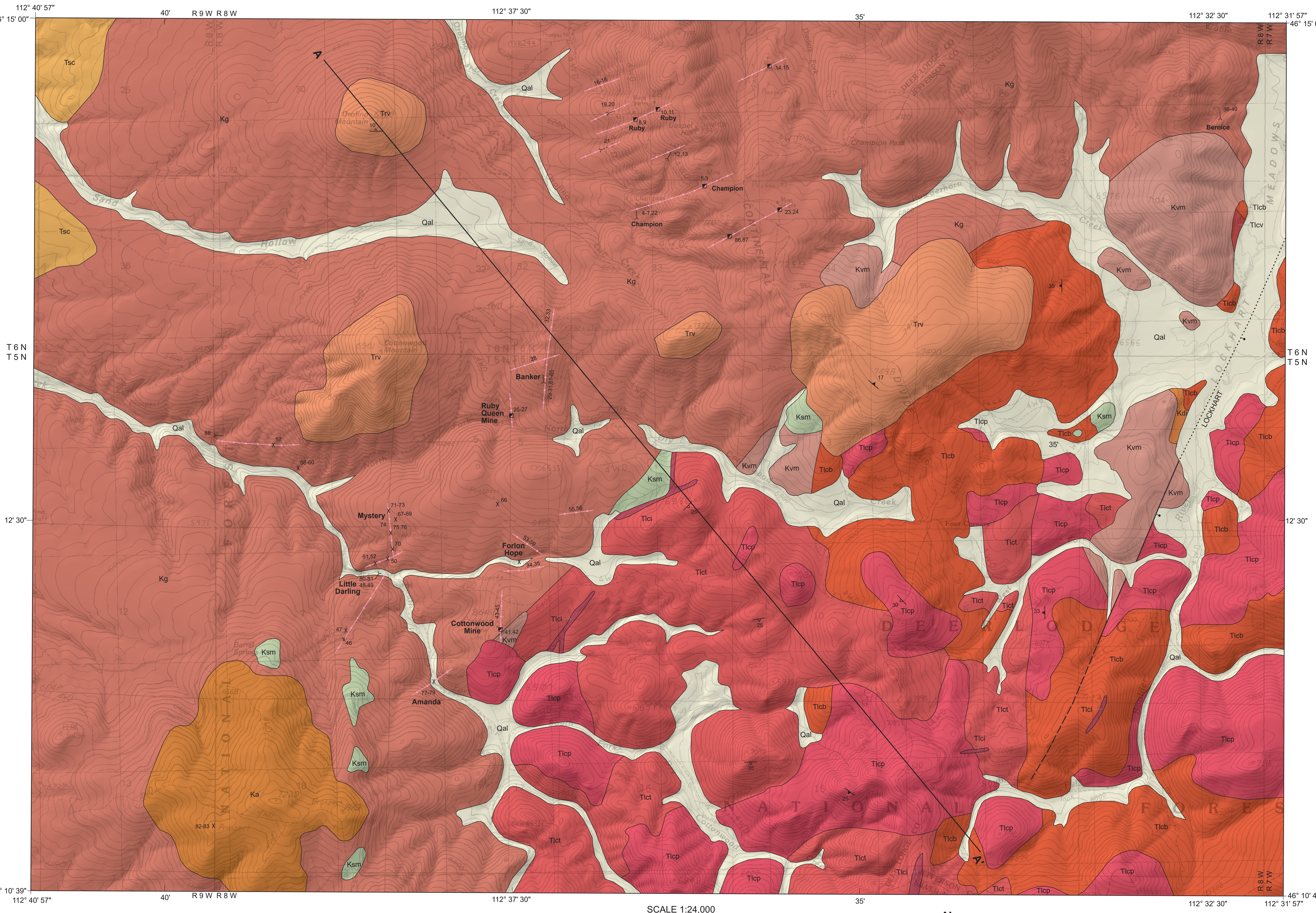
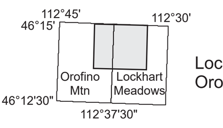


Base map produced by the United States Geological Survey

Orofino Mountain 1:24,000-scale quadrangle map
Control by: USGS, NOS/NOAA, and USFS
Compiled from aerial photographs taken 1954–1956
Field checked: 1987 Map edited: 1989
Projection: Lambert Conformal Conic
Grid:1000 meter Universal Transverse Mercator Zone 12
UTM grid declination: 1°13' West
1988 Magnetic North Declination: 16°30' East
Vertical Datum: National Geodetic Vertical Datum of 1929
Horizontal Datum: 1927 North American Datum

Lockhart Meadows 1:24,000-scale quadrangle map
Control by: USGS, NOS/NOAA
Compiled from aerial photographs taken 1954–1956
Field checked: 1987 Map edited: 1989
Projection: Lambert Conformal Conic
Grid:1000 meter Universal Transverse Mercator Zone 12
UTM grid declination: 1°08' West
1988 Magnetic North Declination: 16°30' East
Vertical Datum: National Geodetic Vertical Datum of 1929
Horizontal Datum: 1927 North American Datum

