Geologic Map of the Sandpoint Quadrangle, Bonner County, Idaho

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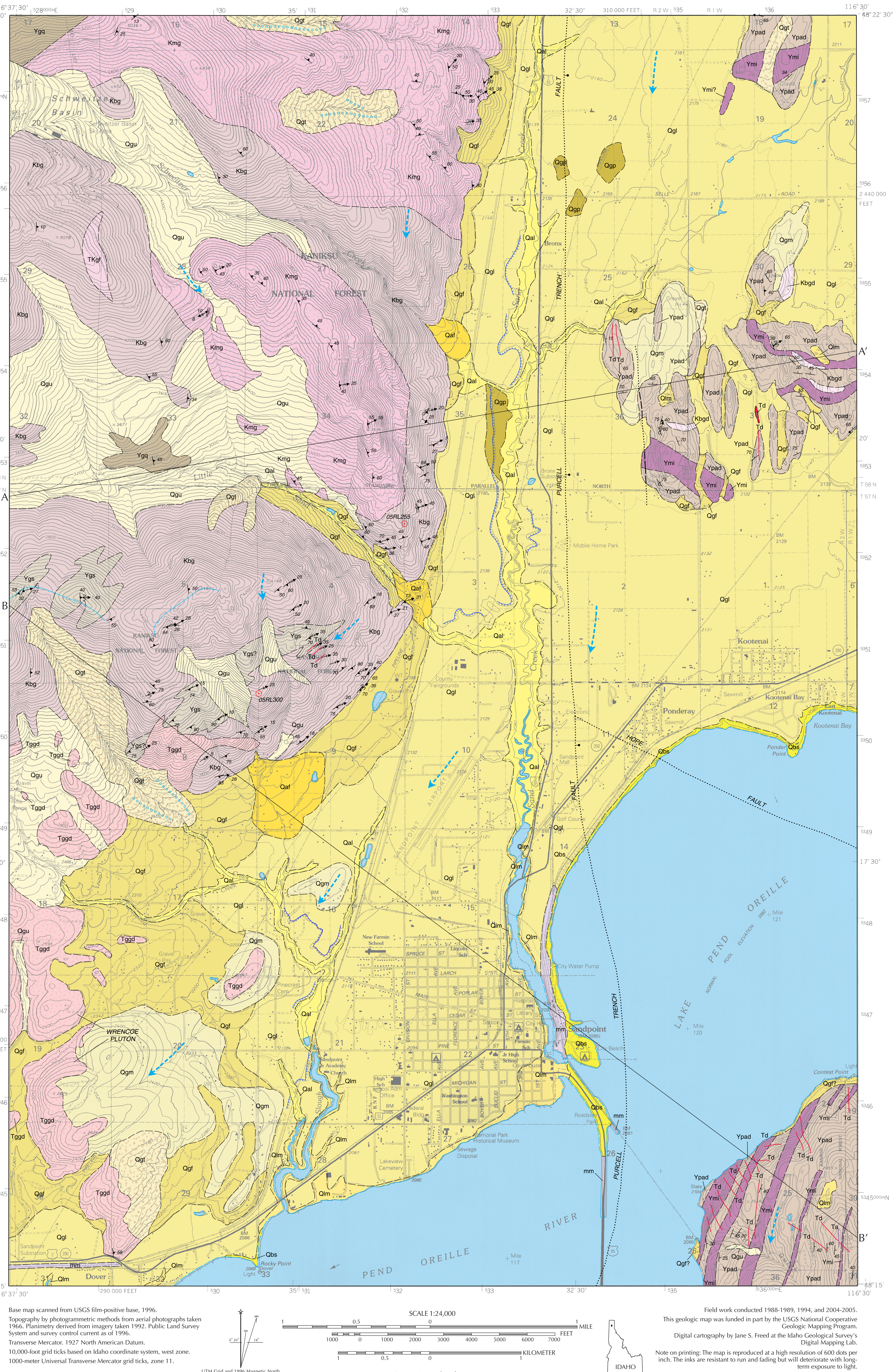
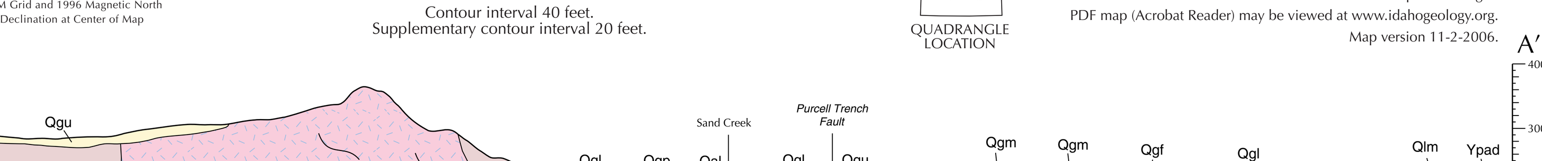
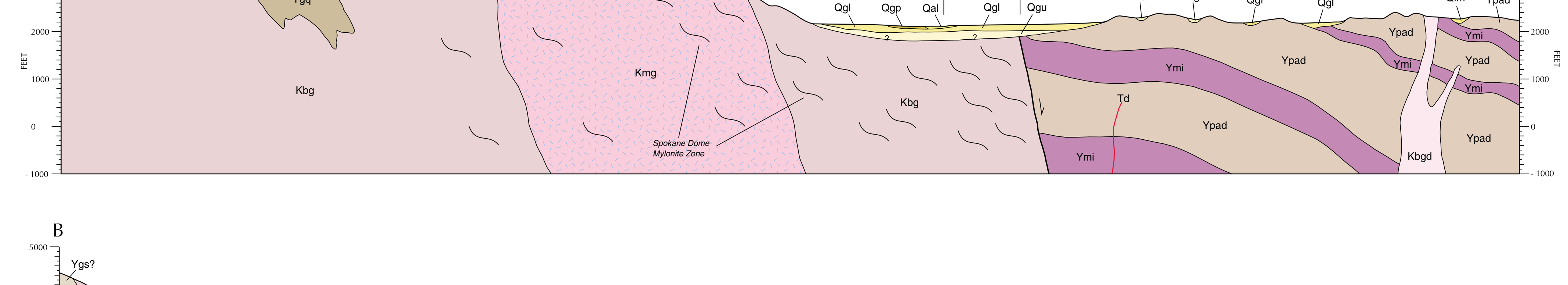


