

INTRODUCTION

Eocene volcanic rocks overlie the Butte Quartz Monzonite pluton of the Cretaceous age Boulder Batholith. Granitic intrusions of the Butte Quartz Monzonite have metamorphosed the Quadrant Quartzite of Pennsylvanian age and also the Elkhorn Mountains Volcanics that form a volcanic covering over the Boulder Batholith. In most of the Lockhart Meadows 7.5'-quadrangle, the Lowland Creek Volcanics were deposited directly on the Butte Quartz Monzonite.

Whole-rock chemical analyses of Lowland Creek Volcanics samples show a compositional range from the rhyolite and dacite to the andesite and trachyte compositional fields (Dudas and others, 2010). ⁴⁰Ar/³⁹Ar dates of between 52.9 to 48.6 Ma (Dudas and others, 2010) indicate that it took almost 5 million years to deposit this volcanic sequence. Rhyolite flows overlying Lowland Creek Volcanics in the northern part of the quadrangle are likely part of the Avon volcanic sequence well exposed 40 km (24 miles) to the north (Trombetta, 1987). Sapphires and gold have been mined from placers on the South Fork of Dry Cottonwood Creek. We speculate that Lockhart Meadows was the site of a glacial lake and that glacial lake sediments underlie the alluvium in this meadow.

DESCRIPTION OF MAP UNITS

- Quaternary Surficial Units**
- Qal** Alluvium of modern channels and flood plains - Gravel, sand, silt, and clay along active streams that consist of locally derived material.
 - Qac** Alluvium and colluvium, undivided - Mainly covered soil containing poorly sorted clasts from local exposures deposited by sheet wash and, to a lesser extent, other fluvial processes.
 - Qaf** Alluvial fan - Sub-angular to subrounded, poorly sorted, locally derived cobble to boulder gravel, sand and silt.
 - Qls** Landslide - Mass-wasting deposit characterized by a hummocky surface, willows and springs, the inferred landslides at the head of Alaska Gulch formed on ash-flow tuff breccias.

- Avon Volcanics - (informal name)**
- Tavv** Vitrophyre - Flow-banded, glassy groundmass porphyry with rare black quartz megacrysts.
 - Tavf** Rhyolite - Rhyolite flows, flow breccias, bedded breccia, and tuff (Smedes, 1968). Rhyolite flows are characterized by euhedral black quartz phenocrysts, less abundant embayed quartz megacrysts, and subhedral K-spar phenocrysts in light gray groundmass. Estimated exposed thickness is 200 m (660 ft).