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



Location of
Oro Fino Mining District map

SCALE 1:24,000

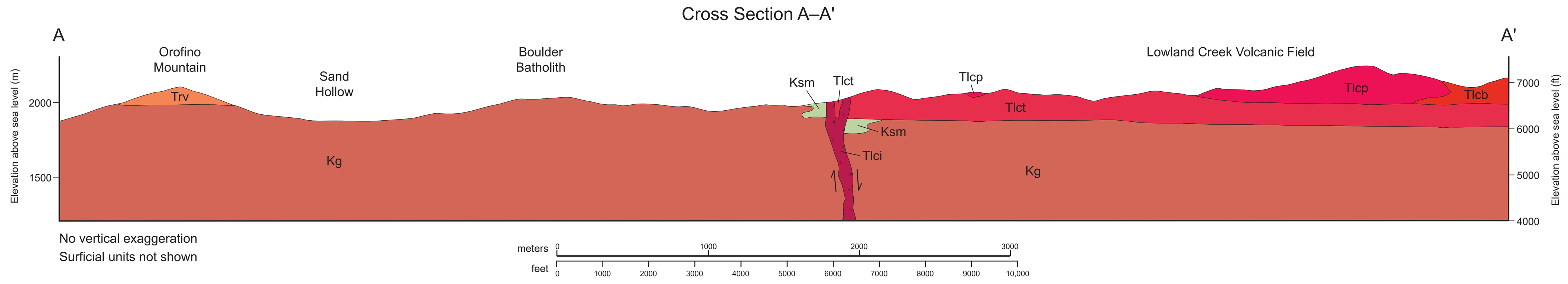
1 MILE | 1000 0 1000 2000 3000 4000 5000 6000 7000 FEET | 1 KILOMETER

CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

N

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
http://mbmg.mtech.edu

Cross Section A–A'



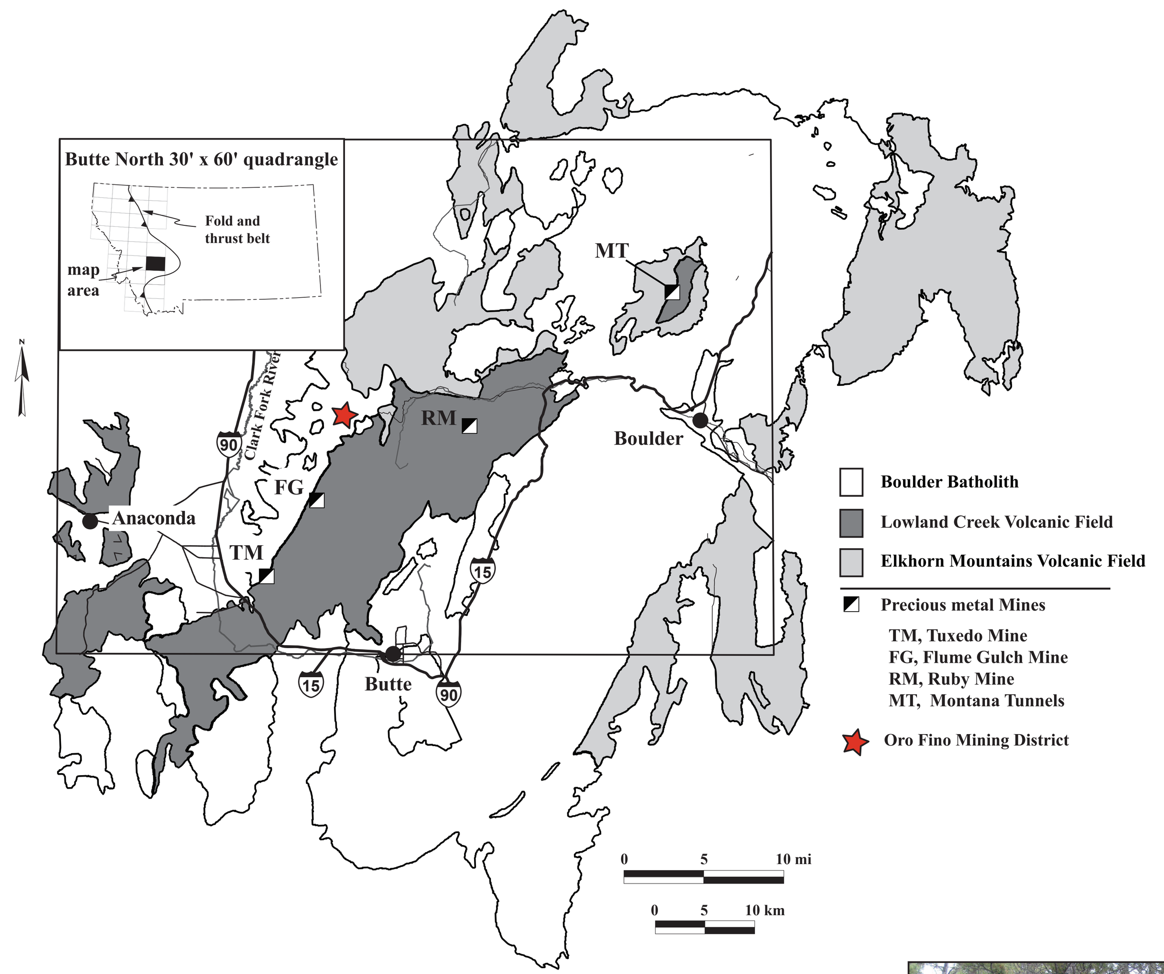
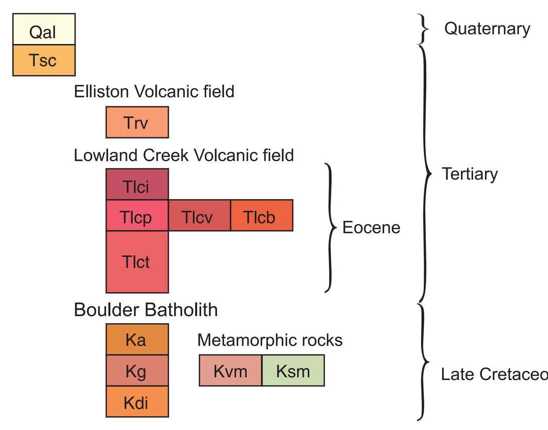


