Geologic Map of the Smiths Ferry Quadrangle, Valley County, Idaho

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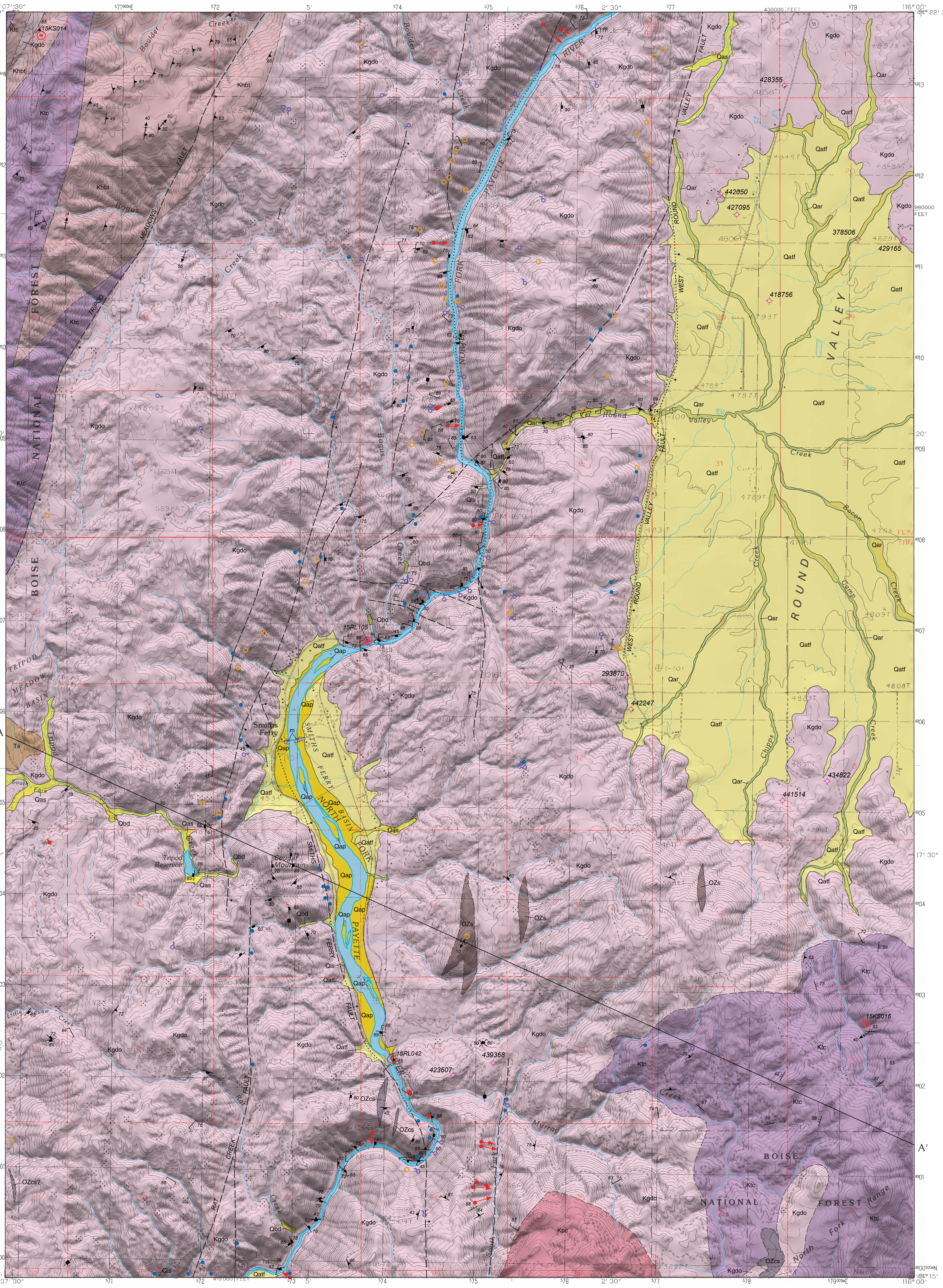
2017



Base Map Credit

Base digitally scanned from 24,000-scale USGS film separates, 1989.

