UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Preliminary geologic map of the Gypsy Peak area, Pend Oreille County, Washington, and Bonner and Boundary Counties, Idaho

By

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INTRODUCTION

This map is part of a 1:48,000-scale preliminary geologic map series covering the Sandpoint 2° quadrangle. The series is a by-product of the Sandpoint 2° project, conducted under auspices of the Regional Framework Studies Program and the Branch of Western Regional Geology. All the maps are 15' blocks that have been photographically mosaiced from published 7.5' topographic quadrangles. The preliminary geologic map series is designed to fill out areas within the Sandpoint 2° quadrangle not covered by geologic mapping at a scale of 1:62,500 or larger. Maps of this series make geologic information available as the project progresses so that interested parties do not have to wait until completion of the entire 2° sheet. In addition, a greater amount of information can be presented on the more detailed base of the preliminary maps than will appear on the final 2° compilation.

The preliminary maps are more detailed and accurate than reconnaissance maps, but because they are the outgrowth of 2° 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 released in more formal publication series. The coverage is relatively detailed in some areas but almost reconnaissance in others. The maps should therefore be considered preliminary and subject to refinement.

The part of the geologic map northwest of the Slate Creek fault was compiled directly from the map of Dings and Whitebread (1965) with only minor modifications and almost no field checking. The few modifications resulted from re-mapping or re-interpretation of peripheral areas, but most were only simplifications necessitated by the reduction of scale from 1:24,000 to 1:48.000.

DESCRIPTION OF MAP UNITS

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

Qls LANDSLIDE DEPOSITS (Quaternary)--Unconsolidated, unsorted material derived through rapid or slow downslope movement. Clast size ranges from boulders to silt. Does not include talus.

GRANODIORITE OF HALL MOUNTAIN (Cretaceous)--Medium to fine-grained biotite granodiorite. Modal composition ranges from tonalite to granodiorite, but most of pluton is granodiorite (see modal diagrams). Muscovite appears primary, although postdates crystallization of biotite, and probably is late stage. Biotite in most of rock is brown or olive-green but near quartz veins and quartz veinlets is reddish-brown. Muscovite spacially associated with biotite; rarely occurs as solitary crystals not in contact with biotite. Potassium feldspar is microcline; crystals characteristically include numerous relatively large plagioclase, and less commonly, biotite crystals. Included minerals impart poikilitic look to microcline on stained slabs. Accessory minerals include epidote, clinozoisite, allanite, zircon, apatite, rutile, and minor opaque minerals. Rocks of Hall Mountain pluton strongly resemble rocks of Boulder Mountain pluton petrologically, mineralogicaly, and modally. Rocks of Reeder Crek pluton in map area to southeast are similar but coarser grained. Above is description of general rock type; characteristics and variations of individual plutons are described below.

Kh HALL MOUNTAIN PLUTON--Average color index is about 9, and ratio of biotite to muscovite averages 10:1. Plagioclase ranges from about an_{25} to an_{35}, but averages closer to calcic end of that range. Quartz occurs as irregular shaped grains about 4mm in size, which are commonly aggregates of smaller broken and rehealed fragments. Rock is hypidiomorphic-granular in interior parts, but lineate and(or) foliate in outer parts. Development of directional fabric is gradational; appears to be primary. Pluton has noticably chilled margins of finer grained rock suggesting emplacement into relatively cool host rock. Relatively low temperature environment also reflected in presence of narrow contact metamorphic aureoles in which megascopic recrystallization rarely extends more than 10 m to 20 m from pluton. North part of pluton relatively unaltered but south part is highly sericitized, locally cut by quartz veinlets, and contains dissemminated pyrite. Biotite from northernmost part of pluton yielded potassium argon age of 99.0 ± 3.0 m.y. (Miller and Engels, 1975; recalculated using current IUGS approved constants (Steiger and Jager, 1977)).

Kbm BOULDER MOUNTAIN PLUTON--Contains only minor muscovite. Pluton underlies about 8 km^2 in map area, and about 12 km^2 south and east of map area. Average color index is 13; biotite is only mafic mineral. Plagioclase composition between an_{30} and an_{35}. Potassium feldspar generally finer grained than other minerals in rock, Quartz forms 1 cm phenocrysts near margins of pluton; is same size as other minerals in most of body. Biotite is subhedral to anhedral, varies greatly in grain size. Conspicuous dearth of opaque mineralsin most of pluton. Texture is seriate in most of body. At many places around margin of pluton, rock shows chilled textures. Numerous large quartz bodies and anomalous amounts of molybdenum are present in southern part of pluton, possibly other parts. Castor and others (1981) report a core of fine-grained to microcrystalline porphyry and extensive rock alteration near center of pluton. Rock intrudes Proterozoic Y Prichard Formation and Ravalli Group. Differs from Hall Mountain pluton in that it is slightly more mafic, more calcic, and contains lower proportion of muscovite; similar to Hall Mountain rock in all other respects. Considered co-genetic with Hall Mountain pluton, and thus, of Cretaceous age. Both bodies are probably separate plutons derived from same magma type as Reeder Creek pluton in map area to southeast.

