Geologic Map of the Grangeville East Quadrangle, Idaho County, Idaho

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2007

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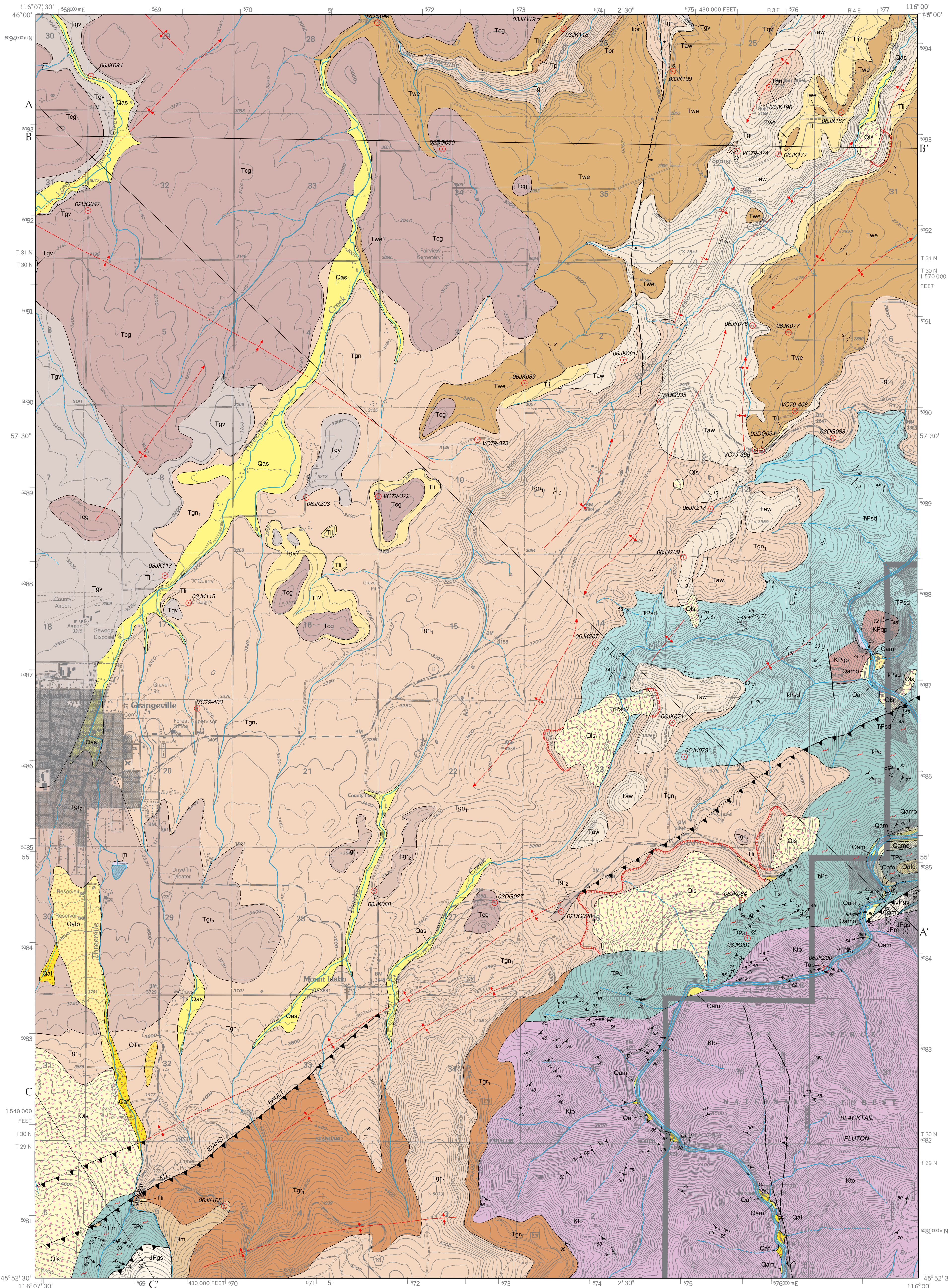


Base map scanned from USGS film-positive base, 1995.
Topography compiled 1961. Planimetry derived from imagery taken 1992. Public Land Survey System and survey control current as of 1995. Partial field check by U.S. Forest Service 1995.
Transverse Mercator. 1927 North American Datum.
10,000-foot grid ticks based on Idaho coordinate system, west zone.
1000-meter Universal Transverse Mercator grid ticks, zone 11.
National geodetic vertical datum of 1929.

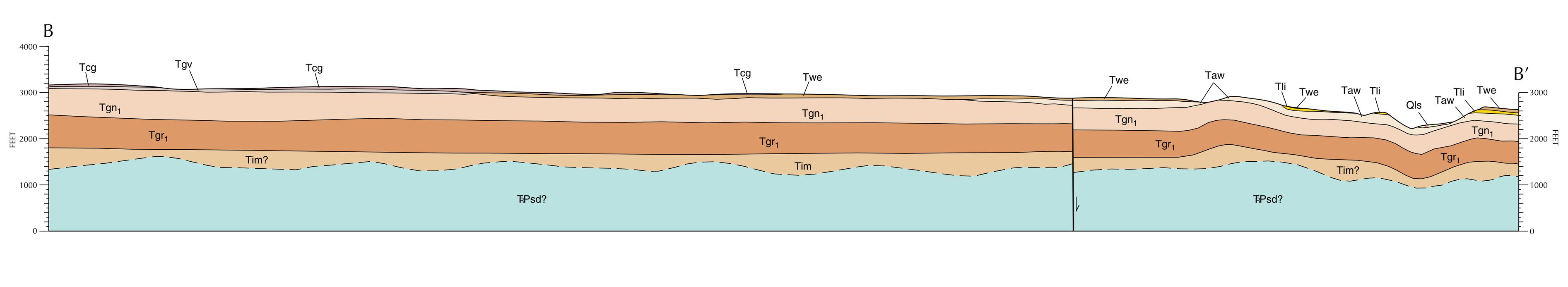
UTM Grid and 1967 Magnetic North Declination at Center of Map

