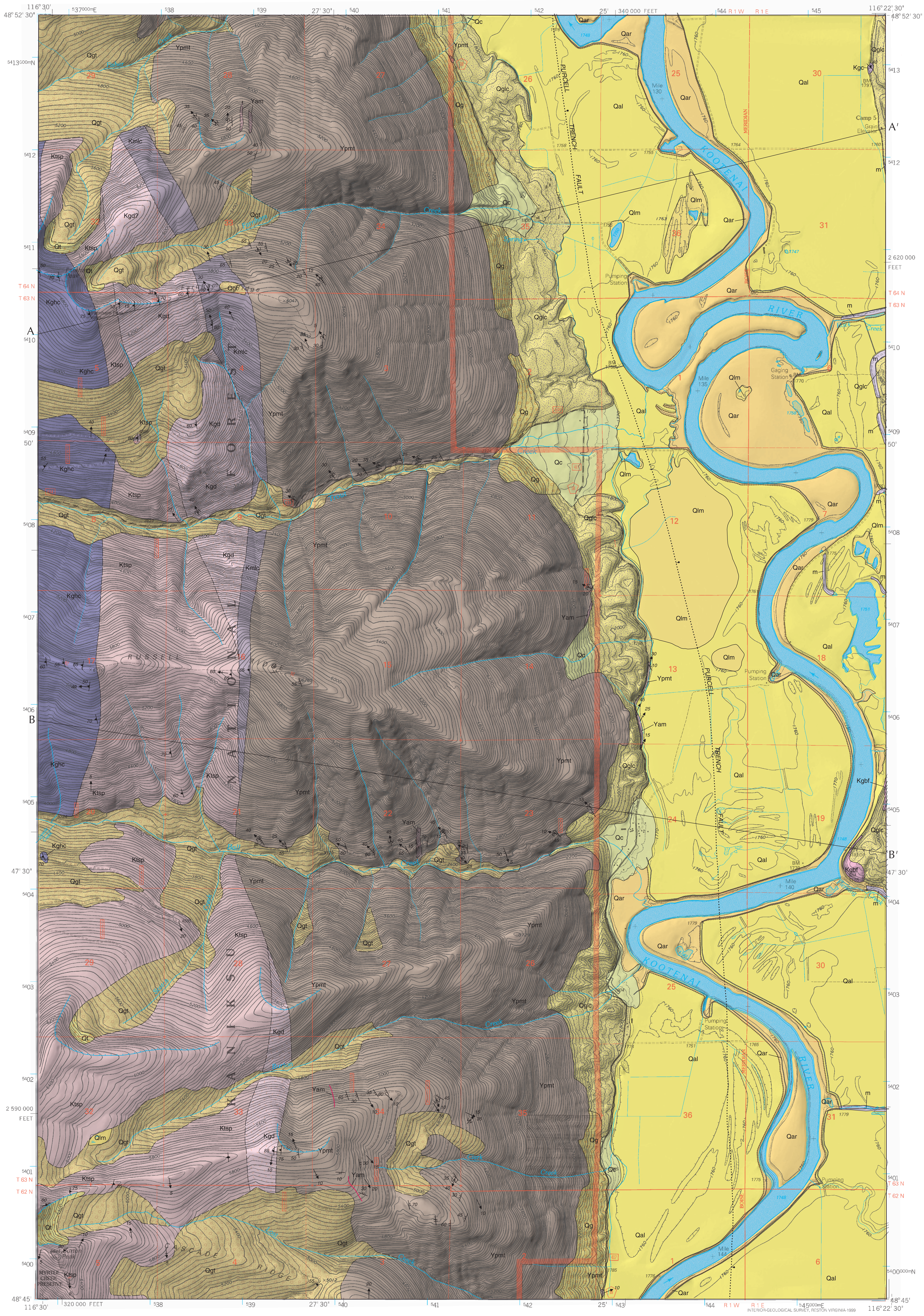
Geologic Map of the Farnham Peak Quadrangle, Boundary County, Idaho

Roy M. Breckenridge, Reed S. Lewis, Russell F. Burmester, and Mark D. McFadden

2013



Base Map Credit

Base digitally scanned from 24,000-scale USGS film separates, 1996.