Water bodies digitized from 2009 NAIP imagery.

Shaded elevation from 10 m DEM.

Topography by photogrammetric methods from aerial photographs taken 1980. Field checked 1981.

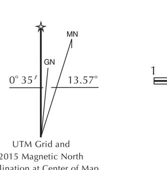
Map edited 1985.

Projection: Idaho coordinate system, west zone (Transverse Mercator). 1927 North American Datum.

10,000-foot grid ticks based on Idaho coordinate system, central zone.

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

Declination from NOAA National Geophysical Data Center.



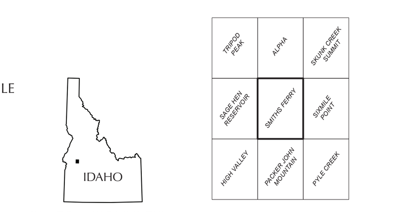
SCALE 1:24,000

1 0.5 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 0.5 0 1 KILOMETER

Contour interval 40 feet



QUADRANGLE LOCATION

ADJOINING QUADRANGLES

Field work conducted 2015 and 2016.

Digital cartography by Jane S. Freed at the Idaho Geological Survey's Digital Mapping Lab.

Geologic map was funded by the Idaho Transportation Department.

Technical review by Dennis M. Feeney and Renee L. Breedlovestrout.

Map version 2-23-2018.

PDF (Acrobat Reader) map may be viewed online at www.idahogeology.org.

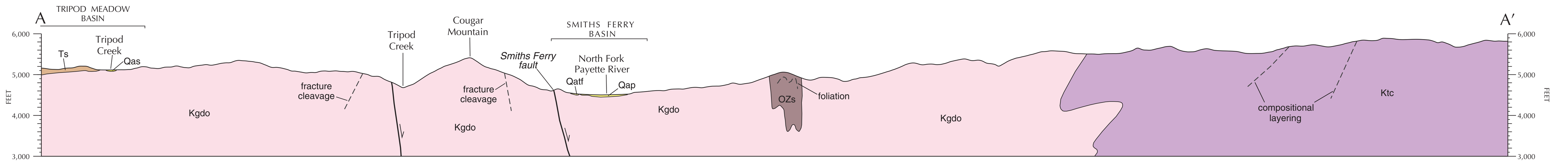
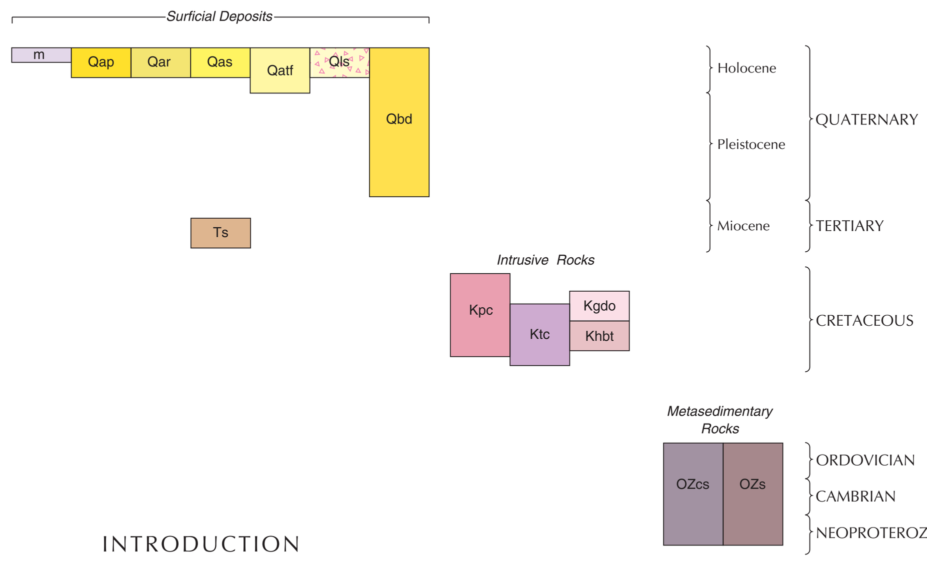


Table 1. Major oxide and trace element chemistry of samples collected in the Smiths Ferry quadrangle.