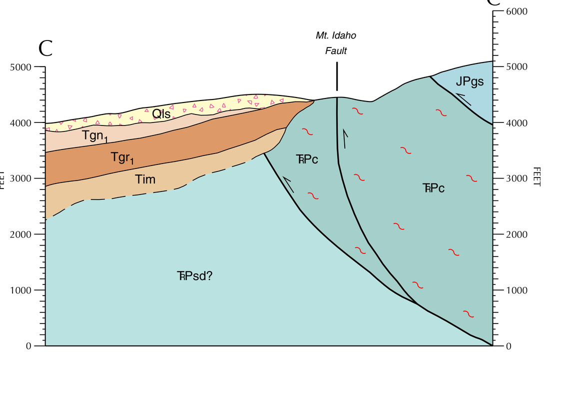
SCALE 1:24,000

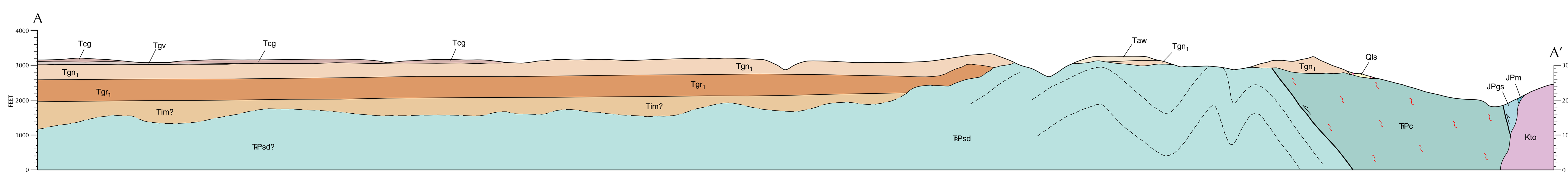
Contour interval 40 feet.
Supplementary contour interval 20 feet.

IDAHO
QUADRANGLE LOCATION

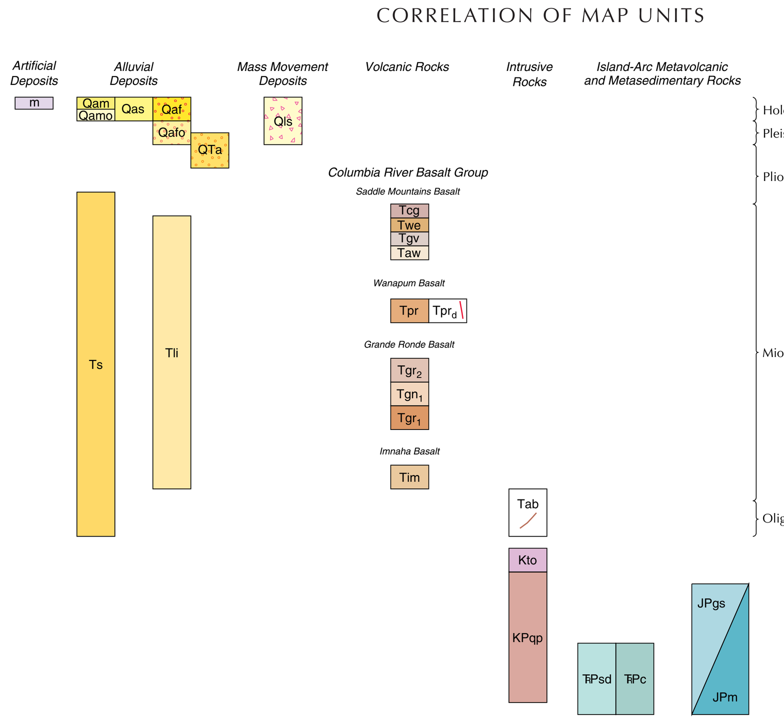
Field work conducted 2006.
This geologic map was funded in part by the U.S. Geological Survey National Cooperative Geologic Mapping Program, USGS Award No. 06HQAG0020.
Digital cartography by Jesse S. Bird and Jane S. Freed at the Idaho Geological Survey's Digital Mapping Lab.
Note on printing: The map is reproduced at a high resolution of 600 dots per inch. The inks are resistant to run and fading but will deteriorate with long-term exposure to light.
PDF map (Acrobat Reader) may be viewed at www.idahogeology.org.
Map version 6-7-2007.







CORRELATION OF MAP UNITS



INTRODUCTION

The geologic map of the Grangeville East quadrangle depicts rock units exposed at the surface or underlying thin surficial cover of soil and colluvium. Thicker surficial deposits of alluvium and landslides are also depicted where they mask or modify the underlying rock units or form significant mappable units. The map is the result of field work conducted in 2003 and 2006 by the authors. Previous work includes that of Bond (1963), reconnaissance mapping and sampling in the area from 1978 to 1980 (Camp, 1981; Swanson and others, 1981), and unpublished mapping by Paul Myers (1977-1982).

Much of the quadrangle is underlain by Miocene basalt flows of the Columbia River Basalt Group. Permian to Triassic island-arc rocks of the Seven Devils Group and Permian to Cretaceous intrusive rocks are exposed in the canyon of the South Fork Clearwater River and in a window through the basalt on the uplifted side of the Mt. Idaho structure. The basalt flows invaded ancestral drainages and flooded the preexisting topography. Structural warping of the basalt occurred both during and after emplacement, in part controlling the distribution of younger basalt units, stream development, and the cutting of the South Fork Clearwater River canyon. The Mt. Idaho front is characterized by steep dip slopes of basalt units overlying basement rock, a setting that contributed to a large mass movement and accumulation of landslide debris in the southwest corner of the quadrangle. Other major landslides are also associated with the contact between basalt and basement rocks. The plateau soils include loess parent material (Barker, 1982), but loess deposits are thin and not included on this map. In addition to its present channel, South Fork Clearwater River alluvial deposits form a terrace remnant of an older regime of the river.

DESCRIPTION OF MAP UNITS

Throughout the following descriptions and later discussion of structure, we use the metric system for sizes of mineral or clast constituents of units. However, we use English system for thickness and distance measurements because that system is used on the base map.

ARTIFICIAL DEPOSITS

m **Made ground (Holocene)**–Artificial fills composed of excavated, transported, and emplaced construction materials of highly varying composition, but typically derived from local sources.