Kgp MONZOGRANITE OF GRANITE PASS (Cretaceous)--Leucocratic muscovite monzogranite and biotite-muscovite monzogranite. Medium- to coarse-grained; non-porphyritic; contains no discernible directional fabric. Average color index 0 to 3; averages about 6 percent muscovite. Underlies about 20 km^2 within, and 13 km^2 east of, map area. Relatively uniform lithologically, but appears compositionally zoned in that biotite occurs consistently, though sparsely, within outermost 0.5 km of pluton, but only locally within interior of body. Biotite commonly intergrown with muscovite in single grains. Potassium feldspar is microcline, and plagioclase is albite (an_3 average). Unit forms distinct pluton with well defined contacts in contrast to heterogeneous two-mica intrusive masses of igneous complex of the Selkirk Crest east of map area. Intrudes Prichard and Burke(?) Formations, Ravalli Group, and Wallace Formation all of Proterozoic Y Belt Supergroup. Muscovite from southwest part of pluton yields potassium-argon age of 97.8 ± 2.9 m.y. (Miller and Engels, 1975; recalculated using current IUGS constants), represents minimum age, owing to slight thermal resetting or slow cooling. Radioactivity of this pluton much higher (average about 220 cps*) than most granitic rocks in region (average about 90 cps); contains some areas over 300 cps.

Khg HETEROGENEOUS GRANITIC ROCKS (Cretaceous)--Leucocratic muscovite-biotite monzogranite. Extremely variable with respect to composition and texture. [1/] Color index averages about 5; ranges from less than 1 to over 20 in local irregular-shaped mafic zones. Biotite and opaque mineral(s) are only mafics. Most biotite is deformed, anhedral, and commonly disaggregated grains. Muscovite may be secondary. Plagioclase composition variable, but most less than an_{18}. Potassium feldspar is microcline. Texture is highly seriate; much of rock has thin (1 mm thick), discrete, sharply bounded cataclastic zones. Locally porphyritic and pegmatitic; boundaries between texture and grain size variations in body are in places sharp and elsewhere gradational. Schlieren with granitic textures and gradational borders are common. Body may represent a hybridization of late stage parts of the Granite Pass and Boulder Mountain plutons.

Ol
Olq LEDBETTER SLATE (Ordovician)--Fissile carbonaceous black slate, blocky fracturing black argillite and siltite, finely laminated argillite and fine-grained quartzite, and minor limy argillite and limestone. Some slate contains carbonate-bearing zones; much of slate contains pyrite. Bedding well-defined and laminated in some rock but extensive slate masses occur in which recognizable bedding never existed or has been destroyed by cleavage. Lenses and thin beds of fine-grained black quartzite (Olq) most abundant in middle 300 m of formation. Dolomite beds uncommon, probably restricted to upper 150 m of formation. Abundant graptolitic beds in lower part of formation establish Early Ordovician age, but Middle Ordovician graptolites occur higher in section (Park and Cannon, 1943; and Dings and Whitebread, 1965). Conformably

1/ *Counts per second. All radioactivity measurements made with Geometrics model GR-101A scintillometer. Readings from this instrument were consistently about 15 percent lower than readings from several other scintillometers with which it was compared in the field. All of the other scintillometers had larger sodium iodide crystals, however.

overlies altered Metaline Limestone in northernmost part of area; all other contacts are faults. Thickness in Metaline area to west estimated to be 670 to 760 m by Dings and Whitebread (1965).

Ꞓmg
Ꞓmd
Ꞓmb
Ꞓma

METALINE LIMESTONE (Cambrian)--Subdivided into three lithologic units by Dings and Whitebread (1965), who emphasize the units are not formational members. From youngest to oldest: Ꞓmg, gray massive limestone. Medium-gray, irregularly mottled, fine-grained, massively bedded limestone; sparse medium-gray chert through most of unit. Contains several dolomite zones of irregular thickness; at least 540 m thick in map area to west. Ꞓmd, bedded dolomite. White to light-gray, fine- to medium-grained dolomite. Some beds of black to dark-gray dolomite with streaks and spots of white dolomite; black shale interbeds near base. Most medium to thick bedded, but no bedding recognizable over large areas. Contains 1 m- to 3 m-thick beds of intraformational breccia with matrix of black dolomicrite in middle part of unit. Other beds in this part of unit have en echelon veinlets of white crystalline dolomite, called zebra banding by Dings and Whitebread (1965). Unit appears to be at least 1160 m thick (Dings and Whitebread, 1965). Ꞓmb, bedded limestone. Dark-gray to black, thin bedded phyllitic limestone and limy phyllite in lower 115 m. Grades upward into blue-gray limestone and impure shaly limestone with irregular wavy bedding. Contains oolitic and algal-bearing zones. Upper 120 m are dark-gray to black thinly interbedded limestone, shale, and limy shale; bed thickness ranges from 0.5 to 15 cm. Weathers gray and brown. Contains Middle Cambrian trilobites about 180 m above base (Dings and Whitebread, 1975). About 7 km west of map area, unit is at least 290 m thick. Ꞓma, silicified and dolomitized Metaline Limestone. Rock commonly medium to dark gray, irregularly brecciated. Consists of variable amounts of crystalline dolomite, coarse calcite, some limestone, sparse jasperoid, and locally sulfide minerals. Sedimentary structures almost everywhere destroyed. Many small bodies not shown on map (Dings and Whitebread, 1965). Includes Josephine Breccia of Mills (1977), the main ore-bearing rock in the zinc-lead mines of the Metaline area 9 km to west.