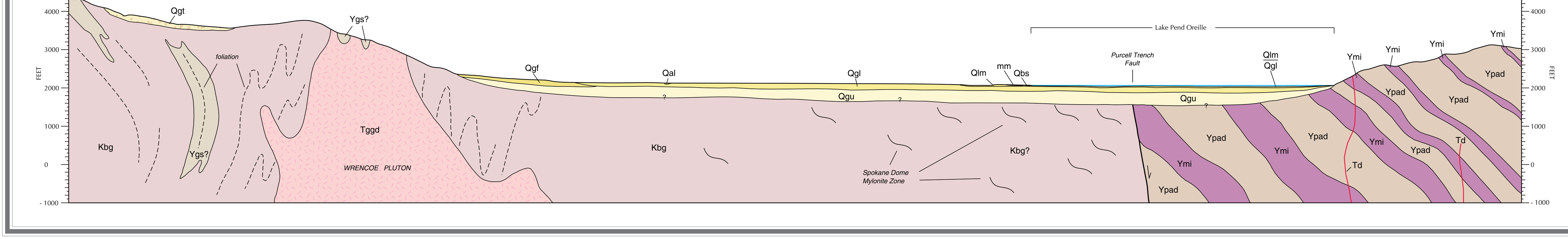
Base map scanned from USGS film-positive base, 1996.
Topography by photogrammetric methods from aerial photographs taken 1966. Planimetry derived from imagery taken 1992. Public Land Survey System and survey control current as of 1996.
Transverse Mercator. 1927 North American Datum.
10,000-foot grid ticks based on Idaho coordinate system, west zone.
1000-meter Universal Transverse Mercator grid ticks, zone 11.



