UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

PRELIMINARY GEOLOGIC MAP OF THE COOLIN AREA

by

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INTRODUCTION

This map is part of a 1:48,000 scale preliminary geologic map series covering the Sandpoint 2^{o} quadrangle. The series is a by-product of the Sandpoint 2^{o} project, conducted under the Regional Framework Studies Program and the Branch of Western Regional Geology. All the maps are 15' blocks that have been photographically mosaiced from existing 7.5' topographic quadrangles. The series is designed to fill out areas within the Sandpoint 2^{o} 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 the necessarily long time needed to complete the entire 2^{o} sheet. In addition, these maps present more information than will appear on the final 2^{o} compilation, and they are better suited for field use than will be the compilation.

The maps are more detailed and accurate than reconnaissance maps, but because they are the outgrowths of 2^{o} scale mapping and subject to the inherent haste necessary to cover so large an area in a reasonable length of time, they are not the quality of finished U.S.G.S. 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.

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. Glacial lake deposits of clay, silt, and sand in southern third of quadrangle, especially in Priest River, Quartz Creek, and Pine Creek drainages; at least 50 m thick locally.

Tc CATACLASTIC ROCKS RELATED TO NEWPORT FAULT ZONE--(Tertiary) Mylonite, chlorite breccia and other cataclastic rocks derived from both plutonic and metamorphic rocks. Ranges from noticeably broken and sheared rock near margins of zone to chlorite breccia in central and upper part. At least two periods of movement recorded; early ductile deformation, probably related to emplacement of Selkirk Crest igneous complex, and later brittle deformation that cross cuts, and in places obliterates, first stage ductile features. Most of ductile zone not coincident with brittle zone; ductilely deformed rocks included in this unit only where coincident with brittle zone. Zone cuts 50 m.y.-old Silver Point Quartz Monzonite near Newport, Washington (Miller, 1974b).

ROCKS OF SELKIRK CREST IGNEOUS COMPLEX

The Selkirk Crest igneous complex is a large mass of predominantly muscovite-biotite granitic rocks between the Priest River valley and the Purcell Trench, which lies 20 km east of the quadrangle.

The complex is made up of more than a dozen bodies north, northeast, and east of the Coolin map area, but only four units occur in the area. Several of these units are not totally igneous, but contain substantial amounts of included metamorphic rock. Virtually all of the bodies making up the complex are two-mica rocks, and they are closely related in age, composition, and origin. These bodies (i.e., map units) are not individual plutons per se, in that they were probably not emplaced as distinct plutonic entities. Rather, the entire complex was probably a single intrusive mass and the textural and mineralogical features that distinguish individual bodies comprising the mass resulted from localized physical conditions and compositional inhomogeneities that developed as, or were present when, the complex was emplaced. Relative movement between individual bodies making up the complex could have been large or small during emplacement, regardless of how far the complex traveled through the crust as a unit. The composition of the complex as a whole varies between relatively wide limits, although these limiting compositions can be found within almost all of the individual constituent bodies. Modal diagrams were not made for the two main map units that occur in the Coolin map area because they are too heterogeneous on all scales to take representative samples objectively. The individual bodies making up the complex differ from one another primarily in texture, and to a lesser degree in composition, but in any particular map unit, dikes, pods, or small bodies of almost all other units in the complex can be found. Contacts, both internal to, and between map units that make up the

complex, are gradational over intervals ranging from a cm to more than a km wide. Along many of the contacts this gradation is an alternating series of irregular dike-form masses made up of the rock types of the two bodies in contact. In most cases, the major lithology of one body can be found in any of the other bodies, either as small intrusions or inclusions. No single textural and(or) compositional characteristic distinguishes one body from another; rather, a set of characteristics, one or more of which may be common to other bodies in the complex, distinguish one map unit from another. The southern extent of the Selkirk Crest igneous complex is ill defined. Some elements of the mass extend south to the Pend Oreille River where relations are complicated by older rocks and several hornblende-biotite plutons that are not part of the complex. South of the Pend Oreille River, similar two-mica rocks extend to the northern edge of the Columbia River Group basalts south of Spokane. At the latitude of the study area the west side of the complex is bounded by the Newport fault, and the east side is bounded by a probable fault in the Purcell Trench. All rocks sampled within the complex for potassium-argon dating have yielded concordant ages on coexisting mica pairs that range between 44 m.y. and 54 m.y. (Miller and Engels, 1975). These apparent ages may or may not represent emplacement ages. In addition to numerous inclusions, screens, and pendants of Belt Supergroup rocks, some elements appear to be Cretaceous, Triassic(?), and Precambrian granitic rocks that were caught up and incorporated as units in the two-mica magma. The 44 m.y. to 54 m.y. potassium-argon apparent ages may represents cooling or

uplift ages; actual emplacement of the complex may have occurred several million years earlier. Because of uncertainties in both absolute and relative ages, the units making up the complex are described as they occur from south to north.