Ꞓm

MAITLEN PHYLLITE (Cambrian)--Formation consists of interbedded phyllite, quartzite, phyllitic carbonate rocks, and carbonate rocks. Lower half made up of phyllite beds from a few centimeters to several tens of meters thick and beds of quartzite from a few centimeters to about one meter thick; proportion of quartzite to phyllite decreases upward in section. Upper half of formation grades from almost pure phyllite to phyllitic limestone. Most of lower part is pale gray-green phyllite with 1 to 10 cm interbeds of tan or gray argillaceous quartzite. Internal deformation, chiefly small-scale folding, cleavage, and slip cleavage common in this part of section. Much of layering in unit probably transposed bedding; sedimentary structures only locally preserved. Limy upper part of formation consists of thin layers (beds?) of dark gray impure limestone and dolomitic limestone with phyllitic partings. Much of rock, even where mostly limestone, looks like phyllite. Appears to grade upward into Metaline Limestone. Grades downward into Gypsy Quartzite. A zone of archaeocyathid-bearing limestone (Ꞓmr), the Reeves Limestone Member of Yates (1964), found at base of formation some places. Limestone varies from 0 to 200 m in thickness; probably tectonically thinned and thickened. Some carbonate-bearing phyllite above Reeves Limestone Member locally. Thickness of Maitlen in map area to west, as calculated from outcrop width, about 2650 m. This figure is approximation, at best, due to pervasive internal deformation present throughout formation. Archaeocyathids near base of formation are late Early Cambrian age (Little, 1960).

Ꞓg GYPSY QUARTZITE (Cambrian)--Unit forms relatively undeformed 2-km-wide belt through western part of map area. Total thickness, as calculated from outcrop width, averages about 1425 m. Formation is predominantly medium- to fine-grained quartzite, with lesser amounts of conglomeratic quartzite and phyllitic argillite. Gypsy Quartzite rests unconformably on Proterozoic Z(?) Three Sisters Formation. About 280 m of massively bedded white vitreous quartzite makes up basal part of Gypsy and is overlain by about 75 m of interbedded brown and green argillite and argillaceous quartzite. Argillitic rocks rest beneath about 170 m of crossbedded purple, white, and black striped quartzite. Striped quartzite overlain by about 450 m of pink, white, and tan quartzite in which a few striped beds occur. About 440 m of interbedded quartzite and argillite form the top of the formation. Argillite beds become progressively more abundant up section in this part of formation, and exposure becomes progressively poorer. Contact between Gypsy and overlying lower part of Maitlen Phyllite is gradational; it is placed at base of 60 m-thick archeocyathid-bearing limestone in Maitlen. Thin beds of carbonate-bearing quartzite are interbedded with quartzite and argillite in uppermost 200 m of Gypsy. Although only isolated free cheeks found in map area, 75 km to the southwest this zone has produced well preserved early Early Cambrian trilobites and gastropods (Miller and Clark, 1975).

WINDERMERE SUPERGROUP (Proterozoic Z)

Zt THREE SISTERS FORMATION OF WALKER (1934)--Quartzite, conglomeratic quartzite (grit), conglomerate, phyllitic quartzite, and phyllite. Mapped as part of Gypsy Quartzite by Park and Cannon (1943). Current mapping shows Three Sisters is unconformably overlain by Gypsy Quartzite. Fromation originally defined by Walker (1934) for section in southern British Columbia. Contact between Three Sisters and underlying Monk Formation appears to be gradational. Lower contact of Three Sisters placed at base of lowest occurring quartzite or grit bed; for most of its length in map area this contact is a fault. On both sides of South Salmo River, formation appears to be unfaulted and is 2100 m thick as calculated from outcrop width. Lower 700 m of formation consists of 80 or 90 percent gray to brownish-gray argillite interlayered with beds of quartzite and grit up to 5 m thick. About 1100 m of white, tan, green, and pink grit, quartzite, and conglomerate overlie the argillitic rocks. Next 100 m consists of green conglomerate that contains a 1-m-thick lava flow (greenstone) in middle part of it, about 35 m of probable volcaniclastic rock. Grit and quartzite similar to that in 1100-m thick center part of formation make up upper 100 m of formation. Three Sisters contains no fossils; it is probably Proterozoic Z in age because of its stratigraphic relation to Gypsy Quartzite.

