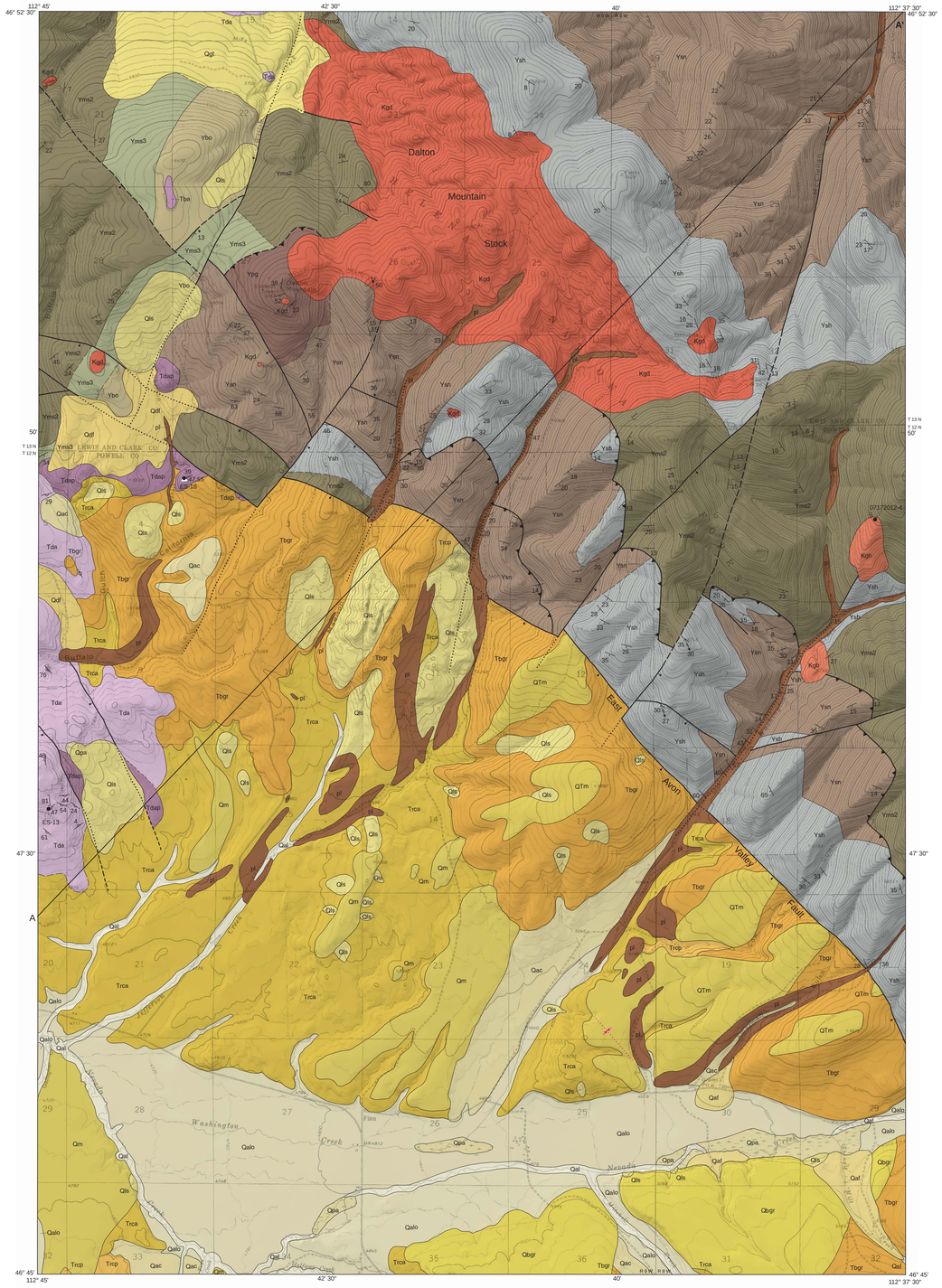
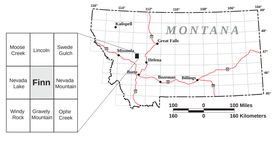
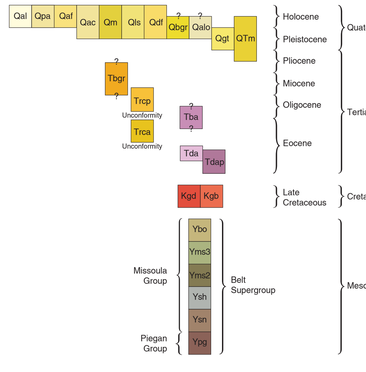


