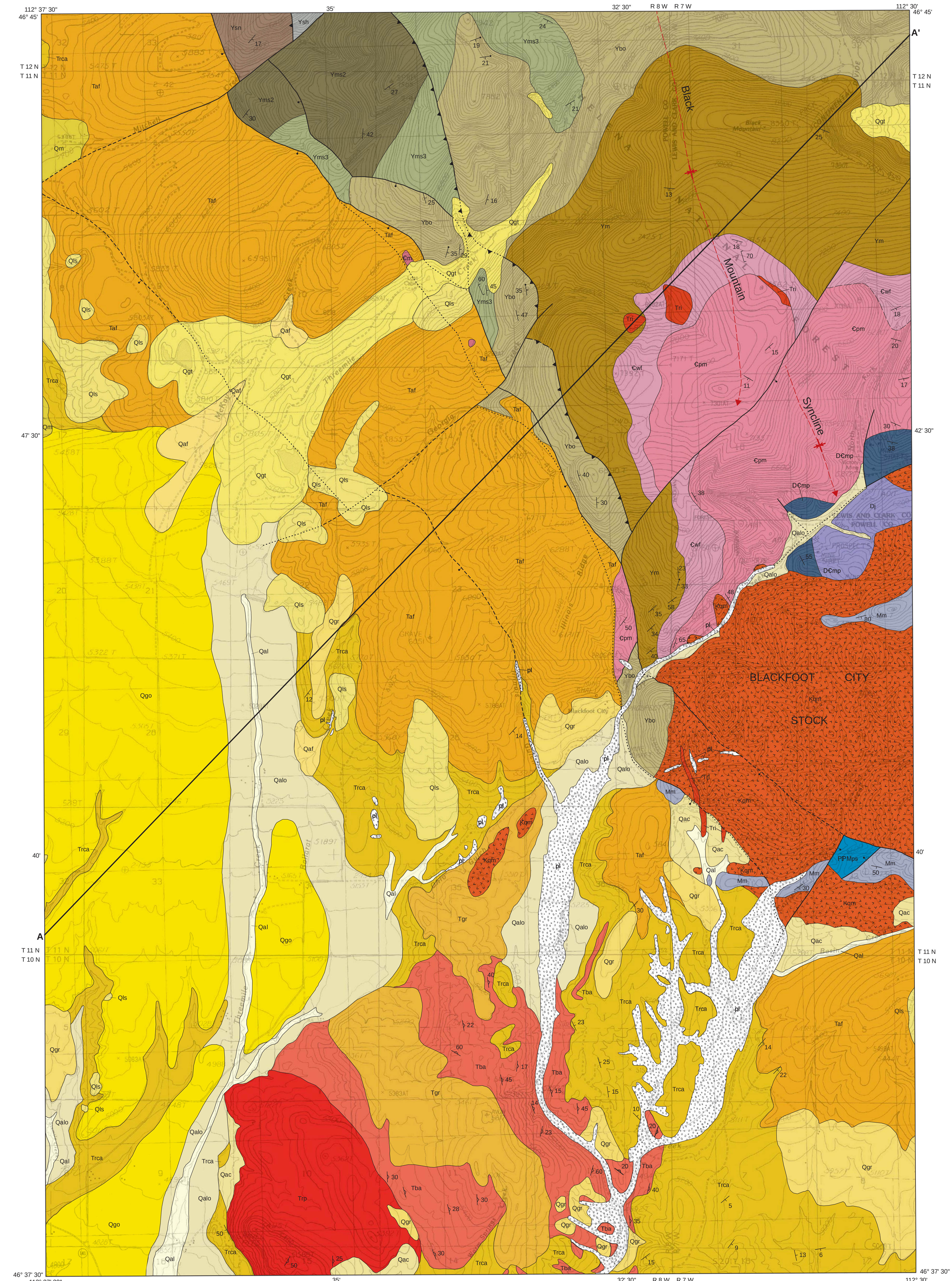

Base map produced by the United States Geological Survey
Control by: USGS, NOS/NOAA and USFS
Compiled from aerial photographs taken 1984
Field checked: 1985; Map edited: 1989
Projection: Lambert Conformal Conic
Grid:1000 meter Universal Transverse Mercator Zone 12
UTM grid declination: 1° 08' East
1989 Magnetic NorthDeclination: 16° 30' East
Vertical Datum: National Geodetic Vertical Datum of 1929
Horizontal Datum: 1927 North American Datum

