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Preliminary geologic map of the Orwig Hump area, Washington and Idaho

by

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INTRODUCTION

This map is part of a 1:48,000-scale preliminary geologic map series covering the Sandpoint $1^{\circ}x2^{\circ}$ quadrangle. The maps of this series are being Open-Filed in order to make geologic information available as the project progresses so that interested parties do not have to wait for completion of the entire $1^{\circ}x2^{\circ}$ sheet. In addition, a greater amount of information is presented at the 1:48,000-scale of the preliminary maps than will appear on the final compilation. The bases for all maps in the series are 15-minute blocks formed by photographic mosaics of published 7.5' topographic quadrangles.

The preliminary maps are more detailed and accurate than reconnaissance maps, but because they are the outgrowth of 2-degree-scale mapping and limited by the haste necessary to cover so large an area in a reasonable length of time, they are not the quality of U.S. Geological Survey maps of similar scale released in more formal publication series such as GQ or MI maps. The map information is relatively detailed in some areas but almost reconnaissance in others, so all maps in this series should be considered preliminary and subject to refinement.

DESCRIPTION OF MAP UNITS

Qag GLACIAL AND ALLUVIAL MATERIAL (Quaternary)--Includes till from both alpine and continental glaciations, and all alluvial material in modern drainages.

Klc GRANODIORITE OF LE CLERK CREEK--(Cretaceous)--Fine-grained biotite granodiorite. Contains trace amounts of muscovite, which may be secondary. Plagioclase about an_{30}. Potassium feldspar is microcline. Thin scattered grains of biotite are medium brown. Color index about 10. Accessory minerals include apatite, zircon, and opaque minerals. Rock is fine grained, contains irregularly, but widely scattered, blocky 1- cm plagioclase grains and in places has a poorly developed foliation. Forms elongate, dike-like body. Appears to intrude Galena Point Granodiorite (Kg) and granodiorite of Bunchgrass Meadows (Kb); also in contact with Hungry Mountain body, but relationship between the two is unclear.

GRANODIORITE OF HALL MOUNTAIN (Cretaceous)--Medium- to fine-grained muscovite-biotite granodiorite. Named for Hall Mountain in adjacent map area to north (Miller, 1983). Occurs as six non-contiguous plutons, five of which are all or partly in Orwig Hump map area; all have similar lithology and texture. Although not described as a Hall Mountain-type pluton, granodiorite of Reeder Creek is probably a coarser grained pluton related to this group. A general description of the representative Hall Mountain rock type is given here; characteristics and variations of specific plutons are described under individual pluton headings below. Modal composition ranges from tonalite to granodiorite, but mostly is granodiorite (see modal diagram). Biotite in most of rock is brown or olive-green but near quartz veins and quartz veinlets is reddish-brown. Muscovite appears primary, although may be late stage; forms clusters with biotite, rarely as solitary crystals not in contact with biotite. Potassium feldspar is microcline; crystals characteristically enclose numerous, relatively large plagioclase, and less commonly biotite, crystals. Enclosed minerals impart poikilitic look to microcline on stained slabs. Accessory minerals include epidote, clinozoisite, allanite, zircon, apatite, rutile, and minor opaque minerals. Biotite from northernmost part of main Hall Mountain pluton north of map area yielded potassium-argon age of

99.0 m.y. (Miller and Engels, 1975; recalculated using current IUGS approved constants (Steiger and Jager, 1977). Muscovite from small non-contiginous stock north of Tillicum Peak pluton (Khtp) at north edge of map area yielded a potassium-argon age of 96.4 m.y. (Miller and Theodore, 1982). All Hall Mountain plutons contain, or are associated with, anomalous amounts of one or more of the following: Au, Ag, W, Mo, and Bi (Miller and Theodore, 1982; and Miller and Frisken, 1984). Individual pluton descriptions follow.

Kho ORWIG HUMP PLUTON--Average color index about 15, higher than most Hall Mountain plutons. Ratio of biotite to muscovite about 5:1. Plagioclase averages between an_{30} and an_{35}. Potassium feldspar is microcline. Orwig Hump body has the lowest average potassium feldspar content of all the Hall Mountain plutons. Rock is typically medium grained, non-porphyritic, and except near margins, massive. Up to 0.5 percent epidote in millimeter-sized grains found throughout pluton. Accessory minerals include zircon, apatite, tourmaline, and opaque minerals. Along parts of the northern and eastern margins, rock has irregularly oriented foliation, and is finer grained than interior of pluton. Forms an approximately 16 km^2 oval pluton, around which are wrapped Proterozoic rocks on its north, east, and west sides; southern contact with Bunchgrass Meadows granodiorite is not exposed.