SEDIMENTARY AND MASS MOVEMENT DEPOSITS

Alluvial Deposits

Qam **Alluvium of the South Fork Clearwater River (late Holocene)**–Channel and flood-plain deposits that are part of the present river system. Two grain-size suites are typically present: well-sorted and rounded pebble to boulder gravel in river bars and islands, and coarse sand in thin shoreline deposits. Gravel clasts include granitic, basaltic, and metamorphic rocks.

Qamo **Older alluvium of the South Fork Clearwater River (early Holocene)**–Primarily stratified sand and well-rounded pebble to boulder gravel in terrace remnants that are above modern levels of the South Fork Clearwater River. Height above present mean water level is 30-40 feet. Interfingers with colluvium and alluvial-fan deposits at toe of canyon slope.

Qas **Alluvial deposits in local drainages and tributaries to the South Fork Clearwater River (Holocene)**–Stratified silt, sand, and clay with minor intercalated subrounded to subangular pebbles and cobbles. Gravel clasts predominantly basalt. Thickness 5-20 feet.

Qaf **Alluvial-fan deposits (Holocene)**–Crudely bedded, poorly sorted brown muddy gravel deposited by mountain-front streams and tributaries to the South Fork Clearwater River. Mountain-front gravel is composed of subangular to subrounded pebbles, cobbles, and boulders in a silt and clay matrix. Clast lithologies are predominantly basalt. Thickness 10-20 feet. Fan deposits on the South Fork Clearwater River are predominantly tonalite and trondhjemite from *Kto* unit. Thickness 5-20 feet.

Qafo **Older alluvial-fan deposits (Pleistocene)**–Poorly sorted gravel deposits of incised alluvial fan remnants. Clast lithologies are predominantly basalt, but include metamorphic rocks. Thickness 10-20 feet.

QTa **Alluvial gravel deposits of ancient streams draining Mt. Idaho uplift (Pliocene or Pleistocene)**–Crudely bedded pebble to cobble gravel with a sandy, clayey matrix. Pebble clasts are subrounded to rounded. Only one small remnant mapped. Clast lithologies include basaltic, granitic, and metamorphic rocks. Moderately weathered. Thickness 2-10 feet.

Ts **Sediment, undivided (Miocene or Pliocene)**–Isolated gravel deposit at elevation 3260 feet along the Mt. Idaho-South Fork Clearwater River road. Deposit includes rounded boulders up to 1 meter in diameter of biotite tonalite. Location and stratigraphic position suggests it represents an alluvial channel gravel of postbasalt age but older than the cutting of the South Fork Clearwater River canyon.

Latah Formation Sediments

Sediments of the Latah Formation interbedded within the basalt sequence. Stratigraphically equivalent to the Ellensburg Formation in Washington (Swanson and others, 1979).

Tli **Latah Formation, sedimentary interbed (Miocene)**–Clay, silt, sand, pebble, and cobble deposits interbedded between basalt flows or at the basement rock-basalt contact. Sands are typically arkosic. Pebbles and cobbles are usually well rounded; composition varies depending on source area. Interbeds are probably more extensive than mapped. Deposited t as a result of repeated damming of drainages by basalt flows. In the older basalt units, interbeds are mostly restricted to marginal areas near prebasalt basement rocks. In younger units, interbeds are generally associated with developing structures on the basalt surface.

MASS MOVEMENT DEPOSITS

Qls **Landslide deposits (Holocene and Pleistocene)**–Poorly sorted and poorly stratified angular pebbles, cobbles, and boulders mixed with silt and clay. Deposited by slumps, slides, and debris flows. In addition to the landslide deposit, the unit may include the landslide scarp and the headwall (steep area adjacent to and below the landslide scarp) from which material broke away (see Symbols). Location of landslide deposits is typically controlled by the presence of sedimentary interbeds and the interface between basalt units and underlying basement rocks. Landslides range in age from ancient, relatively stable features, to those that have been active within the past few years. Large landslide deposit in the southwest corner of the map is probably an ancient feature that may be early Pleistocene or older. The Mt. Idaho road crosses a large landslide that was locally reactivated in the 1990s.

VOLCANIC ROCKS

Columbia River Basalt Group

The stratigraphic nomenclature for the Columbia River Basalt Group follows that of Swanson and others (1979) and Camp (1981). In Idaho, the group is divided into four formations. From oldest to youngest, these are Imnaha, Basalt, Grande Ronde Basalt, Wanapum Basalt, and Saddle Mountains Basalt. Imnaha Basalt is poorly exposed along the Mt. Idaho fault zone. Grande Ronde Basalt, from oldest to youngest, has been subdivided into the informal R_1, N_1, R_2, and N_2 magnetostratigraphic units (Swanson and others, 1979). Of these units, flows of the R_1, N_1 and R_2 are exposed in the quadrangle. Grande Ronde basalt commonly forms the upland surface or is veneered by one or more flows of the more restricted Wanapum Basalt and Saddle Mountains Basalt. Wanapum Basalt is restricted to one flow of the Priest Rapids Member in the Threemile Creek drainage at the north edge of the quadrangle. Saddle Mountains Basalt units cap most of upland surface in the northern half of the quadrangle. Basalt units were identified using hand sample characteristics, paleomagnetic signatures, geochemical signatures, and compilation of previous data. Representative samples of most basalt units were collected for chemical analysis. These samples supplement previous ones collected by V. E. Camp (written commun., 2002). Our sample locations and those of Camp are identified on the map. Analytical results are listed in Table 1. Samples were analyzed at Washington State University's GeoAnalytical Laboratory.

Saddle Mountains Basalt

Tcg **Basalt of Craigmont (Miocene)**–Fine- to medium-grained phyric basalt, uncommon to common plagioclase phenocrysts -5 mm in length, rarely 7-10 mm in length; uncommon olivine about 1 mm in diameter; some manganese(?) oxide cavity filling. Normal magnetic polarity. Outcrops uncommon and generally poorly exposed. One flow with a thickness of 50-150 feet, possibly thicker locally. Forms the capping unit in the northern part of the quadrangle and pinches out southward east of Grangeville. Equivalent to the Craigmont Member of Camp (1981).

