GEOLOGIC MAP OF THE STIBNITE QUADRANGLE, VALLEY COUNTY, IDAHO

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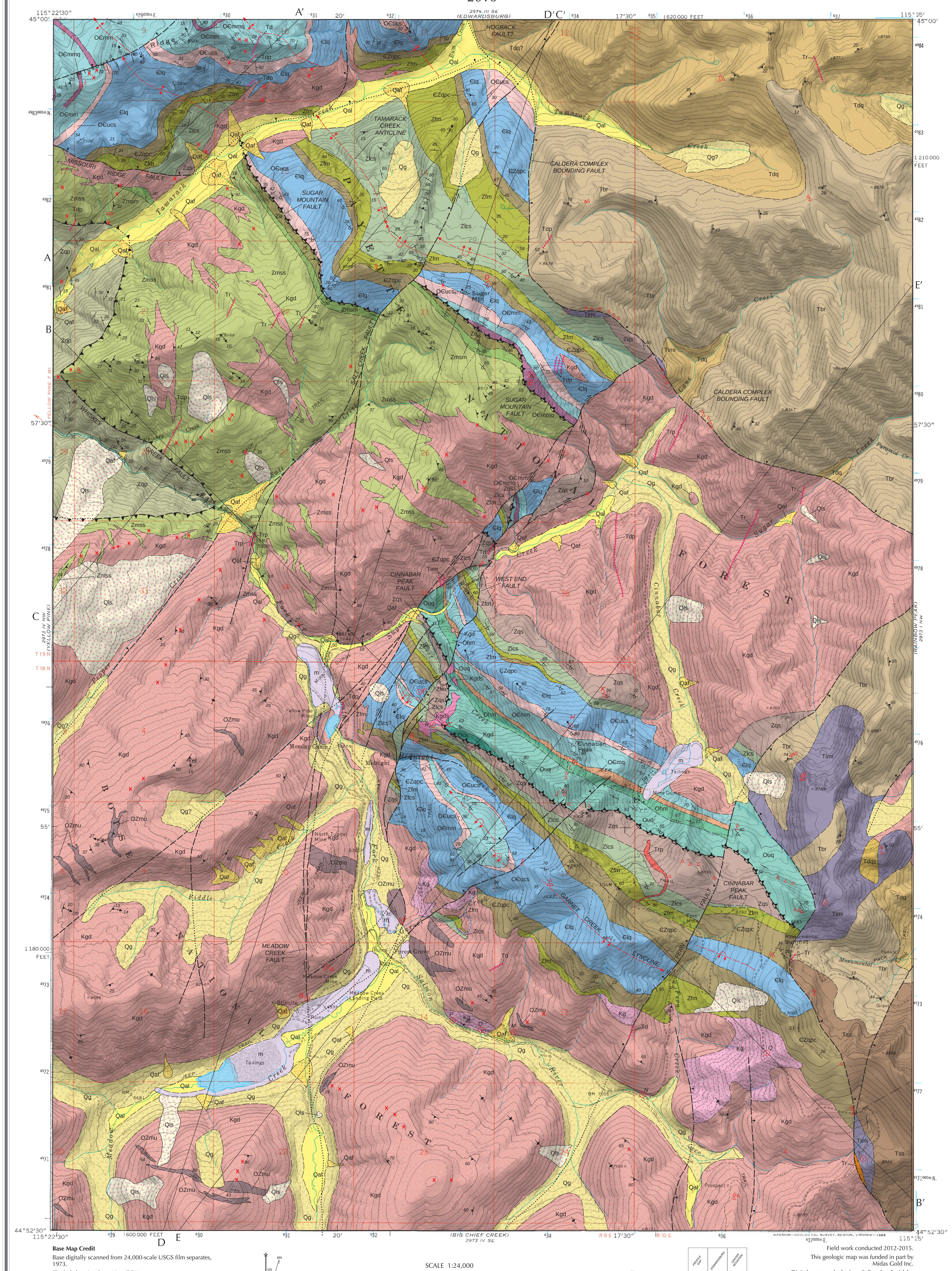
2016



Base Map Credit
Base digitally scanned from 24,000-scale USGS film separates, 1973.
Shaded elevation from 10 m DEM.
Topography by photogrammetric methods from aerial photographs taken 1964 and 1972. Field checked 1973.
Projection: Idaho coordinate system, west zone (Transverse Mercator). 1927 North American Datum.
10,000-foot grid ticks based on Idaho coordinate system, west zone.
1000-meter Universal Transverse Mercator grid ticks, zone 11.
Declination from NOAA National Geophysical Data Center.

SCALE 1:24,000

Contour interval 80 feet

QUADRANGLE LOCATION

ADJOINING QUADRANGLES

Field work conducted 2012-2015.
This geologic map was funded in part by Midas Gold Inc.
Digital cartography by Jane S. Freed at the Idaho Geological Survey's Digital Mapping Lab.
Technical review by Niki E. Wintzer, Stephen E. Box, Renee L. Breedlovestrout, Dennis Feeney, Virginia S. Gillerman, and Michael E. Ratchford.
Editorial review by Alyson R. Kral.
Map version 2-13-2017.
PDF (Acrobat Reader) map may be viewed online at www.idahogeology.org.

Table 1. U-Pb zircon ages for igneous rocks and detrital zircons in the Stibnite quadrangle and Profile Creek area.

Map Letter	Sample number	Sampler	Latitude*	Longitude*	UTM Easting**	UTM Northing**	Location	Unit	Unit name	Lithology	Analyst	Results

*NAD 27
**UTM, Zone 11, NAD 83
Analyses are by laser-ablation ICP-MS methods performed at Washington State University, Pullman, Washington, or at Boise State University, Boise, Idaho.

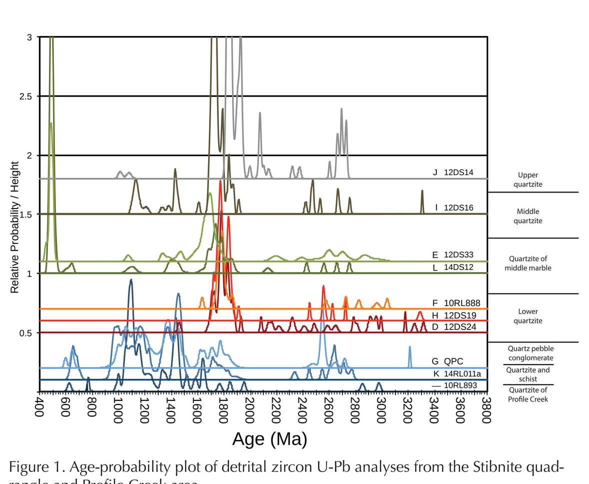
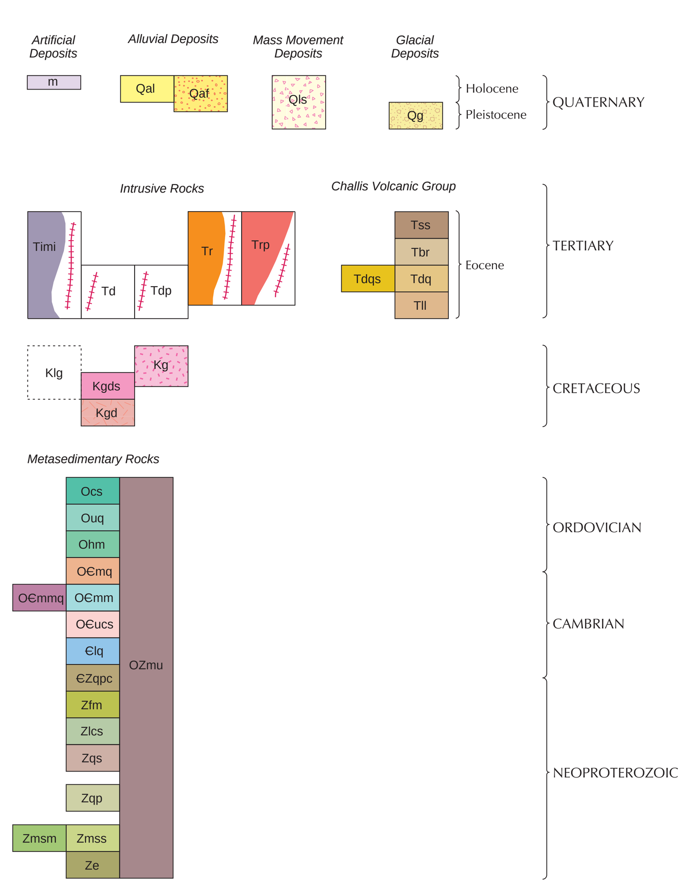


Figure 1. Age-probability plot of detrital zircon U-Pb analyses from the Stibnite quadrangle and Profile Creek area.

