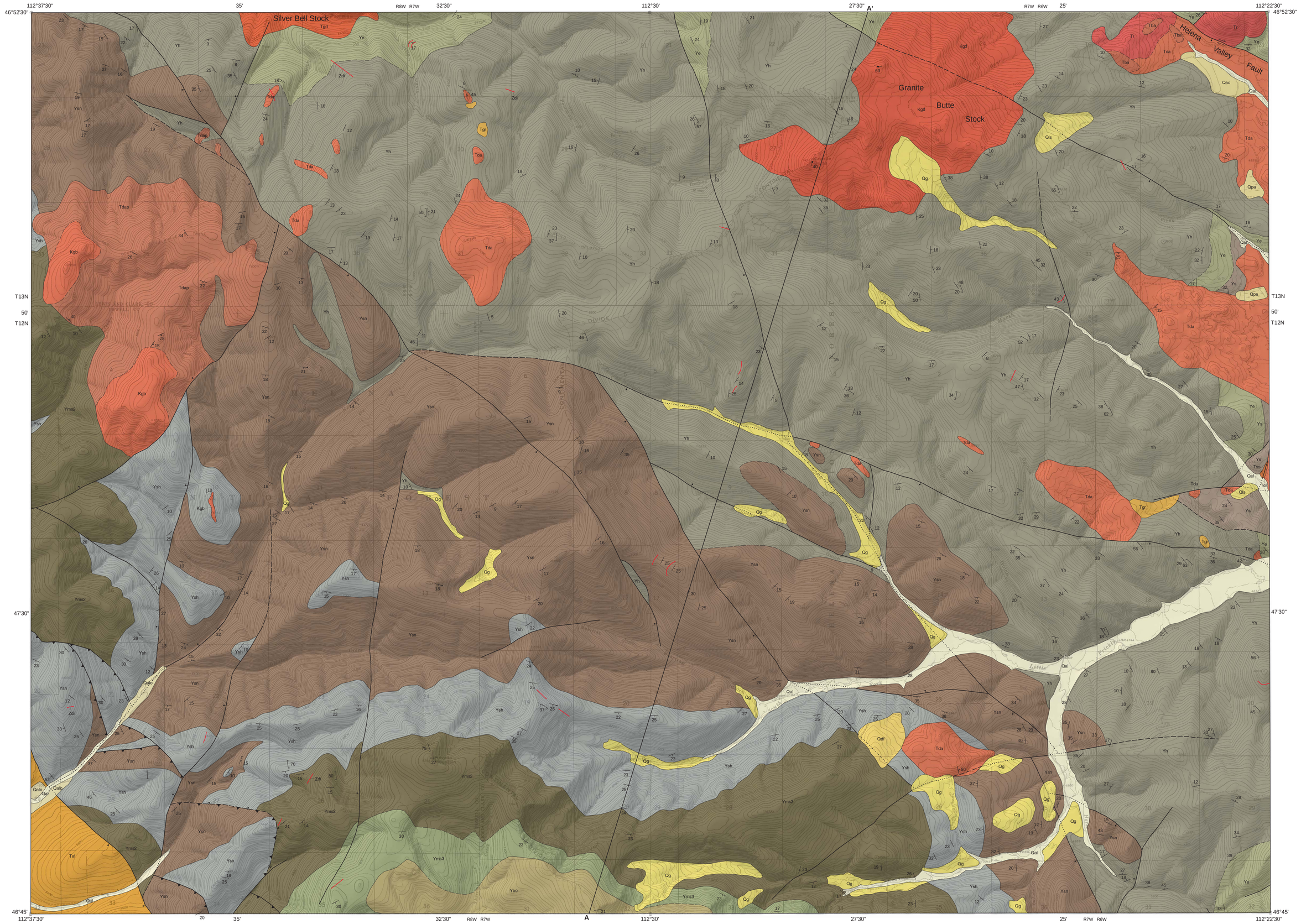


DESCRIPTION OF MAP UNITS

Qal **Alluvium (Quaternary: Holocene)**—Gravel, sand, silt, and clay along modern streams and tributaries. Clasts 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)**—Sand, silt, and organic matter deposited in swamp, marsh, or pond environments; often associated with floodplain deposits along streams. Thickness probably less than 10 m (33 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. Variable thickness, generally less than 10 m (33 ft).