Shaded elevation from 10 m DEM.

Topography compiled 1963. Planimetry derived from imagery taken 1992.

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

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

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

UTM Grid and 1996 Magnetic North Declination at Center of Map

0° 25′ 18.5°

SCALE 1:24,000

Contour interval 40 feet
Supplementary contour interval 10 feet

QUADRANGLE LOCATION

ADJOINING QUADRANGLES

SMITH FALLS	COPELAND	HALL MOUNTAIN
PYRAMID PEAK	FARNHAM PEAK	RITZ
ROMAN NOSE	MORAVIA	BONNERS FERRY

Field work conducted 2012.

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

Technical review status: Authors only.

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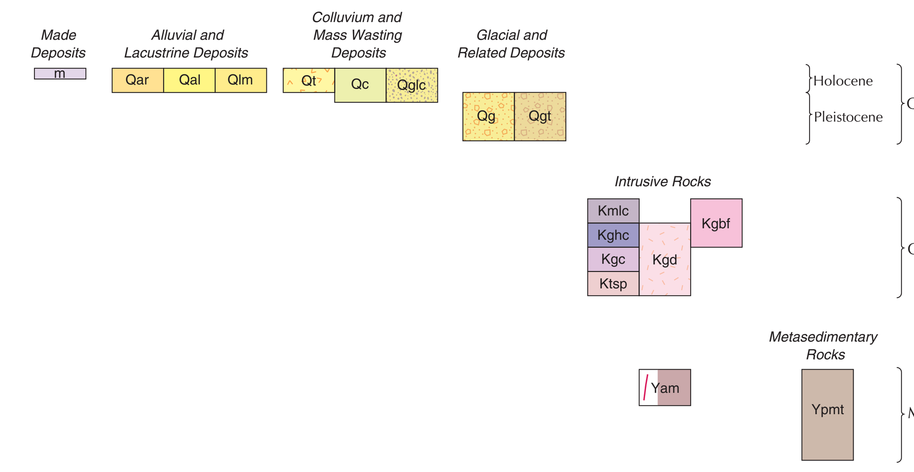
Map version 11-5-2013.

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

CORRELATION OF MAP UNITS



INTRODUCTION

Quaternary deposits on this 1:24,000-scale quadrangle were mapped in 2012 by R.M. Breckenridge. Bedrock was mapped in 2012 by R.S. Lewis, R.F. Burmester, and M.D. McFaddan to modify previous mapping (Miller and Burmester, 2004) for consistency with unit definitions and contact placements used in more recent mapping to the south (Lewis and others, 2008). Locally, contacts and attitudes were augmented with work by F.M. Miller (1979, 1981, and 1993; unpublished 1:24,000-scale mapping). Plutonic rock descriptions are modified from Miller and Burmester (2004).

The oldest and most abundant rocks in the Farnham Peak quadrangle are metasedimentary rocks of the Priest River complex (Fig. 1). These were probably derived from the Mesoproterozoic Prichard Formation of the Belt-Purcell Supergroup, which hosts Cretaceous plutonic rocks. Bedrock units east of the Purcell Trench are nondeformed intrusive rocks whereas those to the west are more metamorphosed and deformed metasedimentary and intrusive rocks. During Pleistocene glaciations, the Cordilleran Ice Sheet repeatedly advanced southward through the quadrangle from Canada. Cosmogenic ^{10}Be surface exposure ages (mean weighted) constrain the glacial maximum ice limit near the Clark Fork ice dam at 14.1 ± 0.6 ka (Breckenridge and Phillips, 2010). Kame deposits near the United States-Canada border constrain the ice recession (^{10}Be range) from 13.3 to 7.7 ka (William Phillips, written commun., 2011). Locally, tributary valley glaciers of the Selkirk Range contributed to the ice stream. Glacial till, outwash, and lacustrine deposits filled the valleys. After retreat of the continental ice, mountain valley glaciers persisted in the higher cirques of the Selkirk Range.