TKsm MIXED GRANITIC AND METAMORPHIC ROCKS (Tertiary and(or) Cretaceous)--Chiefly leucocratic two-mica granitic rocks, schist, amphibolite, and minor gneiss. Granitic rocks range in composition from tonalite to alkalic monzogranite; color index generally between 5 and 10, even in tonalite. Most have muscovite and biotite, some only biotite. Allanite ubiquitous, garnet locally common, sphene absent. Plagioclase averages calcic andesine, even in tonalite; potassium feldspar is perthitic orthoclase, microcline locally. Rock is extremely heterogeneous; made up of small bodies and dikes that grade by texture and (or) composition into one another. Most common type is leucocratic even-grained two-mica monzogranite, but extensive areas underlain by dikes and bodies of pegmatite and alaskite. Cataclastic texture common in much of the unit; best developed along west margin. Much of rock is foliated and lineated, partly induced by ductile and locally brittle cataclasis; grades from well developed in western part to irregularly developed at east edge of quadrangle. Metamorphic rocks, chiefly sillimanite-muscovite-biotite-plagioclase-quartz schist, make up about 25 to 45 percent of unit. Andalusite abundant locally. Metasedimentary rocks interlayered with amphibolite; commonly garnet-bearing. Metamorphic rocks occur mainly as screens and irregular bodies from a few tens to a few

thousand m in length. Shape and orientation of bodies irregular, but generally elongate parallel to foliation, especially in western part of unit. Distribution of metamorphic pods in granitic rocks extremely irregular on local scale, but found almost everywhere in unit. Pegmatite and alaskite dikes common within large and small metamorphic masses. Most metamorphic rocks probably derived from Proterozoic Y Prichard Formation of Belt Supergroup and from mafic sills in Prichard Formation.

TKsg GRANITIC ROCKS OF BIG CREEK (Tertiary and(or) Cretaceous)--Chiefly biotite granodiorite. Contains minor muscovite and garnet. Biotite is red-brown in thin section, and makes up about 8 percent of rock. Potassium feldspar is white microperthitic orthoclase; occurs as milled megacrysts as much as 3 cm long. Plagioclase is calcic oligoclase and also milled. Rock shows intergranular cataclasis; most has foliation and poorly developed gneissic texture. Degree of cataclasis and fabric development decrease eastward. Unit forms two east-southeast trending bodies; largest at least 4 km long and 1 km wide. Extends at least 3 km into quadrangle to east, but southeast extent not mapped. Rock is relatively uniform in appearance and contains almost no metamorphic inclusions. Is considered to be a pre-Selkirk Crest complex plutonic rock of unknown age, caught up and metamorphosed during emplacement of the complex.

TKslp MIXED LEUCOCRATIC GRANITIC ROCKS (Tertiary and(or) Cretaceous)--Mostly leucocratic two-mica rocks with numerous dikes. Basically

same granitic rocks as TKsm, but consistently contains less than 10 percent metamorphic rocks; about equal proportions of schist, amphibolite, and gneiss. Greatest percentage of granitic rocks appear to be even-grained two-mica monzogranite, although pegmatite and alaskite abundant. Extreme degree of textural and compositional heterogeneity. Occurs as two irregularly shaped bodies with broad gradational contacts. Cataclasis apparent in most of rock, becoming pronounced in western part. Contacts of unit roughly follow internal and external foliation. Other small areas of granitic rocks similar to this unit occur in TKsm, but are either too small, too poorly exposed, or their contacts are too gradational to map.

TKscb MAFIC GRANODIORITE OF CAVANAUGH BAY (Tertiary and(or) Cretaceous)--Biotite granodiorite; average color index about 14. Contains only minor muscovite with a few local exceptions. Porphyritic; potassium feldspar phenocrysts range from 1.5 to 4 cm, average about 2 cm. Concentrations of phenocrysts variable from a few per m^2 of outcrop to several hundred per m^2. Heterogeneous with respect to composition and texture but not as much so as most units in Selkirk Crest igneous complex. Rock is noticeably more mafic than average for complex. Grain size ranges from fine to coarse, but part of variability due to milling of minerals during and after emplacement. Large potassium feldspar (orthoclase) and plagioclase (average an_{30}) crystals are cataclastically rounded with fine-grained trains of quartz and feldspar between them. Main part of unit extends 11 km north-northeast from where it

occurs in Coolin map area. Almost all rock in west part of unit is foliated and lineated. Lineation consists of penetrative alignment of elongate clusters of biotite crystals. Segregation of biotite into clusters defines poorly developed foliation; probably formed during emplacement of complex. Much biotite not in plane of foliation, particularly in eastern part of mass. Fine-grained gray dikes and coarse pegmatite dikes common throughout unit. Dikes show cataclasis, particularly in western part of unit, but in places cross-cut main cataclastic foliation.