Figure 1. Location map. Geology after Vuke and others (2007).

CORRELATION DIAGRAM



MAP SYMBOLS

- Contact: dashed where approximately located
- Normal fault: dashed where approximately located, dotted where concealed, bar and ball on downthrown side
- 55,56 Vein; numbers indicate sample identifiers (see appendixes)
- 10,11 Shaft; numbers indicate sample identifiers (see appendixes)
- 12,13 Adit; numbers indicate sample identifiers (see appendixes)
- x 46 Prospect pit; number indicates sample identifier (see appendixes)
- 33 Inclined flow banding—showing strike and dip. If value not shown, strike and dip is less than 30°.
- 25 Inclined compaction foliation—showing strike and dip

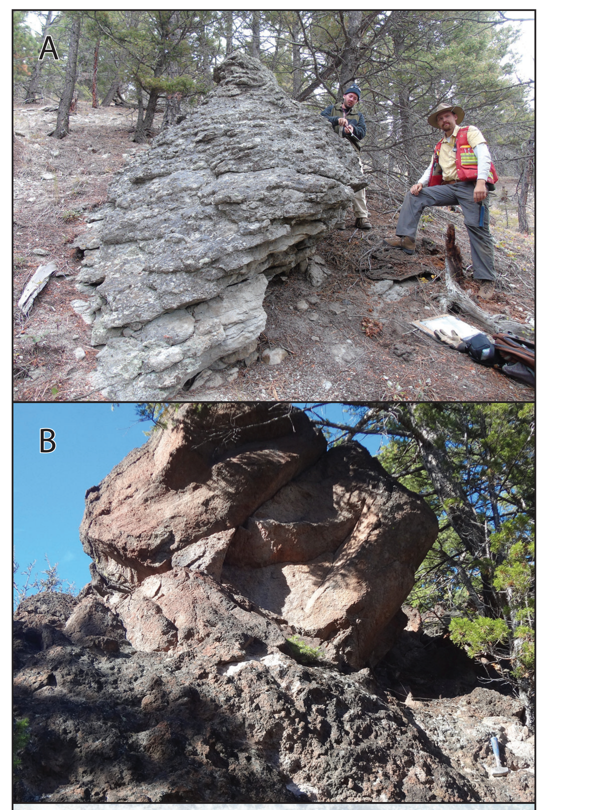


Figure 2. Rock photographs. (A) Non-welded Eocene rhyolite tuff (unit Tlct). (B) Rhyodacite porphyry lava breccia (unit Tlcb). (C) Fiammé in moderately welded Tertiary rhyolite ignimbrite (unit Trv).

INTRODUCTION

Veins in the Oro Fino mining district host precious metal (Ag > Au) ore deposits that formed during Eocene caldera-cycle magmatism in the Lowland Creek volcanic field. Eocene volcanic activity marked the conclusion of regional basement-cored, Laramide-style deformation (Houston and Dilles, 2013). The Oro Fino district follows a northeast trend of mines that contain Eocene epithermal mineralization within the Late Cretaceous Boulder Batholith (e.g., Foster, 1987; Metesh and Scarberry, 2016). The Tuxedo mine sits on an estimated 6 million tons of Au- and Ag-bearing breccia that forms a 2-mi-long northeast-trending ridgeline. Ore minerals include ruby silver (proustite and pyargyrite) and argentite, which occur in onionskin-textured chalcedony bands. The Flume Gulch mine contains Au and Ag ores in altered and brecciated rhyolite intrusions (Hargrave, 1990). The Flume Gulch mine is located about 7 mi northeast of the Tuxedo mine and shares a similar geologic setting. Like the Tuxedo mine, gold–silver mineralization at the Flume Gulch mine is due to rhyolite intrusion and hydrothermal circulation in a caldera wall setting. Gold and silver ores occur in altered and brecciated rhyolite intrusions that form a semi-circular 0.5-mi wide ridge that extends northeastward for about 3 mi. For a detailed summary of alteration assemblages, prospecting, and historical mine activities in Flume Gulch, see Hargrave (1990). Au-Ag mineralization at the Montana Tunnels mine is hosted in a feeder structure for an eroded maar volcano that formed at around 51.9 Ma (Olson and others, 2017). Au occurs in electrum, pyrite, and sphalerite, whereas silver is found principally in galena (Sillitoe and others, 1985).