Qls **Landslide deposit (Quaternary: Holocene or Pleistocene)**—Mass-wasting deposit consisting of stable to unstable, unsorted mixtures of clay to boulder sediment. Surfaces of deposits characterized by large, angular blocks of Helena and Spokane Formations. Estimated thickness less than 30 m (100 ft).

Qdf **Debris-flow deposit (Quaternary: Holocene and Pleistocene)**—Matrix-supported deposit of local, upslope-derived rock. Matrix is fine-grained; clasts are generally subangular and angular, ranging from granules to boulders. Thickness generally less than 20 m (75 ft).

Qalo **Alluvium, older than Qal (Quaternary: Holocene? and Pleistocene)**—Fluvial gravel in wider channels than occupied by present-day underfit streams. Clasts generally rounded to subrounded cobbles and smaller, but boulders also present. Estimated thickness less than 10 m (33 ft).

Qg **Glacial deposit (Quaternary: Pleistocene)**—Unconsolidated, locally derived, poorly sorted, fine-grained sediment to boulders. Predominantly quartzite with subordinate granitic and volcanic clasts. Occurs as isolated deposits along drainages. Thickness probably less than 50 m (165 ft).

Taf **Alluvial-fan deposit (Tertiary)**—Poorly to moderately sorted boulder and cobble gravel that contains sand, silt, and silty-clay layers. Clasts composed primarily of locally derived quartzite and argillite. Estimated thickness as much as 230 m (750 ft).

Tgr **Gravel deposit (Tertiary)**—Isolated thin lag deposits of quartzite cobbles and boulders; found on ridge tops and higher slopes above modern drainages. Occurs as scattered cobbles and boulders to deposits probably less than 10 m (33 ft).

Tba **Basalt and basaltic andesite (Tertiary: Oligocene–Eocene)**—Black, holocrystalline, massive basalt and basaltic andesite lava flows with occasional phenocrysts of plagioclase, clinopyroxene and orthopyroxene, olivine, biotite, and rare, resorbed quartz. Locally vesicular. Weathers to light brown, angular to subrounded blocks.

Tvs **Volcanic sediment (Tertiary)**—Poorly consolidated deposits of volcaniclastic sandstone with interbeds of siltstone, mudstone, and claystone. Sandstone deposits are yellowish gray, massive, and contain sparse, subrounded quartz and feldspar grains in a matrix of reworked ash and glass shards. Exposed in small side drainage of Marsh Creek in the northeast corner of section 8, T. 12 N., R. 6 W.

Tr **Rhyolite (Tertiary: Eocene)**—White to light purplish porphyritic to slightly porphyritic rhyolite. Up to 10 percent phenocrysts of euhedral to subhedral feldspar, biotite, and minor hornblende in an aphanitic siliceous groundmass. Feldspar, biotite, and other dark minerals commonly altered. Contains rare lithic clasts of red and green argillite from underlying Belt rock. Includes some extrusive rhyolite tuff. May be equivalent to the upper series of rhyolitic flows of the Crater Mountain volcanic complex (north of the map area) mapped by Melson (1964) and Parker (1995).

Tda **Dacite (Tertiary: Eocene)**—Dark gray and dark greenish gray aphanitic to porphyritic dacite. Lava flows typically exhibit conspicuous flow foliation and form flaggy, angular talus, often with red iron stain on parting surfaces. Aphanitic lavas exhibit a strong trachytic texture consisting mainly of plagioclase microcrystals, but also including minor amounts of pyroxene, magnetite, and volcanic glass. Slightly porphyritic flows contain <10–15 percent phenocrysts of amphibole and plagioclase, and occasional biotite.

Tdap **Dacite, porphyry (Tertiary: Eocene)**—Gray, green, and red weathering dacite with distinctive coarse, porphyritic texture. Dacite flows contain phenocrysts of plagioclase and minor amphibole, biotite, and quartz. The aphanitic groundmass typically has a trachytic texture of aligned micro-laths of plagioclase, with minor amphibole, biotite, and magnetite. Carapaces of autobreccia several meters thick typically encompass coherent interiors of individual lava flows. Dacite lavas typically weather to blocks or plates.