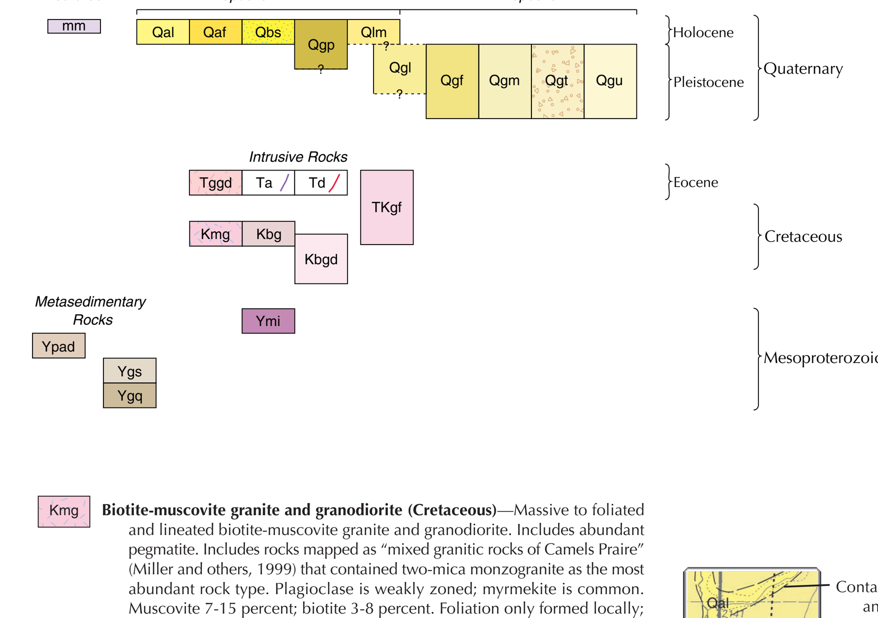
Contour interval 40 feet.
Supplementary contour interval 20 feet.

Field work conducted 1988-1989, 1994, and 2004-2005.
This geologic map was funded in part by the USGS National Cooperative Geologic Mapping Program.
Digital cartography by 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 running and fading but will deteriorate with long-term exposure to light.
PDF map (Acrobat Reader) may be viewed at www.idahogeology.org.
Map version 11-2-2006.





CORRELATION OF MAP UNITS



INTRODUCTION

Quaternary deposits on this 1:24,000-scale Sandpoint quadrangle were mapped in 1988-1989 and 2004-2005 by R.M. Breckenridge. Surficial mapping of part of the quadrangle by A.F. Harvey III (1984b) aided our compilation. Bedrock was mapped during five weeks of field work in 2005 by R.S. Lewis, R.F. Burmester, and M.D. McFaddan. S.E. Box mapped this and adjoining quadrangles to the north and west in reconnaissance in 1994. Our mapping was augmented with structural data from Doughty (1995).

Low metamorphic grade metasedimentary rocks of the Belt-Purcell Supergroup, Precambrian in age, occupy the eastern and southeastern parts of the Sandpoint quadrangle. Dominantly granitic rocks of Cretaceous age that occupy the western part are locally mylonitized. In between is the unexposed Purcell trench fault that was active in the Eocene, broadly coincident with intrusion of the Wrencoe pluton in the southwestern part of the quadrangle.