Plutonic rocks, including the Boulder Batholith (fig. 1), formed throughout southwestern Montana during Mesozoic contraction and Cordilleran arc magmatism (Tilling and others, 1968; Hamilton, 1988; Rutland and others, 1989; Saleeby and others, 1992; Lageson and others, 2001; Gaschnig and others, 2011). The Boulder Batholith extends from Butte to Helena and consists of about 15 plutons exposed over 4,500 km^2. The roof of the batholith crystallized beneath a cover of volcanic rocks of similar age and composition. The Elkhorn Mountains volcanic field (e.g., Klepper and others, 1957) erupted over a period of about 10 Ma (Tilling and others, 1968; Olson and others, 2017). The batholith is more or less zoned in terms of age and composition (Tilling and others, 1968; Klepper and others, 1971; du Bray and others, 2012). Granodiorite to gabbro plutons along the north, east, and southern margins of the batholith crystallized between about 81 and 76 Ma, while the principal body, the Butte pluton, formed between about 75 and 74 Ma (Lund and others, 2002; Berger and others, 2011). The Boulder Batholith hosts a world-class ore deposit at Butte (Houston and Dilles, 2013; Czehura, 2006).

Magmatism resumed in western Montana during the Cenozoic and persisted until about 30 Ma (Mosolf, 2015). The Lowland Creek volcanic field (Smedes, 1962; Smedes and Thomas, 1965); (fig. 1) formed at around 53 to 48 Ma (Dudás and others, 2010), and during the earliest phase of Cenozoic volcanism in Montana. The volcanic field consists of intracaldera deposits including collapsed tuff blocks (fig. 2A), fumaroles and rhyodacite porphyry lavas (fig. 2B); (Scarberry, 2017; Olson and others, 2017) that are similar to those of the 38 to 18 Ma U.S. Great Basin ignimbrite province (Axen and others, 1993; Best and others, 2013). Cenozoic volcanic deposits in Montana are generally older and smaller in volume compared with those in the Great Basin.

Previous Mapping

The geologic map presented here draws on work from several existing studies. Williams (1951) produced a geologic map of an area east of Warm Springs, Montana that included the Oro Fino mining district. Smedes (1968), and Hargrave and Berg (2013) mapped in the region at 1:48,000 and 1:24,000 scale, respectively, with a focus on the geology of the Lowland Creek volcanic field. Berg and Hargrave (2004) mapped the Deer Lodge Valley at 1:48,000 scale, and Elliott and McDonald (2009) mapped and assessed geologic hazards in Silver Bow County at 1:48,000 scale.

UNIT DESCRIPTIONS
Sediments

Qal **Alluvium and colluvium (Holocene—Pleistocene)**—Well-sorted gravel, sand, silt, and clay along modern streams and floodplains. Includes fan deposits adjacent to stream channels, talus slope debris, colluvium, and landslides. Thickness is variable but less than 10 m.

Tsc **Sixmile Creek Formation, undivided (Tertiary—Middle and Late Miocene)**—Likely the Anderson Ranch member of the Sixmile Creek Formation that is differentiated along the eastern edge of the Deer Lodge Valley (Sears and others, 2009). Poorly lithified, tan to light gray, moderately to poorly sorted silt to coarse sand. The composition of sand grains is analogous to that of bedrock exposed east of the Deer Lodge Valley, suggesting a local clast source. Contains 5- to 60-cm-thick beds of matrix-supported, very coarse sand to pebble conglomerate with silty to sandy matrix, interpreted to be debris flow deposits. Includes 0.1- to 3-m-thick beds of clast-supported pebble to cobble conglomerate, with subrounded to rounded clasts of predominantly local affinity. These beds are interpreted to be small to major channels. Commonly includes 10- to 30-cm-thick massive light gray ashy silt to fine sand beds. Thickness is estimated to be up to 3 km in the Deer Lodge Valley based on drillhole data (Berg and Hargrave, 2004).

Cenozoic Volcanic Rocks

Elliston volcanic field

Mosolf (2015) described a >1 km sequence of lavas and fragmental volcanic rocks west of Helena and assigned the vent-proximal deposits to three volcanic fields: Avon, Garnet Range, and Crater Mountain. These volcanic fields post-date the Eocene Lowland Creek volcanic field and are collectively referred to here as the Elliston volcanic field. The Elliston volcanic field consists of a 48 Ma to 46 Ma lower series dominated by intermediate composition lavas, and a 41 Ma to 39 Ma upper series that consists mainly of voluminous rhyolite lavas and tuffs. Bimodal, basalt–rhyolite lavas and ash-flow tuffs are interstratified with the Renova Formation and formed between about 37 and 30 Ma (Mosolf, 2015).