Twe **Basalt of Weippe (Miocene)**–Medium- to coarse-grained basalt with scattered to common plagioclase phenocrysts 2-5 mm long; abundant olivine crystals and clots generally visible to the naked eye. Reverse magnetic polarity as determined in the laboratory; field magnetometer readings are commonly conflicting and weak. Consists of one flow with a thickness of 50-150 feet. Commonly weathered to saprolite. K/Ar age reported as 12.9 ± 0.8 (Kauffman, 2004). Occurs stratigraphically above the basalt of Grangeville at several locations.

Tgv **Basalt of Grangeville (Miocene)**–Medium to dark gray, fine- to medium-grained basalt with common plagioclase phenocrysts 1-4 mm in length and scarce to common olivine grains generally <1 mm in diameter that tend to weather pinkish or orangish. Reverse magnetic polarity as determined in the field and the laboratory. Consists of one flow ranging from about 30-80 feet thick. Paleomagnetic directions for the Grangeville Member are similar to, although slightly different from, those for the basalt of Weippe (Idaho Geological Survey, unpublished paleomagnetic data). We conclude the Grangeville basalt was most likely erupted during the same reverse polarity epoch as the younger basalt of Weippe. Equivalent to the Grangeville Member of Camp (1981).

Taw **Asotin Member and Wilbur Creek Member, undivided (Miocene)**–Dark gray, fine-grained basalt with scattered plagioclase phenocrysts 1-4 mm in length and occasional to common olivine grains <1 mm in diameter. Normal magnetic polarity. Chemical compositions typical of both members and intermediate between members are documented in the quadrangle, indicating mixing of magmas or flows. Occurs as a drainage-filling flow along Mill Creek; thickens to the north and east.

Wanapum Basalt

Tpr **Priest Rapids Member (Miocene)**–Medium to dark gray, fine- to medium-grained basalt with common plagioclase phenocrysts 2-8 mm in length and common olivine grains 1-2 mm in diameter. Reverse magnetic polarity. Consists of one flow of Lolo chemical type (Wright and others, 1973) documented by sampling in Threemile Creek canyon near the north edge of the quadrangle. Probably filled a shallow trough developed on the Grande Ronde basalt surface.

Tpr$_d$ **Priest Rapids Member dike (Miocene)**–One dike with Priest Rapids chemistry (sample 06JK201; Table 1) cuts *ŦPc* unit. The basalt is greenish gray with tan-brown weathering rinds and fine-grained, in part phyric with 1-2 mm plagioclase laths.

Grande Ronde Basalt

Tgr$_2$ **Grande Ronde Basalt, R_2 magnetostratigraphic unit (Miocene)**–Medium to dark gray, fine-grained basalt, commonly with a sugary texture. Uncommon to common 1-2 mm plagioclase phenocrysts. Reverse magnetic polarity, although field magnetometer readings commonly give weak normal or conflicting results, particularly near the top of the R_2 section. Consists of one or two thin flows that probably underlie Grangeville and occur as small remnants east of Grangeville. Generally poorly exposed and weathered, commonly to saprolite.

Tgn$_1$ **Grande Ronde Basalt, N_1 magnetostratigraphic unit (Miocene)**–Dark gray, fine-grained generally aphyric to plagioclase microphyric basalt. Normal magnetic polarity. Number of flows not determined, but estimated at three to five. Flows near the top of the sequence are commonly 50-70 feet thick and typically sugary textured with scarce small plagioclase phenocrysts 1-3 mm in length. Flows lower in the sequence are typically thicker, generally 100-200 feet. Maximum exposed thickness is about 500 feet.

Tgr$_1$ **Grande Ronde Basalt, R_1 magnetostratigraphic unit (Miocene)**–Mostly dark gray, fine-grained aphyric to microphyric basalt. Uncommon plagioclase phenocrysts 2-4 mm in length in one or more flows. Reverse magnetic polarity, although flows near the R_1-N_1 boundary commonly have inconsistent and weak field magnetometer polarity readings; therefore the mapped contact is poorly constrained. Outcrop characteristics of flows are similar to those in the Grande Ronde N_1 unit. Exposed thickness is about 400 feet.

Imnaha Basalt

Tim **Imnaha Basalt (Miocene)**–Medium- to coarse-grained, sparsely to abundantly plagioclase-phyric basalt; olivine common; plagioclase phenocrysts generally 0.5-2 cm but some are as large as 3 cm. Flows examined in the field have normal polarity. Poorly exposed along the road from Grangeville to Florence where it is structurally disrupted along the Mt. Idaho fault. Also found as float at elevations as high as 4,900 feet south of the Mt. Idaho fault.

INTRUSIVE ROCKS

Tab **Basalt dike (Tertiary?)**–One weathered and sheared basalt dike cuts *Kto* unit along Highway 14. The rock is fine grained and greenish gray with tan-brown weathering rinds. Chemical analysis (sample 06JK200; Table 1) indicates this basalt is unrelated to Columbia River basalt units. It has some chemical characteristics similar to the Onaway Member of the Potlatch Volcanics (Kauffman and others, 2006) in that it plots in the trachyandesite field on a total alkali-silica diagram, but correlation with the Onaway Member is speculative.

Kto **Tonalite and trondhjemite (Cretaceous)**–Light gray biotite tonalite cut by dikes and pods of light gray, fine-grained to pegmatitic, muscovite-bearing trondhjemite. Tonalite characterized by a distinctive mottling due to the presence of large biotite plates; weathers to micaceous light tan grus. Generally medium grained, with plagioclase comprising approximately 60-65 percent and quartz 25-30 percent of the rock. Biotite plates locally are as large as 2 cm, comprise from 5-10 percent of the unit, and define a foliation that is locally strong. Garnet is common. Muscovite is present locally as small grains that grew along the crystallographic axes in plagioclase. Epidote is locally conspicuous in hand specimens and interpreted to be primary on the basis of textural relations with other minerals. Initial $^{87}Sr/^{86}Sr$ values are low (<0.704; Criss and Fleck, 1987). Referred to as trondhjemite of the Blacktail pluton by Myers (1982). However, normative values for five samples plot in the tonalite field on an Ab-An-Or diagram (after Barker, 1979). Muscovite trondhjemite dikes and pods are tonalite and granodiorite by IUGS classification (Streckeisen, 1976), but normative values for one dike sample plot in the trondhjemite field on an Ab-An-Or diagram (after Barker, 1979). Weathers to a micaceous light tan fine grus. Composed of 55-70 percent plagioclase, 3-15 percent potassium feldspar, 20-30 percent quartz, 1-2 percent biotite, and conspicuous muscovite comprising as much as 10 percent. Garnet and epidote are locally present as accessory minerals. Epidote was observed in veins and as subhedral crystals. The trondhjemite is commonly more resistant to weathering than the tonalite and can mask the presence of tonalite where float is abundant. Unit belongs to a suite of trondhjemite and tonalite plutons that occur along and west of (outboard) the Salmon River suture and which contain primary epidote indicative of high pressure (8 kb) crystallization (Zen and Hammerstrom,). U-Pb zircon dating has yielded 116-119 Ma ages in tonalite and trondhjemite of the Sixmile Creek pluton to the north near Orofino (Lee, 2004) and an age of about 118 Ma in tonalite in the Hazard Creek complex to the south near McCall (Manduca and others, 1993).

