Base map produced by the United States Geological Survey
Lick Creek 1:24,000-scale quadrangle map
Control by: USGS, NOS/NOAA, and USFS
Compiled from aerial photographs taken 1965–66
Field checked: 1974. Photoinspected 1990
Boundaries and names revised 1994
Projection: Lambert Conformal Conic
Grid:1000 meter Universal Transverse Mercator Zone 12
UTM grid declination: 1°56' West
1994 Magnetic North Declination: 16.5° East
Vertical Datum: National Geodetic Vertical Datum of 1929
Horizontal Datum: 1927 North American Datum

N

SCALE 1:24,000
1 1/2 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
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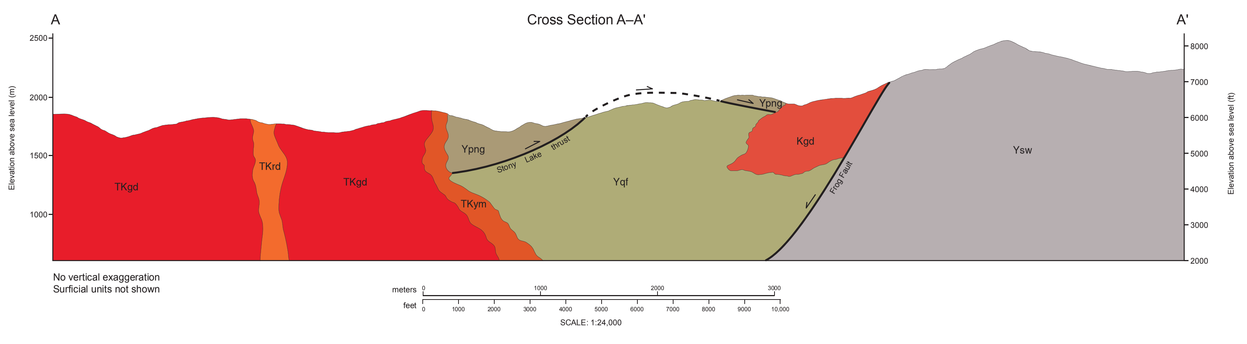

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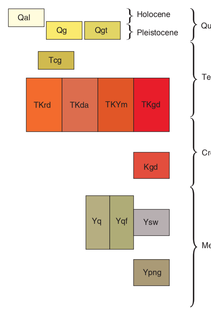
GIS production: Yiwen Li and Paul Thale, MBMG. Map layout: Susan Smith, MBMG.

CORRELATION DIAGRAM



MAP SYMBOLS

- Contact: dashed where approximately located
- Fault: dashed where approximately located, dotted where concealed, bar and ball on downthrown side
- Reverse or thrust fault: dashed where approximately located, dotted where concealed, teeth on upthrown block
- 10 — Plunge and bearing of outcrop-scale fold
- 16 — Strike and dip of inclined beds
- 15 — Strike and dip of bedding where stratigraphic tops were confirmed using primary sedimentary structures
- 25 — Inclined metamorphic foliation
- Horizontal metamorphic foliation
- Horizontal bedding
- Tectonic breccia—Lithified quartz-cemented breccia containing angular quartzite clasts and abundant slickensides

INTRODUCTION

The Montana Bureau of Mines and Geology (MBMG) chose the north half of the Lick Creek 7.5′ quadrangle for 1:24,000-scale mapping because previous maps (Wallace and others, 1989, scale 1:50,000; Desmarais, 1983, scale 1:48,000; and Ruppel and others, 1993, scale 1:250,000) show the area as a structurally complex part of the Wisdom 30′ x 60′ quadrangle. The MBMG and the USGS STATEMAP Advisory Committee have prioritized completion of the geologic map of the Wisdom quadrangle, and the Lick Creek 7.5′ quadrangle will contribute to its completion.

GEOLOGIC SUMMARY

Complexly faulted Mesoproterozoic metasedimentary rocks intruded by Cretaceous through Tertiary igneous rocks underlie the Lick Creek quadrangle. The metasedimentary strata are part of the Belt Supergroup, and represent the Piegan Group of the middle Belt and Lemhi subbasin strata of the upper Belt (Burmester and others, 2016). A major thrust fault, correlated with the Stony Lake thrust in the central Sapphire Mountains (Lonn and others, 2003; Sears, 2016), places calc-silicate gneiss over quartzite of the younger Lemhi strata. This fault is structurally higher than the Georgetown thrust exposed farther east (fig. 1). Exposures in the northwest corner of the Lick Creek quadrangle show that the fault is folded and dips 0–30° west–southwest (cross section A–A′). A late Cretaceous granodiorite pluton cuts the fault and constrains its minimum age to 73–74 Ma (Wallace and others, 1989). The calc-silicate gneiss in the hanging wall is complexly deformed (fig. 2), and layering probably represents transposed bedding. Fine-grained quartzite in the footwall is tentatively correlated with upper Lemhi subbasin strata. The quartzite is locally severely brecciated adjacent to the fault (fig. 3).