Tgd **Granodiorite (Tertiary)**—Phaneritic to porphyritic granodiorite composed of plagioclase, orthoclase, biotite, hornblende, and occasional quartz. The contact with country rock is highly irregular with wide contact aureoles of hornfels. Mapped as the Silver Bell Stock by Whipple and others (1987) with a reported K-Ar age of 52.0 Ma (Schmidt and others, 1994).

Kgd **Granodiorite (Cretaceous)**—Light to dark gray, equigranular to weakly porphyritic granodiorite composed of plagioclase, potassium feldspar, quartz, biotite, and amphibole. Mapped as the Granite Butte Stock and dated at 77.9 ± 2.6 Ma (biotite) and at 109.1 ± 4.7 Ma (hornblende) (Schmidt and others, 1994).

Kgb **Gabbro (Late Cretaceous)**—Dark gray to greenish black, equigranular to porphyritic, medium- to coarse-grained quartz gabbro composed primarily of pyroxene and plagioclase with minor biotite and magnetite. Pyroxenes form prismatic crystals as much as 4 mm long.

Zdi **Diorite (Neoproterozoic)**—Grayish green fine-grained diorite sills and dikes in the Shepard (Ysh), Snowslip (Ysn), Helena (Yh), and Empire (Ye) Formations. Typically less than 1 m (3 ft) thick. Poorly exposed and difficult to trace laterally. Often show strong fracture cleavage.

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 reported to be 460 m (1,495 ft) thick in this area (Schmidt and others, 1994).

Yms3 **Mount Shields Formation, member 3 (Mesoproterozoic)**—Grayish red to blackish red fine-grained quartzite to argillite couples and couplets with abundant desiccation cracks, mud chips, 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 mud chips at the bases of the quartzite beds. 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. 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; mud cracks 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 to be consistent with mapping 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. Thickness about 610 m (2,000 ft), similar to that reported in the Austin 7.5' quadrangle to the east (Berg and Lonn, 2011).

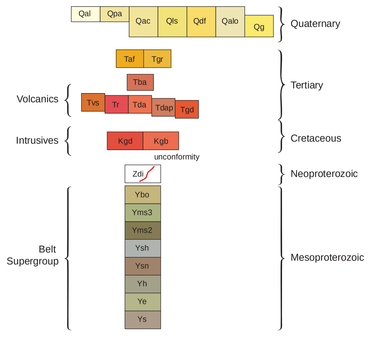
Ysn **Snowslip Formation (Mesoproterozoic)**—Interbedded intervals of quartzite to red argillite couplets, and dark green siltite to light green argillite couplets and microlaminae. Desiccation cracks and mud rip-up clasts are common. Argillite beds often contain irregular "bumps" that may be ill-defined 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).

Yh **Helena Formation (Mesoproterozoic)**—Gray to dark gray dolomitic limestone, limestone, calcareous siltite, dark gray argillite, and minor fine-grained quartzite; weathers yellowish orange to gray. The upper 300 m (1,000 ft) consists of cycles of dark gray limestone interbedded with dark gray calcareous argillite. Typically forms platy talus slopes and may correlate with the Wallace Formation (Winston, 2007). Below this interval, the Helena Formation is characterized by cycles consisting of a basal clastic zone of tan to gray siltite and fine-grained quartzite overlain by tan dolomite and capped by dark gray argillaceous limestone (Schmidt and others, 1994). Outcrops typically characterized by planar and wavy lamination, molar-tooth structure, synaresis cracks, oolites, recessive weathering calcitic pods, asymmetrical ripple marks, scour-and-fill, and fluid-escape structures. Near intrusions, it is metamorphosed to calc-silicate and hornfels. Gradational contact with underlying Empire Formation is placed at first interval where siliciclastic and calcitic beds, with sharp scoured bases overlain by intraclasts of molar-tooth fragments, predominate. Estimated thickness about 1,525 m (5,000 ft).

Ye **Empire Formation (Mesoproterozoic)**—Grayish green, medium green, and light green argillite and siltite. Thinly bedded; often lenticular with microlaminae and mud cracks and some calcareous and dolomitic beds with rare stromatolites. Gradational contact with underlying Spokane Formation is placed at first thick (>1 m) interval of green argillite. Thickness about 610 m (2,000 ft).