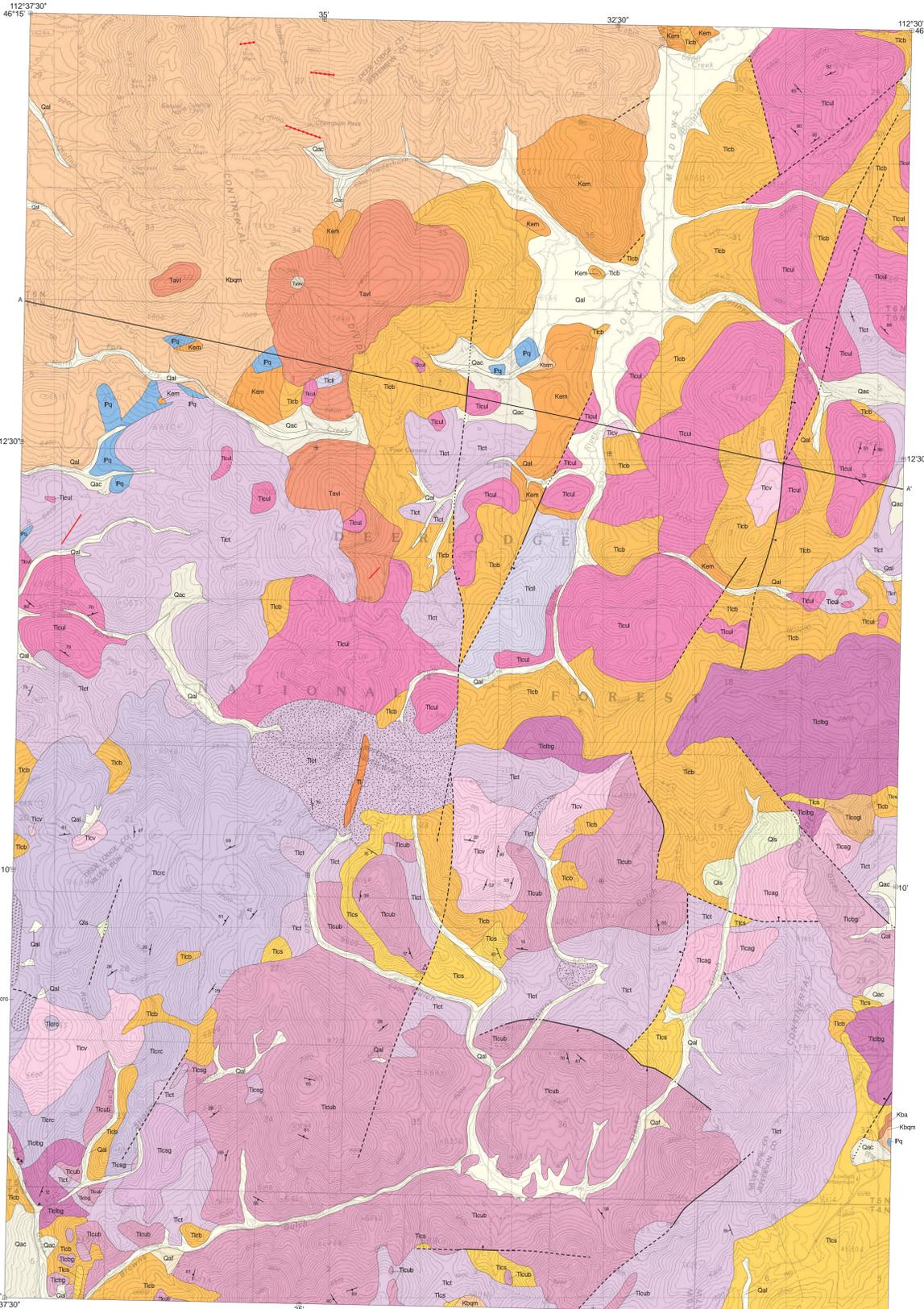
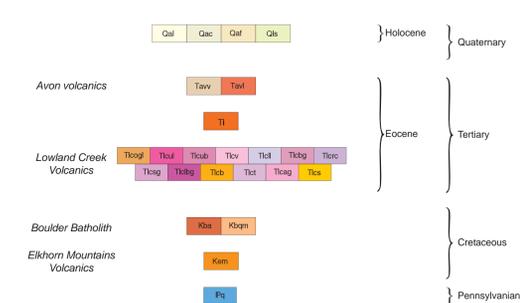
Lowland Creek Volcanics
NOTE: The following descriptions are taken in large part from Hargrave (1990).