A significant north-striking, down-to-the-west normal fault, well exposed near Frog Point, bisects the quadrangle and is therefore named the Frog Fault. The fault separates the Stony Lake thrust complex from gently dipping Swauger Formation of the Lemhi subbasin (Burmester and others, 2016). The exposed Swauger Formation is thought to be within the footwall of the Stony Lake thrust, and also in the hanging wall of the structurally lower Georgetown thrust (fig.1; cross section A–A′). The Frog Fault cuts the Tertiary–Cretaceous intrusions, the Stony Lake thrust, and preserves Tertiary conglomerate in its hanging wall, indicating a Tertiary age. The Frog Fault appears to continue north–northeast into the north-adjacent Philipsburg 30′ x 60′ quadrangle (fig. 1), although it was not recognized on that map (Lonn and others, 2003). In the northwestern part of the map, a significant northwest-striking fault separates quartzite of the Lemhi subbasin (?) from calc-silicate gneiss of the Piegan Group. New mapping outside the quadrangle shows that this fault bends northward and continues into the north-adjacent Philipsburg 30′ x 60′ quadrangle (fig. 1), although it was not recognized on that map (Lonn and others, 2003).

Tertiary–Cretaceous granodiorite intrusions (Kgd and TKgd) were studied and described by Desmarais (1983) and Wallace and others (1989), who obtained late Cretaceous potassium–argon ages from the unit in the northern part of the map. No isotopic ages are available for the other pluton (unit TKgd), which is compositionally similar.

Poorly sorted, angular conglomerate (Tcg) that likely represents a Tertiary debris flow deposit is preserved on a ridge in the hanging wall of the Frog Fault in the south-central part of the map. Pleistocene glaciation resulted in extensive deposits of till and glaciofluvial material, particularly in the valley bottoms.

DESCRIPTION OF MAP UNITS

QUATERNARY AND TERTIARY DEPOSITS

Qal **Alluvium (Holocene)**—Moderately well- to well-sorted gravel, sand, silt, and clay in modern stream channels and floodplains. Thickness probably less than 25 m (75 ft).

Qg **Glacial deposits, undivided (Holocene and Pleistocene)**—Mostly unsorted sandy to clayey boulder till with subangular to subrounded clasts. Characterized by a mixture of huge granite boulders derived from the Sapphire Batholith (unit Kgd) and quartzite. Also includes glacial outwash, fan, kame, and esker deposits. As thick as 100 m (330 ft).

Qgt **Glacial till (Holocene and Pleistocene)**—Unsorted sandy to clayey boulder diamictite containing huge subangular to subrounded boulders of granodiorite and quartzite. Mapped above the confluence of Sign and Moose Creeks in the central part of the map. Thickness probably less than 30 m (100 ft).

Tcg **Conglomerate (Oligocene or Miocene?)**—Unconsolidated, poorly bedded, poorly sorted, boulder-gravel deposits with clasts composed solely of subangular to subrounded quartzite boulders and cobbles without the large granite boulders that characterize units Qgt and Qg. Preserved on the downthrown western side of the Frog Fault on a ridgetop as much as 150 m (500 ft) above the modern drainages. Probably deposited in a system of coalescing alluvial fans and debris flows in the late Tertiary. Preserved thickness less than 100 m (300 ft).

INTRUSIVE IGNEOUS ROCKS

Distribution and descriptions of the intrusive igneous units were modified from Desmarais (1983) and Wallace and others (1989).

TKrd **Rhyolite (Cretaceous or Tertiary)**—Porphyritic rhyolite dikes that intrude hornblende granodiorite (unit TKgd) in the southern part of the map. Contains 3–5 percent fine-grained phenocrysts of plagioclase, quartz, biotite, and hornblende in a gray groundmass (Wallace and others, 1989).

TKda **Dacite (Cretaceous or Tertiary)**—Porphyritic dacite dikes that intrude hornblende granodiorite (unit TKgd) and quartzite (unit Ysw) in the southern part of the map. Contains 20 percent fine- to medium-grained phenocrysts of plagioclase, quartz, hypersthene, biotite, and hornblende (Wallace and others, 1989).