The geomorphic subsections of the quadrangle include parts of the Selkirk Range and the Selle Lowlands (Savage, 1967). During Pleistocene glaciation, a lobe of the Cordilleran Ice repeatedly advanced southward along the Purcell Trench from Canada. Tributary valley glaciers from the Selkirk and Cabinet Ranges contributed to the ice stream that scoured the Pend Oreille Lake basin and blocked the Clark Fork valley forming Glacial Lake Missoula. Glacial deposits of the Selle Lowlands fill the depression of the Purcell Trench and are interbedded with catastrophic flood deposits from outbursts of glacial Lake Missoula that ended about 15,000 years ago. After retreat of the continental ice, alpine 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 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). Bedding thicknesses and lamination type are after McKee and Weir (1963), and Winston (1986). Thicknesses and distances are given in abbreviation of metric units (e.g., dm=decimeter). Multiple lithologies within a rock unit description are listed in order of decreasing abundance. Soil series are from Weisel and others (1982). Unified Soil Classifications of the surficial units are from Harvey (1984a).

MAN-MADE DEPOSITS

mm **Made land (historical)**—Highway fills along US 95 and bridges, railroad right of way, and trestles. Numerous small fills in and around Sandpoint are unmapped.

ALLUVIAL AND LACUSTRINE DEPOSITS

Qal **Alluvium (Holocene)**—Varied silt, sand, and gravel deposits in modern stream drainages. Coarser toward Selkirk Mountains and finer in the Selle Lowlands. Moderately sorted to well sorted silt, sand and pebble and cobble gravels with occasional boulders. Mostly reworked glacial deposits in the lowlands and post glacial colluvium in the mountains. Typical soils are silt loam to sandy and gravelly loam. Unified Classification is GP-GM and SP-SM Soil series of Hoodoo and Wrencoe. Thickness is up to several meters.

Qaf **Alluvial fan deposits (Holocene)**—Mixed pebble to cobble gravel deposited as fans at the mouth of local drainages. Mostly subangular to angular clasts derived locally from colluvium and glacial deposits on steep slopes. Unified Classification is GM and SM. Soils mainly of the Colburn, Pend Oreille, and Bonners series. Thickness 1-10 m (3-33 feet).

Qbs **Beach deposits (Holocene)**—Coarse sand to silty sand and gravel deposited along the shoreline of Lake Pend Oreille. Mostly are moderately sorted. Forms accreted beaches, bars and spits in areas of lower wave energy along the shore. Deposits are classified as GW-GP and SW-SP and lack soil cover. Thickness up to several meters.

Qlm **Lake deposits (Holocene)**—Consists of soft clayey silt; at depth is locally underlain by late glacial outwash, till, or Missoula Flood deposits. The upper limit of the unit and Lake Pend Oreille is controlled by Albeni Falls Dam. The maximum water level is 631m (2071.7 feet) and the normal minimum is 625 m (2051.0 ft). The unit thickens into Pend Oreille Lake basin. Soils include Cape Horn and Hoodoo series. Thickness 1-10 meters.

Qgp **Peat deposits (Pleistocene to Holocene)**—Organic muck, mud and peat bogs in poorly drained paleoglacial outwash channels and kettles of the Selle Lowland. Interbedded with thin layers of fine sand, silt and clay. Soils of the Pywell series and Pt in the Unified Soil System. Thickness varies from 1-5 m.

GLACIAL AND FLOOD-RELATED DEPOSITS

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. Occasional 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 movement deposits. May include some interbedded lake sediments. Soils mainly silt loam of the Pend Oreille series. Thickness varies from several to tens of meters.

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. Includes kame terraces along the south margin. Soils include silt loams and gravelly silt loams of the Pend Oreille and Vay-Ardtoo series. Thickness varies; may exceed 50 m (160 feet).

Qgm **Deposits of ground moraine (Pleistocene)**—Silty to sandy boulder till and poorly stratified compact lodgment till. Mostly ground moraine and some interbedded proglacial deposits. Extensive deposit occupies the Selle Lowland and probably underlies *Qgl*; includes kame terraces along the east slopes of the Selkirk Mountains. Soils include silt loams and gravelly silt loams of the Pend Oreille and Vay-Ardtoo series. Thickness varies; may exceed 50 m (160 feet).