- Ti** Dike - Possesses both intrusive and extrusive characteristics, probably due to near surface emplacement. Matrix contains equant plagioclase, biotite, and quartz grains. Phenocrysts include plagioclase, biotite and trace apatite. North of American Gulch forms an elongate ridge with closely spaced (1-5 cm) vertical joints.
- Tlcof** Olson Gulch lahar - Large blocks of highly altered Lowland Creek volcanic rock encased in very fine grained, green matrix. Blocks are so altered they resemble tuff. Original texture appears similar to the flow on the west side of the same ridge as the lahar; porphyritic light-gray glassy groundmass and mafic glomerocrysts. Rims on plagioclase, biotite, and amphibole phenocrysts are altered. Brick red, fine grained clasts, up to 2.5 cm, are present locally. In hand specimen, the matrix looks like a siltstone.
- Tlcl** Upper lava - Red, pink, and brown porphyritic lava with quartz, plagioclase, biotite and less abundant sanidine phenocrysts in an aphanitic groundmass. Basal parts of some flows are glassy, basal breccia zones widely distributed. Highly contorted flow banding is conspicuous. Slight porphyllite alteration is mostly restricted to brecciated areas. Kaolinitic alteration occurs near the head of the South Fork of Dry Cottonwood Creek. The upper lava unit includes small bodies of related intrusive rock whose boundaries could not be determined (modified from Smedes, 1968). Exposed thickness of the upper lava is estimated to be less than 300 m (1,000 ft).
- Tlclb** Upper Browns Gulch flows - Conspicuous, green altered phenocrysts and cumulo-ophitic aggregates distinguish the upper Browns Gulch lava flow from all other flows. Nontronite (Lester Zeehen, pers. commun., 1989), a Fe-rich smectite, is present in the flow's upper part, resulting from the feldspar phenocrysts weathering. The lower Browns Gulch lava lacks the green altered phenocrysts but has yellowish-brown (monimite?) phenocrysts instead. The lower part tends to have a darker gray groundmass, and pinkish orange phenocrysts relative to the upper portion.
- Tlcv** Mormon Gulch vitrophyre - Dark-gray to grayish-black, glassy groundmass is almost equally abundant as white to light pink, 2-3 mm plagioclase phenocrysts. Light gray to clear quartz phenocrysts are about the same size. Biotite and sparse hornblende are scattered throughout. The overall effect is one of a sugary and even-textured flow, which in places, resembles an intrusive rock.
- Tlcl** Lower lava - Gray, brown, purple, red, and greenish-black lava flows with well-developed brecciated upper parts and thin lower parts with well-developed planar flow layering; a basal breccia zone is present in some flows. Plagioclase, clinopyroxene, hornblende, quartz, accompanied by sparse sanidine and biotite are set in a devitrified groundmass. Propylitic alteration is widespread, generally more pronounced in each flow's upper brecciated zones; chalcedony or opal pervades the groundmass, and brecciated parts of flows are cut by a network of quartz veins (Smedes, 1968). Exposed thickness is estimated to be less than 200 m (700 ft).
- Tlclb** Butcher Gulch lava - Upper part is dense and exhibits well developed, consistent flow banding and lineation. Large scree slopes with angular talus form on this unit, as opposed to the rubby scree slopes of the Lower Browns Gulch lava. Locally, the lava and its basal breccia overlie the ash-flow tuff and contain relatively less biotite than other flows in the map region. Alignment of titanite (?), biotite, microclites, and phenocrysts is conspicuous. Flow has characteristic prominent, large phenocrysts (up to 1 cm) of euhedral to subhedral sanidine, and rounded quartz phenocrysts. Euhedral, wedge-shaped titanite with opaque rims is unique to this flow. Light gray to medium bluish gray, locally with grayish-yellow layers. The flow's color grades to pale purple-red to the south.
- Tlcs** Rocky Canyon lava - Pale red or purple with white plagioclase phenocrysts set in a fine grained, red matrix with a dusting of fine grained opaques throughout. Porphyritic, with 0.75 mm or larger plagioclase, biotite, trace amphibole and quartz phenocrysts. A maroon soil formed by the weathering of this flow is indicative of the flow's presence. The hatched pattern on the map indicates areas of hydrothermal alteration.
- Tlcsb** Strozzy Gulch lava - Dense, very fine grained dark-gray matrix with a trace of rounded quartz phenocrysts and small irregular voids. The voids are filled with a dull, gold to yellow, unknown mineral and lined with a soft, white, clay-like mineral.
- Tlclb** Lower Browns Gulch lava - Porphyritic vitrophyre flow with pinkish-orange phenocrysts in a glassy, dark gray groundmass. Flow banding is well developed locally and not contorted, as in other flows. In hand specimen, is recognizable by large, euhedral feldspar and lesser amounts of quartz phenocrysts and distinctive, glassy groundmass. Reddish-black outcrops are rounded, knobby, and weather to a light gray soil.

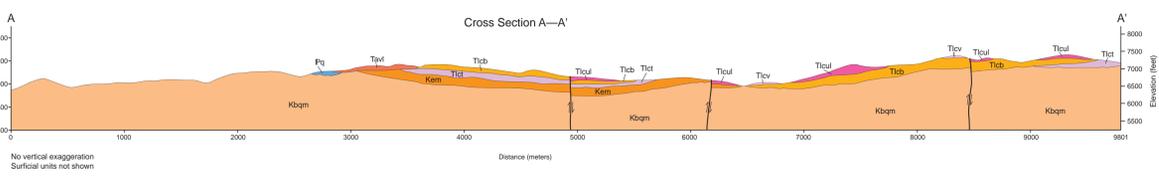
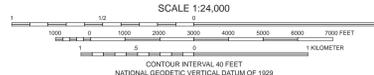
MAP SYMBOLS

- Metalliferous vein
- Dike
- Contact
- Fault: dashed where approximately located; dotted where concealed; bar and ball on downthrown side
- Attitude of inclined flow banding
- Attitude of vertical flow banding
- Attitude of inclined bedding and planar features caused by alignment of compressed lapilli in ashflow tuff
- Volcanic flow breccia
- Hydrothermal alteration

CORRELATION DIAGRAM



Lockhart Meadows
Base map produced by the United States Geological Survey
Control by USGS, NDS/NOAA
Compiled from aerial photographs taken 1954-1956
Field checked: 1959
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



MBMG Open-File 629
Geologic Map of the Lockhart
Meadows 7.5' Quadrangle
West Central Montana

Phyllis A. Hargrave and Richard B. Berg