CORRELATION OF MAP UNITS



INTRODUCTION

The Stibnite quadrangle is underlain by metamorphosed sediments of Neoproterozoic and Paleozoic age within the Stibnite and Missouri Ridge-Sugar Mountain roof pendants. They have undergone lower amphibolite facies metamorphism of probable Cretatceous age. These strata have been extensively intruded by several pulses of Cretaceous magma, and are complexly folded with apparent reverse, normal, and (or) strike-slip fault movement. Some of the structures were extensively mineralized and have been exploited to produce gold, tungsten, antimony, and mercury. Most of the metasedimentary rocks are nearly vertical to overturned and young to the southwest. All of these factors add to the difficulty of correlating units between areas separated by intrusive rock. Volumetrically minor Eocene dikes, sills, and small intrusions are also present. In the eastern part of the quadrangle down-faulted Eocene volcanic rocks fill a caldera collapse structure. Quaternary surficial deposits occur in stream beds and glaciated areas.

Geologic mapping was conducted during the summers of 2012, 2013, 2014, and 2015. The work of Smitherman (1985) on the Stibnite roof pendant was used extensively by the present authors and many of his unit names are utilized in this study. Virginia Gillerman of the Idaho Geological Survey conducted parallel research on the ore deposits in the quadrangle. Preliminary results are presented in Gillerman and others (2014). Previous studies that focused on the mineralization in the area include Schrader and Ross (1925), Currier (1935), White (1940), Cooper (1951), and Cookro and others (1988). Foliation measurements in intrusive rocks are in part from unpublished mapping by B.F. Leonard (U.S. Geological Survey Field Records Library).

SYMBOLS

Contact: dashed where approximately located.

Normal fault: ball and bar on downthrown side; dashed where approximately located; dotted where concealed.

Thrust fault: teeth on upper plate; dashed where approximately located; dotted where concealed.

Overturned thrust fault: teeth in direction of dip; dashed where approximately located; dotted where concealed.

Right-lateral strike-slip fault: dashed where approximately located; dotted where concealed.

Reactivated(?) right-lateral strike-slip fault: bar and ball on downthrown reactivated segments; dashed where approximately located; dotted where concealed.

Reactivated(?) left-lateral strike-slip fault: bar and ball on downthrown reactivated segments; dashed where approximately located; dotted where concealed.

Anticline axial trace: dashed where approximately located; dotted where concealed. Arrow indicates plunge.

Overturned anticline axial trace: dashed where approximately located.

Syncline axial trace: dashed where approximately located; dotted where concealed. Arrow indicates plunge.

Overturned syncline axial trace: dashed where approximately located.

40 Strike and dip of bedding.

Strike of vertical bedding.

15 Strike and dip of bedding where sedimentary structures show bedding to be upright.

65 Strike and dip of bedding where sedimentary structures show bedding to be overturned.

58 Strike and dip of bedding where stratigraphic position indicates bedding is likely overturned.

30 Strike and dip of foliation.

Strike of vertical foliation.

60 Estimated strike and dip of foliation.

40 Strike and dip of mylonitic foliation.

75 Strike and dip of flow or compaction foliation in volcanic rocks.

50 Bearing and plunge of lineation, type unknown.

15 Bearing and plunge of mineral lineation.

30 Bearing and plunge of crenulation lineation.

Bearing and plunge of small fold axis.

Bearing and plunge of asymmetrical small fold showing clockwise rotation viewed down plunge.

Location of Klg.

Tectonic breccia.

Quartz vein.

Open pit mine headwall.

Location and letter of samples used for age determination (See Table 1).

Location and letter of samples used for chemical analysis (See Table 2, Plate 2).

DESCRIPTION OF MAP UNITS

In the following unit descriptions and later discussion of structure we use the metric system for sizes of mineral or clast constituents of rock units and also for small-scale features of outcrops. Unit thickness and distance are listed in both meters and feet (m/ft). Grain size classification of unconsolidated and consolidated sediment is based on the Wentworth scale (Lane, 1947). Intrusive rocks are classified according to IUGS nomenclature using normalized values of modal quartz (Q), alkali feldspar (A), and plagioclase (P) on a ternary diagram (Streckeisen, 1976). Volcanic rocks are classified by total alkali versus silica chemical composition according to IUGS recommendations (LeMaitre, 1984).

SEDIMENTARY DEPOSITS

m **Made ground (Recent)**—Mine dumps, tailings piles, and disturbed glacial and stream deposits along East Fork of the South Fork of the Salmon River, Meadow Creek, and upper Cinnabar Creek. Not shown in upland areas. Consists of cobble, pebble, boulder, sand, and silt-sized material. Many of the dumps and tailings have been re-contoured.

Qal **Alluvium (Holocene)**—Silt, sand, pebbles, and cobbles formed as channel or overbank deposits. May include terrace deposits along Tamarack Creek. Clasts are rounded and locally show crude stratification and sorting.

Qls **Landslide deposits (Holocene)**—Silt- to boulder-sized debris; subangular to angular clasts are poorly sorted. Formed by slope failure and characterized by hummocky surface and fan-shaped plan view.

Qaf **Alluvial fan deposits (Holocene)**—Pebbles, cobbles, sand, and silt deposited near the mouth of streams where the gradient decreases. Clasts are rounded; deposits locally stratified.

Qg **Glacial deposits (Pleistocene)**—Unsorted to poorly sorted cobbles, gravel, boulders, and sand deposited as lateral, ground, and end moraines. Includes outwash material in the lower elevations. Some material has been re-worked by streams. Lateral moraine deposits extend as much as 125 m (410 ft) above valley floor.

INTRUSIVE ROCKS

Tr **Rhyolite dikes (Eocene)**—Light to medium gray rhyolite with less than 15 percent phenocrysts of quartz (as much as 2 mm in length and typically partially resorbed), potassium feldspar (as much as 2 mm in length), plagioclase, and minor biotite. Phenocrysts are set in an aphanitic matrix of quartz and feldspar. Locally aphyric.

Trp **Rhyolite porphyry dikes (Eocene)**—Light gray to light pink, highly porphyritic rhyolite containing as much as 70 percent phenocrysts of quartz (typically partially resorbed), potassium feldspar, plagioclase, and minor biotite. Phenocrysts are as much as 20 mm in size, set in an aphanitic groundmass of quartz and feldspar.

Td **Dacite dikes (Eocene)**—Medium gray to dark green-gray, fine-grained to aphanitic dacite with sparse phenocrysts of plagioclase, biotite, and hornblende.

Tdp **Dacite porphyry dikes (Eocene)**—Dark gray to dark green-gray dacite with conspicuous white phenocrysts of plagioclase as long as 10 mm in a fine-grained to aphanitic groundmass. Phenocrysts that comprise as much as 50 percent of the rock consist of plagioclase, potassium feldspar, hornblende, biotite, and minor quartz.

Timi **Intermediate and mafic intrusive rocks (Eocene)**—Dark green-gray to black, weakly porphyritic dacite to basaltic andesite. Phenocrysts that comprise <10 percent of the rock consist of white plagioclase as much as 4 mm in length, minor hornblende, and, locally, biotite or pyroxene. No visible quartz. Two whole-rock geochemical samples are dacite in composition (Table 2, Plate 2). Fisher and others (1992) show the exposure north of Monumental Summit as Tertiary latite lavas. We found no vesicles, autoclastic breccia, or other indications of volcanic origin. Instead we interpret this unit as entirely intrusive. It occurs as composite dikes, sills, and small stocks with multiple internal contacts and heterogeneous composition and texture. In places intrusion was along the ring fracture/caldera bounding fault zone of the Thunder Mountain caldera complex following post-eruption collapse of the caldera floor. Two dikes north of Sugar Creek near the center of section 25 contain dark, dense very fine-grained rock that displays a conspicuous thick weathering rind and may be Miocene(?) basalt or basaltic andesite.

Klg **Leucocratic granite (symbol only) (Cretaceous)**—White to light gray, generally fine- to locally medium-grained biotite-muscovite granite. Unit is shown as point data on map and does not show on cross sections. Equigranular with subequal amounts of quartz, plagioclase, and potassium feldspar. Muscovite occurs as disseminated flakes as much as 2 mm in size, comprising a maximum of 5 percent of the rock. Biotite is rare. Termed "alaskite" by previous workers. Occurs primarily as dikes cutting both country rock and *Kgd*, but also as small stocks. Two phases of leucocratic granite intrusion are noted; pre- and post-*Kgd*. Many ore bodies in the Stibnite area are localized at the intersections of leucocratic granite dikes and faults or favorable host sediments (Chris Dail, oral commun., 2012). Post-*Kgd* intrusion emplaced the greater volume of leucocratic granite and appears to be temporally associated with intrusion of *Kg*. Compositions of the leucocratic granite and *Kg* are similar; the latest-stage leucocratic granite perhaps forms dikes that radiate from *Kg* bodies. U-Pb age determination on sample from drill core near the Meadow Creek landing field is 87.9 ± 4.9 Ma (Table 1). Age is based on seven zircon rim analyses on four zircons by laser-ablation ICP-MS methods at Washington State University (Richard Gaschnig, written commun., 2011). Large error is due to a low number of zircons found in sample. Gillerman and others (2014) report an age on "alaskite" as 83.6 ± 0.1 Ma collected from a drill hole north of the Yellow Pine pit. This intrusion cuts *Kgd* and is mineralized (Virginia Gillerman, written commun., 2014). Leucocratic granite both cross-cuts and is deformed by the folding in the area, indicating multiple intrusive ages.