Base from U.S. Geological Survey
Finn 7.5' topographic quadrangle
Map date: 1968
Projection: UTM zone 12; 1927 NAD
UTM grid declination 1°14' West
1968 Magnetic North Declination 19° East
Contour Interval 40 feet; NGVD of 1929

SCALE 1:24,000
CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929



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 movement
- Reverse or thrust fault: teeth on upthrown block; dashed where approximately located
- Syncline: dotted where concealed
- Strike and dip of inclined beds
- Strike and dip of cleavage
- Strike of vertical cleavage
- Strike and dip of joints
- Bedding/cleavage intersection
- Strike and dip of volcanic foliation
- Strike of vertical volcanic foliation
- U-Th-Pb zircon age (Ma)
- Geochemical analysis
- pl — Placer workings

Table 1. Bulk rock geochemical data from samples collected in the Finn 7.5' quadrangle.

Sample ID	ES-13	ES-18	07172012-4
Map unit	Tda	Tda	Kgb
Latitude	46.796	46.829	46.825
Longitude	-112.749	-112.730	-112.630
Major elements (wt %)			
SiO^2	64.76	66.79	50.96
TiO^2	0.53	0.65	0.64
$Al2O^3$	15.78	14.63	11.96
FeO*	3.99	4.32	9.19
MnO	0.04	0.03	0.17
MgO	0.70	1.32	13.72
CaO	2.68	3.21	8.48
Na^2O	4.12	3.96	2.28
K^2O	3.53	3.31	2.07
P^2O^5	0.28	0.34	0.33
Sum	96.40	98.56	99.81
LOI	2.78	1.33	0.25
Trace elements (ppm)			
Ni+	18.9	81.1	332.2
Cr+	26.7	139.0	744.9
V+	44.7	66.5	171.4
Ga+	21.6	17.5	13.4
Cu+	8.9	11.6	74.9
Zn+	99.0	58.6	86.9
La	73.3	59.1	12.6
Ce	117.9	110.5	26.4
Pr	13.7	12.4	3.4
Nd	47.1	44.0	14.3
Sm	6.4	6.2	3.0
Eu	1.7	1.6	1.0
Gd	4.0	3.6	2.9
Tb	0.5	0.5	0.4
Dy	2.4	2.2	2.7
Ho	0.4	0.4	0.5
Er	0.9	1.0	1.5
Tm	0.1	0.1	0.2
Yb	0.7	0.8	1.3
Lu	0.1	0.1	0.2
Ba	2414.0	2104.0	598.0
Th	11.8	10.3	1.3
Nb	10.2	9.1	3.2
Y	11.1	10.4	13.5
Hf	4.5	4.0	1.7
Ta	0.5	0.5	0.2
U	2.0	2.7	0.4
Pb	20.9	20.1	6.3
Rb	77.5	62.1	38.3
Cs	1.5	1.2	4.0
Sr	912	1183	635
Sc	5.5	8.8	25.5
Zr	185.4	160.6	64.5