Khtp TILLICUM PEAK PLUTON--Average color index about 7; ratio of biotite to muscovite about 3:1. Overall texture and mineralogy typical of Hall Mountain type, but slightly more leucocratic. Pluton is elongate northwest-southeast, on projection of older Johns Creek fault from map area to north. Underlies about 6 km^2 . Has numerous micro-shears that increase in number and degree of development toward western edge of pluton. Shears visible but not obvious in hand specimen; in thin section, manifested by trains of broken and rehealed quartz and feldspar, and broken, disaggregated, and partially recrystallized biotite and muscovite. East side of pluton has numerous quartz veins and localized areas of sericitic alteration; disseminated pyrite abundant locally. All panned concentrates of sediments from streams draining north and east sides of pluton contain anomalous amounts of W, Bi, Mo, Ag, and Pb. Included with this pluton is a small non-contiguous mass, about 900 m long and averaging about 200 m in width, 1.5 km to the northeast. Miller and Theordore (1982) referred to this stock as the Harvey Creek body, but it is here included with the Tillicum Peak pluton, because it resembles the Tillicum Peak pluton in most respects, expect the amount and degree of alteration and quartz veins in the smaller stock is much greater. Sparse but visible molybdenite is present in many of the quartz veins.

Khp PAUPAC CREEK PLUTON--Average color index about 10, but more variable than in most Hall Mountain-type plutons. Biotite to muscovite ratio variable also, ranging from 3:1 to 10:1. Underlies 6 to 7 km^2 in an elongate, east-west oriented body mostly west of map area. Intrudes Middle and Late Proterozoic rocks on north, east, and west, and granodiorite of Molybdenite Mountain (Kmm) on south. Most of pluton is medium to fine grained with a well-developed primary foliation. Mineralogy about same as most other Hall Mountain plutons, except for variability in micas, and slightly higher than normal potassium feldspar content. In map area to west, entire northwest border of pluton is cut by numerous close-spaced dikes and veins consisting largely of potassium feldspar and quartz. All panned concentrates from streams draining north side of pluton contain anomalous amounts of W, Bi, and Ag.

Khbm BOULDER MOUNTAIN PLUTON--Medium- to fine-grained biotite granodiorite with only minor muscovite. Pluton underlies about 15 km^2 northeast of map area and 5 km^2 in map area. Average color index is 13; biotite is only mafic mineral. Biotite varies greatly in grain size from place to place in the pluton. Accessory minerals are zircon, apatite, and epidote; rock has a conspicuous dearth of opaque minerals. Texture is seriate in most of body. At many places around margin of pluton, rock is finer grained, apparently chilled. Castor and others (1981) report a core of fine-grained to microcrystalline porphyry and extensive rock alteration near center of pluton (area underlying head waters of Zero Creek). Numerous large quartz veins and pods, and anomalous amounts of molybdenum are present in southern part of pluton, possibly other parts. Rock intrudes Middle Proterozoic Prichard Formation and possibly other formations of Belt Supergroup.

Khl LOOP CREEK PLUTON--Small pluton mostly covered by Quaternary deposits; projected contacts beneath Quaternary deposits enclose about 5 km^2, mostly south and west of map area. Mineralogy of exposed rock varies within range of typical Hall Mountain-type plutons; grain size more variable than most. Medium- to coarse-grained in central part and fine-grained around margins. All of the limited exposures of this pluton contain numerous pyrite-bearing quartz veins.

(end description of Hall Mountain plutons)

Kr GRANODIORITE OF REEDER CREEK (Cretaceous)--Medium-grained biotite granodiorite; forms large pluton in map area to east. Most Reeder Creek granodiorite contains about 0.5 percent fine-grained muscovite. Average color index is 11. All potassium feldspar is microcline, occurring chiefly as phenocrysts that average 2 cm across. On stained slabs, microcline shows irregular-shaped, poikilitic-looking texture typical of Hall Mountain rocks. Poikilitic appearance results from inclusion of at least 50 percent (by volume) plagioclase. Included plagioclase is randomly oriented; not concentric with outer crystal form of microcline; irregular shape of microcline suggests many phenocrysts were in incipient stage of formation when body crystallized. Plagioclase averages about an_{30}. Large and small grains of gray quartz contrast with lighter-colored feldspars; grain size variation gives rock slight seriate texture. Size of biotite is also variable; all is anhedral with ragged borders. Accessory minerals include allanite, epidote, zircon, apatite, and opaque minerals. Texture and mineralogy varies only slightly throughout pluton. An exception is a mafic zone of lineate rock along the northwest and southwest borders. Cretaceous age is assigned on basis of compositional and textural similarities with nearby plutons of known Cretaceous age. Intrudes Middle Proterozoic Prichard Formation; appears to intrude granodiorite of Priest Lake east of map area.

Km MONZOGRANITE OF MIDDLE CREEK (Cretaceous)--Leucocratic biotite monzogranite; some rock contains muscovite, most does not. Deeply weathered and very poorly exposed. Color index averages about 5. Texture highly variable from fine, even-grained to pegmatitic; contacts between textural types ill-defined and gradational. At a few places quartz forms 1-cm-long subhedral phenocrysts. The unit could be a series of dikes in Galena Point Granodiorite (Kg), but is too deeply weathered and poorly exposed to verify the relationship.