Trv **Rhyolite, undifferentiated (Eocene—Middle Oligocene)**—Smedes (1968) mapped rhyolite flows, flow breccia, vitrophyre lava, dikes, bedded breccia, and tuff in the vicinity of the Oro Fino mining district. Volcanic deposits described as porphyritic flow-banded rhyolite lavas, breccia, and vitrophyre by Hargrave and Berg (2013) are included in the unit. In the northwestern map corner, on top of Oro Fino Mountain, the unit consists of moderately welded rhyolite ignimbrite that contains fiammé, or compacted pumice, that are 10 cm (4 in) long (fig. 2C). Fresh surfaces of the ignimbrite are characterized by alternating pink and gray bands. The ignimbrite is crystal-poor, with about 5 percent phenocrysts consisting of euhedral black quartz, subhedral sanidine, and some embayed quartz megacrysts. The ignimbrite is not dated, but based on textural and mineralogical similarities it may correlate with 39 Ma rhyolite ash-flow tuffs described by Mosolf (2015) in the Elliston volcanic field.

Lowland Creek volcanic field

The 53–49 Ma Lowland Creek volcanic field (fig. 1; Smedes, 1962; Dudás and others, 2010) contains suites of andesite–rhyolite that formed during two main eruptive cycles (Foster, 1987). The volcanic pile is about 915 m (3,000 ft) thick between Butte and Anaconda and consists of rhyolitic outflow tuff and near vent and intracaldera deposits of andesite–rhyolite tuff, lavas, breccia, intrusions, and lava domes. Epithermal Au-Ag mineralization formed after caldera collapse (Foster, 1987) and occurs throughout the volcanic field (fig. 1). Au-bearing diatreme and fumarole deposits at Montana Tunnels and the Ruby Mine, respectively, are intracaldera deposits (Sillitoe and others, 1985; Foster, 1987) and Au-Ag mineralization at the Tuxedo and Flume Gulch Mines formed via fluid circulation along a resurgent caldera vent wall. For additional details related to the ore setting and production at these mines, see Metesh and Scarberry (2016).

Tlci **Dike rocks (Eocene)**—Smedes (1968) described porphyritic dike rocks associated with lava flows (unit Tlcp), and lamprophyre dikes that cut all other units in the volcanic field. Includes subvolcanic dikes described by Hargrave and Berg (2013) that exhibit subvertical compaction foliation and contains plagioclase, biotite, and quartz phenocrysts. The unit is silicified and brecciated along the SE margin of the Butte Granite (Kg) where the dike rocks may follow a caldera ring fracture (see cross section). A northeast-trending rhyolite dike is continuous for nearly a kilometer north of Ramsay, located about 20 km (12 mi) south of the Oro Fino mining district. This rhyolite dike crystallized at around 51.08 Ma and contains inherited Cretaceous–Archean zircon grains (Scarberry, 2019).

Tlcp **Rhyodacite porphyry lavas (Eocene)**—Dark gray to gray and maroon, coarsely porphyritic, rhyodacite (Derkey and Bartholomew, 1988; Dudás and others, 2010; Scarberry and Elliott, 2016). The lavas are platy, crystal-poor (10–15 percent), and display near-planar flow banding towards the base of individual flows, and in contrast the lavas are crystal-rich porphyry with highly contorted flow bands towards the tops of individual flows. The primary phenocrysts include plagioclase crystals that are commonly 5 mm or longer, biotite, hornblende, and quartz in a devitrified and oxidized groundmass. Smedes (1968) mapped older and younger sets of lavas that differ mainly in their degree of propylitic alteration, whereby the alteration is widespread in the older lavas and not the younger lavas. Hargrave and Berg (2013) described nine different lava flow sequences northwest of Butte. $^{40}Ar/^{39}Ar$ ages of 51.79 ± 0.51 Ma (Scarberry and Elliott, 2016) and 51.79 ± 0.07 Ma (Dudás and others, 2010) are reported for the unit. 52.87 ± 0.26 Ma clasts of rhyodacite are observed in rhyolite tuff (Tlct) near Anaconda ($^{40}Ar/^{39}Ar$; Dudás and others, 2010). The sequence is up to 350 m thick locally.

Tlcv **Rhyodacite vitrophyre (Eocene)**—Black and vitric lava that contains abundant plagioclase phenocrysts and occasional biotite. The unit is exposed at, or near, the base and margins of the porphyry lava sequence (Tlcp) and is a facies of the same volcanic pulse. The vitrophyre is over 100 m thick where it is brecciated and banked into rhyolite ignimbrite (Tlct) west of Butte.

