Geologic Map of the Moravia Quadrangle, Boundary County, Idaho

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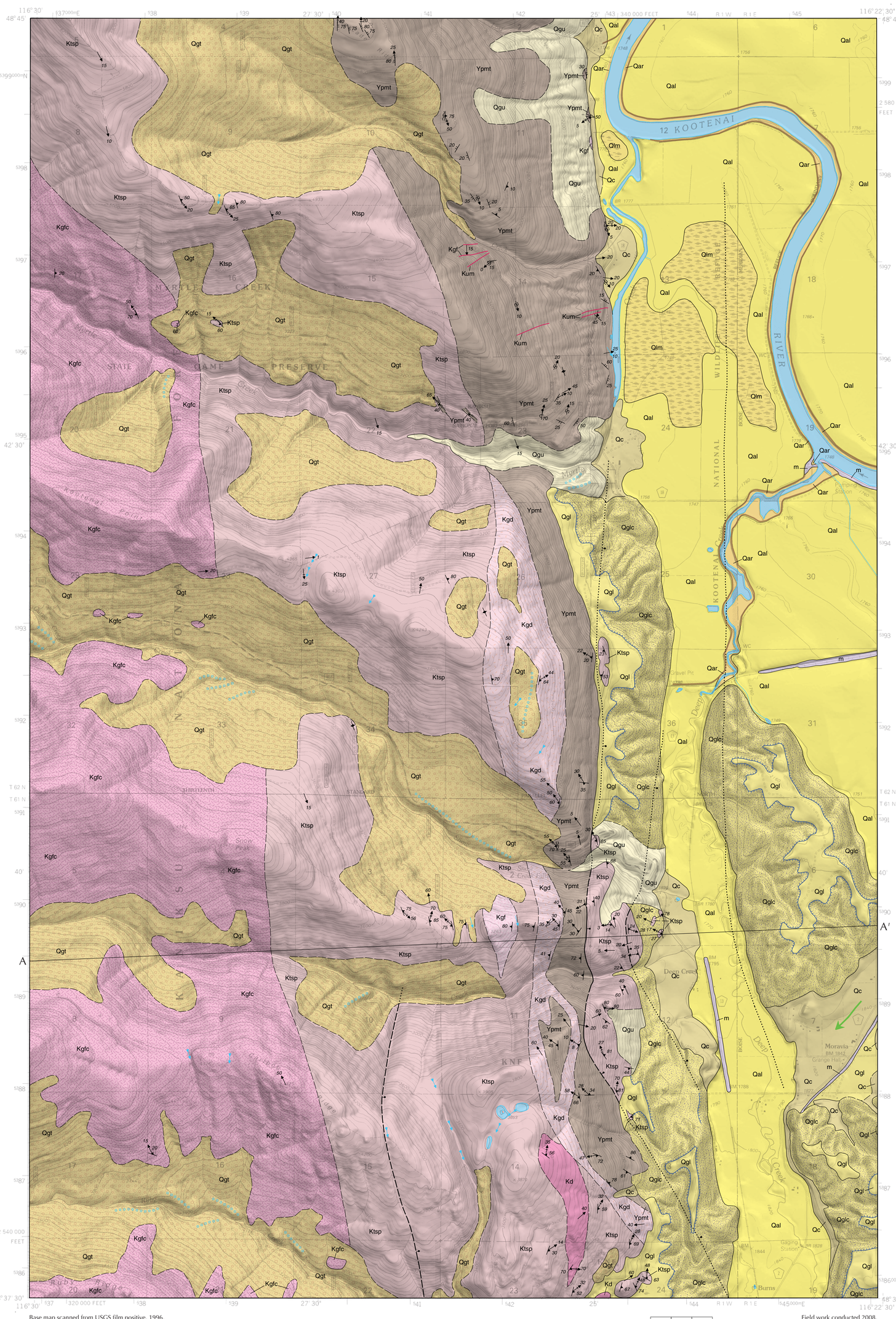

Base map scanned from USGS film positive, 1996.