Kh MONZOGRANITE OF HUNGRY MOUNTAIN (Cretaceous)--Medium- to coarse-grained muscovite-biotite monzogranite. Contains abundant irregularly distributed potassium feldspar (microcline) phenocrysts; in some areas rock is over 50 percent phenocrysts, in other areas, contains almost none. All phenocrysts have abundant small plagioclase crystals oriented concentrically with respect to outer crystal form, presumably reflecting growth zonation. Average plagioclase composition an_{20}; most crystals highly zoned. Quartz present as large gray crystals or crystal aggregates; gray contrasts with white of feldspars more than in most granitic rocks in region and is a distinguishing characteristic. Biotite is only mafic mineral; color index averages 7. Muscovite forms smaller crystals than other minerals in rock; nowhere exceeds 1 percent of rock, and is difficult to see in outcrop. Accessory minerals include zircon, apatite, allanite and opaque mineral(s). Texture is porphyritic with hypidiomorphic-granular groundmass; rock has no directional fabric. Pluton underlies about 90 km^2, partly east of map area. Grades inward to monzogranite of Gleason Mountain (Kgm) through decrease in grain size and concentration of phenocrysts. Monzogranite of Hungry Mountain similar to monzogranite of Tango Creek which occurs 8 km to the northeast in the Priest Lake map area (Miller, 1982); the two may be separate plutons originating from same magma. Hungry Mountain pluton intrudes no sedimentary or metamorphic rock; appears to intrude Galena Point Granodiorite but contact relations poorly exposed and ambiguous. Sample collected in Sec. 23, T. 36 N., R. 45 E., yielded potassium-argon apparent ages of 93.2 m.y. on biotite and 96.7 m.y. on muscovite (Miller and Engles, 1975; recalculated using current IUGS approved constants (Steiger and Jager, 1977)).

Kgm MONZOGRANITE OF GLEASON MOUNTAIN (Cretaceous)--Leucocratic muscovite-biotite monzogranite. Medium-grained, but locally fine- or coarse-grained. Contains sparse microcline phenocrysts up to 4 cm in much of body especially where gradational into coarse-grained porphyritic monzogranite of Hungry Mountain. Gleason Mountain rock essentially the same chemically, modally, and mineralogically as Hungry Mountain monzogranite, but differs texturally. Compare Hungry

Mountain modes to Gleason Mountain modes. Gleason Mountain pluton underlies 35 km^2, partly east of map area. Average plagioclase composition is about an_{18}. Potassium feldspar is microcline. Biotite is only mafic mineral; average color index about 7. Biotite:muscovite ratio varies greatly even on outcrop scale; most rocks have less than 1 percent muscovite. Typical rock is even grained to seriate, but pluton as a whole has large variation in grain size. Irregularly-shaped pegmatitic and aplitic pods with diffuse gradational borders occur throughout body; in this respect resembles (and may be related to) monzogranite of Middle Creek. Eastern body of Gleason Mountain monzogranite intrudes no sedimentary or metamorphic rocks; surrounded by monzogranite of Hungry Mountain on all but east end. Western body appears to intrude Galena Point Granodiorite, but contact relations poorly exposed and ambiguous. Probably genetically related to, and same age as, monzogranite of Hungry Mountain on basis of gradational contacts and similar mineralogy.

Kmm GRANODIORITE OF MOLYBDENITE MOUNTAIN (Cretaceous)--Muscovite-biotite granodiorite. Average color index about 7. Biotite:muscovite ratio averages about 3:1, but varies between 2:1 and 10:1. Average plagioclase composition about an_{22}. Potassium feldspar appears to be both microperthitic orthoclase and microcline. Biotite slightly chloritized in much of pluton; intergrown with muscovite in all rocks. At a few places muscovite is 1 cm across, but is less than 5 mm in most rocks. Accessory minerals include apatite, zircon, epidote, and sparse opaque minerals. Rock contains scattered, poorly-formed 2 to 3 cm-long potassium feldspar phenocrysts in part of pluton, but most is subequigranular. Average rock is coarse grained, but grain size is highly variable, especially around margins; appears chilled against granodiorite of Yocum Lake (Ky). Rock is slightly foliated at places due to flattening of large quartz grains and parallel alignment of mica and potassium feldspar. Pluton underlies about 48 km^2, mostly west of map area, appears to intrude granodiorite of Yocum Lake, and is intruded by Paupac Creek pluton of granodiorite of Hall Mountain. Sample from western part of pluton yielded concordant potassium-argon ages of 103 m.y. on both biotite and muscovite (Miller and Engels, 1975; recalculated using current IUGS approved constants (Stieger and Jager, 1977)).