KPqp **Quartz porphyry (Permian to Cretaceous)**–Quartz-phyric rock that is probably a shallow intrusive body. Highly altered and consists almost entirely of quartz, sericite, and iron oxides. Historic mining activity at the Dewey Mine near the confluence of Mill Creek and the South Fork Clearwater River exploited Cu-Au mineralization in and near southwestern part of unit. Rocks on east side of the South Fork Clearwater River are less altered and contain feldspar phenocrysts. Adits, shafts, and exploratory pits associated with mining activity appear to have targeted heavily brecciated and silicified zones in the unit. Anderson (1930) reports three to four mineralized zones trending about N 10° E and dipping 75° SE. In places, centimeter- to decimeter-wide zones of mylonite fabric are developed with north-northeast-striking foliation; at one location, a shallow south-plunging lineation was observed.

ISLAND-ARC METAVOLCANIC AND METASEDIMENTARY ROCKS

Seven Devils Group

ŦPsd **Seven Devils Group, undivided (Permian to Triassic)**–Greenschist metamorphosed volcaniclastic, volcanic, and sedimentary rocks intruded by associated dikes and sills. Exposures are dark gray to dark green-gray on fresh surfaces and light to medium greenish gray on weathered surfaces. Recognizable protoliths include volcanic flow and intrusive (mostly sills) rocks, volcanic breccias, and epiclastic conglomerate, greywacke, siltstone, and argillite. Flow and intrusive rocks are commonly plagioclase ± hornblende porphyritic, containing up to 30 percent conspicuous white to greenish white blocky plagioclase phenocrysts as large as 6 mm and hornblende as long as 1 cm in a fine-grained groundmass. Volcanic breccia and epiclastic conglomerate display angular to subangular volcanic clasts as large as 30 cm in a fine-grained matrix containing plagioclase crystals and smaller lithic fragments. Finer grained epiclastic rocks are poorly to moderately sorted and also contain common feldspar crystals and volcanic lithic fragments. Minor gray-green, red, and purple chert beds as thick as 4 inches were observed locally. All lithologies are altered in varying degrees to chlorite and epidote. These rocks are interpreted to possibly correlate with the andesitic to basaltic rocks of Wild Sheep Creek Formation of the Seven Devils Group (Vallier, 1977), although the presence of chert is anomalous for this correlation.

Seven Devils Group(?)

ŦPc **Chlorite-epidote-actinolite schist and gneiss (Permian to Triassic)**–Chlorite-epidote-actinolite schist and gneiss with subordinate intrusive rocks. Medium to dark green where fresh and light to medium green on weathered surfaces; weathers easily to fine, dark gray to brownish gray soil. Ubiquitous greenschist-grade metamorphism; mylonitic and brittle shearing heavily overprint the original texture and mineralogy of this unit. Epidote veins and stringers are common. Commonly contains plagioclase porphyroclasts in fine-grained matrix of greenschist metamorphic minerals. Intrusive rocks also typically mylonitic and include fine-grained porphyritic granite with 3-6 mm bluish quartz phenocrysts. Exposures north of the Blacktail pluton in the northern part of sec. 35, T. 30 N., R. 3 E., locally contain hornblende schist and may be fault slivers of the gneiss and schist unit (*JPgs*) or higher grade (contact metamorphic?) equivalents of the chlorite-epidote-actinolite schist. Unit occupies a position between low-grade (lower greenschist grade) metamorphic assemblages in the Wallowa terrane to the northwest and considerably higher grade (amphibolite grade) metamorphic assemblages in the Riggins Group rocks to the southeast. Interpreted to be primarily igneous in origin and equivalent to the Seven Devils Group. Unit lies within an approximately 1.2 mile wide northeast-striking shear zone characterized by multiple discrete northeast-striking mylonite zones ranging from inches to many hundreds of feet in width. Kinematics on these zones are interpreted as dextral, southeast-side-up as described further in "Structure" section below. These rocks are locally observed to be folded to open and inch-scale tight chevron and isoclinal folds with varying fold axes, especially near mylonitized portions of the unit. Pegmatites intruding the chlorite schist are both deformed and undeformed.

AMPHIBOLITE-FACIES METAMORPHIC ROCKS

Amphibolite-facies metasedimentary (and metavolcanic?) rocks that are east of and either structurally or stratigraphically above the Wallowa accreted terrane assemblage, but are west of continental North American rocks (Myers, 1982; Hoover, 1986). May be equivalent to the Orofino series exposed 36 miles to the northwest (Anderson, 1930; Hietanen,) or to the Riggins Group of Hamilton (1963) exposed 40 miles to the south. Onasch (1977) and McCollough (1984) interpreted the Riggins Group as lateral equivalents of the Seven Devils Group and Martin Bridge Formation (Limestone). Lund and others (1993) mapped similar rocks in the Slate Creek area 30 miles to the south as "rocks of the North Fork block". In the map area, we interpret these rocks to be thrust over rather than stratigraphically above the *ŦPc* unit.