SYMBOLS

Contact: dashed where approximately located.

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

45 Strike and dip of compositional layering.

Strike of vertical compositional layering.

81 Strike and dip of foliation.

55 Estimated strike and dip of foliation.

60 Strike and dip of foliation that varies at outcrop scale.

Strike of vertical foliation.

29 Bearing and plunge of lineation, type unknown.

10 Bearing and plunge of mineral lineation.

45 Bearing and plunge of crenulation lineation.

10 Bearing and plunge of small fold axis.

15 Bearing and plunge of of asymmetrical small "S" fold showing counterclockwise rotation viewed down plunge.

Cirque headwall: ticks on glaciated side.

Levee.

DESCRIPTION OF MAP UNITS

Intrusive rocks are classified according to International Union of Geological Sciences (IUGS) nomenclature using normalized values of modal quartz (Q), alkali feldspar (A) and plagioclase (P) on a ternary diagram (Streckeisen, 1976). Mineral modifiers are listed in order of increasing abundance for igneous rocks. Grain size classification of unconsolidated and consolidated sediment is based on the Wentworth scale (Lane, 1947). Grain sizes are given in abbreviation of metric units and unit thicknesses and distances are listed in both meters and feet; elevation in feet only. Multiple lithologies within a rock unit description are listed in order of decreasing abundance. Soil descriptions for Quaternary units are after Chugg and Fosberg (1980) and Weisel (2005).

MAN-MADE DEPOSITS

m **Made land (historical)**—Roadway fills, railroad rights of way, and levees of the Kootenai River alluvial flood plain.

ALLUVIAL AND LACUSTRINE DEPOSITS

Bonners Ferry and the surrounding area experienced flooding of the Kootenai River alluvial valley from the 1920s through the 1960s. In 1972, Libby Dam was completed upstream in Montana. A system of levees and pump stations in the alluvial flood plain is used to manage farming of drained croplands with both seasonal and permanent wetlands in the Kootenai National Wildlife Refuge of the U.S. Fish and Wildlife Service.

Qar **Active river wash (Holocene)**—Silt, clay, and sand deposits in the active channel and floodplain confined by levees of the Kootenai River. Most channel substrate represent a modern deposit related to the closure of Libby Dam in 1972 (Barton, 2003; Barton and others, 2004). The shaded topography was derived from older data and does not match new planimetry shown on the base map in the Kootenai River channel.

Qal **Alluvium (Holocene)**—Alluvial deposits of the Kootenai River and tributary streams. Mostly finer grained in the Kootenai River alluvial plain and coarser grained in tributary drainages. Moderately sorted to well-sorted silt, sand, and local pebble and cobble gravels. Mostly reworked glacial deposits in the river valley and postglacial colluvium in the surrounding mountains. Schnoorson-Ritz-Farnhampton soils association; typical soils are very deep silty clay loams, silt loams, and mucky silt loams in basins and swales and on low terraces, flood plains, and natural levees. Thickness is several meters to more than 10 m (6 to >30 ft).

Qlm **Lacustrine and mud deposits (Holocene)**—Organic muck, mud, and peat bogs in poorly drained paleoglacial outwash channels and kettle depressions. Interbedded with thin layers of fine sand, silt, and clay. Soils of the Pywell series. Thickness ranges from 1 to 5 m (3 to 16 ft).

COLLUVIAL AND MASS WASTING DEPOSITS

Qc **Colluvial deposits (Holocene)**—Silt, sand, and gravel colluvium. Forms debris fans and colluvial aprons along steeper escarpments and gullies of terraces and benches. Includes small unmappable mass movements. Mostly in escarpments of *Qglc* where mapped. Varied thickness as great as several meters.

Qt **Talus deposits (Holocene)**— Blocky and tabular, poorly sorted angular clasts of talus below cirque headwalls and cliffs oversteepened by glaciation. Generally no soil development. Varied thickness usually 3-9 m (10-30 feet).