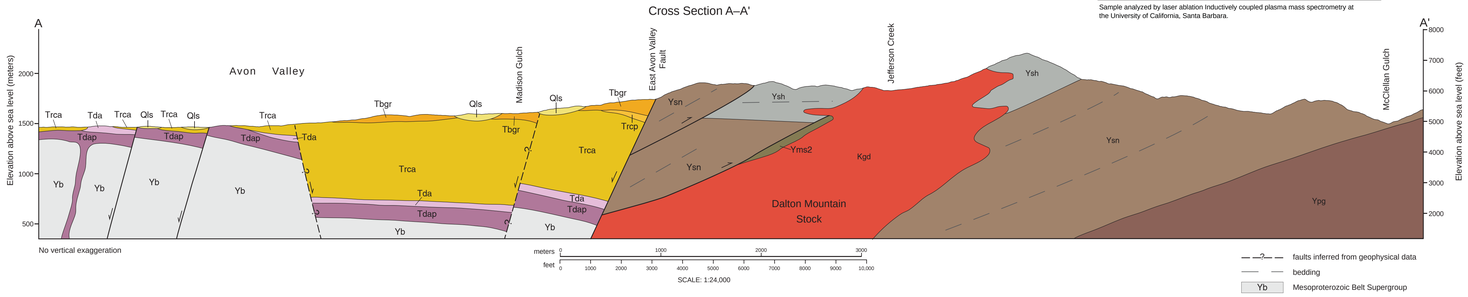
All samples analyzed by X-ray fluorescence (XRF) and inductively coupled plasma mass spectrometry (ICP-MS) at the Washington State University GeoAnalytical Lab. All major elements and trace elements denoted by + were analyzed by XRF. all other trace elements were measured by ICP-MS.
FeO* indicates all Fe expressed as Fe^{2+}. LOI is loss on ignition.

Table 2. U-Pb zircon age from the Finn 7.5' quadrangle.

Sample	Map Unit	Latitude	Longitude	Age (Ma)	2σ
ES-18	Tdap	46.8288	-112.7299	47.55	0.16

Sample analyzed by laser ablation inductively coupled plasma mass spectrometry at the University of California, Santa Barbara.

Cross Section A–A'



Maps may be obtained from:
Publications Office
Montana Bureau of Mines and Geology
1300 West Park Street
Butte, Montana 59701-8997
Phone: (406) 496-4167 Fax: (406) 496-4451
http://www.mbmg.mtech.edu

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GIS production: Ken Sandau and Paul Thale, MBMG. Map layout: Susan Smith, MBMG.

INTRODUCTION

The Montana Bureau of Mines and Geology (MBMG), in conjunction with the STATEMAP advisory committee, selected the Finn 7.5' quadrangle in west-central Montana for detailed mapping to provide new information on stratigraphy and structure in an area where only reconnaissance mapping (Lewis, 1998; 1:250,000 scale) existed. The detailed mapping is part of the MBMG's effort to complete the Elliston 30' x 60' quadrangle (1:100,000 scale) geologic map. The northern, mountainous part of the Finn quadrangle is predominately U.S. Forest Service or Bureau of Land Management administered land; the southern part encompasses the north end of the Avon Valley (fig. 1) and is mostly privately owned.

GEOLOGIC SUMMARY

The northern part of the Finn quadrangle is underlain by Mesoproterozoic Belt Supergroup metasedimentary rocks, including the middle Belt Piegan Group and the upper Belt Missoula Group. The Piegan Group, which includes the Helena and overlying Wallace Formations (Winston, 2007) occurs as poorly exposed calc-silicate rocks adjacent to the Dalton Mountain Stock. Because of the poor exposure and metamorphism, the individual formations could not be differentiated. Overlying the Piegan Group are the Snowslip, Shepard, Mountain Shields (members 2 and 3), and Bonner Formations, which are part of the upper Belt Missoula Group. The Missoula Group strata comprise an approximately 4,400 m section of quartzites, argillites, and dolomites.

The Belt strata were intruded by Late Cretaceous granodiorite of the Dalton Mountain Stock and smaller bodies of gabbro (table 1, map unit **Kgb**). These intrusive rocks are considered satellite bodies of the Cretaceous Boulder Batholith (Schmidt and others, 1994). Several gold mines and placer deposits are associated with the intrusive rocks.