Sample number	Latitude	Longitude	Unit name	Map unit	Lithology	Major elements in weight percent												Trace elements in parts per million																	
						SiO_2	TiO_2	Al_2O_3	Fe_2O_3*	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Total	LOI	Ni	Cr	Sc	V	Ba	Rb	Sr	Zr	Y	Nb	Ga	Cu	Zn	Pb	La	Ce	Th	U	Co
15KS014	44.3727	-116.1202	Hornblende-biotite granodiorite	Khbt	hornblende-biotite tonalite	59.11	0.88	17.61	6.71	0.13	3.35	7.48	3.11	1.16	0.47	100.01	1.19	9	52	16	129	1143	29.2	720	292	21.0	13.0	22.0	12	113	14	22	54	3.3	<0.5	14
15KS016	44.2751	-116.0067	Mixed biotite tonalite complex	Ktc	fine-grained biotite tonalite	61.22	1.41	17.84	5.98	0.08	1.75	5.06	3.85	1.81	0.61	99.61	0.87	5	20	5	68	1021	92.8	628	463	21.5	32.8	29.2	11	127	13	63	129	24.8	1.4	7
15RL034	44.2847	-116.1294	Older biotite granodiorite	Kgdo	biotite granodiorite	67.97	0.53	16.39	3.27	0.05	0.91	4.13	3.83	2.17	0.36	99.61	0.61	5	15	3	46	1335	61.5	824	323	11.1	15.9	25.2	5	76	20	50	114	15.0	1.8	1
15RL042	44.2716	-116.0719	Older biotite granodiorite	mafic Kgdo	biotite granodiorite/tonalite	64.32	0.70	16.44	4.77	0.09	2.00	5.12	3.56	2.31	0.51	99.82	0.58	6	23	17	94	1544	67.8	730	250	27.8	22.7	25.0	11	110	17	75	180	20.3	<0.5	6
15RL105	44.3129	-116.0752	Older biotite granodiorite	Kgdo	biotite granodiorite	72.52	0.27	15.31	1.69	0.04	0.48	2.98	3.84	2.55	0.19	99.87	0.53	5	21	1	22	1108	61.5	661	230	8.7	9.0	23.7	7	38	12	24	51	10.2	1.1	<1

* Total Fe expressed as Fe_2O_3.
Latitudes and longitudes are in the 1927 North American Datum (NAD27).
All analyses performed by X-ray fluorescence methods at Franklin and Marshall College X-Ray Laboratory, Lancaster, Pennsylvania.

CORRELATION OF MAP UNITS



INTRODUCTION

The Smiths Ferry quadrangle is underlain by biotite granodiorite, hornblende-biotite tonalite (equivalent to the Payette River tonalite), a mixed biotite tonalite complex, and a pegmatite-leucogranite complex, all parts of the western border phase of the Cretaceous Idaho batholith. These rocks intrude small screens of amphibolite facies schist and calc-silicate rocks of inferred latest Precambrian to Ordovician age. Conspicuously absent from the area are the pervasive Eocene Challis dikes that occur in much of the Idaho batholith. The Smiths Ferry region is faulted by north-northeast to south-southwest striking normal faults that divide the area into a system of fault blocks. The down-dropped blocks have formed three distinct north-south trending basins, which, from east to west, include Round Valley, Smiths Ferry, and Tripod Meadow. Smiths Ferry is the lowest basin, and occurs along the North Fork of the Payette River, forming a low-gradient reach along the otherwise dramatically steep-gradient river. Most subsidiary streams to the North Fork of the Payette River display knick-points that have migrated only a few hundred meters from their confluences with the river, attesting to youthful landscape development as a result of relatively recent normal faulting. Quaternary surficial deposits occur predominantly along the North Fork of the Payette River and in Round Valley.