Kg **Granite (Cretaceous)**—Light gray, medium- to locally coarse-grained equigranular biotite-muscovite granite consisting of subequal quartz, plagioclase, and potassium feldspar. Muscovite occurs as books as much as 3 mm thick. Biotite is minor constituent at some localities. Locally porphyritic with quartz as much as 4 mm in size.

Kgds **Granodiorite of the Stibnite stock (Cretaceous)**—Light gray, fine- to medium-grained equigranular muscovite-biotite granodiorite. Plagioclase feldspar is the principle constituent, followed by quartz and potassium feldspar. Contains both muscovite and biotite and overall is finer grained and more muscovite-rich than K*gd.* Like the more widespread K*gd* unit, the stock has been termed "quartz monzonite" by previous workers, but quartz content is more than 20 percent. May also include some granite. U-Pb age determination on sample from the north rim of the Stibnite pit is 84.9 ± 2.0 Ma (Table 1). Age is based on 10 zircon rim analyses by laser-ablation ICP-MS methods at Washington State University (Richard Gaschnig, written commun., 2011). Gillerman and others (2014) report a similar but more precise age of 85.7 ± 0.1 Ma based on U-Pb TIMS analyses.

Kgd **Granodiorite (Cretaceous)**—Light gray, medium- to locally coarse-grained equigranular biotite granodiorite. Isolated flakes of muscovite as large as 2 mm comprise as much as 2 percent of the rock locally. Plagioclase feldspar is the principle constituent, followed by quartz comprising more than 20 percent, and potassium feldspar. Biotite is the most abundant mafic mineral present, occurring as small (<2 mm) well-disseminated flakes that make up less than 10 percent of the rock. Rare hornblende in mafic inclusions. Myrmekitic intergrowth of feldspar and quartz is conspicuous in thin section. Termed "quartz monzonite" by previous workers, but quartz content and feldspar ratios indicate a granodiorite composition using the classification of Streckeisen (1976). May also include some granite. Locally displays a weak to strong foliation, most of which is probably magmatic. Foliation orientations typically do not parallel mapped faults or the boundaries of the roof pendants. Locally porphyritic with euhedral potassium feldspar crystals as much as 3 cm in length. U-Pb age determination on sample from drill core near the Meadow Creek landing field is 91.2 ± 2.2 Ma (Table 1). Age is based on 13 zircon rim analyses by laser-ablation ICP-MS methods at Washington State University (Richard Gaschnig, written commun., 2011). Gillerman and others (2014) report a similar age of ~89 Ma from "quartz monzonite" collected from a drill hole north of the Yellow Pine pit (U-Pb zircon LA-ICP-MS analysis).

CHALLIS VOLCANIC GROUP

Tss **Sunnyside tuff (Eocene)**—Light tan to medium reddish orange-brown, crystal-rich, moderately to densely welded rhyolitic ash to lapilli tuff. Phenocrysts as much as 5 mm in size of quartz (commonly partially resorbed), sanidine, and rare biotite and hornblende that comprise from 20 percent to 40 percent of the rock are set in a pervasively altered aphanitic groundmass. The unit is made up of multiple cooling units. Some beds contain flattened pumice as much as 15 mm in length. Lithic fragments of volcanics and quartzite as much as 1 cm in size are present at some intervals. The unit is ubiquitously iron stained and weathers to a coarse soil.

Tbr **Buff rhyolite (Eocene)**—Light tan to gray, nearly aphyric, moderately to densely welded rhyolitic ash tuff. Rare phenocrysts are as much as 2 mm in size of quartz (commonly partially resorbed), feldspar, and altered biotite. Phenocrysts comprise less than 10 percent of the rock. The aphanitic groundmass is flow banded with discontinuous dark gray flow and compaction laminae at millimeter or finer scale and is pervasively altered. Flow laminations are commonly folded at millimeter to centimeter scale. Deposit is made up of multiple cooling units and includes rare vitrophyre as much as 8 cm thick containing small porcelain-like spherical masses with concentric layers, and rare, thin (<50 cm) layers of pumice or lithic-rich tuff. Dark, flattened pumice as much as 6 mm in length is present in some layers. Weathers to distinctive thin (2-4 mm) plates that form abundant float; forms poor soil with little vegetation.

Tdq **Dime and quarter tuff (Eocene)**—Multiple cooling units of densely welded, lithic lapilli to ash flow tuff of dacitic composition. Green flattened pumice clasts the size of dimes and quarters, present locally, are diagnostic. More extensively exposed northeast of the map area in the Big Creek drainage (Stewart and others, 2013) and to the south along Indian Creek (Fisher and others, 1992).

Tdqs **Sedimentary rocks of dime and quarter tuff (Eocene)**—Boulders and cobbles of dacitic volcanic rock and biotite granodiorite. Possibly a lahar deposit.

Tll **Lower latite lava (Eocene)**—Crystal-poor, flow-layered latite lavas and porphyritic dacite and rhyodacite flows. Shown only in cross section and on regional geologic map (Fig. 2). Exposed south of map area in Indian Creek drainage (Fisher and others, 1992).

METASEDIMENTARY ROCKS

Lower Paleozoic strata

Ocs **Calc-silicate of Midnight Creek (Ordovician)**—Mixed unit of calc-silicate rock, dolomitic marble, phyllite, and quartzite exposed northeast of the Stibnite pit, north of Midnight Creek. Previously undescribed, this unit appears to be stratigraphically above, and in gradational contact with, the upper quartzite unit. A less likely alternative is that this unit is a fault sliver of the Fern marble and lower calc-silicate unit. Investigation of the contact with the ridge- forming upper quartzite showed no clear evidence of a fault. Instead, a traverse northward (down section) appears to transition from dolomite to phyllite then into interbedded calc-silicate and quartzite, and finally quartzite of the upper quartzite unit. Assuming no fault exists, the likely correlative unit is the Ordovician Saturday Mountain Formation exposed in the Clayton area to the southeast (Hobbs and Hays, 1990).

Ouq **Upper quartzite (Ordovician)**—Light gray to white, fine- to coarse-grained quartzite and minor siltite. Quartzite contains approximately 99 percent quartz as moderately to poorly sorted subrounded grains. Sedimentary structures are commonly obscured by recrystallization and brecciation but local centimeter-scale bedding and planar cross-stratification is observed. Two thin intervals of siltite are present south of Cinnabar Peak and biotite phyllite interbedded with quartzite is present in the upper part of the Cinnabar Creek drainage northwest of Monumental Summit. Thickness approximately 400 m (1,310 ft). Lund (2004) correlated the upper quartzite of Smitherman (1985) with the Moores Lake Formation of Neoproterozoic age. Correlated here with the Ordovician Kinnikinic Quartzite in the Bayhorse area (Hobbs and Hays, 1990) on the basis of high stratigraphic position and detrital zircon ages largely >1800 Ma (sample J, Table 1, from south of Cinnabar Peak) and thus similar to ages from the type Kinnikinic exposed to the southeast near Clayton (Barr, 2009; Paul Link, written commun., 2012). Zircon ages are discussed in more detail in the following section.

Ohm **Hermes marble (Ordovician)**—Light gray to light brown, massive dolomitic marble. Coarsely recrystallized, relatively pure carbonate that is not ribbon laminated. Smitherman (1985) reports altered tremolite porphyroblasts. Includes thin (1 cm and less) discontinuous interbeds of gray chert or jasperoid. Thickness is approximately 100 m (330 ft). Previously correlated with the "gray marble" unit, thought to be of Neoproterozoic or Cambrian age (Lund, 2004). Correlated here with the Ordovician Ella Dolomite in the Bayhorse area (Hobbs and Hays, 1990) on the basis of stratigraphic position.

O€mq **Middle quartzite (Cambrian to Ordovician)**—Light gray, medium- to fine-grained quartzite. Contains approximately 99 percent quartz and 1 percent potassium feldspar. Moderately to poorly sorted and moderately rounded. Bedding locally is centimeter scale, although sedimentary features are largely obscured by recrystallization and brecciation. Thickness approximately 80 m (260 ft). Previously included in the "gray marble" unit, thought to be of Neoproterozoic or Cambrian age (Lund, 2004). The quartzite contains four 500 Ma detrital zircons (sample I, Table 1, from south of Cinnabar Peak) indicating a likely Cambrian or Ordovician age. Not shown in Figure 1 because of discordance >10%. See zircon age discussion in following section.

O€mm **Middle marble (Cambrian to Ordovician)**—Medium gray, mostly massive marble with faint millimeter-scale laminations. Top 10 m consists of millimeter- to centimeter-scale interbeds of marble and resistant silica-rich laminae (ribbon laminated). Medium to coarsely recrystallized. Includes a thin interval of sillimanite-biotite schist in northwest part of map. Locally contains gray anthophyllite as 1cm long "sticks" with square cross section, along with phlogopite, biotite, graphite, and diopside. Thickness is approximately 160 m (525 ft) in the Stibnite roof pendant, but may be greater in the Missouri Ridge-Sugar Mountain roof pendant. Previously included in the "gray marble" unit, thought to be of Neoproterozoic or Cambrian age, and Missouri Ridge Formation, thought to be Neoproterozoic (Lund, 2004). On the basis of stratigraphic position we consider its age to be Cambrian or, less likely, Ordovician.