Qglc **Colluvial deposits of glaciolacustrine sediment (Holocene to Pleistocene)**—Mixed deposits of silt, sand, and gravel colluvium, slope wash, and small landslides. Steep slopes of reworked and locally transported sediments deposited in Glacial Lake Kootenai at the northward retreating ice margin in the Purcell Trench. Fresh excavations and landslide scarps expose well-developed rhythmites and beds of sand and silt with scattered dropstones. Contorted bedding and loading structures are common. Soils are silt loams of the Wishbone-Crash association. Thickness as great as 10 m (30 ft).

GLACIAL AND FLOOD-RELATED DEPOSITS

Qgt **Till deposits (Pleistocene)**—Silt, pebble, and cobble till with local boulders deposited by the local valley glaciers tributary to the Purcell Trench lobe of the Cordilleran Ice sheet. Scattered large boulders on bedrock and till in tributary drainages and on slopes. Poorly stratified till includes some interbedded outwash deposits. Soils include silt loams and gravelly silt loams of the Pend Oreille-rock outcrop and the Stien-Pend Oreille associations. Thickness varies and may exceed 50 m (hundreds of feet) in subsurface.

Qg **Glacial deposits, undivided (Pleistocene)**—Mostly loose cobbly silty sand with a silty fine sand matrix; pebble- to boulder-sized gravel; includes deposits of till and associated outwash deposited by the Purcell Trench lobe of the Cordilleran Ice sheet. Includes proglacial lacustrine sediments in Glacial Lake Kootenai. Stratified to poorly bedded, unsorted to moderately sorted, composed of discontinuous remnants of till and kame terraces; on steeper unstable slopes, may take the form of mass movements. Soils mainly silt loam of the Pend Oreille series. Thickness ranges from 10 to 100 m (30 to 300 ft).

INTRUSIVE ROCKS

Kmlc **Monzonite of Long Canyon (Cretaceous)**—Hornblende-pyroxene monzonite to quartz monzonite. Forms elongate body in northeastern part of Priest River complex. Extremely heterogeneous with respect to composition, color index, grain size, and texture. Average plagioclase composition is calcic oligoclase; nearly all plagioclase is conspicuously unzoned. Quartz averages about 3 percent, rarely greater than 10 percent. Unit contains very abundant sphene, allanite, and apatite; locally these minerals are as long as 5 mm. Grain size of other minerals ranges from fine to coarse; in much of the pluton 3-8 mm long, crudely tabular potassium feldspar grains and 3-5 mm long grains of pyroxene and amphibole are scattered in groundmass of 1-3 mm long equant grains of all minerals. Unit has lineation or foliation that varies irregularly at outcrop scale. Contains inclusions of schist and gneiss and is cut by numerous dikes that constitute as much as 20 percent of unit in places. Body highly deformed but where mapped to the north is younger, at 88.8 Ma U-Pb zircon (Richard Gaschnig, written commun., 2011), than adjacent megacrystic bodies.

Kgbf **Granodiorite of Bonners Ferry (Cretaceous)**—Medium- to coarse-grained biotite granodiorite exposed largely east and southeast of the map. In general, quartz is typically strained in 5 mm monocrystalline grains or clusters of 0.5 mm grains and in myrmekitic intergrowths with feldspar. Plagioclase occurs as strongly oscillatory zoned subhedral small grains and aggregates of smaller anhedral grains. Average plagioclase composition is calcic oligoclase. Potassium feldspar is microcline as 1 cm poikilitic anhedral blocks. Biotite in 2-4 mm thick books, the only mafic mineral, comprises about 5 percent of the rock. Abundant epidote grains with euhedral form in biotite and with allanite cores are probably primary. Exposures within and nearest to the quadrangle include biotite granite and seriate to sparsely porphyritic varieties with salt-and-pepper (diorite?) inclusions 1-5 cm in diameter. Biotite from a sample collected from west of Bonners Ferry gave a $^{40}Ar/^{39}Ar$ age of 87.3 ± 0.6 Ma (Doughty and Price, 2000).