Zm
Zmc

MONK FORMATION--Occurs in two non-contiguous belts, one northwest of Sullivan Creek, and one southeast of Pass Creek Pass. Each section a distinct and different facies of Monk Formation separated by large fault. Each section described separately; Sullivan Creek section: chiefly argillite, but contains substantial amounts of dolomite, conglomerate, diamictite, and quartzite. Lower 150 m of unit is green-matrix conglomerate, which contains high proportion of volcanically derived material. Conglomerate grades upward into 150 m of dark-gray, fissile, indistinctly bedded argillite, the predominant rock type of Monk Formation. Argillite highly cleaved, forms poor outcrops. The 150 m argillite interval overlain by about 50 m of tan-weathering diamictite. More dark-gray argillite overlies diamictite and grades upward into well-bedded gray-green argillite about 50 thick. Gray-green argillite lies immediately below about 20 m of thin-bedded limestone, lower 2 m of which is intraformational limestone conglomerate. Upper 500 m made up of dark-gray carbonaceous-looking argillite and tan thick- to massively-bedded carbonate rocks. Beds of carbonate rocks occur at random intervals in argillite but become increasingly abundant and quartzitic upward in unit. Rests with apparent unconformity on Leola Volcanics and appears to grade upward conformably into Three Sisters Formation. Calculated thickness from outcrop width is about 1150 m.

Pass Creek Pass section: dark gray to black argillite and tan arkosic quartzite. Unit is poorly exposed, highly faulted, and almost everywhere shows strong internal deformation. Most argillite highly phyllitic, well preserved sedimentary structures uncommon. Thin bedded to laminated where bedding preserved, commonly carbonaceous and locally contains abundant pyrite. Unsupported 1/2 to 1 mm quartz grains are common, but sparse in argillite. Quartz grains are blue-gray and nowhere exceeds 1/2 percent of rock. One cm- to 1 m- thick beds of argillite and quartzite pebble conglomerate occur sparsely throughout section. Tan arkosic quartzite appears restricted to lower and middle part of preserved section. Beds are 0.3 to 1.5 m thick separated from one another by several meters of argillite. Indistinct internal stratification within individual beds. Thin fragments of argillite sparsely scattered through quartzite, but not abundant enough to constitute mud-chip breccia. Sorting and degree of rounding poor to fair. Rock has porous look, especially on weathered surface, due to leached out cement, possibly carbonate minerals. Thickness of preserved part of unit 500 m as calculated from outcrop width, but almost certainly internal faults, folds, and slip cleavage are present. Upper contact everywhere in map area is a large fault, probably a thrust fault, but steepened by later tectonism. Conglomerate and diamictite (Zmc) differentiated on map only southwest of Pass Creek Pass.

Zl
Zli

LEOLA VOLCANICS--Unit is made up almost entirely of greenstone derived from basalt flows and tuffaceous and volcaniclastic rocks. Most greenstone recrystallized; small porphyroblasts of blue-green hornblende common. Formation appears to grade downward into Shedroof Conglomerate. No unconformity apparent between the two formations. Contact is placed at base of lowest group of massive flows in Leola. Thickness as calculated from width of outcrop ranges from about 1530 to 1850 m in Sullivan Creek section and from 0 to 475 m in the Pass Creek Pass section. Flows up to 25 m thick are massive and show little primary or secondary internal features except for well developed pillows in lower few hundred meters of formation. Pillows occur locally at other places in formation, but not as well preserved. Greenstone sills (Zli) in Shedroof Conglomerate and Belt Supergroup considered to be intrusive equivalents of Leola. None of greenstone in quadrangle suitable for isotopic dating, but K-Ar whole rock dates on basalt flows from similar greenstone of correlative Huckleberry Formation 75 km southwest of area suggests the basalt was extruded between 827 and 918 m.y. ago (Miller, McKee, and Yates, 1973).

Zs
Zsp
Zsl
Zsq

SHEDROOF CONGLOMERATE-- Occurs in same two non-contiguous fault-separated belts as Monk Formation; each section described separately.