N

SCALE 1:24,000

CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Maps may be obtained from:
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Montana Bureau of Mines and Geology
1300 West Park Street
Butte, Montana 59701-8997
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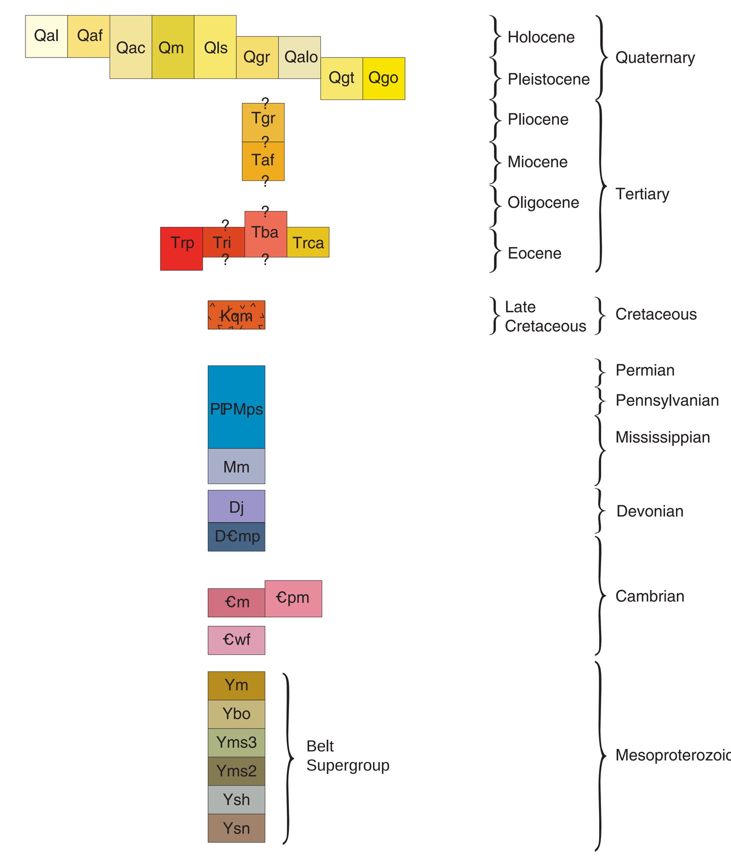
Geologic Summary

The northeastern third of the quadrangle is underlain by Mesoproterozoic Belt Supergroup, Paleozoic sedimentary rocks, and Cretaceous to Eocene igneous rocks. Although Winston (1986) proposed that an east–west Mesoproterozoic down-to-the-north growth fault traversed the quadrangle, we saw no thickness changes in Belt Supergroup Formations in the area. The southwestern 2/3 of the map is underlain by Cenozoic volcanic and sedimentary deposits of the Avon Valley.

Structure is dominated by the north–northwest-trending Black Mountain syncline (Bierwagen, 1964) and northwest-striking thrust and normal faults. Northeast-striking high-angle faults cut the northwest structures. The thrust faults and the Black Mountain syncline may be kinematically linked; the syncline's age is bracketed by the youngest rocks that are involved in the folding and by the cross-cutting Blackfoot City stock, and is therefore inferred to be 77–97 Ma (Schmidt and others, 1994). The northwest-trending, contractional structures including this fold, and the reverse faults, are postulated to be part of the Lewis and Clark Line, a sinistral transpressive structure that formed synchronously with Sevier thrusting during the Cretaceous that was later reactivated during Tertiary extension (Sears and Hendrix, 2004). Northwest-striking, down-to-the-southwest, normal faults control much of the northeast side of the Tertiary Avon Valley. They formed parallel to the contractional structures. Relatively minor northeast-striking, high-angle faults appear to cut all the other structures.

Loen (1990) described four types of Tertiary deposits: Pliocene(?) pediment gravel, Miocene(?) fanglomerate, Miocene (?) siltstone and sandstone, and Oligocene Blackfoot City beds. On the current Ophir Creek quadrangle these deposits are shown respectively as Gravel (Ts), Alluvial-fan deposit (Taf), Renova Formation—Antelope Hill member (Trah), and Renova Formation—Climbing Arrow Member (Trca).