Kr GRANODIORITE OF REEDER CREEK (Cretaceous(?))--Medium-grained biotite granodiorite; most rocks contain about 0.5 percent fine-grained muscovite. Average color index is 11. All potassium feldspar is microcline. Rock appears hypidiomorphic granular in outcrop, but stained slab shows spongey- or poikilitic microcline phenocrysts that average 2 cm in length. Spongy appearance of phenocrysts caused by at least 50 percent, by volume, included plagioclase that is not oriented concentrically with outer crystal forms of microcline; poorly defined crystal forms of microcline suggest many phenocrysts were in incipient stage of formation. Plagioclase averages about an_{30}. Quartz forms large and small crystals, obvious by distinct gray color that contrasts with feldspars; size range gives rock slight seriate texture. Biotite also has range in size and is anhedral with ragged borders. Accessory minerals include allanite, epidote, zircon, apatite and opaque minerals. With only a few exceptions, texture and mineralogy varies slightly throughout pluton. Age is unknown but

probably Cretaceous on basis of mode of occurrence and composition and textural similarities with nearby plutons of known Cretaceous age. Intrudes Proterozoic Y Prichard Formation. Underlies only about 12 km^2 in map area, but about 135 km^2 north of map area. Entire eastern end of pluton bounded by Newport fault.

Kd GRANODIORITE OF DUBIUS CREEK (Cretaceous)--Medium-grained biotite granodiorite. Eastern part approaches tonalite composition, and western part is monzogranite; may be more than one pluton, but exposures so poor, and weathering so deep that it was not possible to map differences. Described in three parts; eastern, central and western parts. Tonalitic eastern part porphyritic with irregularly scattered orthoclase phenocrysts in seriate matrix; orthoclase phenocrysts are near cube-shaped, rarely tabular. Quartz occurs as rounded 1 cm crystals and crystal aggregates. Groundmass potassium feldspar is microcline, fine-grained and interstitial to other minerals. Biotite is only mafic; primary-appearing muscovite in some rocks. Color index 15. Allanite, zircon, apatite, and opaque minerals are common accessories; some sphene in rocks without primary muscovite. Central part makes up most of pluton; is less mafic than eastern rock; average color index of 10. Contains greater proportion of primary muscovite, and has large, irregularly distributed tabular microperthitic orthoclase phenocrysts. Medium-to coarse-grained; groundmass potassium feldspar is untwinned and much coarser-grained than in eastern border rock. Allanite, zircon, apatite, and abundant opaque minerals in small clusters are accessory minerals; no

sphene seen. Pale yellow-green epidote common, but probably secondary. Western part of body slightly more leucocratic then main part and contains over 1 percent muscovite; all potassium feldspar is microcline. This rock included with muscovite-biotite quartz monzonite (monzogranite) by Miller (1974a) in Newport No. 1 quadrangle, but differs from most of that body in that it is much more homogeneous with respect to texture and composition. Westernmost part of Dubius Creek body has some resemblance to granodiorite of Reeder Creek and could be separate stock of that rock type. All rocks of Dubius Creek type have low radioactivity[1/] for two-mica rocks of this type. Sample taken near center of sec. 10, T. 58 N., R. 5 W., yielded near concordant potassium-argon ages of 93.3 ± 2.8 m.y. on biotite and 100 ± 3.0 on muscovite. Age is considered Cretaceous.

Kb MONZOGRANITE OF BIG MEADOWS (Cretaceous(?))--Muscovite-biotite monzogranite and granodiorite. Non-porphyritic to sparsely porphyritic with small phenocrysts. Differs from granodiorite of Dubius Creek chiefly in that it is highly heterogeneous on all scales with respect to texture and composition. Fine-to coarse-grained, but most is medium-to fine-grained. Indistinct foliation in most rock. Averages 1 to 2 percent muscovite, and 6 to 8 percent biotite. Potassium feldspar is microcline, and

[1/] All radioactivity measurements made with Geometrics model GS-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.

plagioclase averages intermediate oligoclase. Zircon, apatite, and sparse allanite and opaque minerals make up accessories. Probably Cretaceous in age by association with and similarities with other Cretaceous plutons.