Kghc **Monzogranite of Hunt Creek (Cretaceous)**—Biotite granodiorite and gneissic granodiorite exposed largely west of the quadrangle where it is characterized by 2-10 cm long potassium feldspar phenocrysts. Potassium feldspar is microcline and microperthite containing patches of microcline. Almost all is in phenocrysts. Plagioclase averages an_{22}. Biotite commonly occurs as ragged-edged grains or groups of grains and is interleaved with very fine-grained muscovite and opaque mineral(s). Concentration of sphene, the most abundant accessory mineral, mimics concentration of biotite. Allanite very abundant; zircon and apatite present in trace amounts. Unit appears to be an early pluton caught up within, and strung out between, other units of Priest River complex (Miller and Burmester, 2004). Zircon U-Pb age between 90 and 95 Ma (J.L. Wooden, written commun., 1994 in Miller and Burmester, 2004); Archibald and others (1984) reported 94 Ma U-Pb age on zircon from Corn Creek gneiss, which is a probable continuation of the unit in Canada; a weighted mean U-Pb zircon age of 97.5 Ma was obtained from a sample of this pluton collected 10 km (6 mi) northwest of the map near Smith Falls (Richard Gaschnig, written commun., 2011).

Kgd **Granodiorite (Cretaceous)**—Foliated to lineated, medium- to coarse-grained granodiorite exposed locally along the east side of the main body of *Ktsp*. Biotite and locally hornblende bearing. Contains potassium feldspar phenocrysts 2-6 cm long locally deformed into augen, particularly on eastern side of unit. Epidote is conspicuous in hand sample. May be eastern outliers of *Kghc*, but local presence of hornblende distinguishes it from *Kghc*.

Kgc **Granodiorite of Copeland (Cretaceous)**—Porphyritic, medium- to coarse-grained hornblende-biotite and biotite quartz monzonite, granodiorite, or monzogranite exposed almost entirely east and northeast of the quadrangle. A single exposure in the northeast corner of the map is coarse grained with 5-10 mm quartz, biotite in well-formed books, and small euhedral sphene wedges. Contains potassium feldspar megacrysts as long as 5 cm and abundant and varied 5-20 cm long mafic inclusions. See Breckenridge and others (2010) for more detailed descriptions. Hornblende and biotite gave potassium-argon ages of 95 Ma and 90 Ma respectively (Miller and Engels, 1975), recalculated using current IUGS constants (Steiger and Jaeger, 1977). A weighted mean U-Pb zircon age of 109.0 Ma was obtained from a sample of this pluton collected 5 km (3 mi) east of the map boundary (Richard Gaschnig, written commun., 2011).

Ktsp **Tonalite of Snow Peak (Cretaceous)**—Tonalite, locally ranging to granodiorite. Unit is characterized by abundant pale green epidote with allanite cores, easily visible in nearly all exposures, and by large, pale, lavender-gray quartz. Average plagioclase composition is intermediate andesine. Most of unit contains almost no potassium feldspar, but scattered phenocrysts of potassium feldspar are present locally. Quartz commonly elongated into crude, rod-shaped grains as long as 1.5 cm. Biotite is the only mafic mineral; color index is higher than most units in Priest River complex and ranges from 11 to 17. Texture is medium to coarse grained; seriate in much of unit. Subtle to prominent foliation and lineation irregularly developed. Zircon from ridge south of Snow Creek, about 12 km (7 mi) south of the map, yielded U-Pb age of 116 ± 2 Ma (Richard Gasching, written commun., 2009).

Yam **Amphibolite (Mesoproterozoic)**—Lineated to foliated amphibolite. Generally fine- to medium-grained hornblende-plagioclase rock. Presumably metamorphic equivalent of mafic sills present in the Prichard Formation.