The youngest rocks exposed in the quadrangle are Tertiary volcanics, and Tertiary and Quaternary valley-fill and surficial deposits. The volcanic rocks are predominantly aphanitic and porphyritic dacite (table 1, fig. 2), trachydacite, and minor basalt. A U-Pb zircon age from a porphyritic flow (map unit **Tdap**) in the NE¼ of sec. 4, T. 12 N., R. 9. W., yielded an Eocene age of 47.55 ± 0.16 Ma (table 2). Tertiary valley-fill deposits include the Renova Formation (Eocene Climbing Arrow Member and Miocene/Oligocene Cabbage Patch member) and overlying boulder gravel deposits. Loen (1990) suggested a late Miocene (?) age for similar gravel deposits near Blackfoot City (south of the map area) and interpreted them as alluvial fans. These gravels have been mined for placer gold.

Quaternary surficial deposits are widespread in the Avon Valley and include alluvium and colluvium along stream drainages, landslides (primarily developed in the Renova Formation), debris flows, gravel mantle deposits, and glacial till in the northwest corner of the map.

Structure

The Finn quadrangle is within the eastern part of the Lewis and Clark line (LCL)—a major western Montana WNW-striking tectonic zone recurrently active since the Proterozoic (Sears and Hendrix, 2004; Wallace and others, 1990; Reynolds, 1979). From Late Cretaceous to late Paleocene, the LCL underwent sinistral (left-lateral) transpression associated with crustal shortening (Sears and Hendrix, 2004). Beginning in late Eocene, deformation has been predominantly dextral (right-lateral) transtension associated with regional Basin and Range extension (Stickney, 2015; Sears and Hendrix, 2004). The major Cretaceous transpressive structures in the Finn quadrangle are northwest-trending thrust faults and regional-scale folds that deform the Belt rocks. The Late Cretaceous Dalton Mountain Stock intrudes the east limb of a broad regional syncline, is northwest–southeast elongate, and may have been intruded during folding and thrust faulting. Younger, NW- and NE-trending, high-angle transtensive oblique-slip faults cut the older structures.

The most prominent fault in the quadrangle, herein called the East Avon Valley Fault, is a down-to-the-southwest, range front fault that separates uplifted Belt rocks in the Nevada Mountains from Tertiary and Quaternary sediments in the Avon Valley. The fault is cut by steep NE-trending faults and forms the northeast boundary of the Avon Valley graben (Reynolds, 1979). Gravity data from the northern Avon Valley (Knatterud and others, 2015) suggest the northeast margin of the graben is a series of southwest-dipping normal or oblique-slip faults. Although NW-trending faults other than the East Avon Valley Fault were not recognized during mapping, faults inferred from the gravity data are shown on the cross section. The West Avon Valley Fault truncates the Miocene–Oligocene Cabbage Patch member of the Renova Formation and Tertiary alluvial fan deposits of probable Miocene age (Loen, 1990), constraining movement on the fault to Miocene or younger.

Although active faults have not been recognized in the Finn quadrangle, recent seismicity indicates continued tectonism on preexisting faults with oblique-normal slip (Stickney, 2015).

PREVIOUS MAPPING

The entire quadrangle was included on small-scale (1:250,000) maps by Lewis (1998) and Wallace and others (1987). Weber and Witkind (1979) completed a reconnaissance geologic map of the southwest quarter of the quadrangle that focused primarily on surficial deposits. Bierwagen (1964) and Melson (1964) mapped parts of the quadrangle's northeast corner.

DESCRIPTION OF MAP UNITS

Qal **Alluvium (Quaternary: Holocene)**—Gravel, sand, silt, and clay along Nevada Creek and its tributaries. Clasts are generally rounded to subrounded, cobble size and smaller, but boulders also present. Thickness generally less than 10 m (33 ft).

Qpa **Paludal deposit (Quaternary: Holocene)**—Argillaceous silt, sand, and organic matter deposited in pond or marsh environments associated with floodplain deposits of Nevada and Washington Creeks. Also associated with a landslide deposit south of Buffalo Creek. Thickness probably less than 5 m (15 ft).

