Geologic Map of the Henderson Ridge Quadrangle, Lemhi County, Idaho, and Ravalli County, Montana

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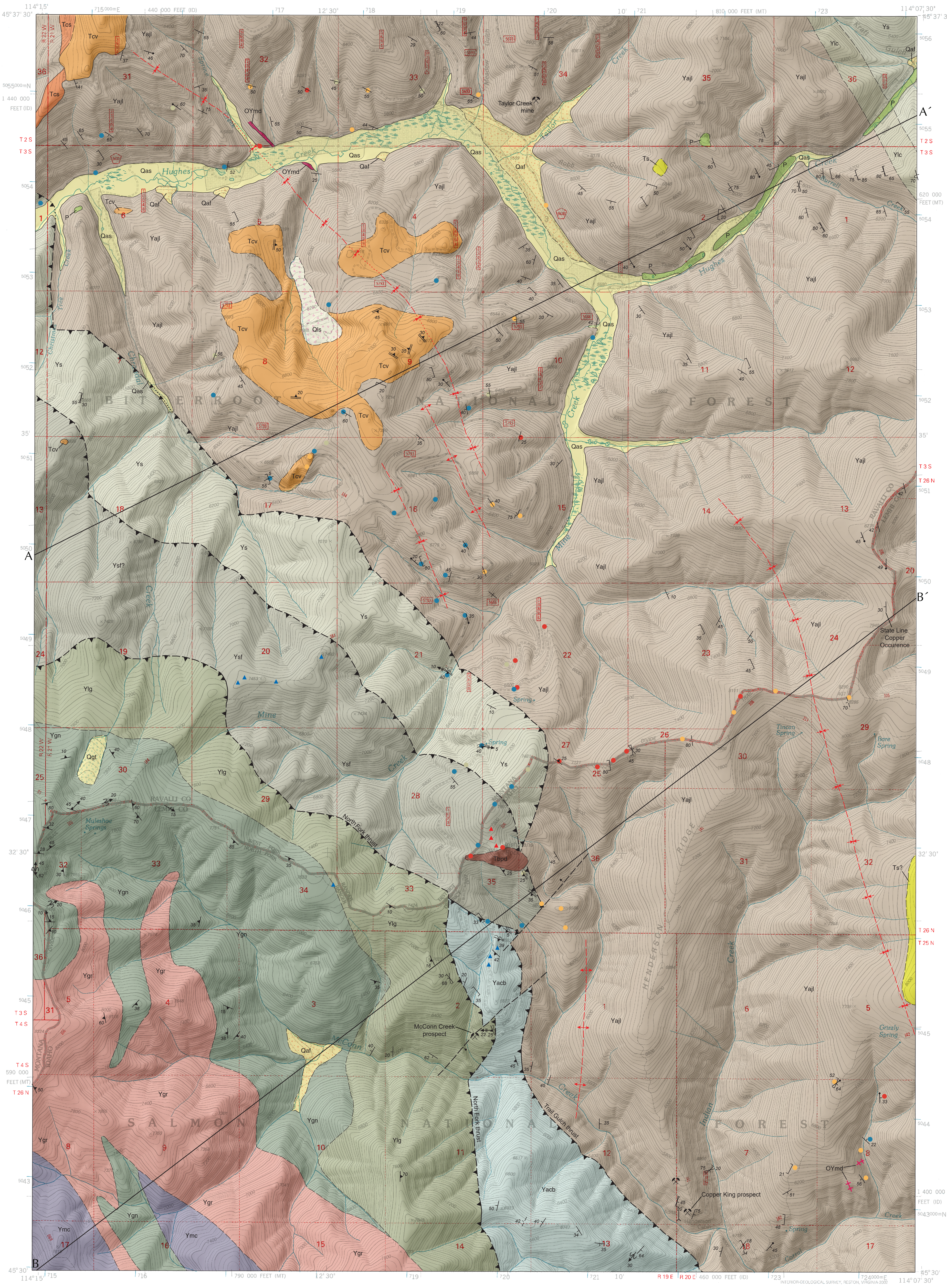
2021



Base Map Credit

Topographic base modified from digitally scanned 1:24,000-scale USGS paper map, 1991 provisional edition, topography compiled in 1985, planimetry derived from imagery taken in 1995.

Transverse Mercator projection. 1927 North American Datum.

10,000-foot grid ticks: State Plane Coordinate System, Idaho Central Zone, Montana, south zone.

1000-meter grid ticks: Universal Transverse Mercator, zone 11.

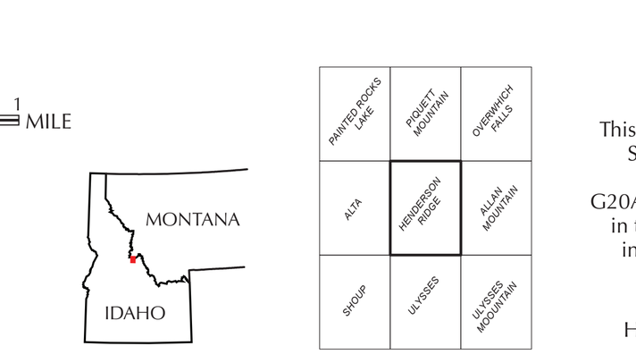
Shaded relief from 10 m DEM.

Declination from NOAA National Geophysical Data Center.

UTM Grid and 2021 Magnetic North Declination at Center of Map

SCALE 1:24,000

Contour interval 40 feet



QUADRANGLE LOCATION   ADJOINING QUADRANGLES

[1] Idaho Geological Survey
[2] Montana Bureau of Mines and Geology

Field work conducted largely in 2020.