Sullivan Creek section: lower third to half of formation is boulder and pebble conglomerate and diamictite with sparse interbeds of conglomeratic feldspathic quartzite. This part of formation characteristically tan to rusty yellow-brown, and contains considerable proportion of carbonate minerals in groundmass. Clast size ranges from over a meter to less than a centimeter; most groundmass material is sand size. Quartzite, tan dolomite, and argillite are most abundant clast types; some granitic clasts present, abundant locally. Sorting poor, and degree of roundness fair to good. Most clasts flattened and elongated, and show preferred orientation parallel to a pervasive slip cleavage everywhere developed in rock. All rocks examined in thin section show recrystallization even where sedimentary structures preserved. Upper part of formation is made up of conglomerate beds with green chlorite- and(or) epidote-bearing matrix. Green beds progressively more abundant higher in formation and may reflect increasing admixture of pyroclastic material, which marks inception of volcanism that dominated during Leola time. In upper 200 m, thin basalt flows, phyllitic quartzite, and metagraywacke beds, probably tuffaceous, are abundant. Other than color, abundance of volcanic material, and relatively large proportion of feldspathic quartzite and metagraywacke beds, upper part of formation similar to lower part. Large wedge of gray green phyllite and sandy phyllite (Zsp) in middle part of formation. As much as 2000 m thick north of Pass Creek, but may be repeated by faulting; thins northeastward. Contains two or more impure carbonate layers (Zsl) up to 150 m thick. Carbonate is brownish-gray to gray slightly dolomitic limestone with

numerous sand size quartz grains and abundant argillaceous material. Only one layer shown, but another occurs about 100 m above greenstone sill at base of phyllite wedge north of Pass Creek Pass. Formation up to 3250 m thick at point of maximum outcrop width. Owing to possible repetition of part of unit by numerous close-spaced slip surfaces, actual thickness could be as little as two-thirds apparent thickness. Unconformably overlies at least two different Belt Supergroup units; gradationally underlies Leola Volcanics. Aalto (1971) considers all or most conglomerate in Shedroof to be of glacial marine origin. Evidence within map area for glacial origin is not conclusive.
<u>Pass Creek Pass section</u>: chiefly pale gray to white, fine- to medium grained, vitreous quartzite (Zsq). Thick to massively bedded; shows little internal stratification. Highly recrystallized; commonly brecciated and stained by iron oxides. Locally contains sparse clasts of angular quartzite to 1 cm across; clasts are abundant in 1 to 3 m thick zones between Harvey and Noisy Creeks. Quartzite in this area also contains several interbedded argillite zones to 30 m thick, and one 5 m thick zone containing calc-silicate minerals. Thickness of quartzite ranges from 50 to 100 m northeast of Johns Creek fault. Southwest of fault it is at least 150 m, but could be as thick as 300 m. Unit is highly folded in latter area. Not differentiated at east edge of quadrangle due to poor exposure. Quartzite included with upper argillite unit in that area, but could be faulted there also. Quartzite interpreted as reworked near shore deposit; contains sparsely disseminated copper (silver?) sulfide minerals where unit intersects Pass Creek Pass road. Gray or greenish-gray phyllite above quartzite at some places; ranges in thickness from 0 to 100 m. About 10 m of diamictite and sandy phyllite found above quartzite where Pass Creek Pass road crosses this unit.

BELT SUPERGROUP (Proterozoic Y)

Ywa_2 WALLACE FORMATION, UPPER ARGILLITE--Black to gray, argillite and phyllitic argillite; much rock is highly phyllitic. One or more well developed slip cleavage(s) most places, especially southeast of Willow Creek in southeast part of map area. Pencil slate common where two intersecting cleavages developed. Bedding relatively well preserved locally between Harvey and Noisy Creeks. There, rock ranges from thinly laminated light-and dark-gray argillite to silty medium-gray argillite that shows no bedding features. 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; normally separated by more than 50 m of carbonate-free argillite. Thickness of unit is about 1425 m as calculated from outcrop width but lower contact is fault everywhere in area. Thickness is estimate only, owing to probable unmapped structures and effect of slip cleavage. Unit is unconformably overlain by Shedroof Conglomerate.

Ywc WALLACE FORMATION, CARBONATE--Gray and tan dolomite and limy dolomite, argillite and siltite; minor limestone. Thin-to thick-bedded, platy-to blocky-weathering. In Gypo Creek area about 1/4 of unit is white fine-grained dolomitic marble; weathers into 3 to 10 m slabs that show fine internal layering. Algal structures present but not abundant. About 1/3 of unit is interlayered argillite and siltite. Much of carbonate is argillaceous and (or) arenaceous. Contains at least one carbonate-free argillite zone up to 50 m thick, but most less than 10 m thick. Unit forms conspicuous rusty red soil. Forms poor exposure most places, but locally is well exposed. Apparent thickness calculated from outcrop width ranges from about 330 m to about 490 m. Thickness variation may be due to internal deformation, pre-Windermere erosion, or both. Unconformably overlain by quartzite or conglomerate of Shedroof Conglomerate at most places. May be equivalent to Sheppard Formation which is found east of Purcell Trench.

