to coarse-grained, poorly sorted, feldspathic quartzite. Abundant trough and planar crossbedding in beds typically 0.5–1.0 m thick. Quartzite beds often separated by thin (0.1–1.0 cm), red to maroon argillite beds. Contains sparse subangular granules and small pebbles. Five slabbed and stained samples from the Ophir Creek 7.5' quadrangle southeast of the Helmville quadrangle contained 50–75 percent quartz, 15–35 percent potassium feldspar, and 5–15 percent plagioclase (Lonn and Vuke, 2015). Thickness about 550 m (1,800 ft).

Yms3 **Mount Shields Formation, member 3 (Mesoproterozoic)**—Grayish red to blackish red, fine-grained quartzite to argillite couples and couplets with abundant desiccation cracks, mudchips, and diagnostic cubic salt casts. Includes green interbeds and some red microlaminae. Thickness about 275 m (900 ft).

Yms2 **Mount Shields Formation, member 2 (Mesoproterozoic)**—Pink to red, poorly sorted, medium- to coarse-grained, feldspathic quartzite. Abundant planar and trough crossbeds. Contains sparse subangular granules. Lower part is thinner bedded than upper, consisting of couples of white to pink, medium-grained quartzite and thin red argillite. Bases of quartzite beds contain abundant red mud chips. The lower part of this unit was included in the top part of the Mount Shields Formation, member 1 of Schmidt and others (1994). Two slabbed and stained samples from the Ophir Creek 7.5' quadrangle southeast of the Helmville quadrangle contained 65–75 percent quartz, 5–15 percent potassium feldspar, and 20 percent plagioclase (Lonn and Vuke, 2015). Thickness about 520 m (1,700 ft).

Ysh **Shepard Formation (Mesoproterozoic)**—Dolomitic and non-dolomitic, dark green siltite and light green argillite in microlaminae. Couplets of non-dolomitic red quartzite to argillite. Poorly exposed, but weathers to thin plates that, when dolomitic, have a characteristic orange brown rind. Ripples and load casts are common; mudcracks are rare. The upper half contains intervals of pink to gray, fine-grained feldspathic quartzite originally included in Mount Shields Formation, member 1 by Schmidt and others (1994). However, we place the formation's upper contact at the top of a 50-m (160-ft)-thick interval of distinctive rose-colored, dolomitic siltite–argillite couplets to be consistent with mapping to the west (Lonn and others, 2010). The lower contact is placed at the bottom of the lowest dolomite-bearing beds. A stromatolite bed is often found near the base. Thickness about 610 m (2,000 ft).

Ysn **Snowslip Formation (Mesoproterozoic)**—Interbedded intervals of quartzite to grayish red argillite couplets, and dark green siltite to light green argillite couplets and microlaminae. Desiccation cracks and mud rip-up clasts are common. Argillite beds often contain irregular "bumps" that may be ill-defined salt casts or structures related to microbial mats. Contains beds and lenses of distinctive, white, coarse-grained, well-sorted, feldspar-poor quartzite containing some well-rounded, frosted (dull, opaque surface) quartz grains. Upper 50–75 m (160–245 ft) is red, flat-laminated, medium-grained quartzite in beds 0.5–1.0 m thick. Lower 50 m (160 ft) dominated by microlaminated green dolomitic siltite and argillite that marks the gradational base with the underlying Piegan Group. Base not exposed but thickness approximately 1,430 m (4,700 ft) on the east adjacent Nevada Lake quadrangle (McDonald and Mosolf, 2016).

Ypg **Piegan Group (Mesoproterozoic)**—Tan and dark gray dolomite, dark gray limestone, dark gray to tan argillite, siltite, calcareous siltite, and fine-grained quartzite; weathers grayish orange to yellowish gray. The upper 300 m (985 ft) consists of dark gray limestone interbedded with dark gray calcareous argillite interpreted to be the Wallace Formation, the upper part of the Piegan Group as defined by Winston (2007). Below this interval, the Helena Formation is characterized by 1 to 7-m-thick cycles with a basal clastic zone of tan to gray siltite and fine-grained quartzite, overlain by tan dolomite, and capped by dark gray argillaceous or stromatolitic limestone. Oolite beds are commonly associated with the stromatolites. Crinkly molar-tooth structure, syneresis cracks, fluid-escape structures, and recessive-weathering calcitic pods are common sedimentary structures. Base not exposed but thickness is about 1,525 m (5,000 ft) on the nearby Nevada Mountain 7.5' quadrangle (McDonald and Lonn, 2015).

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GIS production: Yiwen Li and Paul Thale, MBMG. Map layout: Susan Smith, MBMG. Editing: Susan Barth, MBMG.

MBMG Open-File Report 687

Geologic Map of the Helmville 7.5' Quadrangle, Powell County, Montana

Catherine McDonald and Susan M. Vuke

2017