JPgs **Gneiss and schist (Permian to Jurassic)**–Fine- to medium-grained hornblende gneiss that grades into hornblende ± biotite ± chlorite schist and muscovite-plagioclase-quartz ± biotite ± epidote schist, and epidote-plagioclase quartzite. Hornblende gneiss contains subordinate epidote, zoisite, chlorite, quartz, and plagioclase. Unit occurs on east side of the South Fork Clearwater River and in the southwest part of the map. Limited exposures show mylonitic fabrics with dextral, southeast-side-up kinematics close to contact with *ŦPc* unit to northwest. We interpret this probable thrust-fault contact as the southeast side of the Mt. Idaho shear zone that has juxtaposed *JPgs* against *ŦPc*.

JPm **Marble (Permian to Jurassic)**–Light gray marble. Unit crops out at one locality east of the South Fork of the Clearwater River at the eastern map boundary. A thin lens of marble too small to show at map scale (<10 feet) is also exposed along the South Fork of the Clearwater River in the south-central part of sec. 25, T. 30 N., R. 3 E.

STRUCTURE

The southwest-northeast-trending Mt. Idaho structure has a poorly understood, complex and lengthy history of movement. Included in this feature are the Mt. Idaho shear zone, a sheared, mylonitized zone as much as 1.2 miles wide within the basement metamorphic rocks, and the Mt. Idaho fault, which offsets both basement rocks and the overlying Columbia River basalts. These features, as well as other lesser structures, are discussed in the following sections.

MT. IDAHO SHEAR ZONE

Basement rock assemblages in and near the Mt. Idaho shear zone include the following, from northwest to southeast: (1) folded low-grade metamorphosed Seven Devils Group rocks (*ŦPsd*); (2) intermediate-grade metamorphosed, sheared, and commonly mylonitized rocks interpreted to be Seven Devils Group in a 0.5-1.2 mile wide zone within the shear zone (*ŦPc*); (3) high-grade metamorphosed (amphibolite grade) rocks of hornblende gneiss, schist, and marble (*JPgs* and *JPm*) that are correlative with the Orofino series or Riggins Group assemblages; and (4) biotite tonalite and muscovite trondhjemite of the Blacktail pluton (*Kto*) that displays little fabric other than weakly to moderately developed solid-state foliation in the tonalite along the northwestern and northern margins of the pluton where it intrudes (2) and (3) above. Structures in each of these assemblages are discussed in more detail below.

Rocks within the Seven Devils Group unit (*ŦPsd*), mapped from Mill Creek northward, appear to be folded in close to tight, large-scale folds with wavelengths on the order of tens to many hundreds of feet. Interpretation of the folds is based on dip reversals; no fold hinges were recognized in the field and there is no recognizable repetition of section across the Seven Devils Group assemblage. Stereonet analysis of 25 bedding orientations across the area yielded an average fold axis plunging ~30 degrees to the north-northeast with considerable scatter.

A sheared, mylonitized zone as wide as 1.2 miles consisting of mostly intermediate-grade metamorphosed rocks of the Seven Devils Group (*ŦPc*) can be traced southwestward from the South Fork Clearwater River to southwest of Grangeville where it disappears beneath the Columbia River basalt. The zone may continue southwest to the Salmon River, north and west of White Bird, where mylonitic accreted terrane rocks are exposed, and from there southwest to Pittsburg Landing on the Snake River, where it may join the Klopton Creek thrust mapped by White and Vallier (1994). Mylonite fabrics in this zone consist of mostly northeast-striking, moderately to steeply southeast-dipping foliation and shallowly northeast- to east-plunging stretching lineation. Abundant s-c and extension crenulation fabrics indicate consistent dextral, southeast-side-up shear sense across this zone. Thus, the prebasalt history along this structure was likely oblique, dextral-reverse shear that appears to offset the accreted terrane-continent suture zone by several miles in the adjoining Harpster quadrangle to the east.

To the southeast of the Mt. Idaho shear zone, higher-grade, hornblende-dominated gneiss and schist and minor marble (*JPgs* and *JPm*) occur along the South Fork Clearwater River and in the basement window that occurs just south of Grangeville. These rocks show mylonite fabrics adjacent to the Mt. Idaho shear zone, but they do not persist for more than 30-100 feet from the contact, and are replaced by northeast-striking, southeast-dipping gneissic and schistose banding and foliation.

The northwestern margin of the Blacktail pluton (*Kto*) intrudes part of the Mt. Idaho shear zone and most of the amphibolite-grade rocks to the southeast. Most of the pluton shows little recognizable fabric. However, within a zone approximately 0.5 mile wide along the northwestern margin, weak to moderate solid-state fabrics are developed in the biotite tonalite. This fabric is mostly defined by alignment of biotite phenocrysts. The foliations that are developed are mostly northeast-striking and moderately to steeply southeast-dipping, parallel to the mylonite fabrics in the adjacent Mt. Idaho shear zone. The mylonite fabric is weak or absent from outcrops of muscovite trondhjemite dikes that occur within the tonalite along this margin. We interpret these relationships as indicating that the late-stage dike intrusions of the Blacktail pluton occurred after the deformation of the Mt. Idaho shear zone.

MT. IDAHO FAULT

Miocene reactivation along the Mt. Idaho shear zone appears to be mostly vertical and possibly consists of one or more steeply dipping brittle reverse faults and associated monoclinal flexures. This reactivation, which we have mapped as the Mt. Idaho Fault, is coincident with the northwestern margin of the older mylonite shear zone. Displacement along the fault increases to the southwest from the town of Mt. Idaho, but the amount of offset is difficult to determine because of poor exposures of marker basalt units. However, we estimate at least 500 feet of vertical displacement on the basis of Imnaha Basalt outcrops near the foot of the structure at an elevation of 4,400 feet and float fragments found as high as 4,900 feet. Southwest of the quadrangle, the fault is marked by a breccia zone ranging from 30 feet to 300 feet wide that can be traced across the White Bird Hill quadrangle, where it bends southward, and through the White Bird quadrangle to the town of White Bird. The linear trace of the breccia zone indicates a near vertical fault. This structure may have begun as an anticlinal flexure in early Grande Ronde Basalt time, as evidenced by thinning of Grande Ronde R_1 on top of Mt. Idaho. Grande Ronde N_1 also thins across the structure and Grande Ronde R_2 is absent, although the latter is present on the northeast flank of the mountain. Southwest of the quadrangle, Grande Ronde R_2 and the younger basalt of Grangeville both dip as much as 45 degrees to the northwest on the northwest flank of the mountain, indicating activity along the fault continued into Saddle Mountains time.