TKYm **Mixed granodiorite and Belt metasediments (Tertiary to Mesoproterozoic)**—Mixed unit of meta-Belt sediments complexly intruded by hornblende granodiorite along the intrusive contact and not distinguishable at the 1:24,000 map scale.

TKgd **Hornblende-biotite granodiorite (Cretaceous or Tertiary)**—Slightly porphyritic medium-grained hypidiomorphic granular hornblende-biotite granodiorite commonly with a tonalite border zone. The unit contains 43 percent plagioclase, 31 percent quartz, 8 percent microcline, 6 percent orthoclase, 7 percent biotite, and 2 percent hornblende, with accessory epidote, sphene, apatite, zircon, and clinozoisite (Wallace and others, 1989). In hand sample, hornblende phenocrysts appear more numerous than biotite. Because Wallace and others (1989, 1992) and Ruppel and others (1993) correlated this pluton with Desmarais' (1983) 78 Ma foliated granodiorite, they inferred a Cretaceous age. However, in the Lick Creek map area, this unit is non-foliated and thus may not be correlative. No isotopic age data are available.

Kgd **Biotite-hornblende granodiorite (Cretaceous)**—Porphyritic medium-grained hypidiomorphic granular biotite-hornblende granodiorite. The unit is composed of 42 percent plagioclase, 27 percent quartz, 18 percent microcline, 5 percent orthoclase, 7 percent biotite, and 2 percent hornblende, with accessory sphene, allanite, epidote, apatite, and zircon. This unit yielded K-Ar cooling dates of 73.1 ± 1.2 Ma (biotite) and 74.1 ± 1.5 Ma (hornblende) (Wallace and others, 1989).

MESOPROTEROZOIC UNITS

Metasedimentary rocks of the Mesoproterozoic Belt Supergroup underlie much of the quadrangle. The quartzite units are correlated with units of the Lemhi subbasin that include the Lemhi Group (Ruppel, 1975) and stratigraphically higher units (Burmester and others, 2016). These units are thought to be correlative with the Missoula Group of the upper Belt Supergroup (Lonn, 2014; Lonn and others, 2016). On the Lick Creek quadrangle these units occur in the footwall of the Stony Lake thrust. The calc-silicate gneiss in the hanging wall of the Stony Lake thrust is correlated with the Piegan Group of the middle part of the Belt Supergroup.

Yq **Quartzite (Mesoproterozoic)**—Medium- to fine-grained feldspathic quartzite containing metamorphic biotite and muscovite injected with granodiorite sheets. Decimeter- to meter-thick layering may represent either original or transposed bedding. The unit may be correlative with the sandy Lemhi subbasin strata (Burmester and others, 2016), but a formation name could not be assigned. Reconnaissance outside the Lick Creek quadrangle (fig. 1) suggests that Yq may be continuous with Swauger Formation exposed on the Philipsburg 30′ x 60′ quadrangle (Lonn and others, 2003) where it was mapped as Mount Shields Formation.

Yqf **Fine-grained Quartzite (Mesoproterozoic)**—Gray, very fine- to fine-grained quartzite with abundant sericite. A slabbed and stained sample contained 10 percent K-spar, but the small grain size made estimates of plagioclase content problematic. Layering is interpreted as sedimentary bedding, but an alternative is that it represents transposed bedding. Occurs in the footwall of the Stony Creek thrust on the lower walls of Moose Creek Canyon in the northern part of the map. Commonly brecciated adjacent to the fault (fig. 3). Possibly correlative with the Jahnke Lake member of the Apple Creek Formation that is stratigraphically above the Swauger and Lawson Creek Formations (Burmester and others, 2016).

Ysw **Swauger Formation (Mesoproterozoic)**—Fine- to coarse-grained quartzite in beds ranging from a few centimeters to a meter thick, and separated by dark purple to black argillite layers. Small rounded pebbles and granule-sized quartz grains occur rarely. Argillite layers commonly exhibit desiccation cracks, and some thick sand beds contain crossbeds. Mud rip-up clasts as much as 5 cm across are common. Coarse, floating, well-rounded quartz grains and chalky white feldspar grains are obvious in hand sample. Some quartz grains are well rounded, but feldspar grains are angular, suggesting two source areas. Correlated with the Swauger Formation on the basis of grain size, bed thicknesses, and stratigraphic position observed on the west-adjacent Kelly Lake 7.5′ quadrangle (Lonn and McDonald, 2004) where it was mapped as Bonner and Mount Shields Formation. Exposed thickness is less than 600 m (2,000 ft), but a thickness of about 3,700 m (12,000 ft) is reported for the southern Sapphire Range immediately to the north (Wallace and others, 1989; Lonn and others, 2003; labeled as Mount Shields 2 on both maps and reinterpreted as Swauger Formation by Lonn, 2014 and Lonn and others, 2016). On the Salmon 30′ x 60′ quadrangle, the Swauger Formation is as much as 5,500 m (18,000 ft) thick (Burmester and others, 2016).