CORRELATION DIAGRAM



MAP SYMBOLS

Contact: dashed where approximately located

Fault: short-dashed where inferred, bar and ball on downthrown side; arrows indicate movement

Reverse or thrust fault: teeth on upthrown block; short-dashed where inferred; dotted where concealed

Syncline: showing approximately located trace of axial plane and plunge direction

Strike and dip of inclined beds

Strike and dip of Belt Supergroup rocks where top of bedding is certain

Strike and dip of cleavage

Strike and dip of volcanic foliation

Placer workings

Description of Map Units

Qal **Alluvium (Quaternary: Holocene)**—Gravel, sand, silt, and clay along streams and their tributaries. Clasts generally rounded to subrounded cobble size and smaller, but boulders also present.

Qaf **Alluvial-fan deposit (Quaternary: Holocene)**—Gravel, sand, silt, and clay in deposit with fan-shaped morphology near Threemile Creek and along Ballarat Creek, both on the western side of the map area. Clasts primarily derived from Qgt and Taf.

Qac **Alluvium and colluvium (Quaternary: Holocene)**—Silt, sand, granules, and pebbles deposited on slopes by sheetwash alluvium incorporated with locally derived fine-grained colluvium.

Qm **Mantle (Quaternary: Holocene and Pleistocene)**—Deposit that includes sheetwash alluvium, colluvium, coarse-grained (pebble, cobble, small boulder) lag from older deposits, and regolith.

Qls **Landslide deposit (Quaternary: Holocene or Pleistocene)**—Mass-wasting deposit of rotated or chaotic beds that slid downslope. The bentonitic Climbing Arrow Member and units that immediately overlie it are particularly prone to developing landslide deposits.

Qgr **Gravel (Quaternary: Pleistocene)**—Deposits reworked from Taf and Qgo on slopes below the source deposits.

Qalo **Alluvium, older than Qal (Quaternary: Pleistocene)**—Deposits in broad valleys with underfit streams. Clasts locally derived.

Qgt **Glacial till (Quaternary: Pleistocene)**—Poorly sorted, subangular to subrounded granules, pebbles, cobbles, and boulders in a sandy to locally clayey matrix. Includes boulders as much as 3 m (10 ft) in diameter, dominantly of quartzite and limestone.

Qgo **Glacial outwash (Quaternary: Pleistocene)**—Deposits along Sixmile Creek that represent the terminus of a large glacial outwash fan that continues into the Gravelly Mountain 7.5' quadrangle to the west. Fan is about 6.5 km (4 mi) long. Reworked, subrounded, iron-stained pebbles and cobbles that are dominantly clast-supported.

Tgr **Gravel deposit (Tertiary: Pliocene)**—Poorly to well-stratified boulder, and pebble-cobble gravel, sand, silt, and clay. Includes some lag deposits. Locally contains placer gold. After Loen, 1990.

Taf **Alluvial-fan deposit (Tertiary)**—Dominantly matrix-supported, but locally clast-supported deposit that occurs primarily adjacent to range-front fault. Clasts range from pebble to large boulder size in clay/silt/sand matrix. Clast composition dominantly Belt Supergroup quartzite with subordinate Paleozoic, volcanic, and plutonic rock. Includes local extremely large boulders. Some small areas shown as Paleozoic outcrop within the fan deposits on previous maps are interpreted as buried boulders. Deposit has previously been interpreted as Miocene(?) (Loen, 1990; Schmidt and others, 1994) but may be as old as Eocene based on interfingering relationship with Climbing Arrow Formation primarily observed in Finn 7.5' quadrangle to the north. Deposit contains placer gold (Loen, 1990). May be as thick as 300 m (985 ft).

Tba **Basalt (Tertiary: early Oligocene or late Eocene?)**—Black to dark reddish brown massive flows that weather yellowish red to yellowish brown. Flow tops vesicular with cavities stretched parallel to flow direction. As much as 30% of the vesicles are filled with chalcedony and/or calcite. Ranges microscopically from aphanitic to slightly porphyritic. Augite and plagioclase phenocrysts 1–5 mm (0.04 to 0.20 in) long occur in a pilotaxitic matrix of suboriented plagioclase laths. Accessory minerals include biotite and titanomagnetite or ilmenite. Secondary minerals include hematite and epidote. After Loen, 1990.