OTHER STRUCTURES

Miocene and possibly post-Miocene anticlines, synclines, monoclines, and relatively minor faults disrupt the Columbia River basalt units. The majorityof these structures form a series of northeast-trending, doubly plunging and possibly faulted ridges and associated synclinal troughs northeast of Grangeville. Units as young as the basalt of Weippe are disrupted by these structures. These folds and minor faults may have developed in response to north-south compression against the basement-buttressed Mt. Idaho structure. Other low-amplitude folds in the northeast part of the quadrangle deform the basalt of Craigmont, the youngest basalt unit in the area.

SYMBOLS

Contact: Line showing the approximate boundary between one map unit and another.

Fault: approximately located; dotted where concealed; bar and ball on downthrown side.

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

Fold axis: approximately located; dotted where concealed; arrow indicates direction of plunge.

Monocline.

Monocline, synclinal flexure; shorter arrow on steeper limb.

Monocline, anticlinal flexure; shorter arrow on steeper limb.

Anticline.

Syncline.

Headwall scarp of landslide.

Strike and dip of bedding or basalt flow.

Strike and dip of bedding, top known.

Estimated strike and dip of basalt flow.

Strike of vertical bedding or basalt flow.

Strike and dip of cleavage.

Strike and dip of foliation.

Strike of vertical foliation.

Strike and dip of mylonitic foliation.

Strike and dip of magmatic foliation.

Bearing and plunge of lineation, type unknown.

Bearing and plunge of mineral lineation.

Bearing and plunge of mylonitic lineation.

No fabric.

Breccia.

Sample location and number.

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Table 1. Major oxide and trace element chemistry of basalt samples collected in the Grangeville East quadrangle.