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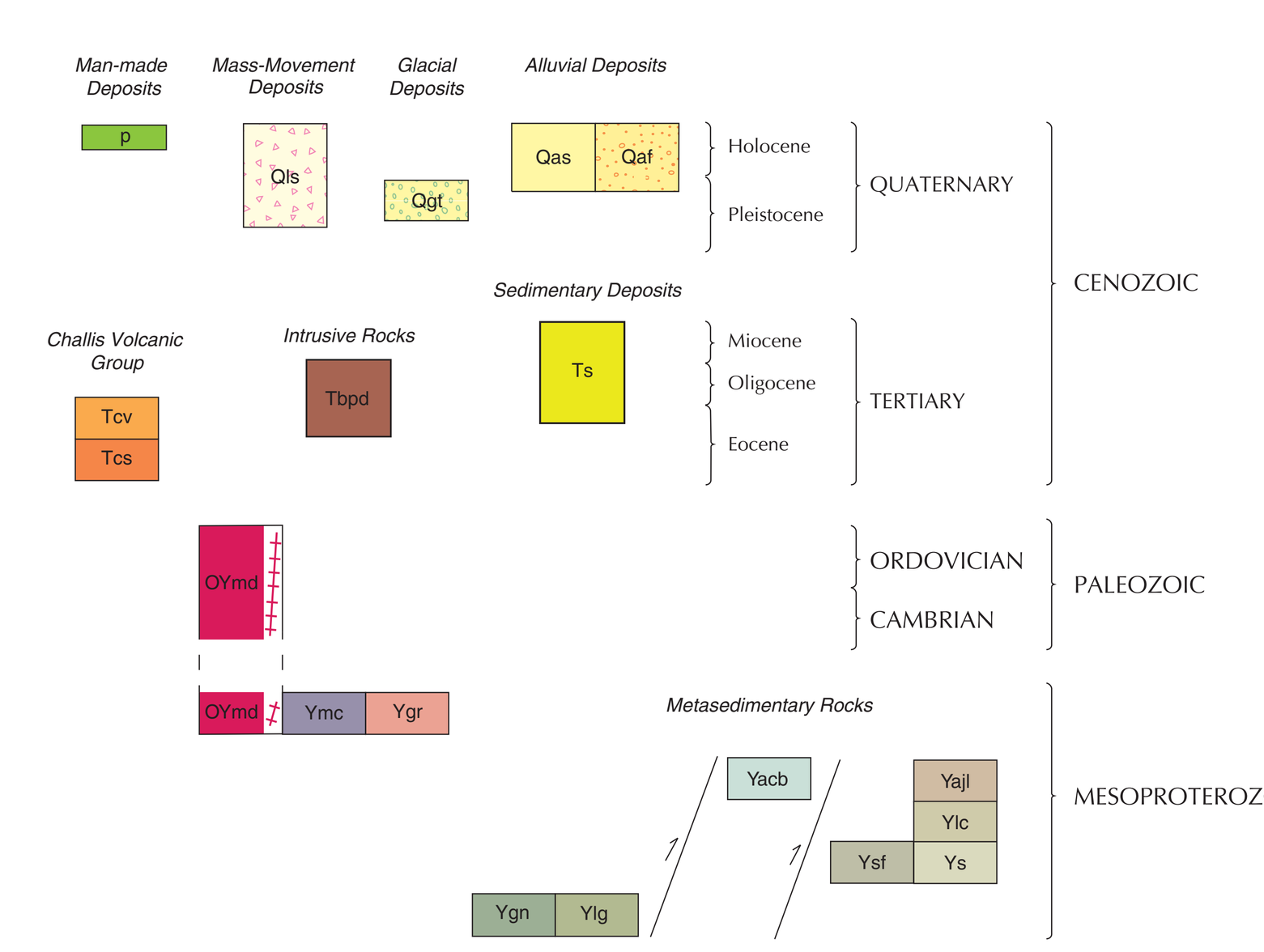
Digital cartography by Jonathan Sandquist and Nathan Hopkins at the Idaho Geological Survey's Digital Mapping Lab.

Technical review by Russell V. Di Fiori and Claudio Berti.

Map version 11-30-2021.

This map can be downloaded in PDF format from www.idahogeology.org and www.mbmg.mtech.edu.

CORRELATION OF MAP UNITS

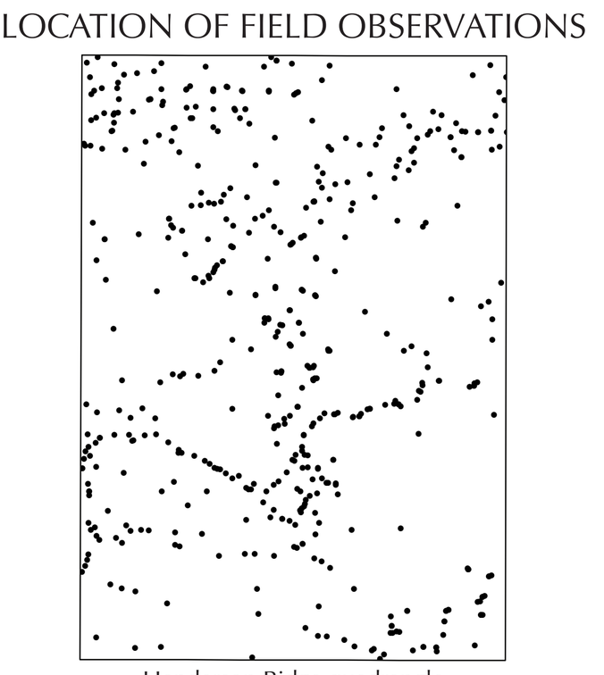


INTRODUCTION

This map is the result of field work largely conducted in 2020. Many concepts for geologic units were developed in the Beaverhead Mountains to the southeast during a 1:24,000-scale collaborative mapping project by the Idaho Geological Survey (IGS) and the Montana Bureau of Mines and Geology (MBMG) that started in 2007 and resulted in geologic maps of the western (Burmester and others, 2016a) and eastern (Lonn and others, 2019) parts of the Salmon 30' x 60' quadrangle (orange outline, Figure 1). Our efforts here were supplemented by the pioneering work of Berg (1977), attitudes from unpublished 1982 mapping by Noranda Exploration Inc. (Noranda, 1982), unpublished 1992 IGS mapping by Keegan Schmidt, Russell Burmester, and Reed Lewis, and unpublished 1996 USGS mapping by Karl Evans. Other previous work includes reconnaissance by Evans and Green (2003). Magnetic susceptibilities were measured with KT-9 and KT-10 Kappameters from Exploranium G.S. Ltd. and reported as averages of typically 10 samples per exposure (Table 1).