Qgl **Glaciolacustrine deposits (Pleistocene to Holocene)**—Massive to finely laminated clay, silt, and sand deposited in ice marginal and post glacial lakes (?) in the Purcell Trench. Exhibits well developed rhythmites and beds of sand and silt. This unit includes deposits in the Selle Lowlands and discontinuous terraces in tributary valleys at about 732 m (2400 feet) and as high as 792 m (2600 feet). Mostly well sorted and finely laminated. Contorted bedding and loading structures are common. Overlain by glaciofluvial outwash deposits on terraces and in tributary valleys. Soils are silt loam and silty sandy loams of the Mission-Cabinet-Odenson series. CL to ML and SM classes in the Unified Soil Classification. Thickness tens of meters to over hundreds of meters in drill holes of the Selle Lowlands.

Qgf **Glaciofluvial deposits (Pleistocene)**—Coarse silt, sand, and gravel deposits derived from glacial outwash. Mostly stratified sands and rounded gravels. Commonly occurs in channels within and interbedded with *Qgl*. Near Dover and downstream, includes coarse cross bedded facies of catastrophic flood gravels from Glacial Lake Missoula floods. Soils are gravelly silt loam to gravelly sand loam of Bonner-Kootenai series. Unified Soil Classification GM, GP, and SM. Thickness one meter to over tens of meters.

INTRUSIVE ROCKS

Td **Dacite dikes (Eocene)**—Biotite dacite dikes, commonly porphyritic with blocky phenocrysts of feldspar up to 3 cm and biotite phenocrysts to 5 mm. Commonly light gray, resistant, and forms cliffs and talus slopes. Dikes are a few meters wide; rarely 50. Some appear to continue for 100 to 1000 m but most are not exposed continuously enough to demonstrate their extent. Concentrated in the southeast part of the map area. Most may be related to the Eocene Wrencoe pluton (*Tggd*) in the southwest part of the quadrangle. Dikes northwest of Sandpoint have mylonitic fabric and may be slightly older.

Ta **Andesite dike (Eocene)**—A single hornblende andesite dike was mapped in the southeast corner of quadrangle. Rock is aphanitic with hornblende and plagioclase phenocrysts.

Tggd **Granodiorite and granite (Eocene)**—Porphyritic hornblende-biotite granodiorite and subordinate equigranular biotite granite, biotite-hornblende quartz monzonite, and biotite-hornblende diorite. Forms the composite Wrencoe pluton. Porphyritic phase contains 2-6 cm long potassium feldspar phenocrysts and is medium to coarse grained. Biotite granite phase is fine to medium grained. Biotite-hornblende quartz monzonite and biotite-hornblende diorite are present near northern contact; both are medium grained and equigranular. All phases have strongly zoned plagioclase feldspar. A sample of the pluton from near Wrencoe (11 km southwest of Sandpoint), was dated by U-Pb zircon at 50.1 ± 6.3 Ma (Whitehouse and others, 1992).

TKgf **Fine-grained granite and granodiorite (Eocene or Cretaceous)**—Fine-grained biotite granodiorite and granite exposed in a single mass south of Schweitzer Creek. Also present as unmapped bodies within *Kmg* and *Kbg* units.

Kmg **Biotite-muscovite granite and granodiorite (Cretaceous)**—Massive to foliated and lineated biotite-muscovite granite and granodiorite. Includes abundant pegmatite. Includes rocks mapped as “mixed granitic rocks of Camels Praire” (Miller and others, 1999) that contained two-mica monzogranite as the most abundant rock type. Plagioclase is weakly zoned; myrmekite is common. Muscovite 7-15 percent; biotite 3-8 percent. Foliation only formed locally; much of it is mylonitic. Kinematic indicators such as s-c fabrics and sheared porphyroblasts indicate top-to-the-east motion.