METASEDIMENTARY ROCKS OF THE PRIEST RIVER COMPLEX

Ypmt **Metamorphosed Prichard Formation (Mesoproterozoic)**—Quartz-biotite-muscovite schist grading to gneiss, and feldspathic muscovite-biotite granofels and quartzite. Locally contains 5-10 mm long lenses of muscovite that may be retrograded sillimanite clots. Sillimanite present in southernmost exposures. Large muscovite grains occur both undeformed in the foliation and crenulated where at angles to foliation. Small bodies of amphibolite, commonly well foliated and lineated, occur within this unit. Intruded by dikes of pegmatite and fine-grained granitic material. Compositional layering is mapped in lieu of bedding because metamorphic grade and deformation make transposition of bedding likely, but granofels to schist gradations are interpreted to have been siltite to argillite graded couplets. Although *Ypmt* crops out the north-south length of the map, the unknown but probably small stratigraphic extent precludes correlation with any particular interval within the Prichard Formation. However, bedding character, rusty weathering, and association with amphibolite interpreted to have been Moyie sills (Anderson and Davis, 1995) suggests protolith is lower Prichard.

STRUCTURE

PURCELL TRENCH FAULT

The contrast in metamorphic grade of metasedimentary and mafic intrusive rock across the Purcell Trench is consistent with the presence of a down-to-the-east fault under Quaternary sediment in the Kootenai River valley (Doughty and Price, 2000). This is a large structure under the west side of the trench that may displace an earlier down-to-the east detachment fault.

FOLDING, FAULTING, AND PENETRATIVE DEFORMATION WEST OF THE PURCELL TRENCH FAULT

Outcrop-scale folds in *Ypmt* typically plunge to the northwest, as do crenulation lineations. Foliations in the plutonic rocks to the west are typically steep whereas lineations tend to be shallow, plunging both north and south. Deformation in the Priest River complex was probably protracted or episodic over a long time and nonuniformly distributed in space. End of deformation may have been by about 70 Ma if the fabric-free felsic dikes in *Ypmt* are related to the nondeformed biotite granite 29 km (18 mi) to the south in the Colburn quadrangle dated as 71.7 ± 1.8 Ma (U-Pb on zircon; Richard Gaschnig, written commun., 2008). Linear and planar (L-S) fabric in *Kmlc* is shared with *Yam* at their contact over Russell Ridge, suggesting that deformation was concentrated between *Kmlc* and *Ypmt*. However, to the north where *Kmlc* was dated, the eastern contact of *Kmlc* is less deformed megacrystic *Kghc*. So, deformation seems more likely synchronous with intrusion of *Kmlc* rather than tied to a particular contact. If true, development of fabric and augen in *Kghc* and *Ktsp* likely is older. It is probable that some deformation in *Ypmt* is even older.