Shaded elevation from 10 m DEM, vertically exagerated 2.5x.

Topography compiled 1963. Planimetry derived from imagery taken 1992. Public Land Survey System and survey control current as of 1996.

Projection Idaho coordinate system, west zone. 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

SCALE 1:24,000

Contour interval 40 feet

QUADRANGLE LOCATION

ADJOINING QUADRANGLES

Field work conducted 2008.

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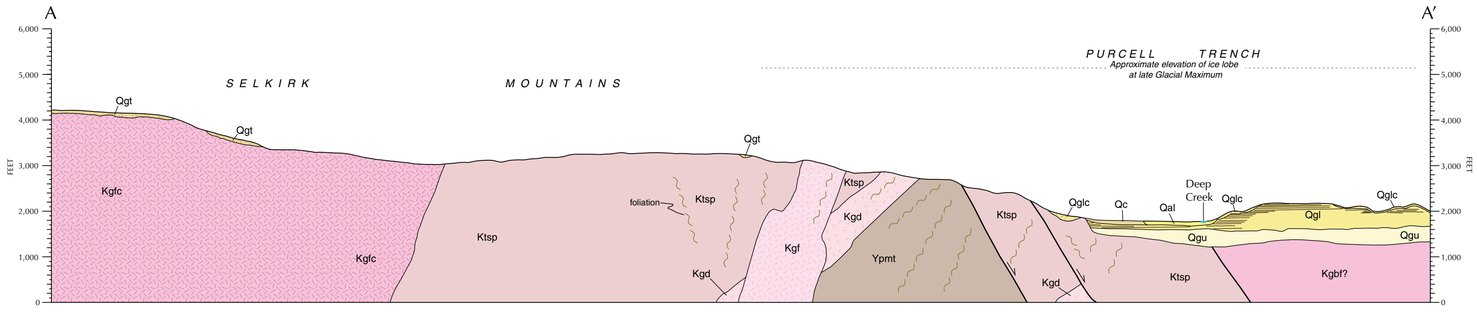
Digital cartography by Loudon R. Stanford and Jane S. Freed at the Idaho Geological Survey's Digital Mapping Lab.

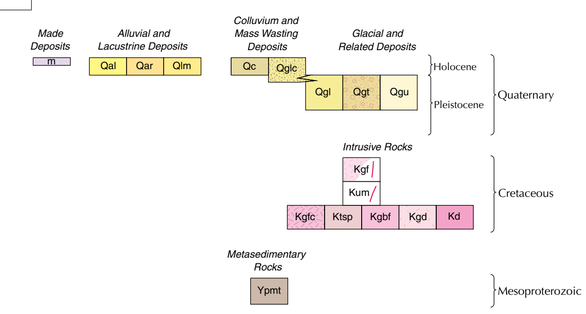
Note on printing: The map is reproduced at a high resolution of 600 dots per inch. The inks are resistant to run and fading but will deteriorate with long-term exposure to light.

Map version 9-3-2009.

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 1985, 1997-8, and 2008 by R.M. Breckenridge. Bedrock was mapped in 2008 by R.F. Burmester, M.D. McFaddan, and R.S. Lewis, and augmented with mapping by F.K. Miller (1981, 1993-4) and P.T. Doughty (1995). Plutonic rock descriptions are modified from Miller and Burmester (2004).

Bedrock is mostly Cretaceous plutonic in origin, with subordinate amphibolite facies metasedimentary rocks probably derived from the Prichard Formation of the Mesoproterozoic Belt-Purcell Supergroup.