Kbg **Biotite granodiorite and granite (Cretaceous)**—Massive to foliated and lineated biotite granodiorite and granite. Locally contains lenses of metasedimentary rock, some of which have been mapped separately as *Ygs*. Includes both medium- and fine-grained phases; the later is subordinate and may be related to the *TKgf* unit. Plagioclase is weakly zoned; myrmekite is common. Biotite 5-16 percent; minor amounts of fine-grained (secondary?) muscovite present locally. Mylonitic foliation is similar that found in the *Kmg* unit. Included in the unit “mixed granitic rocks of Camels Prairie” (Miller and others, 1999) but subdivided here on the basis of the low muscovite content.

Kbgd **Biotite granodiorite (Cretaceous)**—Massive biotite granodiorite exposed in small bodies intrusive into the Prichard Formation east of the Purcell trench fault. In contrast to Cretaceous granitic rocks west of the fault, unit contains subhedral primary(?) epidote and more strongly zoned plagioclase. Myrmekitic textures are common and the potassium feldspar has well developed grid twins.

Ymi **Mafic intrusive rocks, undivided (Mesoproterozoic)**—Medium-grained hornblende gabbro, biotite quartz diorite, biotite-hornblende quartz diorite and fine-grained diorite. Gabbro generally quartz-bearing. Quartz diorite occurs as middle and upper parts of apparently differentiated mafic sills and as separate sills. All may exhibits some granophyric textures. Finer-grained varieties typically in thinner bodies. Probably all are Moyie Sills similar to the sills described by Bishop (1976), Höy (1989), Anderson and Goodfellow (2000), and Gorton and others (2000). Most are tholeiites or differentiates from tholeiitic magma and intruded into middle and lower parts of the Prichard Formation. Intrusion of many sills was at shallow levels closely following sedimentation (Cressman, 1989; Sears and others, 1998). Age of sills in *Ype* is probably close to U-Pb dates on zircons from Plains, Montana, about 120 km southeast (1.47 Ga; Sears and others, 1998), or from near Kimberley, British Columbia about 150 km to the north (1.468 Ga; Anderson and Davis, 1995).

BELT-PURCELL SUPERGROUP

Prichard Formation (Mesoproterozoic)—White to gray siltite, white to gray to black argillite and white to gray fine feldspathic to coarser feldspar-poor quartzite. Siltite typically rusty weathering and planar laminated with black argillite tops, some with white argillite tops. Rusty nature comes from abundant sulfides, commonly pyrrhotite. Average quartzite has 21 per cent feldspar (Cressman, 1985); is lighter weathering in decimeter beds. Bar code-like patterns formed by alternating dark and light siltite and persist over 100 kilometers (Huebschman, 1973). These “marker beds” were used by Cominco for correlation across large areas (Hamilton and others, 2000). Harrison and Jobin (1965) did not subdivide the Prichard Formation and Cominco only subdivided it down to member e. Unit designations for the Prichard Formation follow recent IGS usage in the Trout Peak quadrangle (Lewis and others, 2006).

Ypad **Prichard Formation, members a, b, c and d (Mesoproterozoic)**—Rusty weathering, dark gray siltite and argillite couplets, siltite, and rare lighter quartzite. All members a through d to the east in the Trout Peak quadrangle contain mafic sills as do the rocks assigned to this unit. Couplets typically less than one cm thick and even parallel, although some zones have undulating or uneven bedding, cross lamination and soft sediment disruption. Argillite tops typically darker than siltite but locally are light weathering. Siltite layers both cm- and dm-scale, typically dark gray, some weathering light gray. Some weathered surfaces of massive dm, rusty-weathering siltite exhibit internal mm even laminations. Light gray to white weathering quartzite as isolated dm-scale beds and dm- to rare m-scale beds amalgamated up to several meters thick contain rare medium-grained quartz sand both as basal lags and “floating” grains in a fine-grained matrix. Load features and scour surfaces on a cm scale are common at the bases of some quartzite beds. Cleavage moderately to poorly developed inconsistently across the area. Hosts Moyie sills that range from tabular with differentiated tops to irregular with no differentiation. Well but discontinuously exposed on steep slopes and ridge tops. Units a-d mapped together because size of exposures or fault blocks precluded subdivision.