Tlcb **Breccia (Eocene)**—Predominantly autoclastic flow breccia that formed during emplacement of rhyodacite porphyry lavas (Tlcp) and vitrophyre (Tlcv). Autoclastic flow breccia is monolithologic, matrix- and clast-supported and variably indurated. Autoclastic flow breccia occurs at both the top and base of the porphyry lavas (Tlcp) and vitrophyre (Tlcv). Breccia in vitrophyre is dark, glassy, and monolithologic. Rapid cooling at the outer margins of the porphyry lavas (Tlcp) formed vitrophyre (Tlcv), which turned to breccia in locations where the flow continued to spread. Excellent outcrops of the basal breccia occur in the Opportunity 7.5' quadrangle (Scarberry and Elliott, 2016), where it is recognized by white to salmon pink, poorly indurated and matrix-supported block and ash deposits that transition up section to massive, clast-supported, autoclastic breccia. Autoclastic breccia associated with the top of rhyodacite lavas (Tlcp) is recognized by flow-banded blocks of rhyodacite in a lava matrix (fig. 2B).

Tlct **Rhyolite tuff (Eocene)**—White and gray, lithic- and crystal-rich variably welded tuff. Three distinct horizons are recognized that are gradational to one another. West of Butte the bottom 80 m consists of non-welded, pumice- and lithic- and biotite-rich dacite–rhyolite tuff that ranges in age from 53.36 ± 0.13 to 52.64 ± 0.39 Ma ($^{40}Ar/^{39}Ar$; Derkey and Bartholomew, 1988; Dudás and others, 2010; Scarberry and Elliott, 2016). The base of the section locally contains silicified pebble-sand conglomerate that is cut by chalcedony veins that transition up section to non-welded lithic-rich tuff. The overlying 150 m of the section is non-welded, bedded air-fall and base surge deposits (fig. 2A) that contain sparse, thin, laminar and densely welded tuff interbeds. The uppermost 70 m of the section consists of moderately welded rhyolite tuff with a $^{40}Ar/^{39}Ar$ age of 52.50 ± 0.32 (Scarberry and Elliott, 2016). Moderately welded tuff has a compaction foliation defined by compressed pumice. Gas escape voids that formed during vapor-phase crystallization are also flattened. In total, the sequence is over 300 m thick in the quadrangle. The unit may contain two rhyolite tuff sequences, one that erupted at around 52.9 Ma and the other at around 51.8 Ma (Dudás and others, 2010; Olson and others, 2017). The two rhyolite tuff sequences are difficult to distinguish mineralogically or geochemically (Dudás and others, 2010).

Boulder Batholith and Elkhorn Mountains volcanic field

Ka **Aplite (Late Cretaceous)**—Light tan, sheet-like outcrops that appear bedded in places but lack volcanic or sedimentary structures. The rock is typically fine-grained with a sugary and equigranular texture although moderately coarse varieties occur. Minerals include 10 percent biotite and near equal amounts of quartz and feldspar. Includes small masses of pegmatitic rocks that contain radiating tourmaline crystals, potassium feldspar, and plagioclase. Aplite on the west side of the Boulder Batholith, north of Butte, is 74.8 ± 0.6 Ma (LA-ICPMS, U-Pb on zircon); (Korzeb and Scarberry, 2018).

Kg **Butte Granite (Late Cretaceous)**—Massive jointed granite outcrops that form the principal pluton, by volume, of the Boulder Batholith. Coarse, medium, and fine varieties occur and exhibit normal-zoned plagioclase (45–50%), orthoclase (20–30%), and quartz (5–10%); (Berg and Hargrave, 2004). Contains accessory amounts of sphene, apatite, magnetite, and rare zircon (Weeks, 1974). The Butte Granite has an age of 76.28 ± 0.12 Ma (Martin and others, 1999).

Kdi **Diorite intrusions (Late Cretaceous)**—Isolated brecciated bodies that cross cut contacts locally in the northern part of the Sugarloaf Mountain 7.5' quadrangle (Derkey and others, 1993). Intrusions form a series of aligned rock towers mantled by lava flow breccia near Sugarloaf Mountain (Scarberry, 2016). In part, they represent intrusive equivalents to the basalt–andesite lava sequence (Kema) and most, if not all, of the intrusions pre-date rocks of the Boulder Batholith (Kg). A diorite intrusion in the Emery mining district, located about 16 km northwest of the Oro Fino mining district, has a U-Pb weighted mean age of about 80 Ma (Korzeb and Scarberry, 2018).

Metamorphic rocks

Kvm **Metamorphosed volcanic rocks (Late Cretaceous)**—Thermally metamorphosed andesite and basalt fragmental rocks and related dike rocks and rhyolite welded tuff (Smedes, 1959). Remnants of the lower and middle members of the Elkhorn Mountains volcanic field (Klepper and others, 1957), and the roof and walls of the Boulder Batholith.

Ksm **Metamorphosed sedimentary rocks (Late Cretaceous)**—Roof pendants of the Butte Granite. Blackleaf and Kootenai Formations are the suggested protoliths (Elliott and McDonald, 2009) for these rocks that are metamorphosed to hornfels, quartzite and marble.