The quadrangle is located in the Purcell Trench, a major structural and physiographic feature that trends north-south over 80 miles within the Idaho Panhandle. This part of the trench is drained by the Kootenai River, which flows west from Montana to Bonners Ferry and then northward into British Columbia. During Pleistocene glaciations a lobe of the Cordilleran Ice Sheet repeatedly advanced southward along the Purcell Trench from Canada. Tributary valley glaciers from the Selkirk Range to the west and Cabinet Range to the east contributed to the ice stream. The ice dammed the Kootenai River, formed Glacial Lake Kootenai, and diverted the outlet southward down the trench into the Pend Oreille and Spokane River drainages. Thick sections of glacial till, outwash, and lacustrine deposits filled the depression of the Purcell Trench. After retreat of the continental ice the northward drainage of the Kootenai River was restored. The presence of Glacier Peak tephra (11,200 B.P.) gives a minimum date for retreat of the ice lobe from the trench (Richmond, 1986). Alpine valley glaciers persisted until nearly 10,000 years ago in the higher cirques of the Selkirk and Cabinet Ranges. Holocene alluvium, colluvium, and lacustrine sediments are mostly the product of reworked glacial deposits.

Description of Map Units

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). Mineral modifiers are listed in order of increasing abundance for both igneous and metamorphic rocks. Grain size classification of unconsolidated and consolidated sediment is based on the Wentworth scale (Lane, 1947). Thicknesses and distances are given in abbreviation of metric units (e.g., dm=decimeter). English equivalent units are in parentheses. 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).

Man-Made Deposits

m — **Made land (historical)**—Fill along roadways, embankments, railroad rights of way, and levees of the Kootenai River and the adjacent alluvial flood plain. Numerous small fills are unmapped.

Alluvial and Lacustrine Deposits

Qar — **Active river wash (Holocene)**—Silt, clay, and sand deposits in the active channel and flood plain confined by levees of the Kootenai River. Most channel substrate represents a modern deposit related to the closure of Libby Dam in 1972 (Barton, 2003; Barton and others, 2004).

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 with scattered boulders. Mostly reworked glacial deposits in the river valley and post glacial 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 (Chugg and Fosberg,1980). Thickness is several to more than 10 meters (6 to >30 feet).

Bonners Ferry and the surrounding area experienced heavy flooding of the Kootenai River alluvial valley from the 1920s through the 1960s. Damage was mostly eliminated by the completion of Libby Dam in 1972 (Boundary County Hazard Flood Mitigation Plan, 2009). The Kootenai National Wildlife Refuge of the U.S. Fish and Wildlife Service was established in 1965. The refuge currently manages over 2774 acres mostly in this quadrangle. 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.

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

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. This unit mostly in escarpments of *Qglc* where mappable. Varied thickness up to several meters (15 feet).

Qglc — **Glaciolacustrine deposits (Pleistocene to Holocene)**— Mixed deposits of silt, sand, and gravel colluvium, slope wash, and small landslides. Steep slopes of reworked and locally transported *Qgl*. Soils are silt loams of the Wishbone-Crash association. Thickness up to 10 meters (30 feet).

Glacial and Flood-Related Deposits

Qgl — **Glaciolacustrine deposits (Pleistocene to Holocene)**—Massive to well bedded and finely laminated clay, silt, and sand deposited in Glacial Lake Kootenai at the northward retreating ice margin in the Purcell Trench. Exhibits well developed rhythmites and beds of sand and silt and scattered dropstones. Contorted bedding and loading structures are common. This unit forms several prominent terrace levels from an elevation about 2200' to 2300' and also discontinuous terraces in tributary valleys. Mostly well sorted and finely laminated. Overlain by glaciofluvial outwash deposits on terraces and in tributary valleys. Soils are silt loam and silty sandy loams of the Wishbone-Crash association. Exposed thickness as much as 150 meters (500 feet).

Qgt — **Till deposits (Pleistocene)**—Dense silt pebble and cobble till with local boulders deposited by the Purcell Trench lobe of the Cordilleran Ice sheet. Poorly stratified compact basal till includes ground moraine and some interbedded proglacial deposits. Deposits including kame terraces and some outwash along the south margin. Soils include silt loams and gravelly silt loams of the Pend Oreille-rock outcrop and the Stein-Pend Oreille associations. Thickness varies; several meters (6 feet) to more than 50 meters (100's of feet) in subsurface.