Kg GALENA POINT GRANODIORITE (Cretaceous)--Porphyritic biotite granodiorite. Medium- to coarse-grained. Average plagioclase composition is calcic oligoclase. Most potassium feldspar is pink microperthitic orthoclase, but in some parts of pluton is microcline; present as phenocrysts up to 6 cm and in groundmass. Biotite is chief mafic mineral; trace of hornblende in some rocks. Color index averages 12, but locally as high as 16. Accessory minerals include zircon, apatite, allanite, opaque mineral(s), and sphene; latter ranges from abundant to absent. Texture is porphyritic with groundmass ranging from hypidiomorphic-granular to seriate. Underlies about 170 km^2 in this and adjacent map areas. Intrudes Belt Supergroup; highest stratigraphic unit intruded is lower Wallace Formation. Appears to be gradational into granodiorite of Yocum Lake (Ky). Sample collected on south flank of North Baldy (Sec. 20, T. 35 N., R. 45 E.) yields potassium-argon apparent age of 101 m.y. on biotite (Miller, 1974; recalculated using current IUGS approved constants (Stieger and Jager, 1977)).

Ky GRANODIORITE OF YOCUM LAKE (Cretaceous)--Medium- and coarse-grained hornblende-biotite granodiorite to monzogranite; underlies about 160 km^2 in this and adjacent map areas. Pluton is arcuate in shape, west side cut by the Newport fault west of map area. Average plagioclase composition is intermediate oligoclase which forms subhedral zoned crystals. Potassium feldspar is microcline and microperthitic orthoclase. Ratio of biotite to hornblende averages about 3:1. Color index averages about 14. Accessory minerals include sphene, apatite, zircon, and opaque minerals. Rock is non-porphyritic and has no apparent fabric. Near Leola Volcanics, pluton has higher percentage of plagioclase and mafic minerals; there plagioclase composition about an_{10} higher than typical Yocum granodiorite, and hornblende-biotite ratio is greater than one. Appears to grade into Galena Point Granodiorite by loss of hornblende and introduction of phenocrysts. Sample from northern part of pluton yielded potassium-argon ages of 100 m.y. on biotite, and 99.8 m.y. on hornblende (Miller and Engles, 1975; recalculated using current IUGS approved constants (Stieger and Jager, 1977)).

Ksm GRANODIORITE OF SEMA MEADOWS (Cretaceous)--Porphyritic hornblende-biotite granodiorite. Biotite-hornblende ratio about 2:1. Underlies about 10 km^2.

Medium- to coarse-grained; normally structureless, but at some places has subtle inconsistently oriented lineation defined by sub-parallel hornblende. Composition and grain size variable on outcrop scale in many parts of pluton. Average color index about 18. Phenocrysts are pink microcline; average length about 2.5 cm. Abundant sphene throughout pluton. Other accessory minerals include apatite, zircon, allanite, and opaque minerals; epidote present, but probably secondary. Mafic inclusions common. Rock appears to grade into granodiorite of Bunchgrass Meadows (Kb) through loss of phenocrysts. Age assignment on basis of similarities to nearby Cretaceous plutons.

Kb GRANODIORITE OF BUNCHGRASS MEADOWS (Cretaceous)--Hornblende-biotite granodiorite. Underlies about 35 km^2 surrounding granodiorite of Sema Meadows (Ksm). Very similar, and probably genetically related to, granodiorite of Sema Meadows. Mafic inclusions especially abundant in western part of pluton. Most of pluton is medium grained. Color index, mineralogy, texture, and limits of variation of these properties similar to granodiorite of Sema Meadows. Differs from Sema Meadows body only in that it is non-porphyritic. Very similar to, and possibly a non-contiguous body of, granodiorite of Priest Lake (Kpl).

Kpl GRANODIORITE OF PRIEST LAKE (Cretaceous)--Medium- to coarse-grained hornblende-biotite granodiorite. Underlies small area in east-central part of map area, and about 30 km^2 east of map area (Miller, 1982a). Average plagioclase composition about an_{30}. Potassium feldspar is microperthitic and non-perthitic orthoclase; anhedral, occupies intersticies between other crystals. Hornblende-biotite ratio averages about 1:1, but varies widely. Much hornblende occurs as 1 cm-long stubby prisms; larger than other minerals in rock. Accessory minerals include sphene, zircon, apatite, allanite, epidote, and opaque minerals(s). Sphene obvious in most hand specimens; epidote visible in many. Texture is hypidimorphic-granular and seriate. Coarse-grained to pegmatitic mafic masses present a few places at margin of pluton; some are hornblende-rich orbicular-like masses. Granodiorite intrudes Prichard Formation; age relative to adjacent plutons ambiguous due to poorly exposed contacts. Cretaceous age assigned on basis of modal, chemical, and textural similarities with nearby Cretaceous plutons.