O€mmq **Quartzite within middle marble (Cambrian to Ordovician)**—Light gray, medium- to coarse grained quartzite present locally within the middle marble unit. Locally contains approximately 5 percent potassium feldspar and about 3 percent plagioclase. Thickness is approximately 25 m (80 ft). The quartzite contains abundant 500 Ma detrital zircons (samples E and L, Table 1, from south of Sugar Mountain and Missouri Ridge) consistent with a Cambrian or Ordovician age (see zircon age discussion in following section).

O€ucs **Upper calc-silicate (Cambrian to Ordovician)**—Light to medium gray-green, orange calc-silicate, marble, and silicic layers, which are interbedded on a millimeter to centimeter scale to produce a distinctive "ribbon-laminated" appearance. Minerals include quartz, calcite, biotite, plagioclase, scapolite, wollastonite, diopside, tremolite, muscovite, and magnetite. Serpentine and chlorite (after olivine?) are present in some of the marble. Thickness is approximately 125 m (410 ft). Previously assigned to the "gray marble" unit, of Neoproterozoic or Cambrian age (Lund, 2004). On the basis of stratigraphic position we consider its age to be Cambrian or, less likely, Ordovician.

€lq **Lower quartzite (Cambrian)**—Light gray, medium- to very coarse grained quartzite and minor schist or phyllite. Moderately to poorly sorted, locally bi-modally sorted with coarse grains "floating" in a medium-grained matrix. Most exposures contain little or no feldspar, but a sample of quartzite from Sugar Mountain contains about 5 percent potassium feldspar and trace amount of plagioclase feldspar. Moderately rounded grains. Overall coarser grained and less well sorted than upper quartzite (*Ouq*). Decimeter-scale bedding with diffuse bedding traces that locally display abundant planar cross laminae and, less commonly, trough cross laminae, ripple marks, and diffuse heavy mineral laminae. Thin (<3 cm) discontinuous beds of granule- to pebble-sized material fill scours and are more abundant lower in the unit. The granule beds are locally graded. Thickness is approximately 180 m (590 ft). Previously assigned to the Umbrella Butte Formation of Neoproterozoic to Cambrian age (Lund, 2004). Detrital zircon samples from Cinnabar Peak (F, Table 1), from west of West End Creek (H, Table 1), and from Sugar Mountain (D, Table 1), all contain abundant 1740-1840 Ma grains similar to Cambrian strata in the region. Zircon ages are discussed in more detail in following section.

Lower Paleozoic or Neoproterozoic strata

€Zqpc **Quartz pebble conglomerate (Cambrian to Neoproterozoic)**—Light to medium gray, medium- to coarse-grained quartzite, matrix-supported conglomerate, schistose quartzite, and muscovite-biotite schist. Individual conglomerate beds are as thick as 1 m and make up approximately 15-20 percent of the unit, with the major part being sand to granule size. As noted by Smitherman (1985), pebbles in the central and southeast part of the map are well rounded and commonly flattened and stretched. Most clasts consist of quartz, some of which are bluish, but dark-gray siltite, dark chert, and marble comprise as much as 5 percent of the clast population near the base north of the Fern mine. Overall poorly sorted with pebbles supported by granule and sand-sized matrix. Exposures in the West End pit and Stibnite pit areas are more schistose than those to the south near the Fern mine and clast diversity is greater in the south. Thickness is approximately 100 m (325 ft) but is variable, and locally the unit is not present. Previously assigned to the Umbrella Butte Formation of Neoproterozoic age (Lund, 2004). Detrital zircon ages from the quartz pebble conglomerate (G, Table 1) as young as 685 Ma indicate a Neoproterozoic or younger age (see zircon age discussion below). Rests unconformably on the underlying Fern marble, with channels and karst at the contact (Chris Dail, oral commun., 2012).

Windermere Supergroup(?)

Zfm **Fern marble (Neoproterozoic)**—Medium to dark gray, coarsely re-crystallized marble. Massive to ribbon laminated on a millimeter to centimeter scale. North of Monumental Summit contains thin (< 20 cm) interbeds of quartzite. Dolomite is the principle mineral, with tremolite present locally. Thickness is approximately 40 m (130 ft). Lund (2004) assigned the Fern marble of Smitherman (1985) and underlying calc-silicate rocks to the Neoproterozoic Missouri Ridge Formation. Neoproterozoic age also assigned here on the basis of stratigraphic position. Fossil locality reported from the Fern marble along ridge in sec. 12, T. 18 N., R. 9 E., north of the Fern Mine (Lewis and Lewis, 1982) was visited in 2014 by the authors. Fossil-like structures there were reinterpreted as metamorphic minerals, mostly amphibole.

Zlcs **Lower calc-silicate (Neoproterozoic)**—Medium to dark gray-green, orange calc-silicate rock and calc-silicate marble. Thin bedded and ribbon laminated on a millimeter to centimeter scale. Quartz, biotite, calcite, and muscovite are common; calc-silicate minerals include epidote, tremolite, actinolite, anthophyllite, hornblende, diopside, scapolite, and vesuvianite. Smitherman (1985) reports microcline-rich layers and, in one sample, mats of cross-cutting talc. Thickness is approximately 300 m (980 ft). Lund (2004) assigned the lower calc-silicate and overlying Fern marble to the Missouri Ridge Formation of Neoproterozoic age. We also assign a Neoproterozoic age based on stratigraphic position.

Zqs **Quartzite and schist (Neoproterozoic)**—Interbedded light-gray quartzite and medium- to dark-gray muscovite-biotite-quartz-feldspar schist. Schist that comprises approximately 80 percent of the unit consists of as much as 40 percent small (<1 mm) biotite and muscovite in varying proportions and 60 percent or more fine-grained quartz and plagioclase in varying proportions. At some localities, such as at the headwaters of Fern Creek, the rock is phyllitic siltite (or meta-siltite) rather than schist. Smitherman (1985) reports andalusite, fibrolitic sillimanite, and chlorite, along with accessory minerals tourmaline, zircon, sphene, apatite, graphite, magnetite, and pyrite. Garnet-bearing schist is reported from 610 m (2000 ft) south of the Hermes mine (Smitherman, 1985). Quartzite is medium grained to coarsely recrystallized and moderately sorted and rounded. It contains quartz and muscovite and in one sample 3 percent plagioclase. Locally dark gray due to recrystallization, silicification, or intergranular graphite especially on upper Fern Creek. Thickness is approximately 130 m (425 ft), but lower contact is assimilated by intrusives. Lund (2004) variously assigned this unit to the Neoproterozoic Moores Station and Plummer Point formations at different localities. We too assign a Neoproterozoic age, based on stratigraphic position and similarity of detrital zircon ages (sample K, Table 1) to regional strata of this age as discussed in the following section.

Zqp **Quartzite of Profile Creek (Neoproterozoic)**—Medium gray, medium- to coarse-grained feldspathic quartzite with feldspar content as much as 20 percent. Plagioclase feldspar is in excess of potassium feldspar and some of the feldspar is interstitial or in veinlets, indicating a secondary origin. Bedded on a centimeter scale with planar cross laminations and rare graded beds. Contains millimeter-scale biotite-rich interbeds and centimeter-scale granule beds. Amphibolite sills present locally. Minimum thickness is approximately 500 m (1640 ft); base is not exposed. Lund (2004) assigned this unit to the Gunsight Formation of the Mesoproterozoic age Lemhi Group. A sample collected along Profile Creek, west of the map, contains an abundance of 1090-1150 Ma detrital zircons with one as young as 685 Ma, indicating that these rocks are more likely Neoproterozoic in age. Zircon ages are discussed in more detail in following section.

Windermere Supergroup

Zmss **Schist of Moores Station Formation (Neoproterozoic)**—Schist and minor calc-silicate rocks. Schist is medium to dark gray and consists of as much as 40 percent small (<1 mm) biotite and muscovite in varying proportions and 60 percent or greater fine-grained quartz and plagioclase in various proportions. Locally includes thin quartzite beds, rare calc-silicate gneiss, amphibolite, and biotite muscovite quartz feldspar schist in highly metamorphosed pods, screens, and schlieren within *Kgd* south of the East Fork of the South Fork of the Salmon River and north of Salt Creek. Includes rare matrix-supported quartz pebble conglomerate north of the mouth of Whiskey Creek (44.9593° N, 115.3637° W). Sillimanite is common. Mineral lineations in the schist generally plunge shallowly (10-20 degrees) to the southeast. Thickness unknown because of internal folding and the presence of a foliation that may be transposed bedding. Lund (2004) assigned this unit to the Plummer Point Formation, thought to be stratigraphically low in the sequence. Tentatively mapped here as the younger Moores Station Formation on the basis of stratigraphic position.