METASEDIMENTARY ROCKS OF THE PRIEST RIVER COMPLEX

Ygs **Gneiss and schist (Mesoproterozoic)**—Biotite-quartz-feldspar gneiss and muscovite-biotite schist. Present only as roof pendants or septa in the west-central part of the quadrangle. Gneiss is considered to be equivalent to the Hauser Lake gneiss (Weis, 1968; Weisenborn and Weiss, 1976) and was considered metamorphosed Prichard Formation by Miller and others (1999).

Ygq **Granofels and quartzite (Mesoproterozoic)**—Layered biotite-quartz-feldspar granofels and feldspathic biotite quartzite. Granofels has gneissic layering, but lacks a strong foliation. Plagioclase is the more common feldspar. Unit is more widely exposed in the Mt. Casey quadrangle to the northwest where it also contains thin intervals of calc-silicate rock.

STRUCTURE

HOPE FAULT

Near the center of the Sandpoint quadrangle is a complicated intersection of the Hope fault and the Purcell trench (e.g., Harrison and others, 1972; Doughty and Price, 2000). East of the Sandpoint area, the Hope fault has only down to the southwest normal motion documented during the Eocene (Fillipone and Yin, 1994). However, closer to Sandpoint, dacite dikes become increasingly abundant (Lewis and others, 2006) and en echelon arrangement suggests that there was a component of right slip (Harrison and others, 1992). The fault is diagrammatically shown terminating against the Purcell trench fault on the map, but the intersection is unlikely to be this simple. Displacement probably decreases westward and displacement on the Hope fault may be transferred north and south near its intersection with the Purcell trench fault. North of Clark Fork, Idaho, rocks of the middle Prichard (*Ypf*) are opposite rocks of and above the Wallace Formation, yet nearer Sandpoint, rocks north and south of the Hope fault may be from equivalent stratigraphic levels in the lower Prichard. Given the proximity of Eocene dikes along and near the fault to the east of the intersection and the Eocene Wrencoe pluton to the southwest, it seems likely that the fault was intruded by the Wrencoe and related dikes during at least its last activity, which may have included motion west of the Purcell trench fault.

PURCELL TRENCH FAULT

The Purcell trench fault is nowhere exposed in the Sandpoint quadrangle, but its existence is inferred from contrast of metamorphic grade and deformation in bedrock exposures on the west and east sides of the quadrangle (Miller and others, 1999). Biotite-muscovite and biotite granitoids and amphibolite facies paragneiss and granofels on the west side of the quadrangle contrast sharply with greenschist-facies Prichard Formation on the east side. The Prichard shows generally low-grade burial metamorphism, open folding and faint cleavage development so that sedimentary structures and features are well-preserved. An exception is in the northeast quarter of the quadrangle where cleavage locally becomes more phyllitic and muscovite porphyroblasts occur. According to Miller and others (1999), sharp contrast in metamorphism and deformation persists from about 2 km south of Cocolalla Lake north to just north of Sandpoint, and from 3 km north of the town of Elmira (27 km north of Sandpoint) to the United States-Canada boundary. In between, the two-mica granitic rocks, and to a lesser degree the more highly metamorphosed and deformed rocks typical of the west side of the trench, cross to the east side for a distance of at least 12 km along the fault. North and south of the quadrangle, Cretaceous granitic rocks east of the fault yield Cretaceous potassium-argon ages, but west of the fault yield Eocene cooling ages (Miller and Engels, 1975), reflecting Eocene relative uplift of the west side (Doughty and Price, 1999).