Most bedrock in the quadrangle consists of Mesoproterozoic metasedimentary rocks of the Belt Supergroup, which were intruded, and contact metamorphosed, by a 1380-1370 Ma bimodal igneous suite. Those rocks were displaced and deformed by thrust faults and normal faults. Remnants of the Eocene Challis Volcanic Group and Tertiary sedimentary rocks cover small parts of the map. Quaternary deposits of alluvial, mass-wasting, and glacial origin also cover small areas.

LOCATION OF FIELD OBSERVATIONS



Henderson Ridge quadrangle

SYMBOLS

Contact: dashed where approximately located.

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

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

Syncline axial trace; dotted where concealed.

Anticline axial trace.

Strike and dip of bedding.

Approximate strike and dip of bedding.

Strike and dip of bedding; ball indicates bedding known to be upright.

Strike and dip of bedding, strike variable.

Strike and dip of bedding interpreted to be overturned on the basis of stratigraphic succession or position.

Strike of vertical bedding.

Strike and dip of cleavage.

Strike of vertical cleavage.

Strike and dip of foliation.

Strike and dip of mylonitic foliation.

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

Bearing and plunge of small fold axis.

Bearing and plunge of lineation, type unknown.

Bearing and plunge of mineral lineation.

Bearing and plunge of mylonitic lineation.

Prospect pit.

Adit.

Tectonic breccia.

Tourmaline breccia.

Location of magnetic susceptibility measurement (Table 1; SI units (x10^{-3})).

- 0.03-0.20
- 0.21-1.00
- 1.01-10.00
- 10.01-25.00

DESCRIPTION OF MAP UNITS

The geologic map of the Henderson Ridge quadrangle shows rock units exposed at the surface or underlying a thin surficial cover of soil and colluvium. Igneous rocks are classified using International Union of Geological Sciences nomenclature (Le Bas and Streckeisen, 1991). Grain size classification of unconsolidated and consolidated sediment employs the Wentworth scale (Lane, 1947). Bedding thicknesses and lamination type are after McKee and Weir (1953) and Winston (1986). Time scale is the Geological Society of America version 5.0 (Walker and others, 2018). Grain sizes and bedding thicknesses are given in abbreviation of metric units (e.g., dm=decimeter). Unit thicknesses, distances, and elevations are in both metric and English units. Multiple lithologies within a rock unit description appear in order of decreasing abundance, and descriptions of stratigraphic units are from bottom to top where possible.

MAN-MADE DEPOSITS

p **Placered ground (Holocene)**—Areas in the northeastern part of map along Hughes Creek that were dredged for gold in the 1900s. Disturbance is visible on Google Earth images of the drainage and most placered areas are shown on the U.S. Geological Survey base map. Does not include smaller placer operations along Hughes Creek in the north-central and northwestern part of the map. Also includes two high-elevation gravel deposits reported by Berg (1977), one in the northwestern part of map and the other in the northeastern part.

ALLUVIAL DEPOSITS

Qas **Side-stream alluvium (Holocene to late Pleistocene)**—Subangular to rounded, moderately sorted and stratified pebble to boulder sandy gravel.

Qaf **Alluvial-fan deposits (Holocene to late Pleistocene)**—Angular to subrounded, poorly sorted, primarily matrix-supported pebble to boulder gravel in a sand, silt, and clay matrix.

MASS-MOVEMENT DEPOSITS

Qls **Landslide deposits (Holocene to Pleistocene)**—Limited to a single boulder-rich deposit south of Hughes Creek sourced from *Tcv*.

GLACIAL DEPOSITS

Qgt **Till of last glacial maximum (Pleistocene)**—Single deposit in north-facing cirque in the western part of map. Not visited; mapped on topographic expression only. Likely poorly sorted sandy to clayey boulder till.

SEDIMENTARY DEPOSITS

Ts **Sedimentary deposits (Tertiary)**—High-elevation gravels. Includes remnant gravel deposits in the northeast part of map 240 m (800 ft) above the modern Hughes Creek and deposits 305 m (1,000 ft) above Indian Creek at the southeast edge of the map. A small deposit 100 m (300 ft) above Hughes Creek in the western part of the map was worked for gold and is designated as a placer deposit (*p*) as is one of the two high-elevation gravel deposits 240 m (790 ft) above Hughes Creek in the northeastern part of map. Characterized by well-rounded pebbles, cobbles, and small boulders. The high-elevation gravels in the southeastern part of the map were interpreted as glacial deposits by Stewart and others (2014) in the adjoining quadrangle to the east. Due to the lack of a glaciated highland in this area, they are reinterpreted here as remnants of fluvial deposition. Based on topography, Henderson Ridge may be capped by similar deposits, but it was not visited during this study.