Kmc GRANODIORITE OF MILL CREEK (Cretaceous)--Medium-grained biotite-hornblende granodiorite; underlies about 5 km^2 in this map area and map area to west. Pluton is distinctive due to high color index which averages 23. Biotite-hornblende ratio averages about 1:2, but ranges from all hornblende to all biotite. Plagioclase averages intermediate andesine, but is highly zoned. Potassium feldspar is orthoclase and is mainly interstitial to other minerals. Partially altered clinopyroxene forms cores in some hornblende. Sphene extremely abundant; other accessory minerals include zircon, apatite, allanite, and opaque minerals. Most of pluton is hypidiomorphic granular, but much has irregularly oriented foliation and(or) lineation. Mafic inclusions extremely abundant throughout pluton. Potassium-argon ages on hornblende and biotite from Mill Creek body are 104 and 100 m.y., respectively (R. J. Fleck, personal commun., 1989).

WINDERMERE GROUP (Late Proterozoic)

Zm
Zmc MONK FORMATION--Argillite and quartzite. Occurs only along north edge of Paupac Creek pluton (Khp), but underlies large area in two non-contiguous belts to north. In Orwig Hump area, is chiefly dark-gray to black argillite and tan arkosic quartzite. Unit is poorly exposed, highly sheared, and almost everywhere shows strong internal deformation. Argillite is phyllitic; well-preserved sedimentary structures rare. Thin-bedded to laminated where bedding preserved; commonly carbonaceous and locally contains abundant pyrite. Matrix-supported 0.5 to 1 mm round quartz grains are common, but widely separated in argillite. Quartz grains are blue-gray and nowhere exceed 0.5 percent of rock. One cm to 1 m thick beds of argillite-pebble and quartzite-pebble conglomerate (Zmc) occur sparsely throughout section. Tan arkosic quartzite beds 0.3 to 1.5 m thick appear to be restricted to lower and middle part of preserved section. Arkosic quartzite beds have indistinct parallel-planar internal stratification; are separated from one another by several meters of argillite. Thin fragments of argillite sparsely scattered through arkosic quartzite, but not abundant enough to constitute mud-chip breccia. Some arkosic rock has porous look, especially on weathered surface, due to leached out material, possibly carbonate or feldspar

minerals. North of map area, thickness of preserved part of unit 500 m as calculated from outcrop width, but figure is uncertain due to internal faults, folds, and cleavage.

Zl LEOLA VOLCANICS--Greenstone derived from basalt flows and tuffaceous and volcaniclastic rock. Most greenstone recrystallized; small porphyroblasts of blue-green hornblende common. Unit appears to grade downward into Shedroof Conglomerate, but no unconformity apparent between the units. Contact placed at base of lowest group of massive flows in Leola. North of map area, thickness as calculated from width of outcrop ranges from 0 to about 1,850 m. Flows are massive, up to 25 m thick, and show little primary or secondary internal features except for well developed pillows in lower few hundred meters of formation. Greenstone dikes and sills in Shedroof Conglomerate and Belt Supergroup considered to be intrusive equivalents of Leola. None of greenstone in map area suitable for isotopic dating, but K-Ar whole-rock potassium-argon dates on basalt flows from similar greenstone of the correlative Huckleberry Formation 65 km southwest of area suggest basalt was extruded sometime between 734 and 862 m.y. ago (Miller, and others, 1973), recalculated using IUGS constants (Steiger and Jager, 1977)).

Zsp
Zsq SHEDROOF CONGLOMERATE--Chiefly pale-gray to white, fine- to medium-grained, vitreous quartzite (Zsq), and gray-green phyllite and sandy conglomeratic phyllite (Zsp). Quartzite is thick to massively bedded; shows little internal stratification; highly recrystallized; commonly brecciated and stained by iron oxides. Locally contains sparse angular clasts of fine-grained quartzite to 1 cm across; also contains several interbedded argillite zones to 30 m thick. Thickness of quartzite is at least 150 m, but could be as great as 300 m. Phyllite above quartzite is gray or greenish-gray; ranges in thickness from 0 to 100 m. About 10 m of diamictite and sandy phyllite found above quartzite about 6 km northeast of map area. Shedroof in Orwig Hump map area probably represents near-shore part of a sharply defined Windermere basin. North of map area, Shedroof in a parallel section, representing a deeper part of the basin, is over 3000 m of coarse conglomerate and diamictite.

PRIEST RIVER GROUP (Middle Proterozoic)

Yu PRIEST RIVER GROUP, UNDIVIDED--Argillite, siltite, quartzite, and carbonate rock. Not subdivided due to one or all of following: (1) metamorphism, (2) poor exposure, (3) lack of distinctive lithologies in areas of limited exposure.

Yc_2 UPPER CARBONATE UNIT--Dolomite with minor interbedded siltite and argillite. Dolomite is tan, white, and pale-gray; weathers orange-tan to white. Most dolomite medium-to-thin-bedded, but some thick beds. Thin seams and pods of silica abundant; may have been chert. Very poorly exposed in map area. Calculated thickness from outcrop width 450 m, but may contain concealed faults or folds. Upper contact is unconformity with Windermere rocks above it.