Geologic mapping was conducted during 2015 and 2016. Previous studies are limited, but include thesis work by Ginther (1981) that investigated the engineering-geologic conditions for a proposed underground hydroelectric tunnel development parallel to the North Fork of the Payette River south of Smiths Ferry. The geology of West Mountain and Sage Hen Reservoir area, northwest and west of the quadrangle, was investigated by Braudy (2013) and Braudy and others (2017), and includes portions of the present map. Wilson and others (1976) investigated the geothermal potential of the Cascade area to the north and their mapping extended south into the northern part of the quadrangle. Water well logs (Idaho Department of Water Resources, 2016) and soil data (Soil Survey Staff, 2016) provided information about Quaternary deposits.

SYMBOLS

Contact: dashed where approximately located.

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

80 Outcrop-scale fault, showing dip.

41 Strike and dip of foliation.

25 Strike and dip of foliation, strike variable.

35 Strike and dip of fracture cleavage.

Vertical fracture cleavage.

70 Strike and dip of joint.

Vertical joint.

57 Strike and dip of compositional layering.

10 Bearing and plunge of mineral lineation.

5 Bearing and plunge of slickenlines.

Outcrop lacking fabric.

Shallow landslide: circle shows source; arrow shows path.

15KS016 Geochemical sample (see Table 1).

15KS016 Geochronologic sample (see *Kgdo* description).

293870 Water well shown with Idaho Department of Water Resources WellID number. Water well logs can be found at http://www.idwr.idaho.gov/apps/appswell/RelatedDocs.asp?WellID=xxxxxx (where "xxxxxx" is the six-digit WellID).

Iron-stained rock.

Faulted rock: evidence of brittle faulting, but fault strike direction unknown.

Spring.

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. Distances and unit thicknesses are listed in both meters (m) and feet (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).

SURFICIAL DEPOSITS

m **Made ground (Holocene)**—Granitic boulders, cobbles, and sandy matrix in bridge abutments and in the earthen dam at Tripod Reservoir; thickness less than 6 m (20 ft).

Qap **Alluvium of the North Fork of the Payette River (Holocene)**—Cobbles, boulders, and sand contained in gravel bars and low sandy terraces; generally less than 9 m (30 ft) thick. Along narrow high-gradient reaches, alternating gravel channel bars and pools are typical. Wider lower-gradient reaches have sandy point and longitudinal bars that are exposed during low flows. Some gravel bars can be traced upstream to local sediment sources such as alluvial fans and rock falls.

Qar **Alluvium of Round Valley (Holocene)**—Clay and sand derived from stream terraces and weathered granitic rocks; thickness less than 3 m (<10 ft). Contained in shallow meandering channels and low terraces. Very poorly drained and frequently flooded.

Qas **Alluvium of side streams (Holocene)**—Sand, pebbles, and cobbles derived from granitic rocks. Thickness is generally less than 3 m (<10 ft).

Qls **Landslide deposits (Holocene)**—Shallow slides and slumps forming cones and fans of angular blocks, sand, and silt. Thickness of these deposits is generally less than 6 m (<20 ft). Most failures occur near the top of steep slopes along the North Fork Payette River canyon and along the South Fork of Murray Creek. Recently-active slides are marked by narrow linear scars.

Qatf **Dissected fan and terrace deposits (Quaternary)**—In Round Valley, consists of clay, silty clay, sand, and minor granule to pebble gravels; derived from erosion of terraces, fans, and decomposed granitic rocks. Water well drilling data indicates thickness ranges from about 12 to 27 m (40 to 90 ft). Rarely flooded but has seasonal high water table about 84 cm (33 in) from the surface. In Smiths Ferry area and elsewhere along the North Fork of the Payette River, consists of brown to white sand, sandy clay, and lesser granule to pebble gravels. Deposited by mainstream floods and in alluvial fans at confluence of side streams with main stream. Thickness is generally less than 12 m (<40 ft).