Ypng **Calc-silicate gneiss of Piegan Group (Mesoproterozoic)**—Green to gray, dense, fine-grained, variably schistose rock composed of decimeter- to centimeter-scale layers of diopside, quartz, and plagioclase alternating with very fine-grained biotite quartzite. Calcite and dolomite are not present. Isoclinal folds with axial planes parallel to the regional layering suggest that this layering is transposed bedding (fig. 2A). Correlation with the Piegan Group of the Belt Supergroup is based on its gradation to less metamorphosed strata north of the quadrangle (fig. 1) mapped as Piegan Group (Lonn and others, 2003). Thickness is unknown because of deformation and metamorphism.

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Figure 2. Deformation in the calc-silicate gneiss (unit Ypng). A) Outcrop-scale tight to isoclinal folds (lowest part of outcrop) with axial planes approximately parallel to regional layering suggest that layering is transposed bedding. B) Multiple fold generations are evident in some areas.

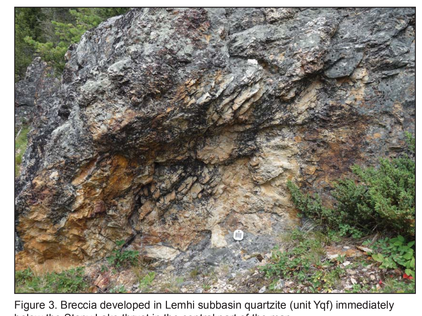


Figure 3. Breccia developed in Lemhi subbasin quartzite (unit Yqf) immediately below the Stony Lake thrust in the central part of the map.

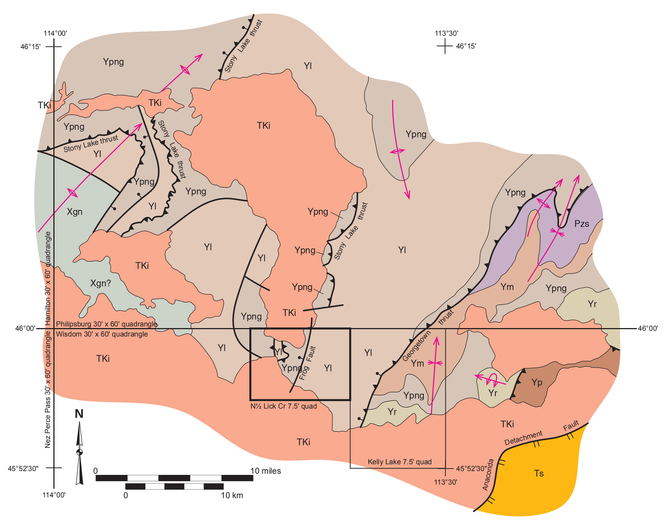
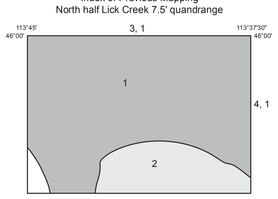


Figure. 1. Simplified geologic map of the southern Sapphire Mountains and northwestern Anaconda Range showing the location of the north half of the Lick Creek 7.5′ quadrangle with respect to 30′ x 60′ quadrangles and major geologic and tectonic features discussed in the text. Ts—Tertiary sedimentary deposits; TKi—intrusive igneous rocks; Pzs—Paleozoic sedimentary rocks; Ym—Missoula Group; Yr—Ravalli Group; Yl—Lemhi subbasin strata; Yp—Prichard Fm; Ypng—Piegan Group; Xgn—gneiss and schist. Geology modified from Lonn and others (2003), Wallace and others (1989), Desmarais (1983), Lonn and McDonald (2004), and includes results of this study.

Index of Previous Mapping
North half Lick Creek 7.5' quandrange



1. Wallace and others, 1989, scale 1:50,000
2. Wallace and others, 1992, scale 1:50,000
3. Lonn and others, 2003, scale 1:100,000
4. Lonn and McDonald, 2004, scale 1:24,000
Desmarais, 1983, entire quad at 1:48,000-scale
Ruppel and others, 1993, entire quad at 1:250,000-scale

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Geologic Map of Part of the Lick Creek 7.5' Quadrangle, Southwest Montana

Jeffrey D. Lonn

2017