Ya_2 UPPER ARGILLITE UNIT--Dark-gray to light-gray argillite and phyllitic argillite. One or more well-developed cleavage(s) in most places. Pencil slate common where two intersecting cleavages developed. Bedding relatively well preserved north of map area. There, rock ranges from thinly laminated light- and dark-gray argillite to unlaminated silty medium-gray argillite. Cross lamination, channel-and-fill, and graded beds present in laminated part of section. Tan to gray dolomite and limy dolomite beds to 2 m thick sparsely scattered through upper part of unit but normally separated by more than 50 m of carbonate-free argillite. Unit is about 730 m thick as calculated from outcrop width, but is fault bounded everywhere in area, and may include undetected faults and folds. Unit is unconformably overlain by Shedroof Conglomerate north of map area (Miller, 1983).

Yc_1 LOWER CARBONATE UNIT (in cross-section only)--Gray and tan dolomite and limy dolomite, argillite and siltite; minor limestone. Thin- to thick-bedded; platy to blocky weathering. Algal structures present but not abundant. About one-third of unit is interlayered argillite and siltite. Much of carbonate is argillaceous and(or) arenaceous. North of map area unit forms conspicuous rusty red soil, and is poorly exposed most places. Apparent thickness calculated from outcrop width north of map area, ranges from about 330 m to about 490 m, but unit is internally deformed and fault bounded. Occupies stratigraphic position of Shepard Formation of Belt Supergroup, and Edna Dolomite of Deer Trail Group (Miller and Whipple, 1989).

Ya_1 LOWER ARGILLITE UNIT--Light- to dark-gray laminated argillite and siltite; most is highly phyllitic. Interbedded with quartzite, tan, carbonate-bearing fine-grained quartzite, and siltite in upper part. Carbonate-bearing beds pinch and swell irregularly along strike; bed thickness ranges from about 1 cm to about 30 cm. Filled syneresis cracks abundant locally. Grades downward into increasingly more phyllitic rocks. Thickness unknown; apparent thickness highly variable due to faulting, folding, and cleavage. Occupies stratigraphic position of Togo Formation of Deer Trail Group (Miller and Whipple, 1989).

BELT SUPERGROUP (Middle Proterozoic)

Ycs CALC-SILICATE UNIT--Interlayered white fine-grained quartzite, brown and white siltite, and pale-green calc-silicate rock, but differs in character from place to place depending on degree of metamorphism. Where thermal metamorphism weak, and dynamic metamorphism strong, common rock assemblage is phyllite, locally with chloritoid, interlayered with highly cleaved tremolitic marble and minor fine-grained quartzite. Plagioclase, actinolitic tremolite, and minor garnet are most common calc-silicate minerals. Brown layers apparently were siltite and argillite beds; metamorphosed to fine-grained quartz, plagioclase, and pale red-brown biotite hornfels. Layering in hornfels, formed by intense cleavage development and modified by thermal metamorphism, results in white, pale-green, and red-brown striped hornfels. Almost all bedding and other primary sedimentary features destroyed by cleavage prior to metamorphism. Thick zone of impure marble found in upper part some places. Calc-silicate unit is probably equivalet to quartzitic carbonate-rich lower Wallace Formation. Thickness unknown owing to faulting and to destruction and reorientation of bedding by cleavage.

RAVALLI GROUP

Yru RAVALLI GROUP, UNDIVIDED--Quartzite and siltite, with minor argillite. Not subdivided due to one or all of following: (1) metamorphism, (2) poor exposure, (3) lack of distinctive lithologies in areas of limited exposure.

Ysr ST. REGIS FORMATION--Interlayered siltite, quartzite, and argillite; some quartzite is vitreous. Color of most rocks is red-brown due to fine-grained mixture of metamorphic biotite, quartz, and feldspar. Medium-to thin-bedded. Possible mud-chip breccias preserved northeast of Tillicum Creek. Thickness about 250 m calculated for outcrop width; unit internally folded, faulted, and cleaved, however. Folds and axial plane cleavage formed prior to thermal metamorphism by surrounding Hall Mountain plutons.

Yr REVETT FORMATION--Predominantly white to pale-gray fine-grained quartzite and siltite in layers from a few centimeters to several meters in thickness. Argillite occurs mainly as bedding plane partings, but a few layers are up to 2 m thick. Internal bedding characteristics of quartzite and argillite apparently destroyed by metamorphism. Siltite most abundant in lower and middle parts of unit. Thickness about 500 m calculated from outcrop width; internal folding and faulting may be present, however.