Qbd **Boulder deposits (Quaternary)**—Granitic boulders and cobbles, sub-angular to sub-rounded, open-framework and matrix-free, poorly sorted; clasts are composed entirely of locally-derived granitic rocks. Thickness is generally less than 6 m (15 ft). Contained within steep-sided reaches of secondary streams incised into bedrock that are adjacent to talus-covered hillslopes. Most deposits are located near the knick-zone separating secondary streams from the North Fork Payette River. Interpreted as corestones derived from spherical weathering of granitic bedrock on hillslopes. Corestones in various stages of development are common on hillslopes underlain by granitic rocks in the map area (Fig. 1). We infer that the corestones become detached from bedrock and move downslope into channels (Fig. 2). Once in low-gradient channels, corestones pile up because stream flow is too low to transport such large clasts.

Ts **Gravel deposits (Miocene?)**—Pebbles topographically above modern stream or terrace levels. Deposits are located in Tripod Meadow basin on west edge of map near South Fork Tripod Creek (sec. 8, T. 11 N., R. 3 E.). Clasts are composed of quartzite and/or quartz.

INTRUSIVE ROCKS

Kpc **Pegmatite-leucogranite complex (Cretaceous)**—Mixed muscovite-quartz-potassium feldspar pegmatite and leucogranite. Muscovite clots locally contain sillimanite +/- biotite +/- garnet. Locally contains small unmapped masses of *Kgdo* or *Kbt*. Occurs along the southern margin of the map and continues south onto Packer John Mountain quadrangle.

Kgdo **Older biotite granodiorite (Cretaceous)**—Light-gray, fine- to medium-grained biotite granodiorite. Characteristically weathers into large boulders (Fig. 1). Commonly weakly porphyritic with euhedral potassium feldspar crystals as much as 3 cm in length. Locally develops a weak magmatic foliation defined by biotite and potassium feldspar. 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 occurs locally along the western side of the unit, and in mafic inclusions. These inclusions are uncommon and typically a few centimeters to meters across. Pegmatite is rare and, where present, is relatively poor in muscovite. It is more common in the east than in the west. Myrmekitic intergrowth of feldspar and quartz is conspicuous in thin section. U-Pb age determination on a sample from 1.4 km (1 mi) northeast of Smiths Ferry (15RL105) was conducted at Boise State University (Mark Schmitz, written communication, 2015). U-Pb dates were obtained for 65 spot analyses on 46 zircon crystals via laser ablation inductively coupled plasma mass spectrometry (LA-ICPMS). Near-concordant spot $^{206}Pb/^{238}U$ ages ranged from 126 ± 15 Ma to 82 ± 3 Ma; a few older discordant analyses with $^{207}Pb/^{206}Pb$ ages ranged from 1.3 to 3.4 Ga. Spot analyses on the cores of zircon crystals are commonly older than spots on the oscillatory zoned mantles. Utilizing cathodoluminescence imagery, the tail toward older ages in the probability density function of the age results was filtered and the remaining 35 spot analyses yield a weighted mean $^{206}Pb/^{238}U$ date of 87.84 ± 0.83 Ma. A second date from immediately west of the map area south of Tripod Meadow is 88.2 ± 3 Ma and within error of the first age. This age is based on zircon rim analyses by LA-ICPMS methods at Washington State University (Sample 10NB22 from the Rat Creek granite, a unit we consider equivalent to *Kgdo*; Braudy and others, 2017). These age determinations indicate that the *Kgdo* unit in the Smiths Ferry area is older than the main mass of biotite granodiorite and two-mica granite that makes up the Idaho batholith to the east, which ranges in age from 80 to 74 Ma (Gaschnig and others, 2010). The biotite granodiorite described from Smiths Ferry can be distinguished from the younger biotite granodiorite to the east by the former's paucity of pegmatite, slightly more porphyritic nature, and slightly finer overall grain size. It also weathers differently, forming characteristic large boulders (corestones) as illustrated in Figure 1.