CHALLIS VOLCANIC GROUP

Tcv **Volcanic rocks, undivided (Eocene)**—Mixed unit consisting of rhyolite tuffs, one with chatoyant sanidine and another with lapilli, and subordinate biotite-hornblende dacite. Likely erosional remnants of an outlier of the Challis Volcanic Group widely exposed 70 km (45 mi) to the south. Berg (1977) described the volcanic rocks east of Crandall Creek as predominantly welded tuff of rhyolitic to latitic composition with collapsed pumice fragments that produce an easily recognizable eutaxitic structure in most specimens. Quartz and potassium feldspar are the primary phenocrysts. Dacite, likely a flow or shallow intrusive rock, is exposed in a northeast-southwest elongate body at point 6917T, south of the rhyolite-dominated exposures mentioned above. Magnetic susceptibility at two dacite outcrops averaged 5.3 x10^{-3} SI.

Tcs **Older sedimentary deposits (Eocene)**—Poorly sorted angular to sub-rounded boulders and cobbles in a silty matrix tentatively interpreted as underlying volcanic rocks in the northwest corner of the map.

INTRUSIVE ROCKS

Tbpd **Basaltic plug and dike (Eocene or Oligocene)**—Red-tan-weathering porphyritic basalt plug at Irishmans Rock along the state line in central part of map. As described by Berg (1977), the porphyritic basalt contains largely labradorite, hypersthene, and clinopyroxene; some of the pyroxene has been replaced by hornblende. A biotite-bearing dike with a trachytic texture extends west of the plug. Pronounced horizontal columnar jointing and vertical, rib-like exposures (Figure 2) are interpreted to reflect intrusion as sheeted dikes. Magnetic susceptibility nearly identical where measured at two widely separated exposures (16.3 x10^{-3} SI).

OYmd **Mafic dikes (Mesoproterozoic, Cambrian, or Ordovician)**—Fine-grained mafic dikes in the southeast part of map and north and south of Hughes Creek in the northwest part of map. Original mafic minerals altered to amphibole and chlorite. Possibly the same age as *Ymc* described below, or Cambrian/Ordovician dioritic rocks southwest of the Beartrack mine (within €i on Figure 1; Evans and Green, 2003).

Ygr **Granite (Mesoproterozoic)**—Light-gray, medium- to coarse-grained, porphyritic granite. Contains megacrysts 3 to 8 cm in length that preserve crystal shape in some areas but are typically deformed into variously elongate augen. Some are entirely microcline; others are microcline rimmed with albite (rapakivi texture). Includes subordinate amounts of equigranular, fine- to medium-grained tonalite or trondhjemite. Widely exposed south and southwest of the map where they are described in more detail by Spence (1984). Zircons from a sample of the Deadwater granite augen gneiss from along the Salmon River in the Ulysses Mountain quadrangle, about 15 km (9 mi) southeast of the map (Z symbol, Figure 1) yielded a U-Pb concordia age of 1,383 ± 4 Ma. (Aleinikoff and others, 2012).

Ymc **Mafic complex (Mesoproterozoic)**—Mixed intrusive unit consisting of amphibolite, gabbro, and diorite. Primarily amphibolite in this quadrangle, but where studied in detail to the south by Spence (1984), some of the gabbroic rocks contain olivine. A U-Pb zircon date of 1,378.7 ± 1.2 Ma on a diabase near the *Ygr* dated sample (Doughty and Chamberlain, 1996) is the best age estimate of this unit; it is not significantly different from age of *Ygr*. Magma mixing textures present regionally where unit is in contact with the granite (*Ygr*) support *Ymc* and *Ygr* comprising a bimodal intrusive suite. Doughty and Chamberlain (1996) suggested that it likely formed during Mesoproterozoic rifting near the end of Belt Supergroup deposition.

MESOPROTEROZOIC STRATA

Metasedimentary rocks of the Mesoproterozoic comprise most of the bedrock in the quadrangle. The strata in the north and east are at the lowest metamorphic grade; those in the southwestern part of the map are locally garnet-bearing. Unit names follow the revised stratigraphic nomenclature (Burmester and others, 2016b) that uses the coarsest unit, the Swauger Formation, to distinguish otherwise similar rocks that occur above and below it.

Yacb **Coarse siltite and banded siltite members of Apple Creek Formation (Mesoproterozoic)**—Thin-bedded siltite and argillite. Strong cleavage and development of phyllite locally obscure sedimentary structures, but where visible, those include graded couplets of light-gray to light-green siltite and dark-gray argillite. Some parts of unit, characterized by ptygmatically folded, discontinuous, silt to sand dikelets in dark argillite caps would be mapped as the banded siltite member, and others with polygonal mud cracks and chips, would be mapped as the coarse siltite member, if either were exposed over sufficient area. Rare intervals contain white spots more abundant in finer-grained bed tops (Figure 3). These may be scapolite, or more likely albite after scapolite. In Ulysses quadrangle to the south, includes decimeter-scale pods of brown-weathering calcitic cemented siltite (unpublished mapping). Overturned to the east everywhere tops are visible. Contains garnets along McConn Creek. Garnets collected 16 km (10 mi) southeast of the map produced ages of 1,173.2 ± 5.5 Ma and 1,136 ± 15 Ma (Lu-Hf), and 1,082 ± 21 Ma (Sm-Nd) (Jeffery D. Vervoort, written commun., 2014, in Lonn and others, 2013). Those garnets predate the latest fabric there, which reflects top-to-the-east oblique shear strain. Magnetic susceptibility at a single outcrop was 0.10 x10^{-3} SI. Top and base not exposed and thickness highly uncertain, but thickness of *Yab* south of the Poison Creek thrust (Figure 1) estimated to be as much as 2,000 m (6,600 ft) (Connor and Evans, 1986). Correlation is based on continuity from the Ulysses Mountain quadrangle (Lewis and others, 2019) through the adjacent Ulysses quadrangle to the south. Maximum depositional age is 1,409 ± 10 Ma, the mean age of 9 youngest zircons from near the Blackbird Mine (Figure 1) (Aleinikoff and others, 2012).