Qaf **Alluvial fan (Quaternary: Holocene)**—Gravel, sand, silt, and clay in fan-shaped deposits along Shingle Mill and Nevada Creeks in the southern part of the map. Large, locally derived clasts are both matrix- and clast-supported. Coarse clast size is dominantly cobbles, but also includes boulders and pebbles. Thickness generally less than 15 m (50 ft).

Qac **Alluvium and colluvium (Quaternary: Holocene)**—Silt, sand, granules, and pebbles deposited on slopes by sheetwash alluvium incorporated with locally derived fine-grained colluvium. Deposits support hay fields along lower Washington Creek. Thickness generally less than 8 m (20 ft).

Qm **Mantle (Quaternary: Holocene and Pleistocene)**—Deposits on pediments 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 6 m (20 ft).

Qls **Landslide (Quaternary: Holocene or Pleistocene)**—Mass-wasting deposits of rotated or chaotic beds. The bentonitic Climbing Arrow Member of the Renova Formation (Trca) and units that immediately overlie it are particularly prone to developing landslide deposits. Thickness generally less than 60 m (200 ft).

Qdf **Debris-flow (Quaternary: Pleistocene or Holocene)**—Matrix-supported deposits of local, upslope-derived volcanic rock and sparse sedimentary rock. Clasts range from granules to boulders. Thickness generally less than 20 m (75 ft).

Qbgr **Boulder gravel (Quaternary: Holocene(?) and Pleistocene)**—Unconsolidated deposits along Nevada Creek of reworked Tbgr. Dominantly weakly stratified rounded pebbles and cobbles in a coarse-grained matrix. Deposits southwest of Dalton Mountain include abundant subangular and angular Belt quartzite boulders as lag on the forest floor, but exposures were not observed. Thickness less than 20 m (70 ft).

Qalo **Alluvium, older than Qal (Quaternary: Pleistocene)**—Fluvial deposits in the Avon Valley in channels wider than those occupied by the present-day underfit streams. Clasts are generally rounded to subrounded cobbles and smaller, but boulders also present. Thickness not known.

Qgt **Glacial deposit (Quaternary, Pleistocene)**—Light brown, brown, and reddish brown granules, pebbles, cobbles, and boulders in a very sandy to silty matrix which locally is clayey and compact. Dominant lithologies are quartzite and argillite. Confined to Willow Creek drainage in northwest corner of map.

QTm **Mantle (Quaternary and Tertiary)**—Bouldery deposits on slopes near the East Avon Valley Fault on the east side of the Avon Valley. Upslope bedrock on the footwall block is not necessarily the source of the deposits.

Tbgr **Boulder gravel (Tertiary)**—Dominantly matrix-supported, but locally clast-supported deposits that primarily occur adjacent to East Avon Valley Fault. Clasts range from pebbles to large boulders in a clay/silt/sand matrix. Clast composition dominantly Belt Supergroup quartzite with subordinate volcanic and plutonic rock. Matrix in many places has incorporated sediment from the Climbing Arrow Member of the Renova Formation (Trca). Deposit has been interpreted as Miocene (Loen, 1990; Schmidt and others, 1994). Contains placer gold (Loen, 1990). May be as thick as 300 m (985 ft).

Trcp **Renova Formation, Cabbage Patch member, informal (Tertiary: Miocene and Oligocene)**—Light tan, tuffaceous, micaceous, siltstone and fine-grained sandstone with local lenses of rip-up-clast breccia. Unit has slumped downslope along the west side of Jefferson Creek. It is also present in southwest corner of map and along Cow Creek where it contains numerous fossil root traces. Similar deposits on Antelope Hill in the Gravely Mountain quadrangle to the south were mapped (Mosolf, 2015) as part of the Cabbage Patch member of the Renova Formation (Trcp). Thickness probably less than 45 m (150 ft) in map area.