REFERENCES CITED

Axen, G.J., Taylor, W.J., and Bartley, J.M., 1993, Space-time patterns and tectonic controls of Tertiary extension and magmatism in the Great Basin of the western United States: Geological Society of America Bulletin, v. 105, p. 56–76.
Berg, R.B., and Hargrave, P.A., 2004, Geologic map of the Upper Clark Fork Valley: Montana Bureau of Mines and Geology Open-File Report 506, 10 p., 2 sheets, scale 1:50,000.
Berger, B.R., Hildenbrand, T.G., and O'Neill, J.M., 2011, Control of Precambrian basement deformation zones on emplacement of the Laramide Boulder Batholith and Butte mining district, Montana, United States: U.S. Geological Survey Scientific Investigations Report 2011–5016, 29 p.
Best, M.G., Christiansen, E.H., and Gromme, S., 2013, Introduction: The 36–18 Ma southern Great Basin, USA, ignimbrite province and flareup: Swarms of subduction-related supervolcanoes: Geosphere, v. 9, p. 260–274.
Czehura, S., 2006, Butte: A world class ore deposit: Mining Engineering, v. 58, p. 14–19.
du Bray, E.A., Aleinikoff, J.N., and Lund, K., 2012, Synthesis of petrographic, geochemical, and isotopic data for the Boulder Batholith, southwest Montana: U.S. Geological Survey Professional Paper 1793, 39 p.
Derkey, P.D., and Bartholomew, M.J., 1988, Geologic map of the Ramsay quadrangle, Montana: Montana Bureau of Mines and Geology Geologic Map 47, 1 sheet, scale 1:24,000.
Dudás, F.O., Ispolatov, V.O., Harlan, S.S., and Snee, L.W., 2010, $^{40}Ar/^{39}Ar$ geochronology and geochemical reconnaissance of the Eocene Lowland Creek volcanic field, west-central Montana: Journal of Geology, v. 118, no. 3, p. 295–304.
Elliott, C.G., and McDonald, C., 2009, Geologic map and geohazard assessment of Silver Bow County, Montana: Montana Bureau of Mines and Geology Open-File Report 585, 88 p., 3 sheets, scale 1:50,000.
Foster, F., 1987, Epithermal precious-metal systems associated with an Eocene cauldron: Lowland Creek volcanic field, southwestern Montana, *in* Berg, R.B. and Breuninger, R.H., eds.: Guidebook of the Helena area, west-central Montana: Montana Bureau of Mines and Geology Special Publication 95, p. 53–54.
Gaschnig, R.M., Vervoort, J.D., Lewis, R.S., and Tikoff, B., 2011, Isotopic evolution of the Idaho Batholith and Challis intrusive province, northern U.S. Cordillera: Journal of Petrology, v. 52, p. 2397–2429.
Hamilton, W.B., 1988, Laramide crustal shortening, *in* Interaction of the Rocky Mountain Foreland and the Cordilleran Thrust Belt, *in* Schmidt, C.J., and Perry Jr., W.J., eds.: The Geological Society of America Memoir 171, p. 27–39.
Hargrave, P.A., 1990, Geology of the Browns Gulch and Flume Gulch area, Deer Lodge, Jefferson and Silver Bow Counties, Montana: Butte, Montana Technological University, M.S. thesis, 98 p., 2 plates, scale 1:24,000.
Hargrave, P.A., and Berg, R.B., 2013, Geologic map of the Lockhart Meadows 7.5' quadrangle west central Montana: Montana Bureau of Mines and Geology Open-File Report 629, 1 sheet, scale 1:24,000.
Houston, R.A., and Dilles, J.H., 2013, Structural geologic evolution of the Butte District, Montana: Economic Geology, v. 108, p. 1397–1424.
Klepper, M.R., Weeks, R.A, and Ruppel, E.T., 1957, Geology of the southern Elkhorn Mountains, Jefferson and Broadwater Counties, Montana: U.S. Geological Survey Professional Paper 292, 82 p.
Klepper, M.R., Robinson, G.D., and Smedes, H.W., 1971, On the nature of the Boulder Batholith of Montana: Geological Society of America Bulletin, v. 82, p. 1563–1580.
Korzeb, S.L., and Scarberry, K.C., 2018, Timing of pluton emplacement and mineralization of the Boulder Batholith, *in* Scarberry, K.C., and Barth, S., eds., Proceedings of the Montana Mining and Mineral Symposium 2017, technical papers and abstracts: Montana Bureau of Mines and Geology Open-File Report 699, p. 39–44.
Lageson, D., Schmitt, J., Horton, B., Kalakay, T., and Burton, B., 2001, Influence of Late Cretaceous magmatism on the Sevier orogenic wedge, western Montana: Geology, v. 29, p. 723–726.
Lund, K., Aleinikoff, J., Kunk, M., Unruh, D., Zeihen, G., Hodges, W., du Bray, E., and O'Neill, J., 2002, SHRIMP U-Pb and $^{40}Ar/^{39}Ar$ age contrasts for relating plutonism and mineralization in the Boulder Batholith region, Montana: Economic Geology, v. 97, p. 241–267.