Yb BURKE FORMATION--Siltite interbedded with lesser amounts of fine-grained quartzite and argillite. Most siltite is medium to thin bedded; average thickness about 5 to 10 cm. Color ranges from white to pale gray depending chiefly on amount of fine-grained metamorphic biotite in the rock. Faint internal laminations may or may not be primary; most bedding features absent or destroyed by metamorphism except on ridge between Granite Creek and Zero Creek. There, rock has cross lamination, ripple marks, and starved ripples. Almost all siltite contains magnetite octahedrons. Quartzite is pale gray to white, in beds up to 0.5 m thick, and is most abundant in upper part of formation. Argillite is gray to dark gray, in zones up to 1 m thick, and only rarely has preserved lamination or bedding. Thickness of Burke calculated from outcrop width is 590 m, but may be thicker or thinner due to internal structure.

Yp PRICHARD FORMATION--Interbedded argillite, siltite, and fine-grained quartzite in about equal amounts. Intruded by numerous sills of tholeiitic composition. Exposed section in map area probably middle to lower-middle part of Prichard, because concordant sills most abundant in that part of section at other localities. Argillite mostly dark-gray and medium- to light-gray, thinly bedded to finely laminated. Siltite is medium- to light-gray and white. Bed thickness up to 1 m, but most 5 cm to 20 cm. Quartzite is white and light-gray. Bed thickness from a few centimeters to several meters. Cross laminations, graded beds, and channel-and-fill structures common in argillite and many siltite beds; quartzite beds relatively structureless internally. Argillite, and to lesser degree siltite, contains abundant pyrite and(or) pyrrhotite; oxidation of iron sulfides forms ubiquitous rust-colored weathered surfaces. Only fragments of section preserved in map area. About 2,700 m thick (excluding sills) northeast of map area; neither top nor bottom exposed. About 5,200 m thick (including sills) in Newport No. 1 quadrangle 30 km to south (Miller, 1974).

Yd METADIA BASE SILLS (Proterozoic Y)--Diabase and gabbro, slightly to moderately metamorphosed, theoleiitic composition (Bishop, 1973). Plagioclase ranges from labradorite to oligoclase depending on metamorphism and differentiation in sill. Mafic mineral is hornblende, except within contact aureole of younger plutons where biotite is present. Some or all hornblende probably derived from metamorphism of primary pyroxene. Quartz generally less than 5 percent of rock; may result from excess silica formed from metamorphism of pyroxene and anorthite to hornblende, quartz, and Al_20_3. Thickness of sills ranges from about 1 m to 400 m in map area. Most sills over 100 m thick show some degree of differentiation and have pegmatitic or relatively leucocratic zone within 10 to 20 m of top. Uranium-lead age on zircon from sill about 60 km to east is 1,430 m.y. (Elston and Bressler, 1980)

STRUCTURE

About 80 percent of the map area is underlain by a series of plutons concentrically arranged around the monzogranite of Gleason Mountain. None of these, with the possible exception of the monzogranite of Hungry Mountain, completely ring the pluton immediately interior to it, but instead form a series of arcuate plutons that aggregately have a concentric configuration. Although the isotopic and relative ages of the plutons are incompletely known, from the available information, there appears to be no sequential relationship between the spatial concentric arrangement of the plutons and the order of emplacement. The strike of Proterozoic wall rocks appears to swing parallel to the boundary of the composite plutonic mass in the northern part of the map area, but is orthogonal to it in the southeastern corner.

The Proterozoic rocks in the northern part of the map area form the south end of a uniformly northeast-striking, west-dipping belt that extends 55 km northeast to the Purcell trench. Despite the consistent northeast strike, this belt is highly faulted and folded internally, and most of the rocks are cut by well-developed cleavage(s). Fold axes generally trend parallel to the northeast strike but are locally disrupted by structures or plutons.

Faults are mainly reverse and thrust faults, but some are probably reactivated west-dipping normal faults related to Late Proterozoic rifting and development of the Windermere basin. In addition, some faults may have a limited amount of reactivation in response to Eocene extension associated with development of numerous core complexes and the Newport fault.

The northeast-striking fault separating the calc-silicate unit from the lower argillite unit appears to be the same structure as the Jumpoff Joe fault, which separates rocks of Belt Supergroup and Deer Trail Group in the Chewelah-Loon Lake area 50 km to the southwest (Miller and Clark, 1975). In addition to separating these two Proterozoic sequences, the Jumpoff Joe fault also separates the northeast-trending structures of the southern Kootenai arc from north-south-trending structures developed in Belt sequences, and thereby delineates the southern edge of the Kootenai arc. In the Orwig Hump area, the distinction between these two trends across the possible extension of the Jumpoff Joe fault is obscured in most places by Cretaceous plutons. The fault suspected to be the extension of the Jumpoff Joe, forms the northwest boundary of clearly identifiable Belt Supergroup[2] units. The two parallel faults northwest of it are probably related to the suspected Jumpoff Joe extension.