Yajl **Jahnke Lake member of Apple Creek Formation (Mesoproterozoic)**—Well-sorted, fine- to very fine grained, medium- to thick-bedded, pale-green to medium-gray, feldspathic quartzite. Mapped largely as quartzite of type II lithology by Berg (1977), who reported abundant heavy-mineral laminae and plagioclase feldspar in excess of potassium feldspar. Bedding and sedimentary structures are difficult to see where cleavage intense, but flat laminations (Figure 4), and less commonly, trough cross laminations, are visible locally. Less abundant are siltite and argillite couplets, and sparse mud chips. Varied magnetite content. Magnetite visible as octahedra or small anhedral blebs in some samples, too fine to see in others. Magnetic susceptibility highest in quartzite beds with mm-scale parallel heavy mineral laminations. Magnetic susceptibility ranged from 0.05 to 24 with average and standard deviation of 4.6 and 6.1 and median of 1.1 (all x10^{-3} SI) on measurements from 62 exposures. Low susceptibility in some exposures due to oxidation of magnetite to hematite. Thickness uncertain because of folding and possible repetition by unmapped faults, and the fact that the top is not exposed. Thickness likely 3,000 m (10,000 ft) with a minimum of 1,500 m (5,000 ft). Continuous from the southeast (Figure 1).

Ylc **Lawson Creek Formation (Mesoproterozoic)**—Siltite, argillite, and quartzite. Mapped as lowermost part of quartzite of type II lithology by Berg (1977) but separated by Stewart and others (2014) in the adjoining quadrangle to the east. Upper contact placement poorly constrained, as is the lower contact north of Hughes Creek. Thickness uncertain, but likely a minimum of 250 m (820 ft).

Ys **Swauger Formation (Mesoproterozoic)**—Poorly sorted variously feldspathic thin- to thick-bedded quartzite. Well-rounded quartz grains are common, and Berg (1977) reported festoon trough cross beds in the easternmost exposures. Typically contains subequal amounts of potassium feldspar and plagioclase feldspar, but some exposures contain little feldspar (Berg, 1977). Gradational up into *Ylc* through interval of quartzite beds that grade up into argillitic tops. Unit is equivalent to quartzites type I and III of Berg (1977), which we interpret to be on opposite limbs of a large, faulted syncline (Figure 1). Uniformly low magnetic susceptibility of 0.05 to 0.61 with mean of 0.22 and median of 0.14 (all x10^{-3} SI) from 6 exposures.

Ysf **Swauger Formation, foliated (Mesoproterozoic)**—Poorly sorted variously feldspathic quartzite that is characteristically foliated. Foliation likely due to deformation in the footwall of the North Fork thrust and additional thrusting to the northeast of that structure. Low magnetic susceptibility 0.03 to 0.26 with mean and median of 0.14 (all x10^{-3} SI) from 4 exposures.

Ylg **Lemhi Group (Mesoproterozoic)**—Fine-grained, thick- to thin-bedded feldspathic quartzite, and minor siltite and argillite. Quartzite beds commonly dm scale, flat laminated, or trough cross bedded. Intruded by granite, likely of Mesoproterozoic or Cretaceous age; grades into *Ygn* with increase of schist and deformation. Includes unmapped amphibolite in vicinity of McConn prospect. Thickness uncertain because of deformation and lack of exposure of the upper and lower contacts. Similar strata to the southeast were mapped as Gunsight Formation (Burmester and others, 2016a; Lewis and others, 2019) but assigned here more conservatively to the Lemhi Group, which contains more than one quartzite-dominated formation and has not been mapped in detail.

Ygn **Gneiss (Mesoproterozoic)**—Gneiss and biotite quartzite, typically with both a leucocratic igneous component and biotite-rich metasedimentary component. Igneous component lacks mafic selvages and is more likely from *Ygr*, or Cretaceous magmas, than partial melt. Tightly folded and locally garnet-rich near the west edge of the map (Figures 5 and 6). Eastern contact with *Ylg* may be faulted where tourmaline breccia is present at one place on the contact along the state line. Most of metasedimentary component likely is *Ylg* based on proximity and quartzite-rich lithology, but the westernmost garnet-rich area contains exposures that are finer grained than typical of the *Ylg* unit.

FAULTS

Several faults traverse the quadrangle. It is likely that more faults exist within the Mesoproterozoic units, but are unrecognized due to the lack of laterally extensive lithologic markers. Named faults within the quadrangle are described below. Most deformation probably occurred during Cretaceous Sevier contraction and Eocene to Oligocene extension. However, it is also likely that some deformation occurred in the Ordovician, Neoproterozoic, during the 1,380-1,370 Ma magmatic event, and as growth faults during deposition of Mesoproterozoic strata.

TRAIL GULCH THRUST

The Trail Gulch thrust continues from the south and southeast where it juxtaposes thinly bedded garnet-bearing phyllite and diamictite-bearing siltite-argillite couplets and quartzite over lower metamorphic grade green and pink, fine-grained feldspathic quartzite and siltite and argillite couplets in the Ulysses Mountain quadrangle (Lewis and others, 2019). There the upper plate rocks are correlated with the diamictite-bearing banded siltite member (*Yab*) found to the south, e.g., in the Cobalt quadrangle (Lewis and others, in prep.) south of the Poison Creek fault (Figure 1). In the North Fork quadrangle (Lonn and others, 2013) and the Ulysses quadrangle (unpublished mapping), the thrust strikes southeast, dips moderately to gently southwest, and is mylonitic with poorly developed lineations that plunge gently west. Shear sense is top-to-the-east. It likely continues to the area northeast of Salmon as the Freeman thrust (Figure 1). On this map it ends near the state line where it appears to be cut out by, or merges with, the North Fork thrust. South of there, it appears to have a low but varied west to south dip and is cut by brittle faults that have north to northeast traces. Where exposed, it is mylonitic (Figure 7) with ill-defined lineations. Tourmaline is common in the mylonites and breccias of the area. Motion here is likely top-to-the east as it is to the south, and oblique to the fault trace. Presence of garnet in the hanging wall suggests post-metamorphic thrust movement.