Trca **Renova Formation, Climbing Arrow Member (Tertiary: Eocene)**—Pale olive, light olive gray, moderate olive brown, and medium light gray bentonitic mudstone, yellowish gray siltstone, and subordinate brownish gray sandstone and gravel/conglomerate lenses. Sandstone dominantly medium- to coarse-grained, with quartz, feldspar, biotite, and rhyolite grains. Gravel/conglomerate consists of clast-supported lenses of rounded granules, pebbles, and cobbles of rhyolite porphyry. A coalbed approximately 0.3 m (1 ft) thick occurs a short distance above the mouth of Jefferson Creek (Pardee and Schrader, 1933) and may be the same as a coalbed near Finn mined for domestic use (Glenna Stuckey, oral commun., 2012). West of Finn and east of Jefferson Creek, fish scales occur in platy siltstone and paper shale beds in a road cut along Highway 141. Bentonitic mudstone typically displays "popcorn" weathering, large desiccation cracks, and is prone to landslide development. Springs in NW¼ sec. 9, and NW¼ sec. 22, T. 12 N., R. 9 W. are concealed by thin crusts of Climbing Arrow Member. Unit referred to as "Blackfoot City beds" by Loen (1990). Base of unit not exposed. Exposed thickness approximately 180 m (600 ft).

Tba **Basalt (Tertiary: Eocene)**—Black, fine-grained, massive basalt flows with scattered olivine and pyroxene phenocrysts. Locally vesicular. Weathers to light brown, angular to sub-rounded blocks. Perhaps age equivalent to basaltic-andesite flows in the Gravely Mountain quadrangle to the south that yielded a U-Pb zircon age of 30.00 ± 0.19 Ma (Mosolf, 2015) and basalt in the Nevada Mountain quadrangle (McDonald and others, 2016) with a K-Ar (whole rock) age of 32.3 Ma (Mitchell Reynolds, written commun., 2014).

Tda **Dacite (Tertiary: Eocene)**—Gray and dark gray weathering, aphanitic to slightly porphyritic dacite to trachydacite lava flow with autobrecciated flow bottoms overlain by massive coherent flow interiors; zones of vesiculation are rarely preserved. Individual 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 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.

Tdap **Dacite, porphyry (Tertiary: Eocene)**—Gray, green, and red weathering dacite to trachydacite lava flows (table 1, fig. 2) with a distinct coarse, porphyritic texture. Lava flows contain subhedral to euhedral phenocrysts of plagioclase (up to ~5 mm) and minor amounts of amphibole, biotite, and quartz. The aphanitic groundmass commonly has a trachytic texture and consists mainly of aligned microlites of plagioclase, but also includes amphibole, biotite, and magnetite. Carapaces of autobreccia several meters thick commonly encompass coherent interiors of individual lava flows. This unit weathers into blocks or plates, with some outcrops forming hoodoos and spires. A sample from the NE¼ sec. 4, T. 12 N., R. 9. W., yielded a U-Pb zircon age of 47.55 ± 0.16 Ma (table 2).

Kgd **Granodiorite (Late Cretaceous)**—Medium to dark gray, equigranular to porphyritic granodiorite composed of plagioclase, potassium feldspar, quartz, biotite and hornblende; forms main body of the Dalton Mountain Stock and associated smaller intrusions. Schmidt and others (1994) report a K-Ar age on biotite of 77.9 ± 2.8 Ma.

Kgb **Gabbro (Late Cretaceous)**—Dark gray to greenish black, equigranular to porphyritic, medium- to coarse-grained quartz gabbro (table 1, fig. 2) composed primarily of pyroxene and plagioclase with minor biotite and magnetite. Occurs as two small bodies along the Washington Creek drainage.

Ybo **Bonner Formation (Mesoproterozoic)**—Pink to red, medium- to coarse-grained, poorly sorted, feldspathic quartzite. Abundant trough and planar crossbeds 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. A slabbed and stained sample contained 55 percent quartz, 35 percent potassium feldspar, and 10 percent plagioclase. Upper contact not exposed but is about 550 m (1,800 ft) thick in the west-adjacent Nevada Lake quadrangle (McDonald and others, 2016).