Kbc MONZOGRANITE OF BLUE CREEK (Cretaceous(?))--Porphyritic monzogranite to granodiorite; average composition is monzogranite. Contains biotite and locally hornblende. Average color index about 11. Plagioclase is calcic oligoclase and potassium feldspar is microperthitic orthoclase. Allanite, zircon, sphene, apatite, and opaque minerals common in most of pluton. Texture is porphyritic with orthoclase phenocrysts as long as 8 cm; groundmass is seriate with no apparent preferentially oriented grains. Contains abundant inclusions, especially near margins. Groundmass, especially near margins, heterogeneous due to abundant 1 to 3 cm^2 areas of relatively high mafic mineral concentration that are not inclusions in that they have diffuse gradational borders. Hornblende more abundant in these areas; may result from melted, but only partially dispersed mafic rock from Proterozoic mafic sills. Abundant leucocratic dike rock in southern part of body; may be part of another pluton, but included with monzogranite of Blue Creek. Considered Cretaceous (?) on basis of similarities with other nearby plutons of known Cretaceous age.

gr UNDIVIDED GRANITIC ROCKS IN MCABEE FALLS AREA (Cretaceous(?))--Fine- and coarse-grained biotite monzogranite and granodiorite. Only limited exposure at 3 localities; presumably underlies most glacial-alluvial deposits west of Newport fault in McAbee Falls area. Made up of oligoclase, microcline, quartz, and biotite. Coarse grained at McAbee Falls with abundant allanite and sphene, and minor apatite, zircon, and opaque minerals; locally slightly porphyritic. Fine-grained in exposures southwest of McAbee Falls; contains no sphene, but abundant secondary (?) muscovite there. Fine-grained rock appears to be hybrid, contaminated by poorly dispersed material from Proterozoic Y Prichard Formation host rock. No preferred mineral orientation in any rock of this unit. Age presumed to be Cretaceous because of resemblance to nearby Cretaceous plutons and because all dated granitic rocks in upper plate of Newport fault have yielded Cretaceous potassium-argon ages.

Ypg PRICHARD FORMATION AND GRANITIC ROCKS UNDIVIDED (Proterozoic Y and Tertiary and(or) Cretaceous)--Schist, quartzite, amphibolite, and leucocratic granitic rocks. About 95 percent metamorphic, 5 percent granitic. Well layered; layers probably correspond to bedding, but all primary sedimentary features destroyed by metamorphism. Most quartzite micaceous and slightly schistose. Sillimanite common, audalusite common locally, fine- to medium-grained muscovite and phlogopitic biotite ubiquitous. Amphibolite layers commonly garnet-bearing; derived from diabase sills in Prichard Formation. Granitic rocks mostly pegmatite and fine-

grained leucocratic muscovite-biotite monzogranite. Unit differs from TKsm by greater percentage of metamorphic rocks and relatively high degree of concordance of granitic rocks. Only about 10 to 20 percent of granitic rock discordant, most in sills or elongate pods parallel to foliation.

Yp PRICHARD FORMATION (Proterozoic Y)--Interbedded argillite, siltite, and fine-grained quartzite in about equal amounts. Intruded by numerous sills of tholeiitic composition. About 2,100 m (excluding sills) in map area; neither top nor bottom exposed. About 5,200 m (including sills) in Newport no. 1 quadrangle 30 km to southwest (Miller, 1974a). Exposed section in map area probably middle to lower part of Prichard, because concordant sills restricted to that part of section at other localities. Argillite mostly dark gray and medium to light gray, thinly bedded to finely laminated. Siltite medium to light gray and white; very fine-grained. Bed thickness up to 1 m, but most 5 cm to 20 cm. Quartzite white and light gray. Bed thickness from a few cm to several meters; numerous siltite and some argillite interbeds. Cross laminations, graded beds, and channel-and-fill structures common in argillite and siltite beds; quartzite beds relatively structureless internally. Argillite and to lesser degree siltite contain abundant pyrite and(or) pyrrhotite; oxidation of iron sulfides forms ubiquitous limonite-colored weathered surfaces.

Yd METADIABASE SILLS (Proterozoic Y)--Diabase and gabbro, slightly to moderately metamorphosed. Tholeiitic 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 occurs. Some or all hornblende probably derived from metamorphism of pyroxene. Quartz generally less than 5 percent of rock; may result from excess silica formed from metamorphism of pyroxene to hornblende. Thickness of sills ranges from about 1 m to 450 m. 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 51 km to east is 1430 m.y. (Elston and Bressler, 1980).