Zmsm **Marble of Moores Station Formation (Neoproterozoic)**—Buff to light gray marble and lesser amounts of millimeter- to centimeter-laminated calc-silicate rock. Thickness 0-40 m (0-130 ft); unit pinches out locally.

Ze **Edwardsburg Formation (Neoproterozoic)**—Predominantly metamorphosed, poorly sorted, faintly mm- to cm-scale bedded fine-grained to granule sandstone with abundant hornblende, epidote, and biotite in the matrix. Rounded quartzite pebbles as much as 8 mm in diameter are common in some horizons, as are dark, angular, flattened/stretched clasts of calc-silicate as much as 6 cm in length. The deposit is matrix supported, with clasts comprising less than 40 percent of the rock. Long axes of clasts plunge 30-40 degrees to the north at one locality. Amphibolite is also present in layers as much as 1 m thick. The unit is most similar to the matrix-supported diamictite and graded volcaniclastic rocks of the Wind River Meadow member of the Edwardsburg as described by Lund (2004) west of Big Creek Guard Station approximately 20 km (12 mi) to the north. Only the Wind River Meadow member of the Edwardsburg Formation is present on Sugar Mountain; the mafic metavolcanics of the Golden Cup member and the clast-supported diamictites of the Placer Creek member are absent. Thickness is estimated to be 50 m (165 ft). The formation is laterally discontinuous and truncated by faults.

OZmu **Metasedimentary rocks, undivided (Ordovician to Neoproterozoic)**—Schist, quartzite, and calc-silicate rocks present as small roof pendants and screens within intrusive rocks. Many contain igneous-like components, including mafic-rich quartz-feldspar rock with abundant sphene and (or) hornblende. Stratigraphic position is uncertain. In the southwestern part of the quadrangle, south and east of Meadow Creek, several relatively large bodies of calc-silicate rock crop out. These are included in *OZmu* because they do not exhibit distinctive characteristics that would allow them to be assigned to or excluded from the *Zlcs* or *O€ucs*.

DISCUSSION OF DETRITAL ZIRCON DATA

Quartzite samples for detrital zircon dating were collected from nine localities within the quadrangle and one locality along Profile Creek two miles west of the quadrangle (Table 1). Individual U-Pb zircon ages were obtained by Vince Isakson and Darin Schwartz using laser-ablation ICP-MS methods at Washington State University and Boise State University.

The Profile Creek sample (unit *Zqp*) has major populations at 1000-1200 and 1400-1500 Ma (Fig.1). A single grain at about 685 Ma is the youngest. The quartz pebble conglomerate (*€Zqpc*), collected near the Stibnite pit (G, Table 1), yielded similar results with major populations at 1000-1250, 1350-1500, and 2550 Ma; three grains are between 620 and 700 Ma. Also similar is sample K from the quartzite and schist unit (*Zqs*) northeast of Cinnabar Peak. Aside from the youngest ages, these results are similar to detrital zircon results from the lower part of the Neoproterozoic to Cambrian Camelback Formation in southeast Idaho (Yonkee and others, 2014) and consistent with a Neoproterozoic to Cambrian age for these rocks. Although few in number, the youngest zircons are likely sourced from the Edwardsburg Formation, which contains volcanic rocks of about 685 Ma and is exposed 20 km (12 miles) to the north (Lund and others, 2003) and in the map area. In contrast, three samples of the overlying lower quartzite (*€lq* from Cinnabar Peak, north highwall of the West End pit, and Sugar Mountain; D, F, and H in Table 1) contain mostly 1740-1840 Ma grains and lack the young Grenville-age and 685 Ma grains. These results are similar to detrital zircon signatures of Cambrian quartzite from other localities in the region such as the Addy Quartzite in northeastern Washington (Linde and others, 2014), the Gold Creek quartzite in northern Idaho (Lewis and others, 2010), the Clayton Mine Quartzite of central Idaho (Paul Link, written commun., 2012), and the Gibbson Jack Formation of southeastern Idaho (Yonkee and others, 2014). Quartzite within the middle marble southeast of Sugar Mountain (*O€mmq*; E, Table1) yielded numerous grains with ages about 500 Ma. That sample contained a second population at about 1680-1800 Ma, and a number of Archean grains. Similarly, sample L from the same unit on Missouri Ridge contained numerous 500 Ma grains. A stratigraphically higher sample from the middle quartzite (*O€mq*) southwest of Cinnabar Peak (I, Table 1) yielded a primary peak of about 1680-1800 Ma, a few Grenville (1060-1140 Ma) ages, and four grains with ages about 500 Ma (but with discordance >10%). The abundance of 500 Ma grains in the former is similar to that reported for the Worm Creek Member of the St. Charles Formation in southeastern Idaho (Todt and others, 2014), which contains only 500 Ma grains and is known to be Upper Cambrian on the basis of fossils and local stratigraphy. The 500 Ma grains are likely sourced from Late Cambrian and Early Ordovician plutons described by Lund and others (2009) that are exposed to the north and east of the quadrangle. Quartzite sampled south of Cinnabar Peak (unit *Ouq;* J, Table 1) contained an abundance of 1800-1950 Ma zircons that is most similar to ages reported from the Ordovician Kinnikinic Quartzite (Barr, 2009; Paul Link, written commun., 2012). Overall, the detrital zircon results support the idea that the majority of the metasedimentary rocks in the Stibnite and Missouri Ridge-Sugar Mountain roof pendants are Paleozoic in age. This finding supports early stratigraphic assignment of these rocks to the Paleozoic (Schrader and Ross, 1925; Shenon and Ross, 1936) based on lithologic features.

STRUCTURE

The deformational history of the metamorphosed sediments of the Stibnite and Missouri Ridge-Sugar Mountain roof pendants is complicated, and includes multiple episodes of contractional folding and faulting as well as extension. The roof pendants lie along the eastern margin of the Cretaceous Idaho batholith, and along the western boundary of the Thunder Mountain caldera complex. Much of the contractional deformation likely predated or was synchronous with the later stages of the emplacement of the early metaluminous suite of the Idaho batholith (100-85 Ma, Gaschnig and others, 2010). Extension was likely synchronous or post-dated the eruption of the Eocene Challis volcanics, and resulted in the preservation of Challis volcanics within and adjacent to the caldera complex in the eastern portion of the map. This extension also formed a series of northeast-striking normal faults within the batholith and roof pendants. Caldera complex bounding faults are discussed in the regional structure section on Plate 2.

GARNET CREEK SYNCLINE

The northwest-trending Garnet Creek syncline exposed within the Stibnite roof pendant is doubly plunging and overturned to the southwest (see cross-section B-B'). It was first described by Smitherman (1985). The syncline is tentatively interpreted to fold the Cinnabar Peak fault at depth.

TAMARACK CREEK ANTICLINE

The Tamarack Creek anticline is exposed within the Missouri Ridge-Sugar Mountain roof pendant in the northwest part of the quadrangle. For most of its exposed trace, the fold is overturned to the southwest. However, near Tamarack Creek the fold becomes upright and the fold wavelength increases. Smaller northeast-trending folds northwest of the Salt Creek fault re-fold the sedimentary units as well as the Tamarack Creek anticline. The Tamarack Creek anticline is interpreted to have formed at roughly the same time as the Garnet Creek syncline (Middle Cretaceous?).

CINNABAR PEAK FAULT

The Cinnabar Peak fault strikes northwest and dips steeply to the northeast. The fault was originally mapped by Smitherman (1985) as a normal fault, but he did not name the structure. The fault places overturned upper quartzite (*Ouq*) next to overturned quartzite and schist (*Zqs*). The fault appears to be parallel or nearly parallel to bedding on both the hanging wall and footwall. The fault zone is poorly exposed, kinematic indicators were not observed, and the interpretation of a fault was largely due to the repetition of strata. Fault relations near the Stibnite stock are also uncertain, but the present interpretation is that the Cinnabar Peak fault is cut by the stock. If correct, the fault would be older than the 85.7 ± 0.1 Ma age of the intrusion.

We tentatively interpret the Cinnabar Peak fault to be an overturned thrust fault, folded by the Garnet Creek syncline (see cross-section E-E'). If correct, thrust motion was originally to the southwest, and represented a hanging wall flat on footwall flat. An alternative, less-favored interpretation is that the Cinnabar Peak fault is a late-stage normal fault that post-dates the Garnet Creek syncline.

SUGAR MOUNTAIN FAULT

The Sugar Mountain fault strikes northwest and dips steeply to the northeast, though it is locally folded. The fault separates overturned lower quartzite (*€lq*) and upper calc-silicate (*O€ucs*) from overturned Edwardsburg Formation (*Ze*) and the marble of Moores Station (*Zmsm*). Both the Edwardsburg Formation and upper calc-silicate units are discontinuous along the fault, though the fault appears to be roughly bedding parallel. The fault zone is characterized by abundant breccia and fracturing, and locally is intruded by Tertiary dikes. Iron staining is common along the fault. We tentatively interpret the Sugar Mountain fault to be an overturned thrust fault folded by the Tamarack Creek anticline. Like the Cinnabar Peak fault, we interpret thrust motion to have originally been to the southwest, and to represent a hanging wall flat on a footwall flat. Some attenuation of the Edwardsburg Formation and the upper calc-silicate units during folding is required for this interpretation.