Trca **Renova Formation: Climbing Arrow Member (Tertiary: Eocene)**—Pale olive, light olive gray, moderate olive brown, and medium light gray, bentonitic mudstone and yellowish gray siltstone. Contains lenses of brownish gray sandstone, and gravel/conglomerate usually with pebble-size clasts dominating the coarser clasts in a sand/granule matrix. Sandstone dominantly medium- to coarse-grained. Gravel/conglomerate consists of clast-supported lenses of rounded granules, pebbles, and cobbles of rhyolite porphyry and other dominantly volcanic lithologies in a sandy matrix. Unit typically displays "popcorn" weathering, large desiccation cracks, and is prone to landslide development. Exposed thickness approximately 90 m (300 ft).

Tri **Rhyolite plugs and dikes (Tertiary: late Eocene?)**—Light gray to light brown, non-foliated, porphyritic, with 10–40% phenocrysts of sanidine and quartz. Dikes at Eureka Gulch are mineralized and occur in the source area for productive gold placers. Accessory minerals include iron oxides and apatite. Dikes in Tiger Gulch contain anhedral sanidine and quartz phenocrysts 1–6 mm (0.04–0.24 in) long in a fine-grained matrix of feldspar and clay, and are typically hydrothermally altered. Dump specimens at Tier Gulch are intensely silicified. Intrusive rhyolite in the mountain area is hydrothermally altered and commonly contains disseminated pyrite. After Loen, 1990.

Trp **Rhyolite porphyry (Tertiary: Eocene)**—Porphyritic rhyolite lava flows are typically gray, white, tan, red, and/or purple weathering. Centimeter- to meter-scale flow foliations give rhyolite outcrops a blocky weathering characteristic. Phenocrysts compose up to 30% of the rock and include quartz, sanidine, oligoclase, biotite, and amphibole in a matrix of glass, clay, and cryptocrystalline material. Devitrification of the matrix varies from none to complete. Lithophysae up to 10 centimeters in diameter are locally abundant and typically eroded and partially filled with chalcedony. Discontinuous zones of vitrophyre and autobreccia separate individual flows.

Kqm **Quartz monzonite of the Blackfoot City stock (Upper Cretaceous)**—Medium-grained, hypidiomorphic granular, equigranular, and porphyritic, biotite-hornblende monzonite, quartz monzonite, and granodiorite. Composition 45% plagioclase, 8–20% potassium feldspar, 16–25% quartz, 8–10% hornblende, 4–7% biotite. Porphyritic and foliated near contacts. Biotite yielded a K–Ar age of 77 Ma. After Schmidt and others, 1994.

PIPMps **Phosphoria and Quadrant Formations, and Snowcrest Range Group, undivided (Permian through Upper Mississippian)**
Phosphoria Formation (Permian)—Gray fine- to medium-grained quartz arenite at top, gray to pale brown, thinly interbedded oolitic, phosphatic sandstone, shale, and chert in the middle, and yellowish limestone, cherty limestone, siltstone, and quartz arenite at bottom. Thickness about 50 m (160 ft).
Quadrant Formation (Pennsylvanian)—Gray to tan, thick-bedded, vitreous, fine-grained quartzite. Thickness 45 m (145 ft). After Schmidt and others, 1994.
Snowcrest Range Group (Lower Pennsylvanian to Upper Mississippian)—Red, purple, gray, and tan shale and siltstone with interbedded red, yellow, and gray limestone and dolomite. About 40 m (130 ft) thick. After Schmidt and others, 1994.

Mm **Madison Group (Upper and Lower Mississippian)**—Upper part is gray, massive biosparite, biomicrite, and micrite. Lower part is thin-bedded gray limestone that contains scattered dark gray, black, and brown chert nodules and lenses. Thickness 450 m (1,460 ft). After Schmidt and others, 1994.

Dj **Jefferson Formation (Upper Devonian)**—Gray to black, thick-bedded, coarsely crystalline, fetid dolomite with thin interbeds of light gray limestone. Thickness 230 m (750 ft). After Schmidt and others, 1994.