Ys **Spokane Formation (Mesoproterozoic)**—Grayish red, red, dark greenish, and purplish red argillite and siltite with even microlaminae and couplets; common desiccation cracks and mud rip-up clasts; some uncracked, lenticular, and undulating couplets and beds of flat-laminated couples. Thickness about 1,830 m (6,000 ft).

CORRELATION DIAGRAM



MAP SYMBOLS

- Contact: dashed where approximately located; dotted where concealed
- Fault: dashed where approximately located; dotted where concealed; bar and ball on downthrown side
- Reverse or thrust fault: teeth on upthrown block; dashed where approximately located; dotted where concealed
- Strike and dip of inclined beds
- Strike and dip of bedding where stratigraphic tops were confirmed using primary sedimentary structures
- Strike and dip of joints
- Strike and dip of volcanic foliation
- Strike and dip of cleavage
- Strike of vertical cleavage
- Diabase dikes and sills (Zdi)

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Nevada Mountain
Base map produced by the United States Geological Survey
Control by: USGS, USC&GS
Compiled from aerial photographs taken 1967
Field checked: 1968
Projection: Polyconic

Grid:1000 meter Universal Transverse Mercator Zone 12
UTM grid declination: 1° 08' West
1968 Magnetic North Declination: 19° East
Vertical Datum: National Geodetic Vertical Datum of 1929
Horizontal Datum: 1927 North American Datum

Contour Interval: 40 feet

Granite Butte
Base map produced by the United States Geological Survey
Control by: USGS, USC&GS
Compiled from aerial photographs taken 1967
Field checked: 1968
Projection: Polyconic

Grid:1000 meter Universal Transverse Mercator Zone 12
UTM grid declination: 1° 03' West
1968 Magnetic North Declination: 19° East
Vertical Datum: Mean Sea Level
Horizontal Datum: 1927 North American Datum

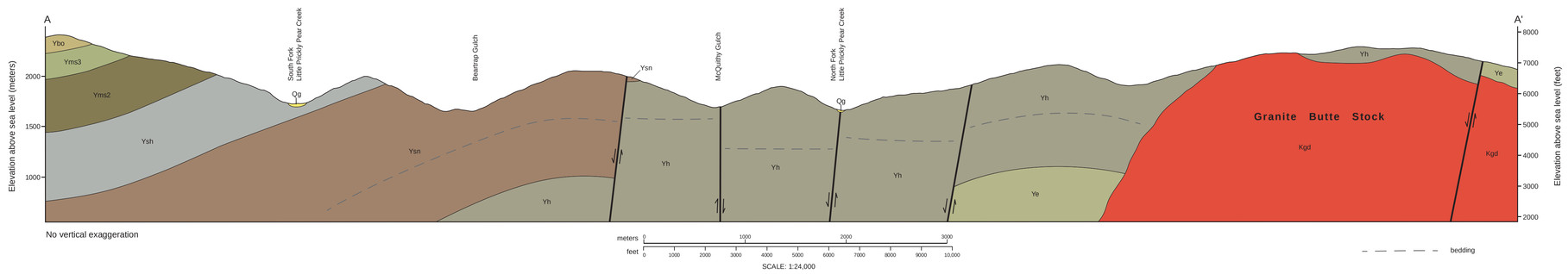
Contour Interval: 40 feet

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

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

Cross Section A—A'



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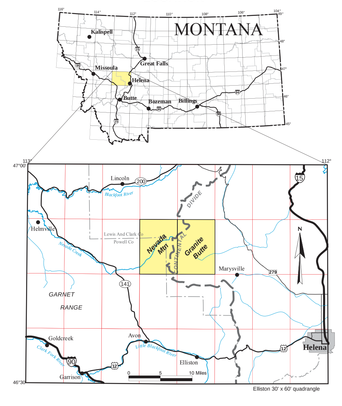

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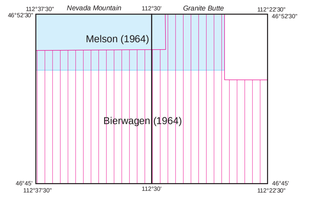

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GIS production: Yiwen Li and Paul Thale, MBMG. Map layout: Susan Smith, MBMG.

MBMG Open-File Report 665

Geologic Map of the Nevada Mountain and Granite Butte 7.5' Quadrangles, West-Central Montana

Catherine McDonald and Jeffrey D. Lonn

2015