Ywa_1 WALLACE FORMATION, LOWER ARGILLITE--Light- to dark- gray laminated argillite and siltite; most is highly phyllitic. Interbedded with tan carbonate-bearing fine-grained quartzite and siltite. Thickness of individual carbonate-hearing beds pinches and swells irregularly along strike; ranges from about 1 cm to about 30 cm. Filled syneresis cracks abundant locally. Northeast of Granite Creek, carbonate apparently leached from most of this rock type. Grades downward into increasingly more quartzitic rock, and where thermally metamorphosed, into quartz-rich calc-silicate rock. Thickness highly variable due to internal faulting, folding, and slip cleavage, and to difficulty of consistent placement of lower contact.

Ywq WALLACE FORMATION, QUARTZITE--Pale gray to white, fine- to medium-grained vitreous quartzite. Differentiated only in Willow Creek area; mapped with lower argillite unit other places. Interbedded with black phyllitic argillite. Numerous quartzite- filled syneresis cracks cut argillite beds. Quartzite beds have irregular thickness. This unit typical of carbonate-rich part of lower Wallace Formation in other areas (Miller, 1974), but in Willow Creek area, no carbonate occurs in quartzite. Appears to grade downward into calc-silicate rock, and upward into mixed lithologies of the lower argillite unit. Average thickness about 200 m as calculated from outcrop width.

Ywcs WALLACE FORMATION, CALC-SILICATE UNIT--Unit has different character from place to place depending on local degree of metamorphism. Most common rock types consist of interlayered white fine grained quartzite, brown and white siltite, and pale green calc-silicate rock. Where thermal metamorphism less intense, but dynamic metamorphism strong, common assemblage is phyllite, locally with chloritoid, interlayered with highly cleaved tremolitic marble and minor amounts of fine-grained quartzite. Plagioclase, actinolitic tremolite, and minor garnet are most common calc-silicate minerals. Brown layers apparently were argillite beds; metamorphosed to fine grained quartz, plagioclase, and phlogopitic biotite. Layering is S_2, formed by intense development of slip cleavage 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 slip cleavage prior to or during metamorphism. Calc-silicate layers sparse in some areas, possibly due to pre-metamorphism leaching of carbonate minerals. Locally includes thick zone of impure marble in upper part. Calc-silicate unit probably roughly equivalent to quartzitic carbonate rich lower Wallace Formation. Thickness unknown owing to faulting and to destruction and reorientation of bedding by slip cleavage.

Yr RAVALLI GROUP(?) UNDIVIDED--Interlayered siltite, quartzite, and argillite; some quartzite is vitreous. Intensely folded and cleaved by axial plane slip cleavage prior to thermal metamorphism. Predominantly white to pale gray siltite and quartzite in layers from a few cm to several m in thickness. Argillite occurrs chiefly as bedding plane partings, but a few layers up to 2 m thick. Argillite layers separated by much greater thicknesses of siltite and quartzite. No bedding preserved in argillite; all is phyllitic or schistose. Thicker layers in quartzite and siltite may be primary beds not destroyed by slip cleavage; thinner layers are S_2. In much of unit, phyllite and schist derived from argillite is structurally intermixed with quartzite and siltite. Upper part of unit generally quartzitic and lower part siltitic; may correspond roughly to Revett and Burke Formations, respectively. Increasingly larger proportion of phyllite gradationally upward. Thickness unknown due to cleavage and folding.

Yp PRICHARD FORMATION--Argillite, quartzite, and siltite. Occurs only in one small area in southeastern corner of quadrangle, but occurs extensively in quadrangles to east and southeast. Argillite chiefly medium to dark gray, forms layers from less than one cm to 10 m thick; moderately well to very well developed laminations within layers. Quartzite is white to light gray, fine grained and medium- to thick- bedded. Siltite is medium- gray, medium- to thick- bedded, but beds commonly show fine internal laminations. Near Boulder Mountain pluton rock noticably recrystallized, commonly with development of andalusite in argillaceous layers.