DꞒmp **Maywood, Red Lion, and Pilgrim Formations, undivided (Upper Devonian to Upper Cambrian)**
Maywood Formation (Upper Devonian)—Red, gray, and grayish green shale, siltstone, limestone, and dolomite. Approximately 10 m (30 ft) thick. After Schmidt and others, 1994.
Red Lion Formation (Upper Cambrian)—Light gray medium- to thin-bedded containing thin interbeds of orange and red weathering siliceous and argillaceous dolomite. About 100 m (325 ft) thick. After Schmidt and others, 1994.
Pilgrim Formation (Upper Cambrian)—Light gray, massive to thinly laminated, finely crystalline and microcrystalline dolomite. About 185 m (600 ft) thick. After Schmidt and others, 1994.

Ꞓpm **Park and Meagher Formations, undivided (Middle Cambrian)**
Park Formation (Middle Cambrian)—Grayish green fissile, waxy shale and interbedded siltstone and gray limestone. Very poorly exposed. Approximately 80 m (260 ft) thick. After Schmidt and others, 1994.

Ꞓm **Meagher Formation (Middle Cambrian)**—Gray thin- to thick-bedded micrite and biomicrite containing distinctive thin interbeds of uneven and discontinuous gold and orange weathering siliceous and argillaceous dolomite. Thickness approximately 180 m (590 ft). After Schmidt and others, 1994.

Ꞓwf **Wolsey and Flathead Formations, undivided (Middle Cambrian)**
Wolsey Formation (Middle Cambrian)—Greenish gray micaceous shale and glauconitic siltstone interbedded with thin beds of gray limestone near the top and with glauconitic quartzite near the base. Very poorly exposed. Thickness approximately 90–120 m (295–390 ft). After Schmidt and others, 1994.
Flathead Formation (Middle Cambrian)—Gray to purple, thin- to thick-bedded fine- to medium-grained to conglomeratic, crossbedded quartz arenite. Contains common well-rounded coarse quartz grains. Thickness 0–30 m (0–100 ft). After Schmidt and others, 1994.

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. Mud cracks and mud rip-up clasts common. Top part is light gray, thick-bedded, fine- to medium-grained, crossbedded quartzite containing abundant red mud rip-up clasts, uncommon red chert rip-up clasts, and abundant thin, red, mud cracked argillite interbeds. About 770 m (2,500 ft) thick.

Ybo **Bonner Formation (Mesoproterozoic)**—Pink to red, medium- to coarse-grained, poorly sorted, very feldspathic quartzite. Abundant trough and planar crossbeds in beds typically 0.5–1.0 m thick. Beds often separated by thin (0.1–1.0 cm) red to maroon argillite beds. Contains abundant well-rounded coarse quartz grains, and sparse subangular granules and small pebbles. Five slabbed and stained samples contained 50–75 percent quartz, 15–35 percent potassium feldspar, and 5–15 percent plagioclase. Poorly exposed contacts make thickness estimates problematic, but are reported to be 460 m (1,495 ft) thick in this area (Schmidt and others, 1994).

Yms3 **Mount Shields Formation, member 3 (Mesoproterozoic)**—Red quartzite to argillite couples and couplets with abundant mud cracks, mud chips, and diagnostic, well-formed cubic salt casts. Includes green interbeds and some red microlaminae. About 275 m (900 ft) thick on the north-adjacent Nevada Mountain 7.5' quadrangle (McDonald and Lonn, 2015).

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 that contain abundant red mud chips at the bases of the quartzite beds and was included in the top part of member 1 of Schmidt and others (1994). In contrast to Bonner Formation, which has potassium feldspar in excess of plagioclase, two slabbed and stained samples contained 65–75 percent quartz, 5–15 percent potassium feldspar, and 20 percent plagioclase. Very difficult to distinguish in the field and in hand sample from the Bonner Formation (unit Ybo). Thickness approximately 460 m (1,500 ft).

Ysh **Shepard Formation (Mesoproterozoic)**—Dolomitic and non-dolomitic, dark green siltite and light green argillite in microlaminae and couplets of non-dolomitic red quartzite to argillite. Poorly exposed, but weathers into thin plates that when dolomitic have a characteristic orangish brown weathering rind. Ripples and load casts are common; mud cracks are rare. The upper half contains intervals of pink to gray fine-grained feldspathic quartzite that were included in Mount Shields member 1 by Schmidt and others (1994). However, we place the 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, although in areas to the west the Snowslip Formation also contains dolomite-bearing intervals (Lonn and others, 2010). A calcitic stromatolite bed is typically found near the base. Thickness is about 650 m (2,100 ft), similar to that in the Austin 7.5' quadrangle to the east (Berg and Lonn, 2011).