NORTH FORK THRUST

The North Fork thrust crosses the quadrangle from southeast to northwest. It places thinly bedded siltite and thicker bedded very fine grained feldspathic quartzite (*Ylg*), its contact metamorphosed equivalent (*Ygn*), and Mesoproterozoic intrusions (*Ygr*, *Ymc*), over garnet-bearing siltite (*Yacb*). To the south in the Ulysses quadrangle (unpublished mapping) it dips southwest and has horizontal lineations and top-to-the-east kinematics.

UNNAMED THRUST FAULTS

Two southeast-striking thrust faults are postulated to parallel the North Fork fault on the north side of the state line in the western part of the map. The southern of these faults is marked by black tourmaline, quartz, and breccia. Swauger Formation (*Ys*) is mapped on both sides, but the hanging wall quartzite is more strongly foliated and contains little obvious feldspar in hand sample, possibly due to silicification. The northern fault is thought to form the contact between the Swauger Formation (*Ys*) and the Jahnke Lake member of the Apple Creek Formation (*Yajl*). Because of poor exposure the exact trace of these two structures is not well known.

MINERALIZATION

HUGHES CREEK PLACERS

As noted by Berg (1977) patented placer mining claims cover much of the Hughes Creek valley. Gold was recovered starting about 1870 and placer operations were ongoing upstream from the confluence of Burrell Creek in 1974. Google Earth images show that the portion of Hughes Creek in the northeast part of the map has been extensively dredged. Deposits there are shown as placers (*p*) on the map.

HIGH PLACER DEPOSITS

Berg (1977) noted that two of the high gravel deposits were worked for placer gold. One is south of Hughes Creek in the western part of the map and the other is north of Hughes Creek in the eastern part of the map. Both are designated as placers (*p*) on the map. The gold in the high-elevation gravels is reportedly rougher than that in Hughes Creek itself.

TAYLOR CREEK (LARRIGON) MINE

The Taylor Creek mine is located on the north side of Hughes Creek in the north-central part of the map. Berg (1977) referred to this property as the Larrigon mine and reported that gold was produced from quartz veins in extensively fractured quartzite.

McCONN CREEK PROSPECT

The McConn Creek prospect, located in the south-central part of the map, is a magnetite-rich zone within *Yacb*. Maps from early 1980s by Noranda Incorporated show the magnetite as metamorphosed banded iron formation. Alternatively, the magnetite may have been remobilized along the North Fork thrust. Details of the Noranda mapping can be found on the Idaho Geological Survey website by examining "Property Details" in the "Mines" web app (https://www.idahogeology.org/webmap?show=mines) for the McConn Creek deposit (IGS ID = EC1068).

COPPER KING PROSPECT

The Copper King prospect near the mouth of McConn Creek in the southeast part of the map consists of an adit, prospect pits, and trenches. Quartz-siderite vein material that contains chalcopyrite and malachite stain is also present. Wall rock of green siltite, argillite, and quartzite shows minimal hydrothermal alteration.

STATE LINE COPPER OCCURRENCE

The State Line copper occurrence, located near the eastern edge of the map, was described by Berg (1977). He noted a sulfide-bearing lens 0.5 m (2 ft) thick that is traceable for about 3 m (10 ft) along strike. The host rock is magnetite-rich quartzite (*Yajl*) and small amounts of chalcopyrite, sphalerite(?), and rare covellite are present in finely intergrown grains.

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Table 1. Magnetic susceptibility measurements of rocks in the Henderson Ridge quadrangle. Values determined from hand specimens or rock faces as measured with a 1995 KT-9 Kappameter from Exploranium G.S. Ltd. and reported in SI units (x 10^{-3}).