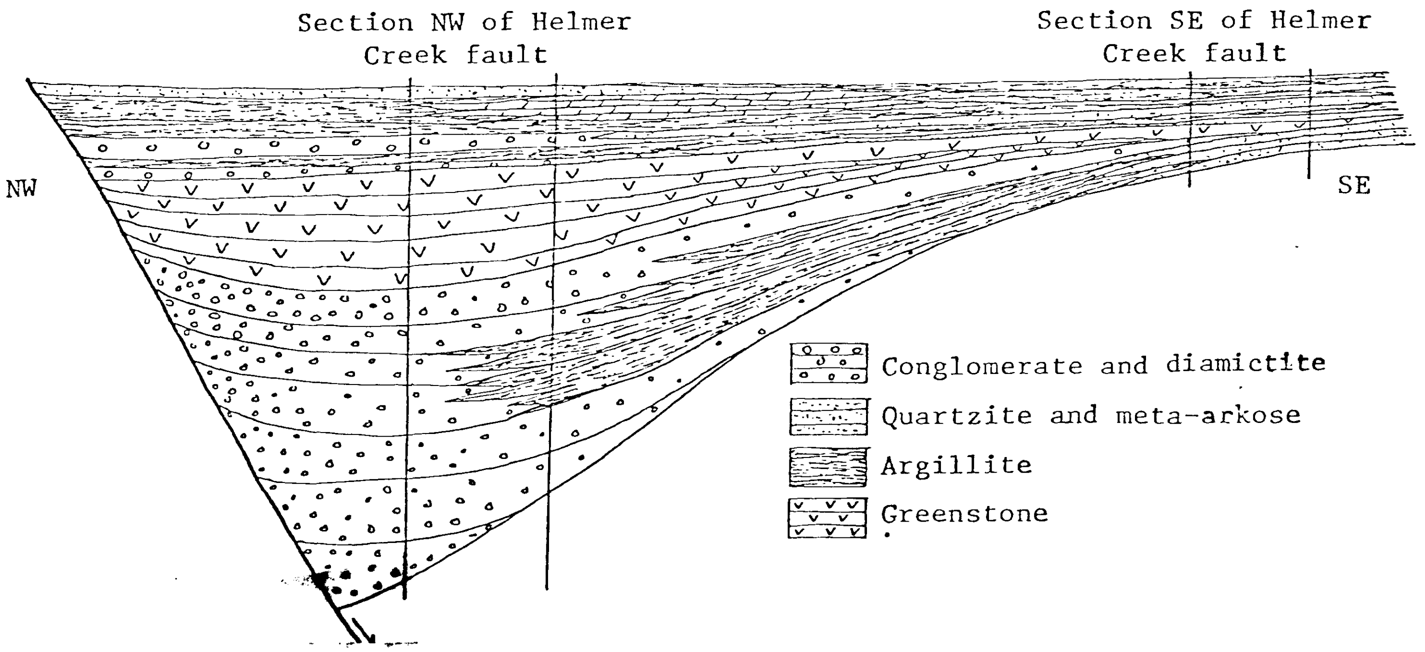
STRUCTURE

The Windermere Group and Early Cambrian rocks in the central part of the map area form a slightly faulted west-dipping, northeast-striking homocline. This relatively uncomplicated structure is flanked on the northwest by highly faulted downdropped Paleozoic rocks in the Pend Oreille River valley, and on the southeast by highly faulted and tightly folded Belt Supergroup and Windermere Group rocks. The highly deformed section in the southeast part of the area was intruded at about 100 m.y. (Miller and Engels, 1975) by four relatively high level plutons after faulting and folding ceased. Several large faults, some of which may have been active concurrently with the numerous northeast-striking faults, transversely cut the regional northeast trend.

The homoclinal section that underlies most of the map area is more deformed than the paucity of faults would indicate. A well developed foliation resulting from a close-spaced slip cleavage is present almost everywhere in the Shedroof Conglomerate and in much of the Leola Volcanics. Clasts are reoriented parallel to the slip cleavage and most primary sedimentary and volcaniclastic features have been destroyed. Faults parallel to the strike of foliation and(or) bedding are difficult to recognize in both the Shedroof and Leola due to the lack of distinctive stratigraphic markers within the formations combined with generally poor exposures; some faults may have gone unrecognized. Internally the Monk Formation, Three Sisters Formation, and Gypsy Quartzite are relatively undeformed except for locally intense cleavage development. The Maitlen Phyllite, however, is relatively incompetent, and highly cleaved and folded on a small scale. Faults parallel to foliation or bedding could easily have gone unrecognized in this unit also.

The northwest-dipping Helmer Creek fault appears to have juxtaposed rocks formed in two contrasting parts of the Windermere basin. The Windermere section southeast of the Helmer Creek fault is much attenuated and lithologically different from the homoclinal section northwest of the fault. In the homoclinal section, the thickness of the combined Shedroof Conglomerate, Leola Volcanics, and Monk Formation is about 6,500 m as calculated from outcrop width. These three formations are only about 1,500 m thick southeast of the Helmer Creek fault, although the uppermost part of the Monk Formation is faulted away. The Shedroof Conglomerate in the attenuated section is relatively clean vitreous quartzite and has only minor conglomerate and phyllite, whereas in the thick homoclinal section the formation is coarse conglomerate, diamictite, feldspathic quartzite, and phyllite. Also in the attenuated section, the Leola is a fraction of the thickness it is in the thick homoclinal section, and the Monk Formation contains no massive diamictite beds or thick carbonate zones that characterize that formation in the thick section. Instead, the Monk has abundant arkosic sandstone beds in the lower half.