The relationship between the Sugar Mountain fault and the Cinnabar Peak fault is uncertain. These two structures, as well as the Stibnite and Missouri Ridge-Sugar Mountain roof pendants, are offset by the Meadow Creek fault. Up-on-the-west and right-lateral motion on the Meadow Creek fault indicates the Missouri Ridge-Sugar Mountain roof pendant exposes a deeper crustal section than the Stibnite roof pendant. Assuming both the Sugar Mountain and Cinnabar Peak faults are overturned folded thrust faults, the Sugar Mountain fault may simply be a separate, deeper level thrust fault relative to the Cinnabar Peak fault. Alternatively, they could be considered the same fault and the Sugar Mountain fault may be linked to the Cinnabar Peak fault by a lateral ramp, present along the dismembered stratigraphic zone north of Sugar Creek. This lateral ramp would have to have been reactivated by the Meadow Creek fault, and the presence of such a lateral ramp may have induced the transtensional bend in the Meadow Creek fault. However, if the Cinnabar Creek and Sugar Mountain faults are both normal faults (i.e. Smitherman, 1985), both may be the same structure, with the Sugar Mountain fault representing the structure at a deeper level.

WHISKEY CREEK FAULT

The Whiskey Creek fault strikes north-northwest, dips moderately to the east-northeast, and places the Moores Station Formation (*Zms*) over the quartzite of Profile Creek (*Zqp*). It occurs only to the northwest of the Salt Creek fault, and is presumably intruded by Cretaceous biotite granodiorite (*Kgd*) to the southeast. The fault is roughly parallel to bedding in the quartzite of Profile Creek. The fault zone is characterized by foliated rock. No kinematic indicators were observed.

The Whiskey Creek fault is interpreted to record thrust motion; however, there is uncertainty due to the ambiguity in the stratigraphic location of the quartzite of Profile Creek (see discussion in the detrital zircon section). We suspect the Whiskey Creek fault is connected with the Sugar Mountain fault at depth, ramping up to a hanging wall flat on footwall flat where the current fault trace is exposed (see cross section C-C').

MISSOURI RIDGE FAULT

The Missouri Ridge fault in the far northwestern corner of the Stibnite 7.5' quadrangle strikes roughly east-west to northeast-southwest, and dips to the north. It places a package of gently folded strata stratigraphically above the quartzite and schist unit (*Zqs*) and below the middle marble (*O€mm*) over more tightly folded rocks of the hanging wall and footwall of the Sugar Mountain fault. We interpret the Missouri Ridge fault to record normal motion, bringing the hanging wall of the Whiskey Creek fault down to the north and east (see cross-section A-A'), placing more gently folded Whiskey Creek hanging wall strata in contact with the more tightly folded rocks adjacent to the Sugar Mountain fault. Movement on the Missouri Ridge fault must post-date thrusting associated with the Whiskey Creek and Sugar Mountain faults, but otherwise is poorly constrained.

MEADOW CREEK FAULT

The Meadow Creek fault is a major regional structure. In the southern Stibnite quadrangle, it strikes north-south, and dips sub-vertical. The strike turns northeastward near the Yellow Pine pit. The fault cuts Cretaceous granodiorite as well as displaces the Stibnite roof pendant from the Missouri Ridge-Sugar Mountain roof pendant. Parts of the fault zone are mineralized.

The Meadow Creek fault has components of both right-lateral and west-side up movement. It is uncertain if the fault has been rotated, and whether the west-side up motion represents original reverse or normal slip. The age of movement is poorly constrained, but must post-date both the emplacement of the Cretaceous granodiorite (*Kgd*) as well as the development of the Garnet Creek and Tamarack Creek folds. It also has at least some post-mineralization movement (Chris Dail; oral commun., 2012).

WEST END FAULT

The West End fault is subsidiary to the Meadow Creek fault. It strikes northeast and dips to the southeast. Movement on the West End fault included both normal and right-lateral components, as shown by drill hole data (Chris Dail, oral commun., 2012). Drill core also demonstrates that, at the West End pit, the West End fault dips steeply (65 degrees) to the east while mineralized zones dip shallowly to the east (Chris Dail, oral commun., 2012).

OTHER FAULTS

A series of northeast-striking normal faults cut the roof pendant, Cretaceous intrusive rocks, and in places the Challis volcanics. The Salt Creek fault, striking northeast and dipping steeply to the northwest, is one of the more important northeast-striking structures. It shows both normal and left-lateral motion, but doesn't displace the Challis volcanic caldera boundary in the upper reaches of Tamarack Creek. Another significant northeast-striking normal fault is the the Fern fault in the southeastern portion of the map area. It dips steeply to the northwest, and cuts metasediments of the Stibnite roof pendant folded by the Garnet Creek syncline. This fault displays a "scissors" type offset with the northwest side down in the south and the southeast side down in the north. It is interpreted to have had both normal and left-lateral movement.