Sample number	Latitude	Longitude	Unit name	Map unit	Major elements in weight percent										Trace elements in parts per million																	
					SiO_2	TiO_2	Al_2O_3	FeO*	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Ni	Cr	Sc	V	Ba	Rb	Sr	Zr	Y	Nb	Ga	Cu	Zn	Pb	La	Ce	Th	Nd
**VC79-366	45.95686	-116.0231	Asotin-Wilbur Creek members, undivided	Taw	52.09	1.68	15.50	10.85	0.17	6.01	9.42	2.48	1.27	0.34																		
**VC79-372	45.95232	-116.07644	basalt of Craigmont	Tcg	53.43	2.90	14.33	12.79	0.17	3.35	7.49	2.83	2.03	0.47																		
**VC79-373	45.95794	-116.06242	Grande Ronde Basalt N_1	Tgn$_1$	54.62	2.34	14.84	12.33	0.21	3.64	6.96	2.70	1.79	0.38																		
**VC79-374	45.98648	-116.02555	Asotin-Wilbur Creek members, undivided	Taw	51.72	1.55	16.28	10.23	0.16	6.00	10.57	2.17	0.86	0.26																		
**VC79-403	45.93135	-116.1021	Grande Ronde Basalt N_1	Tgn$_1$	55.45	2.36	14.92	11.32	0.20	3.50	6.88	2.76	2.00	0.40																		
**VC79-408	45.96077	-116.01742	basalt of Weippe	Twe	52.58	1.93	16.29	9.07	0.15	5.38	11.05	2.64	0.47	0.24																		
02DG027	45.91214	-116.05994	basalt of Grangeville	Tcg	54.14	3.143	14.22	11.47	0.178	3.31	7.86	3.02	2.10	0.568	14	32	31	345	776	49	293	266	50	26.6	24	27	143	10	44	96	7	
02DG028	45.91128	-116.05056	Grande Ronde Basalt N_1	Tgn$_1$	57.84	2.525	14.46	9.71	0.162	2.92	6.70	3.24	2.00	0.446	8	20	38	391	1277	60	354	201	42	14.8	21	27	221	11	41	56	4	
02DG033	45.9581	-116.01203	Grande Ronde Basalt N_1	Tgn$_1$	55.88	2.389	14.04	10.58	0.203	3.79	7.65	3.23	1.77	0.467	10	21	46	378	833	42	367	178	42	12.4	24	20	131	7	35	48	7	
02DG034	45.95686	-116.02214	Asotin-Wilbur Creek members, undivided	Taw	51.96	1.754	15.53	9.88	0.166	5.88	10.63	2.57	1.27	0.382	95	144	32	264	681	27	274	189	37	14.3	20	53	108	10	35	68	5	
02DG035	45.96167	-116.0365	Asotin-Wilbur Creek members, undivided	Taw	52.53	1.727	15.58	9.84	0.173	4.69	11.30	2.56	1.23	0.370	83	154	26	260	735	30	301	184	37	14.4	21	57	109	7	37	49	3	
02DG047	45.98059	-116.1176	basalt of Craigmont	Tcg	53.48	3.069	13.72	12.78	0.261	3.37	7.73	3.23	1.81	0.546	20	24	28	329	779	44	291	259	46	27.8	24	25	138	14	44	85	11	
02DG049	45.99919	-116.0766	basalt of Weippe	Twe	51.49	1.779	14.56	11.06	0.187	6.74	10.83	2.58	0.55	0.229	33	67	39	286	253	9	234	125	28	13.4	21	59	98	0	30	43	3	
02DG050	45.98669	-116.06736	basalt of Craigmont	Tcg	53.20	2.957	13.31	13.69	0.207	3.79	7.43	2.96	1.93	0.530	18	24	25	332	782	48	277	253	46	26.5	22	24	135	12	40	73	6	
03JK109	45.99437	-116.0347	basalt of Weippe	Twe	51.00	1.895	15.14	11.07	0.207	6.42	11.15	2.50	0.37	0.242	37	71	41	303	286	5	243	129	29	14.4	23	58	97	2	41	42	4	
03JK115	45.94179	-116.1033	Grande Ronde Basalt N_1	Tgn$_1$	56.07	2.428	13.88	11.50	0.195	3.39	7.12	3.07	1.89	0.455	11	12	39	352	760	50	335	191	40	15.8	25	29	128	7	29	54	9	
03JK117	45.9445	-116.10667	basalt of Grangeville	Tgv	54.29	1.474	16.49	7.65	0.127	5.75	10.82	2.48	0.77	0.155	26	136	35	221	366	18	254	137	26	16.7	21	69	93	6	13	28	4	
03JK118	45.9986	-116.0502	Priest Rapids Member	Tpr	49.97	3.341	13.91	13.43	0.298	4.86	9.68	2.69	1.04	0.785	46	103	42	391	546	24	298	182	45	16.5	23	48	137	0	32	66	6	
03JK119	45.99987	-116.05083	basalt of Weippe	Twe	51.54	1.862	14.79	10.43	0.208	6.02	11.84	2.54	0.54	0.237	49	63	34	302	619	11	258	126	29	13.5	17	72	96	3	23	38	1	
06JK071	45.92993	-116.0348	Asotin-Wilbur Creek members, undivided	Taw	52.40	1.739	15.26	10.66	0.165	6.01	9.60	2.50	1.29	0.379	75	140	30	270	604	25	261	189	34	12.7	19	50	107	8	34	62	5	30
06JK073	45.92657	-116.03309	Grande Ronde Basalt N_1	Tgn$_1$	55.04	2.303	13.95	12.07	0.207	3.52	7.86	3.11	1.51	0.420	10	11	36	379	637	38	330	170	38	11.0	20	19	135	8	22	50	5	29
06JK077	45.96854	-116.01834	basalt of Weippe	Twe	50.95	1.872	15.23	10.93	0.188	6.61	11.13	2.55	0.31	0.235	40	65	40	304	279	4	244	127	26	11.3	19	56	100	4	16	38	4	21
06JK078	45.96921	-116.02343	Asotin-Wilbur Creek members, undivided	Taw	51.95	1.760	15.72	10.75	0.171	5.88	9.77	2.49	1.14	0.366	82	145	29	278	627	23	262	193	36	12.5	20	52	107	9	31	68	5	33
06JK084	45.91238	-116.02499	Grande Ronde Basalt in landslide	Qls	54.10	2.518	14.10	11.74	0.209	4.22	8.13	3.00	1.59	0.380	12	17	33	361	540	37	349	201	35	13.5	24	36	128	9	22	50	4	29
06JK088	45.91333	-116.07706	Grande Ronde Basalt R_2	Tgr$_2$	56.77	2.498	14.35	10.05	0.172	3.39	7.11	3.17	2.02	0.459	13	6	33	361	965	49	350	199	42	13.8	22	20	143	11	29	61	6	37
06JK089	45.96354	-116.05576	basalt of Weippe	Twe	52.32	1.862	15.14	10.11	0.179	6.03	11.09	2.56	0.48	0.233	41	64	39	303	275	8	247	128	27	12.2	19	57	99	4	16	35	2	20
06JK091	45.96581	-116.04173	Asotin-Wilbur Creek members, undivided	Taw	52.54	1.701	15.32	10.34	0.165	6.16	9.66	2.54	1.22	0.354	82	152	30	268	550	26	258	182	33	12.2	19	53	107	9	30	65	3	33
06JK094	45.99379	-116.11722	basalt of Grangeville	Tgv	52.10	1.301	14.90	8.46	0.167	6.59	13.13	2.44	0.68	0.227	33	138	33	228	387	14	249	120	25	11.9	19	55	83	5	19	34	1	17
06JK108	45.88216	-116.09822	Imnaha Basalt	Tim	49.45	2.548	16.34	12.22	0.207	5.41	9.37	3.21	0.90	0.347	144	97	27	282	306	16	392	178	32	12.0	24	157	125	4	15	39	1	26
06JK177	45.9862	-116.0197	Asotin-Wilbur Creek members, undivided	Taw	51.77	1.652	17.18	8.89	0.159	5.89	11.20	2.36	0.63	0.266	106	253	32	274	477	12	278	153	30	10.6	21	68	99	7	20	46	2	26
06JK187	45.99028	-116.01083	basalt of Weippe	Twe	51.93	1.861	15.29	10.27	0.182	5.98	11.17	2.63	0.43	0.243	41	71	40	303	247	7	245	128	28	11.4	20	65	96	4	18	35	1	21
06JK196	45.99278	-116.02111	Grande Ronde Basalt N_1	Tgn$_1$	56.47	2.396	13.76	11.35	0.195	3.30	6.94	3.01	2.12	0.451	11	6	33	362	876	49	332	190	38	13.2	23	25	130	9	28	63	4	34
06JK200	45.90556	-116.01306	basalt dike	Tab	52.91	2.240	16.86	9.28	0.089	2.66	6.54	4.97	3.21	1.231	6	3	6	81	1082	41	1275	413	23	70.1	28	12	161	9	66	133	6	66
06JK201	45.90861	-116.02417	Priest Rapids Member dike	Tpr$_d$	50.27	3.321	13.57	13.79	0.236	4.79	8.97	2.59	1.64	0.818	33	82	37	359	597	34	260	192	44	15.2	22	43	142	7	27	66	4	39
06JK203	45.95222	-116.08667	basalt of Grangeville	Tgv	54.35	1.493	16.59	7.00	0.131	5.94	10.92	2.59	0.79	0.201	37	156	37	250	471	17	278	142	25	13.1	21	60	105	6	21	43	2	24
06JK207	45.93778	-116.04572	Grande Ronde Basalt N_1	Tgn$_1$	56.35	1.799	14.40	10.32	0.184	4.23	7.89	3.07	1.52	0.245	7	9	33	318	550	42	324	156	30	10.1	22	19	114	9	22	39	2	23
06JK209	45.94632	-116.03325	Asotin-Wilbur Creek members, undivided	Taw	53.42	1.817	15.86	9.43	0.172	4.24	10.70	2.57	1.40	0.398	65	135	30	274	660	30	274	199	36	13.5	20	52	112	10	32	65	4	31
06JK217	45.95109	-116.02936	Grande Ronde Basalt N_1	Tgn$_1$	54.61	2.230	13.81	12.40	0.209	3.95	7.82	3.02	1.55	0.389	12	15	35	378	631	35	323	165	35	10.4	23	20	131	8	21	46	3	27

* Major elements are normalized on a volatile-free basis, with total Fe expressed as FeO.
** Samples collected by V. Camp in 1979. Analytical results used with permission (Camp, written commun., 2002).
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