Measurement ID	Latitude NAD27	Longitude NAD27	Unit	Magnetic susceptibility (SI units x10^{-3})
20RBms011	45.5414	-114.1880	Tbpd	16
20RBms024	45.5422	-114.1835	Tbpd	16
20RBms135	45.5800	-114.2114	Tcv	6.7
20RBms136	45.5811	-114.2109	Tcv	4.0
20RBms025	45.5424	-114.1870	tourmaline breccia	0.075
20RBms143	45.5348	-114.1856	Yacb	0.098
20ACms256	45.5190	-114.1364	Yajl	6.7
20ACms257	45.5175	-114.1293	Yajl	12
20ACms258	45.5132	-114.1313	Yajl	0.20
20ACms259	45.5121	-114.1327	Yajl	7.5
20ACms260	45.5094	-114.1319	Yajl	3.2
20ACms261	45.5104	-114.1420	Yajl	8.6
20ACms262	45.5104	-114.1420	Yajl	0.90
20ACms263	45.5104	-114.1420	Yajl	3.4
20RBms005	45.6092	-114.2414	Yajl	0.10
20RBms006	45.6099	-114.2232	Yajl	0.079
20RBms007	45.6119	-114.2182	Yajl	12
20RBms008	45.6136	-114.2051	Yajl	3.1
20RBms009	45.6061	-114.1775	Yajl	5.7
20RBms015	45.5508	-114.1755	Yajl	11
20RBms016	45.5502	-114.1701	Yajl	20
20RBms017	45.5509	-114.1678	Yajl	25
20RBms018	45.5518	-114.1660	Yajl	13
20RBms019	45.5530	-114.1580	Yajl	5.8
20RBms020	45.5557	-114.1508	Yajl	6.6
20RBms021	45.5573	-114.1498	Yajl	11
20RBms022	45.5578	-114.1449	Yajl	9.5
20RBms023	45.5572	-114.1345	Yajl	2.7
20RBms028	45.5581	-114.1815	Yajl	18
20RBms029	45.5580	-114.1819	Yajl	0.053
20RBms030	45.5642	-114.1776	Yajl	21
20RBms031	45.5608	-114.1818	Yajl	12
20RBms032	45.5604	-114.1830	Yajl	0.35
20RBms033	45.5704	-114.1951	Yajl	0.14
20RBms034	45.5789	-114.2166	Yajl	0.12
20RBms035	45.5871	-114.2246	Yajl	0.19
20RBms036	45.5911	-114.2244	Yajl	0.32
20RBms037	45.5962	-114.2083	Yajl	0.16
20RBms038	45.5986	-114.1931	Yajl	0.12
20RBms039	45.5948	-114.1820	Yajl	1.1
20RBms040	45.5873	-114.1856	Yajl	0.23
20RBms041	45.5859	-114.1884	Yajl	0.12
20RBms042	45.5830	-114.1810	Yajl	12
20RBms043	45.5752	-114.1811	Yajl	7.1
20RBms044	45.5763	-114.1850	Yajl	3.9
20RBms045	45.5755	-114.1990	Yajl	0.13
20RBms046	45.5768	-114.1931	Yajl	0.11
20RBms047	45.5723	-114.1889	Yajl	0.093
20RBms048	45.5696	-114.1861	Yajl	6.2
20RBms049	45.5693	-114.1917	Yajl	0.099
20RBms050	45.5653	-114.1889	Yajl	0.15
20RBms051	45.6171	-114.1872	Yajl	2.8
20RBms052	45.6175	-114.1952	Yajl	0.65
20RBms053	45.6175	-114.2029	Yajl	4.0
20RBms054	45.6184	-114.2074	Yajl	0.30
20RBms055	45.6175	-114.2115	Yajl	15
20RBms056	45.6178	-114.2195	Yajl	2.1
20RBms057	45.6157	-114.2305	Yajl	0.34
20RBms058	45.6130	-114.2406	Yajl	0.12
20RBms137	45.5816	-114.2103	Yajl	0.19
20RBms139	45.5366	-114.1779	Yajl	1.1
20RBms140	45.5361	-114.1752	Yajl	9.7
20RBms141	45.5342	-114.1746	Yajl	1.1
20RBms145	45.5668	-114.1929	Yajl	0.084
20RBms146	45.5855	-114.2062	Yajl	0.17
20RBms147	45.5855	-114.2062	Yajl	0.17
20RBms148	45.5824	-114.2086	Yajl	0.27
20RBms149	45.5930	-114.1709	Yajl	0.15
20RBms004	45.6062	-114.2492	Ys	0.14
20RBms010	45.5593	-114.1914	Ys	0.052
20RBms013	45.5483	-114.1822	Ys	0.077
20RBms014	45.5500	-114.1799	Ys	0.32
20RBms027	45.5523	-114.1865	Ys	0.14
20RBms144	45.5504	-114.1887	Ys	0.61
20RBms012	45.5465	-114.1846	Ysf	0.033
20RBms026	45.5498	-114.1904	Ysf	0.13
20RBms138	45.5396	-114.1805	Ysf	0.26
20RBms142	45.5344	-114.1807	Ysf	0.16