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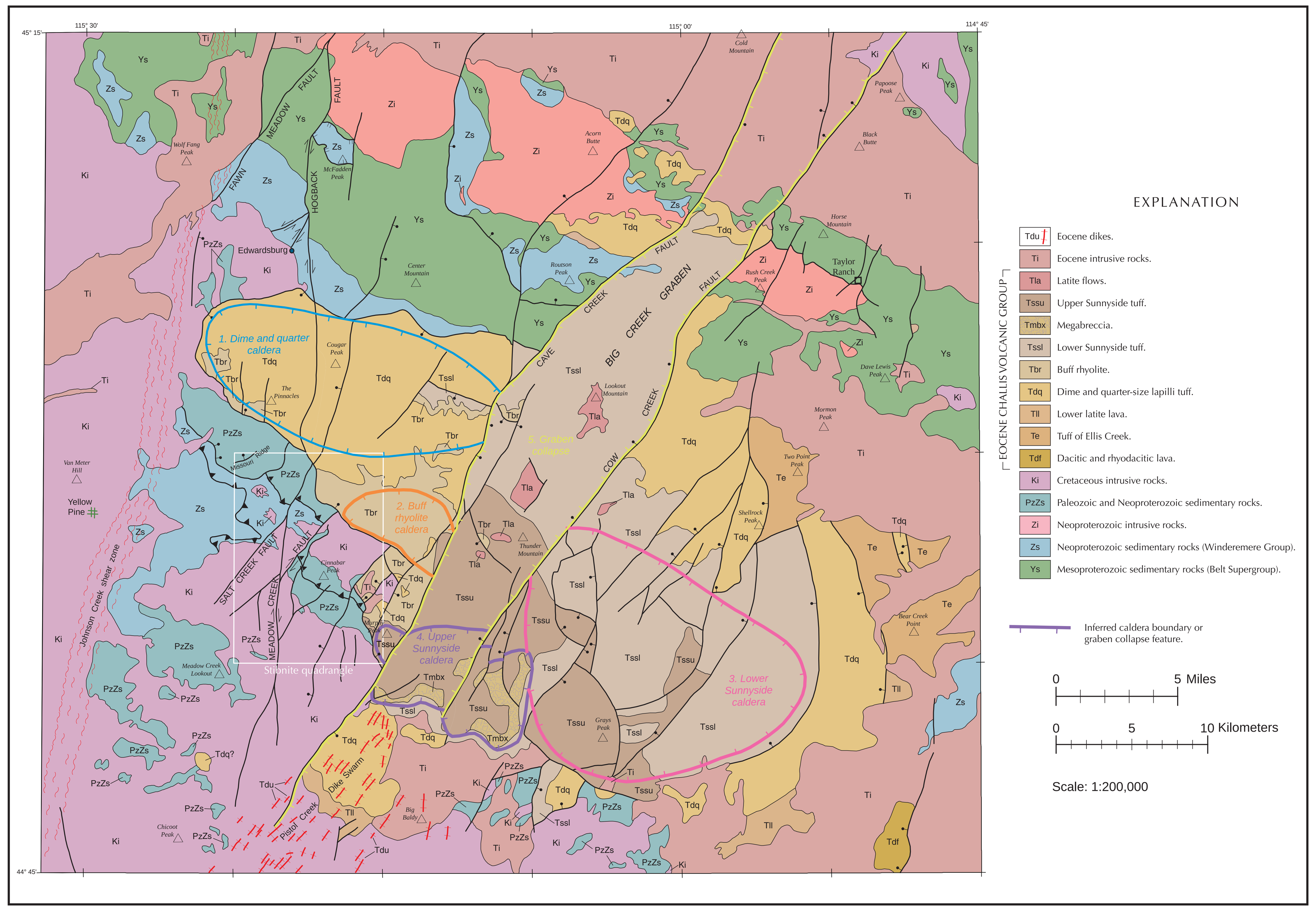
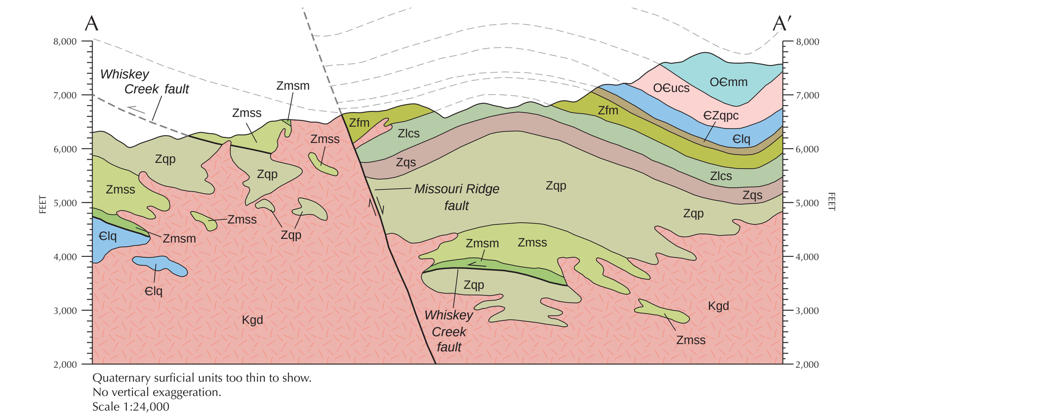
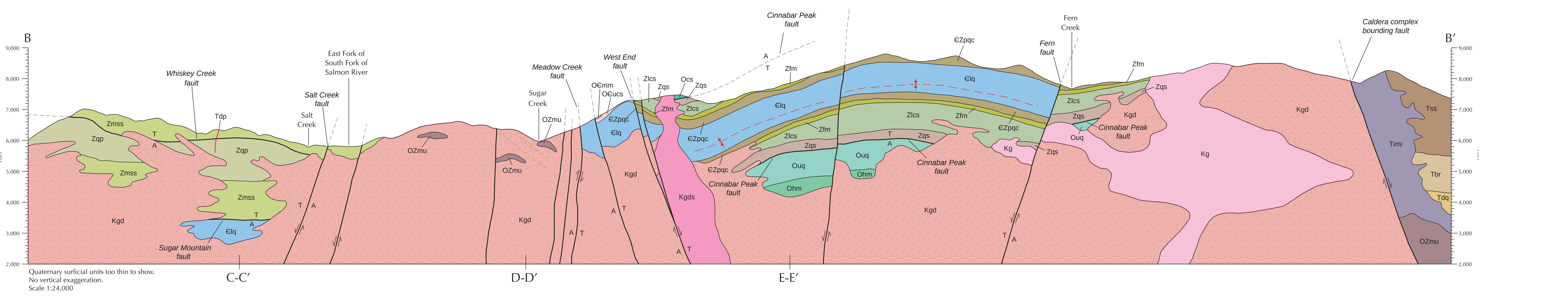
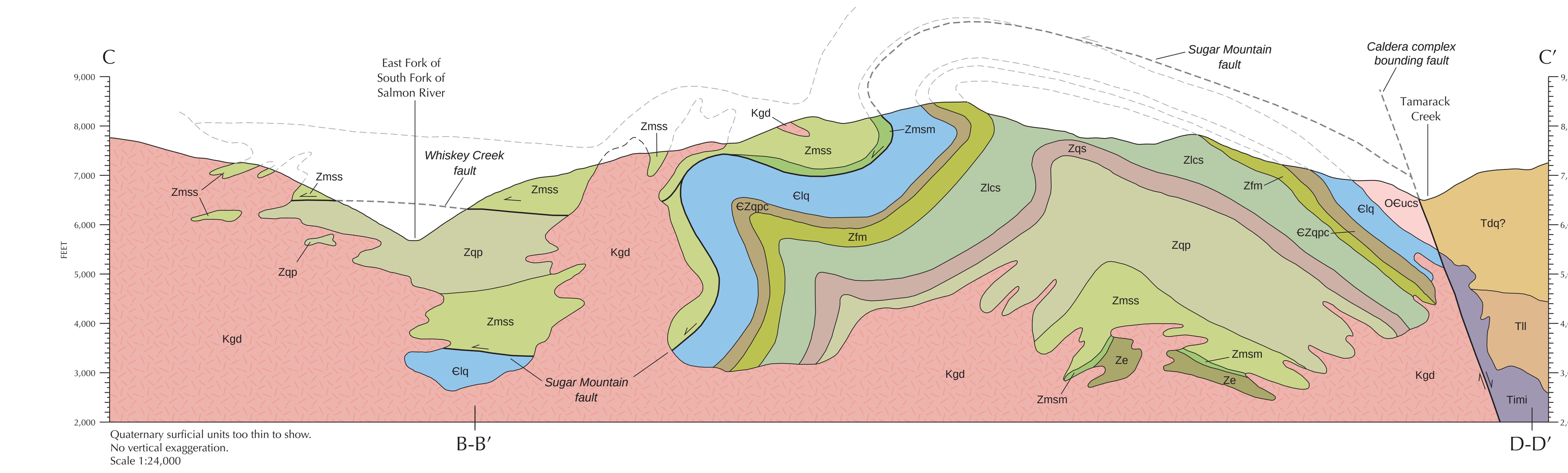
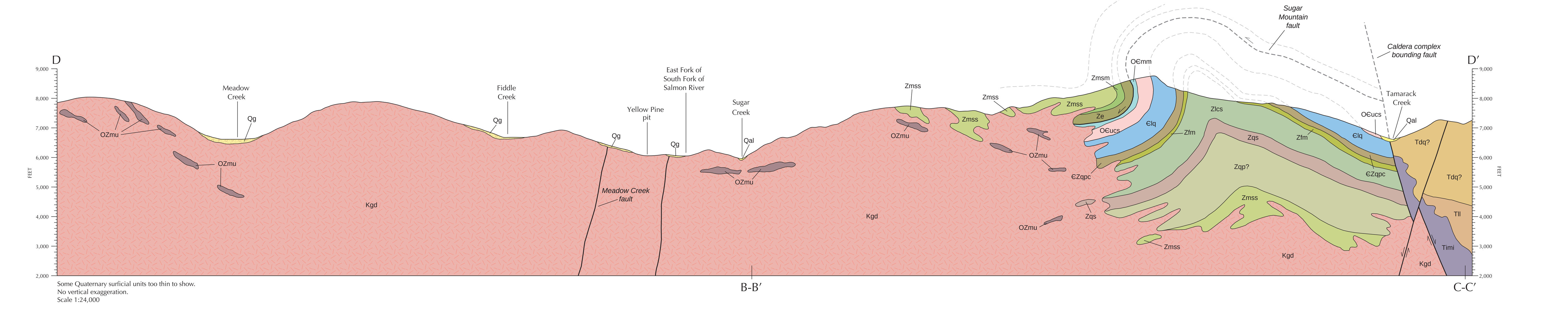


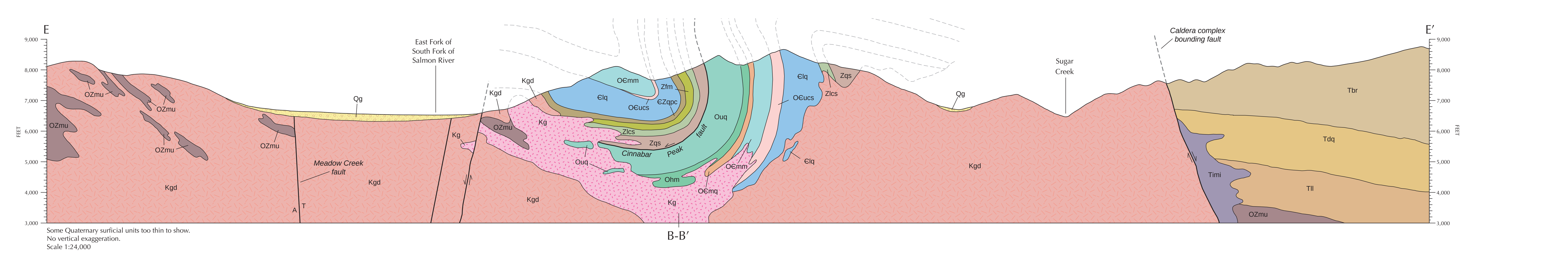
Figure 2. Regional geology of the Stibnite and Big Creek area.











REGIONAL VOLCANIC STRATIGRAPHY AND STRUCTURE

The Stibnite quadrangle is a small piece of the stratigraphically enigmatic and structurally cryptic area that is central Idaho. Figure 2 shows the surrounding area where regional structures and trends illuminate what we find at Stibnite, while at the same time findings from detailed work at Stibnite encourage speculation as to possible connections with what is found outside the confines of the quadrangle. The following discussion is based on work by Stewart and others (2013), Lewis and others (2012), Fisher and others (1992), Lund (2004), and our reconnaissance efforts.

THUNDER MOUNTAIN CALDERA COMPLEX

While the Thunder Mountain area east of the Stibnite quadrangle clearly contains collapse features such as normal faults and megabreccia, the Eocene volcanic field shown in Figure 2 is extremely large, too large to be a single caldera. It is perhaps for this reason that Fisher and others (1992) referred to the area as the "Thunder Mountain cauldron." In this study we term the area a "caldera complex" and propose a possible sequence of events to produce the extensive and dominantly fault-bounded volcanic field that we see at present.