STRUCTURE

The Newport fault in the eastern part of the quadrangle separates two fundamentally different terranes; the Selkirk Crest igneous complex and its associated high rank metamorphic rocks on the east, and barely metamorphosed Belt Supergroup rocks intruded by relatively high-level plutons on the west. The fault strikes roughly north-south, but in the southern part of the area this trend changes to about N., 30 E. Except in the area between East River and Big Creek, the fault within the quadrangle is largely concealed beneath Quaternary deposits. Where it is exposed, the fault appears to dip west at a low to moderate angle, but no dips have been directly measured. Between East River and Big Creek there is relatively good control on the surface trace of the fault across irregular topography; a dip of 30 degrees was calculated for three separate localities in that area. In the Priest Lake 15' map area to the north the fault appears to be steeper.

Within the Coolin map area, rocks of the Selkirk Crest complex exhibit development of progressively more intense cataclasis from east to west. The rocks appear to have responded in a semi-ductile, semi-brittle manner, with almost all products of the cataclasis showing moderate to high degree of recrystallization. The cataclasis involves milling and recrystallization of quartz and feldspars, and disaggregation and wrapping of micas around milled felsic minerals. The fabric formed by this cataclasis is more strongly lineate than foliate, and presumably formed during emplacement of the complex. Eastward from the Newport fault, fabric development progressively decreases.

A moderate to strong streaked-mineral lineation is developed on discontinuous shear planes within the ductilely deformed cataclastic rock and appears to become progressively stronger toward the western edge of the

complex. The lineation strikes generally west, and plunges westward. The discontinuous shears merge with each other to some degree and with apparently flattened and elongated trains of disaggregated quartz and micas to form a foliation of variable strike, but generally west to northwest dip. At the south end of the complex, the foliation strikes conspicuously into the Newport fault at a fairly high angle, and the dip is to the south.

Within and near the actual trace of the Newport fault, the cataclasis is totally brittle and shows almost no recrystallization. This brittle cataclasis is associated with the Newport fault zone only, has almost no directional fabric, and clearly post-dates all or most of the ductile cataclasis accociated with emplacement of the Selkirk Crest igneous complex.

The cataclastic rock subdivisions shown on the geologic map are based on degree of cataclasis exhibited in thin section. The subdivisions portray the approximate configuration and relative degree of cataclasis within the complex, and are strictly qualitative. Criteria definining the zones are given at the end of the section on structure. The degree of cataclasis is completely gradational within the subdivisions and across the boundaries between them; placement of the boundaries is necessarily subjective.

West of the Newport fault the Belt Supergroup rocks are intruded by several Cretaceous and Cretaceous(?) plutons that were emplaced at a relatively shallow level as compared with to the Selkirk Crest rocks. These plutons have relatively narrow contact metamorphic aureoles around them and appear to have disrupted the regional north or northeast strike of the Belt rocks by forceable intrusion.

The Belt rocks are cut by numerous apparently high-angle faults, most of which appear to have less than 1000 m displacement. Because bedding dips at low angles, apparent offsets are exaggerated on several of the faults even

though actual displacements are not great. The concealed faults in the Pine Creek and Binarch Creek drainages, probably have 1000 m or more displacement. None of the high angle faults are known to cut the Cretaceous or Cretaceous(?) granitic rocks. Some of the high angle faults clearly predate the Newport fault, but many may have been active contemporaneously with the Newport fault. Poor exposures do not permit measurement of fault dip, so it is not known if any of the faults bear the listric normal relationship to the Newport fault that has been described by G. A. Davis and others (1980) and G. H. Davis (1980) for listric normal faults and a detachment surface in southeastern California and southern Arizona.

Thin Section Characteristics of Cataclastic Subdivisions

1. Minor cataclasis limited primarily to scattered intergranular granulation
2. Discrete thin zones or small areas of cataclasis, some through-going, but separated by large areas of no cataclasis or by areas where only intergranular milling is apparent.
3. Moderately well developed cataclastic zones; most are continuous across the thin section. Within shear zones quartz is strung out in lens shaped pods of recrystallized fine-grained milled products. Feldspars are rounded and milled. Rock between zones shows obvious cataclasis and milling of quartz and feldspar, but most feldspar is near original grain size.
4. Well developed zones of nearly total cataclasis, many shear zones merging; very little rock that shows only moderate cataclasis between zones.
5. Extreme cataclasis; almost all areas of thin section show cataclasis; only minor number of original feldspar crystals preserved and those are milled and rounded. Mica crystals disaggregated and strung out between trains of cataclasized felsic minerals.

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