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2 No formational names are used for Middle Proterozoic rocks northwest of the fault. These rocks were originally called Priest River Group by Daly (1912), and are essentially the same sequence as the Deer Trail Group to the southwest. Miller and Whipple (1989) made tentative correlations between the Deer Trail Group and Belt Supergroup, but formation names for the Priest River and Deer Trail Groups in the Sandpoint 2° sheet will not be formally established until the interrelationships between these two sequences and the Belt Supergroup are firmly understood.

The northwest-striking fault that nearly intersects the common corner of sections 35, 36, 1 and 2 north of the Tillicum Peak pluton is the offset extension of the Johns Creek fault, which was active in the Late Proterozoic during Windermere time. Even though it had considerable movement along it, very little of this fault is exposed, as it is intruded by the Tillicum Creek pluton here, and by another pluton of the Hall Mountain granodiorite farther to the north. There, the entire depositional thickness of the Shedroof Conglomerate is about 3,250 m northeast of the fault and only 200 m southwest of it (Miller, 1983; Burmester and Miller, 1983).

Faulting in the Belt Supergroup rocks in the eastern part of the map area appears to be high-angle block faulting, but low-dipping faults could easily go undiscovered in this area. All of the faults in this part of the map area appear to pre-date the Cretaceous plutons, and could have had only limited, localized renewed movement during Eocene extension and development of the Newport fault. None of these faults is clearly traceable into the Cretaceous plutons, either in this map area or the map areas to the east (Miller, 1982) or southeast (Miller 1982a).

REFERENCES

Bishop, D. T., 1973, Petrology and geochemistry of the Purcell sills in Boundary County, Idaho: in Belt Symposium, volume II, Idaho Bureau of Mines and Geology, p. 15-66.

Burmester, R. F., and Miller, F. K., 1983, Preliminary geologic map of the Abercrombie Mountain area: U.S. Geological Survey Open-File Report 83-600, 18 p., scale 1:48,000.

Castor, S.B., Berry, M. R., and Siegmund, B. L., 1981, National uranium resource evaluation, Sandpoint quadrangle, Washington, Idaho, and Montana: U.S. Department of Energy Open-File Report.

Daly, R. A., 1912, Geology of the North American Cordillera at the Forty-ninth Parallel: Canada Geological Survey Memoir 38, 1-3, 857 p.

Elston, D. P., and Bressler, S. L., 1980, Paleomagnetic poles and polarity zonation from the Middle Proterozoic Belt Supergroup, Montana and Idaho: Journal of Geophysical Research, v. 85, no. B1, p. 339-355.

Miller, F. K., 1974, Preliminary geologic map of the Newport Number 1 quadrangle, Pend Oreille County, Washington, and Bonner County, Idaho: Washington Division of Geology and Earth Resources Geologic Map GM-7, 6 p., 1 pl., scale 1:62,500.

_______, 1982, Preliminary geologic map of the Priest Lake area: U.S. Geological Survey Open-File Report 82-1063, 25 p., sale 1:48,000.

_______, 1982a, Preliminary geologic map of the Coolin Area: U.S. Geological Survey Open-File Report 82-1061, 20 p., scale 1:48,000.

_______, 1983, Preliminary geologic map of the Gypsy Peak area: U.S. Geological Survey Open-File Report OF-83-601, 28 p., scale 1:48,000.

Miller, F. K., and Clark, L. D., 1975, Geology of the Chewelah-Loon Lake area, Stevens and Spokane Counties, Washington: U.S. Geological Survey Professional Paper 806, 74 p.

Miller, F. K., Engels, J. C., 1975, Distribution and trends of discordant ages of the plutonic rocks of northeastern Washington and northern Idaho: Geological Society of America Bulletin, v. 86, no. 4, p. 517-528.

Miller, F. K., and Frisken, J. G., 2984, W-Mo-Au-A geochemical anomalies associated with the Hall Mountain grandiorite, northeastern Washington: U.S. Geological Survey Open-File Report 84-365, 14 p.

Miller, F. K., McKee, E. H., and Yates, R. G., 1973, Age and correlation of the Windemere Group in northeastern Washington: Geological Survey of America Bull., v. 84, p. 3723-3730.

Miller, F. K., and Theodore, T. G., Molybdenum and tungsten mineralization associated with two stocks in the Harvey Creek area, northeastern Washington: U.S. Geological Survey Open-File Report 82-295, 31 p.

Miller, F. K., and Whipple J. W., 1989, The Deer Trail Group: Is it part of the Belt Supergroup?: in Joseph, N. L., ed., Geologic guidebook for Washington and adjacent areas: Washington Division of Geology and Earth Resources Information Circular 86, p. 3-21.

Steiger, R. H., and Jager, E., 1977, Subcommission on geochronology: Convention on the use of decay constants in geo- and cosmochronology: Earth and Planetary Science Letters, v. 36, p. 359-362.

Streckeisen, A. L., 1973, Plutonic rocks: Classification and nomenclature recommended by the IUGS Submission on the Systematics of Igneous Rocks: Geotimes, v. 18, no. 10, p. 26-30.