SPOKANE DOME MYLONITE

The granodiorite and granite on the west side of the quadrangle locally contain a mylonitic foliation and lineation. The fabric is more pronounced in the east near the mountain front and is only present along discrete shear zones at the western map boundary. This mylonitic fabric contains kinematic indicators that show a consistent top-to-the east motion and is the northeast part of the Spokane dome mylonite zone. The Spokane dome mylonite zone was initially mapped by Cheney (1980), Rehrig and others (1987), and Rhodes and Hyndman (1984), and later studied in more detail by Doughty and Price (1999; 2000). There is disagreement about the relationship between the Spokane dome mylonite zone and the Purcell trench fault. Rehrig and others (1987) related the mylonite to a fault in the Purcell trench (the Purcell-CDA detachment), and considered the entire Priest River complex a typical Cordilleran metamorphic core complex. Rhodes and Hyndman (1984) pointed out that the lack of chlorite breccia at the top of the Spokane dome makes it dissimilar to a classic metamorphic core complex, but suggested that the mylonite is possibly the basal décollement of the Sevier thrust belt. Doughty and Price (1999) showed the Purcell trench fault merging with the Spokane Dome mylonite at depth, whereas Rhodes and Hyndman showed a low-angle Purcell trench fault cutting the mylonite zone at a low angle. To the south in the Coeur d’Alene 30′ x 60′ quadrangle, we showed a similar crosscutting relationship but with a steeper fault and larger intersection angle (Lewis and others, 2002). We suspect that this is true in the Sandpoint area too. We have shown this interpretation on cross sections A-A′ and B-B′.

MAP SYMBOLS

Contact: line showing the boundary between one map unit and another; dashed where approximate. The location accuracy of contact is 80 feet or more on the ground.

High-angle fault: ball and bar indicates downthrown side of a normal fault; dotted where concealed.

Headwall of alpine cirque.

Crest of lateral or end moraine.

Direction of ice flow, Purcell Trench lobe of Cordilleran ice sheet.

Terrace scarp.

Strike and dip of bedding.

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

Strike and dip of overturned bedding.

Strike and dip of cleavage.

Strike and dip of joint.

Strike and dip of foliation.

Strike and dip of vertical foliation.

Strike and dip of mylonitic foliation.

Variable strike and dip of foliation.

Bearing and plunge of lineation, type unknown.

Bearing and plunge of mineral lineation.

Bearing and plunge of mylonitic lineation.

Bearing and plunge of lineation in L tectonite.

Bearing and plunge of small fold axis.

Bearing and plunge of asymmetrical small fold showing clockwise rotation viewed down plunge.

05RL300 Sample location.

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

Sample number	Latitude	Longitude	Unit name	Map unit	SiO_2	TiO_2	Al_2O_3	FeO*	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Total	Ni	Cr	Sc	V	Ba	Rb	Sr	Zr	Y	Nb	Ga	Cu	Zn	Pb	La	Ce	Th	Nb
					Major elements in weight percent											Trace elements in parts per million																	
05RL255	48.3250	-116.5667	Medium-grained biotite granodiorite	Kbg	71.40	0.131	15.72	1.04	0.034	0.41	3.06	4.56	1.84	0.051	98.24	5	2	3	18	759	70	659	81	5	9.2	17	2	28	25	8	18	5	7
05RL300	48.3083	-116.5882	Fine-grained leucocratic granite	Kbg	72.10	0.205	14.41	1.65	0.047	0.52	1.45	3.58	4.52	0.109	98.57	8	3	4	19	1501	148	675	148	18	25.5	19	2	37	53	40	74	16	28

* Total Fe expressed as FeO.
All analyses performed at Washington State University GeoAnalytical Laboratory, Pullman, Washington.