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, consisting of couples of white to pink, medium-grained quartzite and thin red argillite. Bases of quartzite beds contain abundant red mudchips. The lower part 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 east of the Avon Valley 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 weathering rind. Ripples and load casts are common; mudcracks are rare. The upper half of the formation 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 as was done in areas 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. Metamorphosed to pale green, striped hornfels near the contact with the Dalton Mountain Stock. Thickness about 610 m (2,000 ft).

Ysn **Snowslip Formation (Mesoproterozoic)**—Interbedded intervals of quartzite to red argillite couplets, dark green siltite to light green argillite couplets, and microlaminated argillite. Desiccation cracks and mud rip-up clasts are common. Argillite beds often contain irregular "bumps" thought to be ill-defined salt casts or related to microbial mats. Contains beds and lenses of distinctive white, coarse-grained, well-sorted, feldspar-poor quartzite containing some well-rounded, frosted quartz grains. Lower 50 m (160 ft) dominated by microlaminated green dolomitic siltite and argillite. Upper 50–75 m (160–245 ft) is red, flat laminated, medium-grained quartzite in beds 0.5–1.0 m thick. Thickness approximately 1,430 m (4,700 ft).

Ypg **Piegan Group (Mesoproterozoic)**—Adjacent to the Dalton Mountain Stock, carbonates of the Piegan Group are contact metamorphosed to pale to dark green hornfels with diopside and/or tremolite. Thickness not determined.

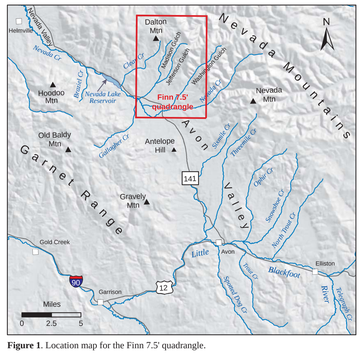

Figure 1. Location map for the Finn 7.5' quadrangle.

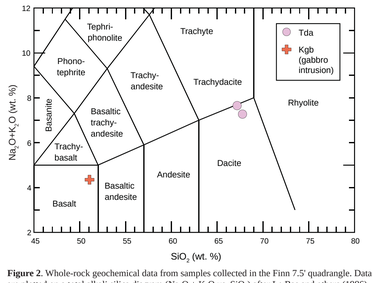

Figure 2. Whole-rock geochemical data from samples collected in the Finn 7.5' quadrangle. Data are plotted on a total alkali silica diagram ($Na_2O + K_2O$ vs. SiO_2) after Le Bas and others (1986).

MBMG Open-File Report 672

Geologic Map of the Finn 7.5' Quadrangle, Lewis and Clark and Powell Counties, Montana