Khbt **Hornblende-biotite tonalite (Cretaceous)**—Light-gray, medium- to coarse-grained hornblende-biotite tonalite. Occurs both as a separate mappable unit and as a phase within the *Ktc* unit. Contains conspicuous, euhedral hornblende up to 2 cm in length. Most of the rock consists of plagioclase feldspar with subsidiary quartz and uncommon potassium feldspar. Biotite content subequal to hornblende and forms flakes less than 3 mm across. Hornblende and biotite, and to a lesser degree quartz and feldspar, define a well-developed foliation and more weakly developed down-dip lineation in the map area. Most fabrics are magmatic; solid-state fabrics are uncommon. *Khbt* unit mapped on quadrangle continues off map to the north where it has been mapped as the Payette River tonalite (Braudy and others, 2017). A sample of this unit from a location on the Snowbank Mountain Road 3.3 km (2 mi) north of the map was dated at 89.7 ± 1.2 Ma (U-Pb zircon SHRIMP analysis; Giorgis and others, 2008). We agree with these authors and consider this unit equivalent to the Payette River tonalite in the McCall area.

Ktc **Mixed biotite tonalite complex (Cretaceous)—**Light-gray, fine-grained equigranular biotite tonalite mixed with subsidiary *Kgdo* and biotite-rich schlieren. Plagioclase feldspar is the principle constituent, followed by quartz and rare potassium feldspar. Sphene occurs at some localities. Locally hornblende rich with abundant euhedral hornblende up to 5 cm. Biotite forms 10 to 20 percent of the rock and commonly occurs in clots with or without hornblende giving the rock a spotted appearance. Well-foliated biotite-rich schlieren up to 3 m in width are common, but rarely show consistent orientations. Within the complex, biotite tonalite and hornblende-bearing biotite tonalite are mutually cross-cutting. Granodiorite of *Kgdo* unit intrudes the other lithologies. Igneous complex exhibits gradational contacts with surrounding *Kgdo*. Two large bodies of *Ktc* were mapped in the quadrangle. *Ktc* in the southeast corner of the map forms a nearly equant, irregular unit surrounded by *Kgdo*. *Ktc* mapped in the northwest corner of the quadrangle is continuous with the Sage Hen orthogneiss unit of Braudy and others, (2017) in the West Mountain area. They report a weighted mean zircon rim age of 93 ± 3.4 Ma (U/Pb LAICP-MS) from a biotite-hornblende tonalite sample of this unit collected from Sage Hen Reservoir 2.8 mi (4.5 km) west of the quadrangle. They interpret this age as a magmatic age.

METASEDIMENTARY ROCKS

OZcs **Calc-silicate rocks (Ordovician? to Neoproterozoic?)**—Deeply weathered, mixed unit of calc-silicate rock, mostly quartz-rich, with variable amounts of pyroxene and biotite grading to quartzofeldspathic biotite schist. No outcrops were observed on quadrangle, but forms outcrops on Packer John Mountain to the south and West Mountain to the northwest; float is a mix of non-foliated quartz-rich rock and biotite schist which displays a well-developed foliation. Unit locally contains minor amounts of sillimanite schist.

OZs **Sillimanite schist (Ordovician? to Neoproterozoic?)**—Mixed unit of muscovite-biotite-sillimanite schist grading to biotite schist and calc-silicate rock. The rock is generally well foliated. Sillimanite occurs as radiating clusters as much as 4 mm across within biotite- and muscovite-rich layers and appears to have grown later than the biotite. These bodies occur as small screens within the intrusive rocks.

STRUCTURE

The main structural trend in the map area is north-northeast to south- southwest, as displayed both by Cretaceous-age fabrics in the intrusive rocks and metasedimentary screens they intrude, as well as the numerous Neogene (and younger?) normal faults that cut them. Older fabrics are best developed in the northwestern part of the map in *Ktc* and *Khbt* units, and include mostly steep east-dipping solid-state foliation with uncommon, mostly steep northeast-plunging, mineral stretching lineation. These fabrics appear to be associated with deformation along the western Idaho shear zone that is exposed across the western side of West Mountain to the west- northwest of the map area (Braudy, 2013; Braudy and others, 2017). These fabrics are absent in the *Kgdo* unit on the map, presumably because intrusion of this unit at ca. 88 Ma post-dated deformation on the Western Idaho shear zone.