Qgu — **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 proglacial outwash and glacial sediments. Scattered large boulders on bedrock and in till. Unstratified to poorly bedded, unsorted to moderately sorted. In tributary drainages and on slopes composed of discontinuous remnants of till and kame terraces; on steeper unstable slopes may take the form of mass movements. May include some interbedded lake sediments. Soils mainly silt loam of the Pend Oreille series. Thickness varies from several to 10 meters (6-31 feet).

Intrusive Rocks

Kgf — **Fine-grained granite (Cretaceous)**—Equigranular fine-grained biotite granite. Forms small masses on ridge south of Snow Creek and along range front near north edge of map; also present as dikes and small unmapped bodies in other bedrock units. Age assignment based on similarity to rock in the Colburn quadrangle to the south dated at 71.7 ± 1.8 Ma (U-Pb on zircons; Richard Gaschnig, written commun., 2008).

Kum — **Ultramafic dikes (Cretaceous)**—Altered massive ultramafic dikes exposed north of Myrtle Creek. Apparently cut by pegmatites and *Kgf*. One near the north edge of the Elmira quadrangle to the south contains olivine, actinolite, and chlorite. Magnetite content high (magnetic susceptibility about 20 x 10^{-3} SI). Cretaceous age based on interpretation that *Kgf* and pegmatites presumed to be Cretaceous intrude it.

Kgfc — **Granodiorite of Falls Creek (Cretaceous)**—Chiefly granodiorite, but grading to tonalite in eastern part. Plagioclase averages sodic andesine. Color index averages 10. Biotite is the only mafic mineral. Minor muscovite present locally; probably primary. Accessory minerals include epidote, allanite, apatite, zircon, and opaque minerals. Magnetite content moderate (magnetic susceptibility about 3 x 10^{-3} SI units). Medium- to coarse-grained; generally seriate. Texture and grain size more varied than in tonalite of Snow Peak (*Ktsp*) to east. Unit contains very abundant fine- to coarse-grained leucocratic dikes and pods. Composition, texture, and concentration of included leucocratic rocks varies greatly over short distances in much of unit.

Ktsp — **Tonalite of Snow Peak (Cretaceous)**—Tonalite, locally ranging to granodiorite. Main body is mapped immediately east of *Kgfc*; smaller body east of *Ypmt* is interpreted as a fault sliver of the main body but could be another unit. 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 present locally. Quartz commonly elongated into crude, rod-shaped grains up to 1.5 cm long. Biotite is the only mafic mineral; color index higher than most units in complex, ranging from 11 to 17. Muscovite generally absent, but found sparsely and irregularly in westernmost part of unit; probably secondary. Magnetite content moderate to high (magnetic susceptibility of 25 samples ranges from 2 to 15 x 10^{-3} SI units and averages 8). Texture is medium- and coarse grained; seriate in much of unit. Subtle to prominent foliation and lineation irregularly developed; generally best developed in eastern part of the main body and the eastern body, which also has more brittle shears. Contains abundant irregularly shaped mafic inclusions ranging from 1 cm to tens of meters. Composition and texture are more uniform than in other plutonic units, but are increasingly varied westward toward gradational contact with *Kgfc*, around concentrations of mafic inclusions, and in the southern part of the map. Zircon from ridge south of Snow Creek yielded U-Pb age of 116 ± 2 Ma (R. Gasching, written commun., 2009).

Kgd — **Granodiorite (Cretaceous)**—Granodiorite exposed locally along the east side of the main body of *Ktsp*, into which it grades. Biotite- and locally hornblende-bearing. Contains potassium feldspar phenocrysts 2-4 cm in length locally deformed into augen. Magnetite content low (magnetic susceptibility in single sample measured 0.6 x 10^{-3} SI units). Includes rocks mapped as tonalite of Snow Peak by Miller and Burmester (2004) and Snow Peak megacrystic granodiorite by Doughty (1995).