The diagrammatic cross section of a reconstructed Windermere basin shown below indicates the two contrasting parts of the basin that appear to have been juxtaposed. Although Windermere units similar to those in the Gypsy Peak



area are exposed along a strike length of about 350 km in the U.S. and southern Canada, these exposures are confined to a relatively narrow zone across the strike. Little is known about the transverse configuration of the Windermere basin, and because of this and because of uncertainties in facies relationships that existed within the basin, the amount of foreshortening across the Helmer Creek fault needed to juxtapose the contrasting sections is unknown. The distance is probably tens of kilometers, however.

In addition to stratigraphic differences, the degree of deformation in the Windermere and Lower Cambrian units that make up the homoclinal section is distinctly less than in the rocks southeast of the Helmer Creek fault; the style of deformation is different in the two sections also. The frequency and tightness of large scale folds increases southeastward from the Helmer Creek fault, and the section is cut by numerous reverse faults that parallel the northeast regional strike.

Identification of the Helmer Creek fault southwest of the Johns Creek fault is uncertain. The strand labeled Helmer Creek fault on the geologic map is the preferred interpretation, but the Harvey fault conceivably could be the same structure as the Helmer Creek Fault. The Helmer Creek fault is offset by two west-northwest striking faults in the vicinity of Pass Creek pass, and has a 3 km apparent right lateral offset along the Johns Creek fault. Movement on the Helmer Creek, Johns Creek, and Harvey faults appears to have been contemporaneous; the faults in the Pass Creek area may be younger. All of the faults clearly predate the approximately 100 m.y. Hall Mountain and Boulder Mountain plutons, although at least one of the northeast-striking faults offsets the Johns Creek fault, suggesting renewed or very late-stage movement along it.

The Harvey and Helmer Creek faults are probably steepened northwest dipping thrust faults, and the Johns Creek fault an apparent tear that affected both plates, but the lower more than upper. The tear, in addition to a contrast in degree of fold, fault, and cleavage development across the Helmer Creek fault, suggests that the lower plate was uplifted from a lower structural level contemporaneously with thrusting. As a result, the upper plate rocks were progressively ramped up on increasingly more deformed rocks as thrusting continued.

With the exception of the two faults near High Rock in the southeast part of the map area, most of the northeast striking faults southeast of the Helmer Creek fault are reverse or steepened thrust faults, and are probably related to the Helmer Creek fault. A wide zone of deformation is associated with the faults near High Rock. Although the fault planes are not exposed, rocks 20 to 30 m from the inferred location of the faults are highly brecciated and(or) phyllonitized. For an additional 100 to 200 m beyond that, especially in the phyllite northwest of the northern fault, the rock is tightly folded and cut by multiple cleavages.

In addition, rock between the faults is intensely altered and bleached, and numerous large quartz veins extend several hundred meters into the phyllite. The relationship between the inferred trace and topography suggests both faults dips southeastward, the opposite direction of all other faults in the footwall of the Helmer Creek fault with this strike. The faults near High Rock may be conjugate southeast-dipping reverse faults, or may be younger than the other northeast-striking faults. The northern of the two appears to have at least some post- Hall Mountain granodiorite movement along it.

The north-northwest striking faults north of Pass Creek may be related to the Johns Creek fault, although unlike the Johns Creek Fault, they appear to be equally well developed in both the upper and lower plates of the Helmer Creek fault. Several faults in the southwest corner of the map area have varied orientations and appear to be relatively young. The faults in the Sullivan Creek area are probably related to tight folding in the core of a large overturned anticline located just west of the map area. The development of this anticline and these faults was probably contemporaneous with movement on the Harvey fault.

The Slate Creek fault forms the eastern structural boundary of the Pend Oreille River valley. In contrast to all other faults in the area, the Slate Creek fault and faults northwest of it, as a group, include both normal faults and high-angle second-order reverse faults. About 10 km west of the map area, the west side of the Pend Oreille River valley is bounded by the Flume Creek fault. Both the Flume Creek and Slate Creek faults are younger than the previously discussed faults and folds, and clearly postdate the Cretaceous plutons.

The Flume Creek fault is interpreted to be an east-dipping normal fault (Burmester and Miller, 1983). Regional geologic relations well south of the Gypsy Peak map area, extrapolated northward to the Flume Creek fault, suggest that movement on the Flume Creek fault was not simple normal slip, however, but that the western block was pushed from beneath the eastern block. An extensional regime was created in the hanging wall of the Flume Creek fault due to the essentially underthrust motion of the footwall. The Slate Creek fault appears to be the easternmost of the high angle, almost chaotic, set of faults now preserved in the Pend Oreille River valley that formed in this extensional regime. Impetus for this underthrusting is interpreted to be the mobilization of infrastructure beneath the U-shaped Newport fault. This moblized infrastructure is now represented by the two-mica complex(es) east and west of the Newport fault, including the igneous complex of Selkirk Crest (see sketch map). This interpretation is consistant with a comprehensive regional tectonic model proposed by R. A. Price (1982).

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