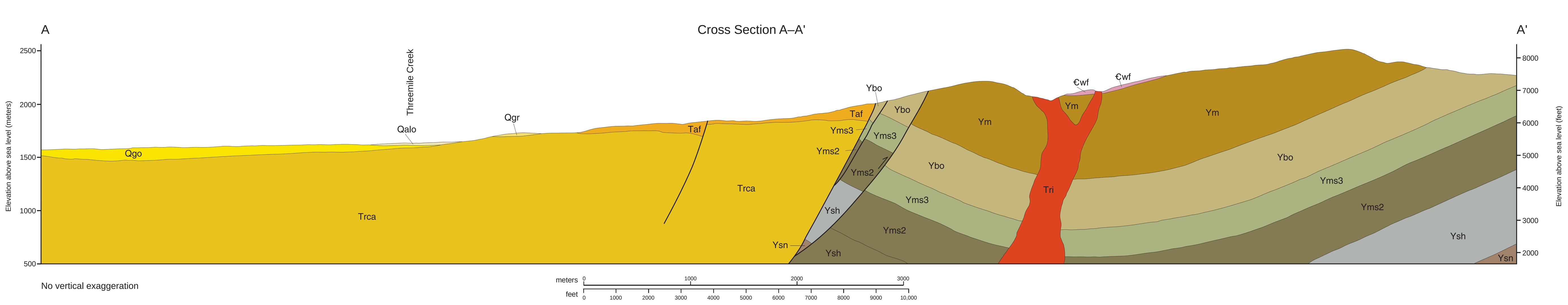
Ysn **Snowslip Formation (Mesoproterozoic)**—Interbedded intervals of quartzite to red argillite couplets, and dark green siltite to light green argillite couplets and microlaminae. Desiccation cracks and mud rip-up clasts are common throughout. Argillite beds often contain irregular "bumps" that may be ill-defined salt casts or structures related to algal mats. Contains beds and lenses of distinctive white, coarse-grained, well-sorted, feldspar-poor quartzite that contains 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 meters thick. Thickness approximately 1,075 m (3,500 ft) on the north-adjacent Nevada Mountain quadrangle (McDonald and Lonn, 2015).

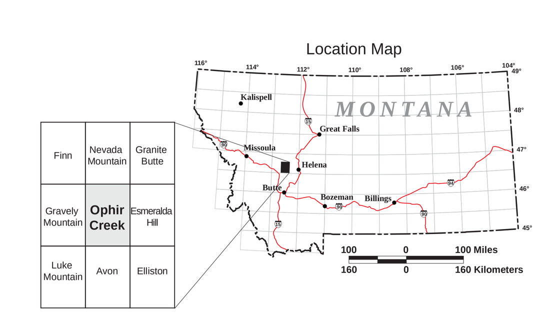
References

Berg, R.B., and Lonn, J.D., 2011, Geologic map of the Austin 7.5' quadrangle, central Montana: Montana Bureau of Mines and Geology Open-File Report 603, 10 p., scale 1:24,000.
*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, 231 p.
*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., 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., and Lonn, J.D., Geologic map of the Nevada Mountain and Granite Butte quadrangles, west-central Montana: Montana Bureau of Mines and Geology Open-File Report 665, scale 1:24,000.
*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 245, 25 p., scale 1:62,500.
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., Orogenic Curvature: Integrating Paleomagnetic and Structural Analyses: Geological Society of America Special Paper 383, p. 173–186.
Winston, Don, 1986, Sedimentation and tectonics of the Middle Proterozoic Belt Basin, and their influence on Phanerozoic compression and extension in western Montana and northern Idaho, in Peterson, J.A., ed., Paleotectonics and Sedimentation in the Rocky Mountain Region, United States: American Association of Petroleum Geologists Memoir 41, p. 87–118.

*Sources of geologic map information

Cross Section A–A'





MBMG Open-File Report 666

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

Compiled and mapped by
Jeffrey D. Lonn and Susan M. Vuke

2015

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