Martin, M., Dilles, J., and Proffett, J.M, 1999, U-Pb geochronologic constraints for the Butte porphyry system [abs.]: Geological Society of America Abstracts with Programs, v. 31, no. 7, p. A380.
Metesh, J.J.. and Scarberry, K.C., 2016, 2017 MBMG Calendar at-a-glance featuring the Big Butte and the Lowland Creek volcanic field: Montana Bureau of Mines and Geology Miscellaneous Publications 60, 1 sheet.
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. 213–231.
Olson, N.H., Sepp, M.D., Dilles, J.H., Mankins, N.E., Blessing, J.M., and Scarberry, K.C., 2017, Geologic map of the Mount Thompson 7.5' quadrangle, southwest Montana: Montana Bureau of Mines and Geology EDMAP-11, 1 sheet, scale 1:24,000.
Rutland, C., Smedes, H., Tilling, R., and Greenwood, W., 1989, Volcanism and plutonism at shallow crustal levels: The Elkhorn Mountains Volcanics and the Boulder Batholith, southwestern Montana, *in* Henshaw, P., ed.: Volcanism and plutonism of western North America; Volume 2, Cordilleran volcanism, plutonism, and magma generation at various crustal levels, Montana and Idaho, Field trips for the 28th International Geological Congress: American Geophysical Union, Monograph, p. 16–31.
Saleeby, J.B., Busby-Spera, C., Oldow, J.S., Dunne, G.C., Wright, J.E., Cowan, D.S., Walker, N.W., and Allmendinger, R.W., 1992, Early Mesozoic tectonic evolution of the Western U.S. Cordillera, *in* Burchfiel, B.C., Lipman, P., and Zoback, M.L., eds.: The Cordilleran Orogen: Conterminous U.S.: Boulder, Colorado, Geological Society of America, 107 p.
Scarberry, K.C., 2016, Geologic map of the Sugarloaf Mountain 7.5' quadrangle, Deer Lodge, Jefferson, and Powell Counties, MT: Montana Bureau of Mines and Geology Open-File Report 674, 1 sheet, scale 1:24,000.
Scarberry, K.C., 2017, Eruption history and origin of precious metal ore deposits: The Eocene Lowland Creek Volcanic Field, southwestern Montana, *in* Korzeb, S., and Scarberry, K.C., Proceedings of the 2016 Mining and Mineral Symposium: Montana Bureau of Mines and Geology Open-File Report 685, p. 38–39.
Scarberry, K.C., 2019, Geologic map of the Ramsay 7.5' quadrangle, southwestern Montana: Montana Bureau of Mines and Geology Geologic Map 72, 1 sheet, scale 1:24,000.
Scarberry, K.C., and Elliott, C.G., 2016, Geologic map of the Opportunity 7.5' quadrangle, Deer Lodge and Silver Bow Counties, MT: Montana Bureau of Mines and Geology Open-File Report 683,1 sheet, scale 1:24,000.
Sears, J.W., Hendrix, M.S., Thomas, R.C., and Fritz, W.J., 2009, Stratigraphic record of the Yellowstone hotspot track, Neogene Sixmile Creek Formation grabens, southwest Montana: Journal of Volcanology and Geothermal Research, v. 188, p. 250–259.
Sillitoe, R.H., Grauberger, G.L., and Elliott, J.E., 1985, A diatreme-hosted gold deposit at Montana Tunnels, Montana: Economic Geology, v. 80, p. 1707–1721.
Smedes, H.W., 1962, Lowland Creek Volcanics, an upper Oligocene formation near Butte, Montana: The Journal of Geology, v. 70, no. 2, p. 255–266.
Smedes, H.W., 1968, Preliminary geologic map of part of the Butte North quadrangle, Silver Bow, Deer Lodge, and Jefferson Counties, Montana: U.S. Geological Survey Open-File Report 68-254, 2 plates, scale 1:6,000.
Smedes, H.W., and Thomas, H.H., 1965, Reassignment of the Lowland Creek Volcanics to Eocene age: The Journal of Geology, v. 73, no. 3, p. 508–510.
Tilling, R.I., Klepper, M.R., and Obradovich, J.D., 1968, K-Ar ages and time span of emplacement of the Boulder Batholith, Montana: American Journal of Science, v. 266, p. 671–689.
Vuke, S.M., Porter, K.W., Lonn, J.D., and Lopez, D.A., 2007, Geologic map of Montana: Montana Bureau of Mines and Geology Map 62, 2 sheets, scale 1:500,000.
Weeks, R.A., 1974, Geologic map of the Bull Mountain area, Jefferson County, Montana: U.S. Geological Survey Open-File Report 74-354, 1 sheet, scale 1:48,000.
Williams, H.G., 1951, Geology and ore deposits of an area east of Warm Springs, Montana: M.S. thesis, Butte, Montana Technological University, 64 p.

Montana Bureau of Mines and Geology

MBMG Bulletin 140, Plate 1

Geologic Map of the Oro Fino Mining District, Montana

Stanley L. Korzeb and Kaleb C. Scarberry

2020