Previous mapping by Fisher and others (1992) has established that at least four of the ash-flow deposits associated with the Thunder Mountain vents were produced by large-volume eruptive events. They also assigned informal names to these four units. The oldest is the dime and quarter tuff sequence (*Tdq*), followed by the buff rhyolite (*Tbr*), the lower Sunnyside tuff (*Tssl*), and finally the upper Sunnyside tuff (*Tssu*). While it is difficult to establish with precision where the collapse boundaries following the four eruptive events might have been, this regional map presents a first attempt at postulating outlines for the linked calderas that may have produced the present caldera complex. These outlines are based primarily on where each ash-flow deposit is preserved and, in the case of the upper Sunnyside tuff, the presence of collapse-associated megabreccia (*Tmbx*). Following the four eruptions, each forming its respective caldera, there was a fifth collapse event, the Big Creek graben collapse. This may have taken place soon after the latest caldera collapse, or over an extended period after volcanic activity ended.

The faults bounding the Big Creek graben extend into the Tertiary intrusive rocks (*Ti*) to the northeast and into Cretaceous batholith rocks to the southwest (*Ki*). Southwest of the upper Sunnyside (*Tssu*) caldera the graben has been down-dropped less and exposes a deeper crustal section containing dime and quarter tuff (*Tdq*) and equivalent Tertiary intermediate intrusive rocks in which are exposed tabular, north-northeast striking intrusive bodies that comprise the Pistol Creek dike swarm (*Tdu*). This indicates that the Pistol Creek dike swarm either post-dates the dime and quarter tuff and pre-dates the upper Sunnyside tuff, or, less likely, that the intrusive event is younger than the upper Sunnyside tuff but the dikes died at depth and did not penetrate the younger, higher level volcanics.

The faults that bound the caldera complex are not uniform in nature, reflecting the compositionally heterogeneous and structurally compromised crustal block in which the magma chambers that fed the Tertiary pyroclastic eruptions developed. Some segments of the caldera-bounding fault system are characterized by large (10 m) blocks of collapse debris such as those found in the Stibnite quadrangle north of Sugar Creek. Portions of the faults bounding the caldera complex have been intruded by mafic Eocene bodies north of Cane Creek (Plate 1), or are marked by abundant breccias and iron staining as is found west of Murphy Peak and south of the Pinnacles (Fig. 2). Local exposures of sediments rest unconformably on *Tdq* and contain internal angular unconformities, indicating that subsidence was a protracted process, at least during formation of the *Tdq* caldera. On the east edge of the Stibnite map a block of biotite granodiorite (*Ki* on Fig. 2) 1 km across lies entirely surrounded by volcanics, with faults on its western and eastern margins; observations did not establish whether the block is rooted or if it is an extremely large slide block.

POSSIBLE EXTENSIONS OF STIBNITE QUADRANGLE FAULTS

The Salt Creek fault was traced by the authors southwest up Salt Creek and off the quadrangle, where it offsets batholithic rocks. The Salt Creek fault also likely continues to the northeast into the dime and quarter caldera near the confluence of Bum Creek with Tamarack Creek, based on linear north-northeast striking creeks and alignment of saddles. It does not appear to significantly displace the caldera-bounding fault, suggesting that post-Challis slip was insignificant.

In the Stibnite quadrangle the Meadow Creek-West End fault zone, predominantly a right-lateral strike-slip structure, offsets the trace of the Cinnabar Ridge fault and the Sugar Mountain fault by some 3.5 km (2.2 mi). This is assuming that the Cinnabar Ridge and Sugar Mountain are the same fault (see Structure section on Plate 1). In the Big Creek quadrangle 20 km (12 mi) to the north the Hogback fault, also a right-lateral strike-slip fault, displaces Neoproterozoic metasedimentary rocks there by approximately 4 km (2.5 mi) (Lewis and others, 2012). This raises the possibility that these two faults are the same. The Hogback fault has been traced with confidence by the authors southward to the northern edge of the dime and quarter caldera (Fig. 2). Recent mapping by the authors suggests that it may continue into the Eocene volcanic deposits as far as the ridge west of Cougar Peak in the central part of the dime and quarter caldera and on to near the confluence of Tamarack and Bum Creeks after which it may trend south-southeast and then southward, defining the southern edge of the Thunder Mountain caldera complex as far as the saddle east of Sugar Mountain (Plate 1). Expression of the fault zone within the volcanics does not demonstrate post-Challis strike-slip movement but is indicated by abundant iron staining, brecciation, and by kilometers-long dikes that cut the volcanics and which are up to 50 m in width.

The northward extension of the Meadow Creek fault is not directly aligned with the most southward known extension of the Hogback fault. North of its intersection with the fault that bounds the caldera complex there is no expression of the Meadow Creek fault within the volcanics. Presumably the fault trace turns northwesterly and provided the zone of weakness along which the segment of the caldera complex bounding fault southeast of Sugar Mountain activated following eruption of the buff rhyolite (*Tbr*). Alternatively, if the Meadow Creek fault and the Hogback fault are not directly connected they may be en echelon right-lateral strike-slip faults. Regardless of their exact relationship, the Meadow Creek fault and the Hogback fault are segments of a deep-seated north-trending system of faults that accommodated largely right-lateral strike-slip motion. The short eastward jog that the Meadow Creek fault takes along the caldera complex bounding fault may be due to strain refraction as the stress generated by the deep, north-south fault zone intersected and interacted with the northwest-striking folded strata of the roof pendant.

Table 2. Major oxide and trace element chemistry of samples collected in the Stibnite quadrangle.

Map letter	Sample number	Latitude*	Longitude*	Lithology	Unit name	Map unit	SiO_2	TiO_2	Al_2O_3	Fe_2O_3†	FeO††	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Sum	LOI	Ni	Cr	Sc	V	Ba	Rb	Sr	Zr	Y	Nb	Ga	Cu	Zn	Pb	La	Ce	Th	Nd	U	Co
							Major elements in weight percent													Trace elements in parts per million																			
M	12DS42	44.8955	-115.3080	hb diorite	Granodiorite	pod in Kgd	59.13	1.127	17.45		5.55	0.103	3.67	5.43	3.39	2.25	0.222	98.31		9	11	13	146	897	66	815	353	17	23.5	20	4	81	5	22	46	6	23	2	
N	12RL154b	44.8890	-115.2894	bt granodiorite	Granodiorite	Kgd	69.33	0.47	15.78	2.81		0.060	0.71	2.50	4.00	3.67	0.360	99.69	0.52	8	11	3	37	1012	149.2	527	268	22.3	51.6	27.2	13	52	16	55	121	28.6		4.7	1
O	12DS43	44.8957	-115.3128	2-mica granite	Granite	Kg	73.05	0.040	14.58		0.91	0.366	0.06	0.86	3.82	4.65	0.095	98.42		0	3	4	6	402	144	200	124	65	41.1	16	1	3	17	20	34	12	15	10	
P	12DS44	44.8967	-115.3169	2-mica granite	Granite	Kg	72.19	0.176	14.32		1.48	0.060	0.29	1.18	3.87	4.13	0.081	97.80		0	5	3	13	640	141	277	126	27	39.9	18	0	30	17	43	79	19	28	4	
Q	12ES016	44.8933	-115.2713	2-mica granite	Granite	Kg	73.91	0.123	14.83		0.59	0.073	0.12	0.43	3.20	4.78	0.136	98.20		0	5	5	8	524	144	187	83	27	47.2	20	1	1	16	26	42	11	16	3	
R	14RL015	44.9272	-115.3198	mu-bt granodiorite	Stibnite stock	Kgds	71.66	0.15	16.34	1.37		0.060	0.41	1.73	4.46	3.11	0.210	99.50	0.95	12	28	1	14	655	133.4	538	150	11.5	28.9	29.7	8	33	2	32	59	6.6		0.5	<1
S	12DS46	44.9088	-115.2628	dacite	Int. and mafic intrusives	Timi	63.07	0.715	15.43		4.72	0.063	2.11	4.25	3.16	3.30	0.229	97.04		7	68	14	96	1086	105	476	219	27	16.5	22	14	71	17	58	91	16	47	3	
T	12ES014	44.8824	-115.2573	dacite	Int. and mafic intrusives	Timi	62.58	0.682	17.24		3.89	0.052	1.70	2.68	4.10	2.92	0.220	96.06		11	59	10	68	1259	89	708	205	17	14.8	23	6	69	18	40	73	12	33	3	

*NAD 27
All analyses by X-ray fluorescence methods.
Samples 12RL154b and 14RL015 analyzed by Stanley Mertzman at Franklin and Marshall X-Ray Laboratory, Lancaster, Pennsylvania; remainder of samples analyzed by Washington State University (WSU) GeoAnalytical Laboratory, Pullman, Washington.
†Franklin and Marshall reports total iron as Fe_2O_3.
††WSU reports total iron as FeO.

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