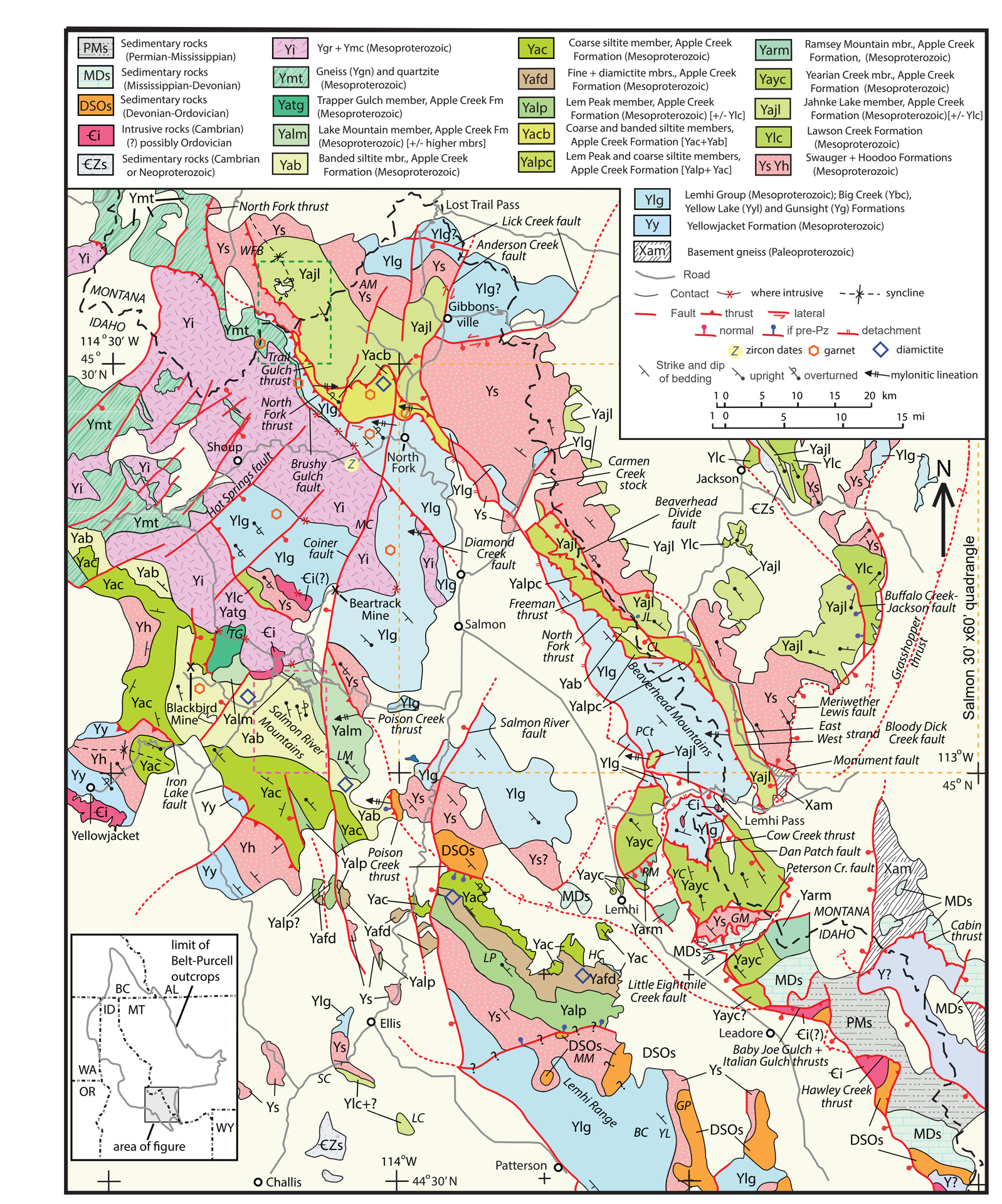

Figure 1. Pre-Mesozoic bedrock geology around Salmon, Idaho. The coarsest clastic unit (Ys and Yh) separates lower formations of the Lemhi Group (in blue) from higher Lawson Creek and Apple Creek formations (greens and yellows). Units are combined where scale or previous mapping makes separating them impractical. Geographic locations are in italics; those for type or reference sections have units in parentheses: AM—Allan Mountain; BC—Big Creek (Ybc); CL-Cowbone Lake; GM-Goat Mountain; GP—Gunsight Peak); HC—Hayden Creek (Ya); JL—Jahnke Lake (Yajl); LC—Lawson Creek (Ylc); LM—Lake Mountain (Yalm); LP—Lem Peak (Yalp); MC—Moose Creek; MM—Mogg Mountain (Ys); RM—Ramsey Mountain (Yarm); TG—Trapper Gulch (Yatg); WFB—West Fork Bitterroot River; YC—Yearian Creek (Yayc); YL—Yellow Lake (Yyl). After Burmester and others (2020) and modified in the north, south, and west to include insights from field work in 2020. Green dashed rectangle is the Henderson Ridge quadrangle, pink dashed rectangle is the Cobalt quadrangle, and orange rectangle is the Salmon 30' x 60' quadrangle.

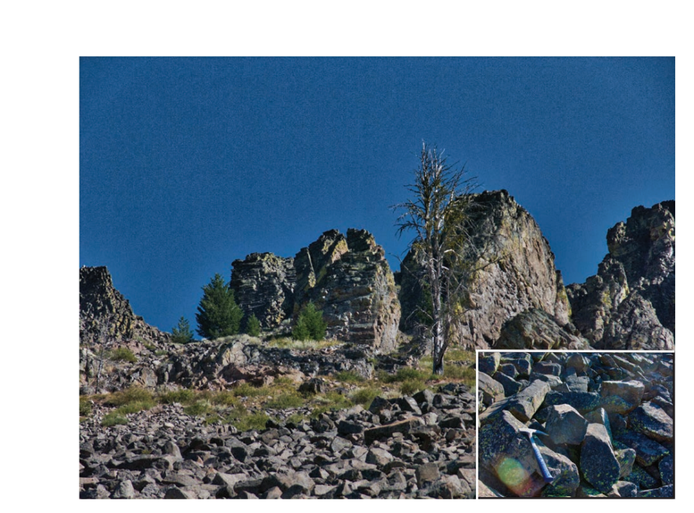

Figure 2. Horizontal columnar jointing developed in basaltic intrusion of Irishmans Rock (*Tbpd*). Inset shows close-up view of the columns in talus. Joints likely reflect emplacement as sheeted dikes.

Figure 3. Quartzite and siltite of the *Yacb* unit 800 m (0.5 mi) south of Irishmans Rock. White spots in the siltite were likely originally scapolite but may now be albite.

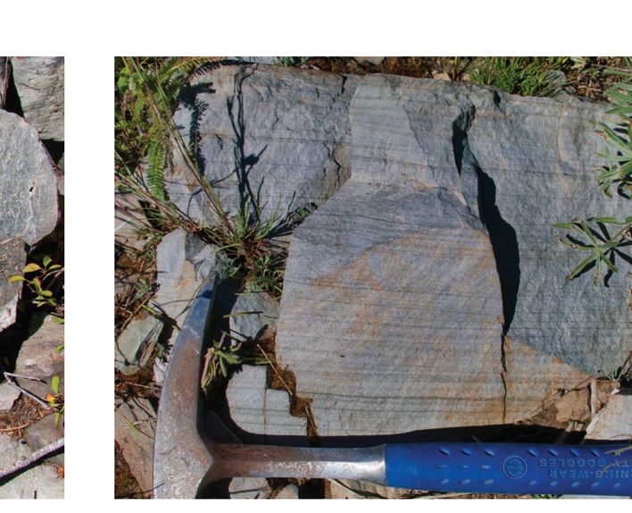

Figure 4. Parallel heavy-mineral laminations with abundant magnetite in Jahnke Lake member of Apple Creek Formation (*Yajl*). Photo about 1 km (0.6 mi) east of the fault contact with Swauger Formation (*Ys*) on state line.

Figure 5. Folded gneiss in *Ygn* along state line near western edge of map.

Figure 6. Garnet-rich gneiss in *Ygn* along state line near western edge of map.

Figure 7. Fabric developed in the Trail Gulch thrust. Mylonite here, and to the north, as well as breccias typically contain tourmaline. Looking west about 1 km (0.6 mi) southeast of state line.