Catherine McDonald, Jesse G. Mosolf, and Susan M. Vuke

2016

REFERENCES

Bierwagen, E.E., 1964, Geology of the Black Mountain area, Lewis and Clark and Powell Counties, Montana: Princeton, N.J., Princeton University, Ph.D. dissertation, 166 p., 3 pls., scale 1:31,250.
Knatterud, L.K., Speece, M.A., Mosolf, J.G., and Zhou, X., 2015, Using gravity and seismic reflection profiling to decipher the structural setting of the Avon Valley, west-central Montana: Northwest Geology, v. 44, p. 5–7.
Le Bas, M.J., Le Maitre, R.W., Streckeisen, A., and Zanettin, B., 1986, A chemical classification of volcanic rocks based on the total alkali silica diagram: Journal of Petrology, v. 27, p. 745–750.
Lewis, Reed S., 1998, Geologic map of the Butte 1° x 2° quadrangle, southwestern Montana: Montana Bureau of Mines and Geology Open-File Report 363, scale 1:250,000.
Loen, J.S., 1990, Lode and placer gold deposits in the Ophir District, Powell and Lewis and Clark Counties, Montana: Fort Collins, Colo.,Colorado State University, Ph.D. dissertation, 268 p.
Lonn, J.D., and Vuke, S.W., 2015, Geologic map of the Ophir Creek 7.5' quadrangle, Lewis and Clark and Powell Counties, Montana: Montana Bureau of Mines and Geology Open-File Report 666, scale 1:24,000.
Lonn, J.D., McDonald, C., Sears, J.W., and Smith, L.N., 2010, Geologic map of the Missoula East 30' x 60' quadrangle, western Montana: Montana Bureau of Mines and Geology Open-File Report 593, 2 sheets, scale 1:100,000.
McDonald, C., Mosolf, J.G., Vuke, S.M., and Lonn, J.D., 2016, Geologic map of the Nevada Lake 7.5' quadrangle quadrangle, west-central Montana: Montana Bureau of Mines and Geology Open-File Report 673, scale 1:24,000.
Melson, W.G., 1964, Geology of the Lincoln area, Montana and contact metamorphism of the impure carbonate rocks: Princeton, N.J., Princeton University, Ph.D. dissertation, 153 p., 4 pls., scale 1:31,680.
Mosolf, J.G. , 2015, Geologic field guide to the Tertiary volcanic rocks in the Elliston 30' x 60' quadrangle, west-central Montana: Northwest Geology, v. 44, p. 213.
Pardee, J.T., and Schrader, F.C., 1933, Metalliferous deposits of the Greater Helena Mining Region, Montana: U.S. Geological Survey Bulletin 842, 318 p.
Reynolds, M.W., 1979, Character and extent of basin-range faulting, western Montana and east-central Idaho, *in* Newman, G.W., and Goode, H.D., eds., Basin and Range Symposium: Rocky Mountain Association of Geologists, p. 185–193.
Schmidt, R.G., Loen, J.S., Wallace, C.A., and Mehnert, H.H., 1994, Geology of the Elliston region, Powell, and Lewis and Clark Counties, Montana: U.S. Geological Survey Bulletin 2045, 25 p., scale 1:48,000.
Sears, J.W., and Hendrix, M., 2004, Lewis and Clark line and the rotational origin of the Alberta and Helena Salients, North American Cordillera, *in* Sussman, A.J., and Weil, A.B., eds., Orogenic curvature: Integrating paleomagnetic and structural analyses: Geological Society of America Special Paper 383, p. 173–186.
Stickney, M., 2015, Seismicity within and adjacent to the eastern Lewis and Clark line, west-central Montana: Northwest Geology, v. 44, p. 19–35.
Wallace, C.A., Lidke, D.J., and Schmidt, R.G., 1990, Faults of the Lewis and Clark line and fragmentation of the Late Cretaceous foreland basin in west-central Montana: Geological Society of America Bulletin, v. 102, p. 1021–1037.
Wallace, C.A., Schmidt, R.G., Lidke, D.J., Waters, M.R., Elliott, J.E., French, A.B., Whipple, J.W., Zarske, S.E., Blaskoski, M.J., Heise, B.A., Yeoman, R.A., O'Neill, J.M., Lopez, D.A., Robinson, G.D., and Klepper, M.R., 1987, Preliminary map of the Butte 1° x 2° quadrangle, western Montana: U.S. Geological Survey Open-File Report OF-86-292, scale 1:250,000.
Weber, W.M., and Witkind, I.J., 1979, Reconnaissance geologic map of the southwestern quarter of the Finn quadrangle, Lewis and Clark, and Powell Counties, Montana: U.S. Geological Survey Open-File Report OF-79-442, scale 1:24,000.
Winston, D., 2007, Revised stratigraphy and depositional history of the Helena and Wallace Formations, Mid-Proterozoic Piegan Group, Belt Supergroup, Montana and Idaho, USA, *in* Link, P.K., and Lewis, R.S., eds., Proterozoic Geology of Western North America and Siberia, SEPM Special Publication 86, p. 65–100.