FAULTS

Tripod Meadow fault

This down-to-the-east normal fault extends across the northwest corner of the map. Topographic expression consists of subdued topography on the east side of the fault (hanging wall) and a small amount of Tertiary sediment (*Ts*) is preserved above Tripod Creek. No outcrop exposures were observed.

Rat Creek fault

This north-south fault extends into the quadrangle from the south, where exposures of sheared, atypically light-colored granitic rock are common along the structure. At that location, the straight trace of the North Fork of the Payette River is a result of brittle faulting having formed easily eroded granitic material. The fault extends at least as far north as the southwest flank of Cougar Mountain and it may continue northward along an unnamed fault trace west of Smiths Ferry. Topographic expression is limited to a series of aligned notches and slightly lower average elevation on the east side of the fault.

Smiths Ferry fault

This north-south fault parallels Highway 55 south of Smiths Ferry. Evidence for faulting was noted in 2016 along a new logging road cut on the southeast flank of Cougar Mountain. Topographic expression is limited to subdued topography on the east side of the fault, forming the Smiths Ferry basin. The northwest and southeast extensions of this fault are uncertain, but it is likely that the low-gradient portion of the North Fork of the Payette River in the Smiths Ferry basin is related to down-on-the-east faulting along this structure.

West Round Valley fault

The West Round Valley fault is a down-to-the-east normal structure. The trace of the fault lies east of the linear bedrock escarpment defining the western edge of Round Valley, where it is concealed by Quaternary deposits. A parallel zone of faulted rock is present in portions of the footwall adjacent to the fault. Round Valley has been interpreted as a graben bounded by the West Round Valley and North Fork Range faults (Schmidt and Mackin, 1970; Anderson and others, 2007 and references therein; Sprenke and others, 2007).

An unnamed northeast-trending fault joins or is truncated by the West Round Valley fault in sec. 19, T. 12 N., R. 4 E. This fault trace is marked by a prominent topographic lineament and areas of faulted rock.

OUTCROP-SCALE STRUCTURES

Joints

Subparallel fracture surfaces with spacing on the order of tens of centimeters to a few meters were mapped as joints. Many of these have secondary growth of muscovite and quartz along the joint surface (Fig. 3).

Fracture Cleavage

Subparallel fracture surfaces with spacing on the order of millimeters to a few centimeters were mapped as fracture cleavage. These zones of closely spaced fractured rock are developed in granitic rocks and are present over widths of a few centimeters to tens of centimeters (Fig. 4). Some of these zones show offset where appropriate markers are present, but most show no apparent offset. Many outcrops contain more than one orientation of fracture cleavage. Our preferred interpretation is that these surfaces are shear surfaces developed along small fault zones. An alternative explanation is that they represent weathered joint sets, perhaps a result of freeze-thaw activity.

GEOCHEMISTRY

Five granitic samples were collected and analyzed by X-ray fluorescence spectroscopy for comparison to the main phase of the Idaho batholith to the east (Table 1). Two of the biotite granodiorite (*Kgdo*) samples (15RL034 and 15RL105) have SiO_2 concentrations of 72.52 and 67.97 percent, respectively. The latter is similar to the average value for the main phase (biotite granodiorite and two-mica granite) of the batholith reported by Lewis and others (1987). However, Fe_2O_3 and CaO concentrations are higher, and the K_2O concentration is lower than the average for the main phase of the batholith. Note that sample 15RL034 was collected immediately west of the map at the same locality of the U-Pb age determination by Braudy and others (2017) mentioned above (88.2 ± 3 Ma) and that 15RL105 was collected northeast of Smiths Ferry at the same locality as the sample dated for this study (87.84 ± 0.83 Ma). These two samples from the *Kgdo* unit are weakly peraluminous (aluminum saturation index slightly above 1.0) and thus less aluminous than most samples from the main phase of the batholith. Sample 15RL042 is from an anomalous biotite-rich variety of *Kgdo* and is metaluminous, as is a sample of the hornblende-biotite tonalite unit (*Khbt*; 15KS014). Sample 15KS016 from a fine-grained biotite tonalite lithology in the mixed biotite tonalite complex (*Ktc*) is weakly peraluminous and thus similar in that regard to samples 15RL034 and 15RL105 from the *Kgdo* unit. It differs, however, in having higher Al_2O_3 and Fe_2O_3 concentrations, and a lower K_2O concentration.