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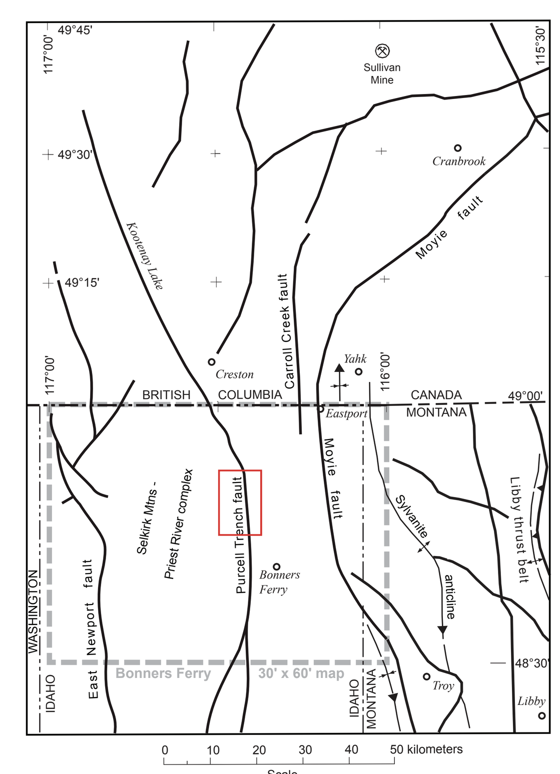
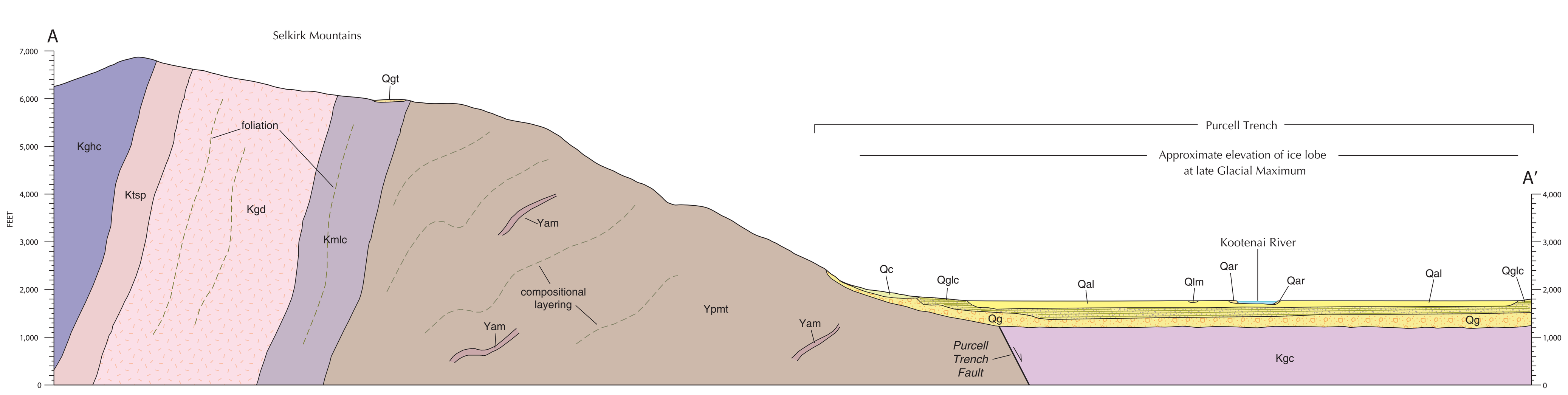
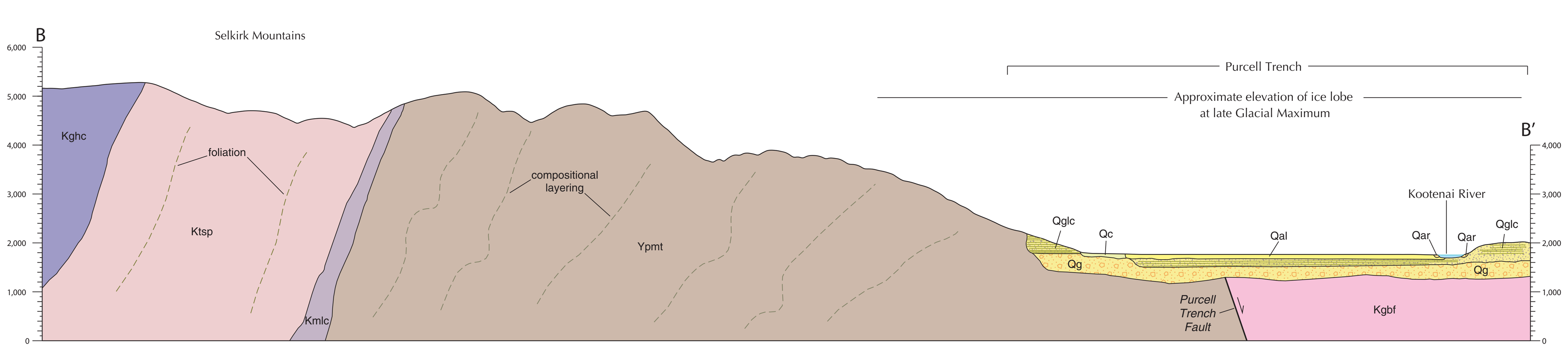


Figure 1. Location of Farnham Peak 7.5 quadrangle (red box) with respect to major structural and physiographic features.





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