Kgbf — **Granodiorite of Bonners Ferry (Cretaceous)**—Medium- to coarse-grained biotite granodiorite. Shown only in cross section and projected into area on the basis of outcrops east of map.

Kd — **Diorite (Cretaceous)**—Coarse-grained epidote-biotite-hornblende diorite. Mapped by Doughty (1995) but not well described. Includes rocks mapped as granitic and metamorphic rocks, undivided, by Miller and Burmester (2004).

Belt-Purcell Supergroup

Ypmt — **Metamorphosed Prichard Formation (Mesoproterozoic)**—Quartz-biotite-muscovite schist grading to gneiss, and feldspathic muscovite-biotite quartzite. Locally contains 5 -10 mm long lenses of muscovite that may be retrograded sillimanite clots. 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 at least from Cascade Creek to Caribou Creek. Commonly intruded by pegmatite and dikes similar to *Kgf*. Also is only host observed for *Kum*. Although compositional layering is mapped in lieu of bedding because metamorphic grade and deformation make transposition of bedding likely, siltite to argillite graded couplets are still recognizable as granofels to schist gradations. Recrystallization and development of metamorphic fabric appear to increase southward, perhaps due to greater uplift or deformation to the south. Includes small septae in the eastern part of *Ktsp*. Although unit crops out nearly the north-south length of the map, its probably small but unknown 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 suggests protolith is lower Prichard.

Structure

The main structures within the map area are penetrative foliation and lineation in both the metasedimentary rocks and older granitic intrusions. Plastic folding as well as more brittle folding and faulting is common in the metasedimentary rocks; brittle faulting is common in all units. Most fabrics strike parallel with the Selkirk crest and range front. Lineations in the plutonic rock generally trend northwest with moderate to steep plunges, although exceptions abound. Inclusions of foliated material in and cross-cutting of earlier foliated rocks by less foliated intrusions are consistent with a protracted history of deformation and intrusion, which may explain the diversity of attitudes.

Most easily recognized in the metamorphosed Prichard Formation and perhaps isolated to it are small asymmetrical folds (S shaped when viewed north), commonly with shallow dipping faults through their middles. Offsets to the west of tops of the folds and dikes cut by the faults are consistent with sense of shear from the folds. This deformation may record late-stage west-directed shortening during Cretaceous contraction.

Latest faulting is manifest near the range front by generally east dipping slicked surfaces with slickenlines trending east to northeast. Possibly concurrent with this was mylonitization of *Ypmt* quartzite on Cascade Ridge where S-C fabric indicates southeast oblique normal fault motion down to the east. This probably dropped the eastern metasedimentary package down against the western block dominated by plutonic rock. Such down-to-the-east faulting may be distributed strain coincident with formation of the northern Purcell Trench fault. Based on low contrast in cooling ages across the eastern contact of *Ypmt* near the mouths of Snow and Caribou creeks compared to the larger contrast across valley fill to the east (Doughty and Price, 2000), the main trace of the fault may be buried in the Kootenai River valley (Purcell Trench).

Symbols

- Contact: dashed where approximately located.
- Fault: dashed where approximately located; dotted where concealed; bar and ball on downthrown side.
- 65 — Strike and dip of bedding; ball indicates bedding known to be upright.
- 10 — Strike and dip of compositional layering.
- 24 — Strike and dip of foliation.
- Strike and dip of vertical foliation.
- 55 — Strike and dip of mylonitic foliation.
- 8 — Bearing and plunge of lineation, type unknown.
- 15 — Bearing and plunge of mineral lineation.
- 35 — Bearing and plunge of mylonitic lineation.
- 70 — Bearing and plunge of crenulation lineation.
- 20 — Bearing and plunge of asymmetrica l small fold showing counterclockwise rotation viewed down plunge.
- 5 — Bearing and plunge of asymmetrical small fold showing clockwise rotation viewed down plunge.
- Flow direction of glacial outlet flood.
- Bearing of glacial striation.
- Levee.
- Terrace scarp, steep.
- Direction of ice flow across divide.
- Crest of lateral or end moraine.

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