REFERENCES

Anderson, L.W., LaForge, R.C., and Liu, P., 2007, Probabilistic seismic hazard study for Cascade Dam–Boise Project, Idaho: U.S. Bureau of Reclamation Technical Memorandum No. 86-68330-2007-04, 27 p.

Braudy, N., 2013, Deformation history of West Mountain, west-central Idaho: Implications for the western Idaho shear zone: University of Wisconsin-Madison M.S. thesis, 136 p.

Braudy, N., Gashnig, R.M., Wilford, D., Vervoort, J.D., Nelson, C.L., Davidson, C, Kahn, M.J., and Tikoff, B., 2017, Timing and deformation conditions of the western Idaho shear zone, West Mountain, west-central Idaho: Lithosphere, v. 9, no. 2, p. 157-183.

Gaschnig, R.M., Vervoort, J.D., Lewis, R.S., and McClelland, W.C., 2010, Migrating magmatism in the northern US Cordillera: In situ U-Pb geochronology of the Idaho batholith: Contributions to Mineralogy and Petrology, v. 159, p. 863–883.

Ginther, P.G., 1981, Geologic investigation and mapping of the North Fork Payette River, Banks to Smiths Ferry, Idaho: Washington State University M.S. thesis, 77 p.

Giorgis, S., McClelland, W., Fayon, A., Singer, B.S., and Tikoff, B., 2008, Timing of deformation and exhumation in the western Idaho shear zone, McCall, Idaho: Geological Society of America Bulletin, v. 120, p. 1119–1133.

Idaho Department of Water Resources, 2016, All Permitted Wells, in GIS Data, Maps and Spatial Data, Idaho Department of Water Resources. Available at: http://www.idwr.idaho.gov/GeographicInfo/GISdata/wells.htm (accessed 16 August 2016).

Lane, E.W., 1947, Report of the subcommittee on sediment terminology: Transactions of the American Geophysical Union, v. 28, no. 6, p. 936-938.

Lewis, R.S., Kiilsgaard, T.H., Bennett, E.H., and Hall, W.E., 1987, Lithologic and chemical characteristics of the central and southeastern part of the southern lobe of the Idaho batholith, *in* Vallier, T.L., and Brooks, H.C., eds., Geology of the Blue Mountains Region of Oregon, Idaho, and Washington: U.S. Geological Survey Professional Paper 1436, Chapter 9, p. 171-196.

Schmidt, D.L., and Mackin, J.H., 1970, Quaternary geology of Long and Bear Valleys, west-central Idaho: U.S. Geological Survey Bulletin 1311-A, 22 p., 2 sheets, scale 1:62,500.

Sprenke, K.F., Stickney, M.C., and Peterson, J.L., 2007, The 2005 Alpha Earthquake Swarm, Valley County, Idaho: Idaho Geological Survey Staff Report S-07-3, 49 p.

Soil Survey Staff, 2016, Valley County area, Idaho: Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available at: http://websoilsurvey.nrcs.usda.gov/ (accessed 22 November 2016).

Streckeisen, A.L., 1976, To each plutonic rock its proper name: Earth-Science Reviews, v. 12, p. 1-33.

Wilson, M.D., Applegate, J.K., Chapman, S.L., and Donaldson, P.R., Geothermal investigation of the Cascade, Idaho area, 1976, Unpublished Boise State University Department of Geology and Geophysics report for the Idaho Nuclear Energy Commission, 44 p., map scale 1:62,500.

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Figure 3. Joint surface in *Kgdo* along which quartz and muscovite have crystallized.

Figure 1. Typical weathering of *Kgdo* unit into corestones.

Figure 2. Example of *Qbd* deposit near the mouth of Rat Creek.

Figure 4. Cleavage formation in *Kgdo* characterized by closely spaced fracture surfaces.