Initial Evaluation of Bedrock Geology and Economic Mineralization Potential of Southern Whitesail Lake Map Area (NTS 093E/02, 03), West-Central British Columbia

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INTRODUCTION

Regional Geological Setting

The eastern Bella Coola (NTS 093D) and southern Whitesail Lake (NTS 093E) 1:250 000 map areas comprise a region of rugged mountainous topography and limited access on the eastern margin of the Coast Mountains. These map areas straddle the transition zone between the Coast and Intermontane morphogeological belts, and encompass the boundary between igneous and metamorphic rocks of the Coast Plutonic Complex on the west and Jurassic and Cretaceous volcanic-sedimentary successions of southwestern Stikinia on the east (Fig. 1, 2). Bedrock geological mapping and economic mineral assessment in the eastern Bella Coola (NTS 093D) map area have been the primary focus of the 2001–2004 Bella Coola Targeted Geoscience Initiative (TGI), a coordinated federal-provincial project designed to improve understanding of the geological evolution for this part of the central coast region and assess the economic potential of little-known Mesozoic volcanic assemblages in the region (Haggart *et al*., 2004, and references therein). During the 2004 field season, the geological framework established by the Bella Coola TGI was extended to the north, into the southern Whitesail Lake map area (NTS 093E/02, 03), under the auspices of the Rocks To Riches Program, by a combined research team from the University of Wisconsin – Eau Claire, the University of British Columbia and the Geological Survey of Canada.

The primary area of interest includes the Foresight Mountain (NTS 093E/03) and Tesla Lake (NTS 093E/02) 1:50 000 map sheets in the south-central Whitesail Lake map area, on the eastern side of the Coast Mountains west of Tweedsmuir North Provincial Park (Fig. 1). This area contains Jurassic and Cretaceous volcanic successions on the western edge of Stikinia that are known to host volcanogenic massive sulphide (VMS) mineralization elsewhere in the Cordillera, as well as Jurassic to Eocene plutonic bodies along the eastern margin of the Coast Plutonic Complex that are known hosts for a variety of porphyry deposits (Woodsworth, 1980; Dawson *et al*., 1991; Diakow *et al*., 2001). Stream sediment geochemistry (Regional Geochemical Survey data; Lett *et al*., 2002), associated MineMatch anomaly clusters and MINFILE occurrences suggest the potential for economic mineralization in both Mesozoic volcanogenic successions of western Stikinia and plutonic bodies along the eastern margin of the Coast Plutonic Complex (Fig. 1). This investigation integrates regional bedrock mapping, stratigraphic and structural analyses, geochronology, plutonic and volcanic geochemistry, and isotopic analyses to document the regional geological framework and to provide a first-order assessment of the economic mineral potential in the area.

This report briefly describes the geology of the south-central Whitesail Lake 1:250 000 map area (NTS 093E/02, 03), documented by detailed bedrock mapping during the 2004 field season (Fig. 2). This bedrock mapping is a continuation of regional mapping conducted to the south by the Bella Coola TGI project (Haggart *et al*., 2004, and references therein). The preliminary results from this investigation are integrated with a detailed analysis of Hazelton Group volcanic stratigraphy in the eastern half of the Tesla Lake 1:50 000 map area by Gordee *et al*. (this volume).

GEOLOGICAL SETTING

Volcanic Assemblages

Hazelton Group

Volcanic rocks of the Early and Middle Jurassic Hazelton Group form a thick (>4 km), broadly bimodal volcanic succession consisting of basaltic and basaltic andesite flows interbedded with and overlain by dacitic to rhyolitic tuff, lapilli tuff, tuff-breccia, tuffaceous sedimentary rocks and associated rhyolitic domes and flows. These rocks are widespread and well preserved in the eastern third of the map area and occur in well-exposed, generally eastward-younging, gently dipping structural panels along the eastern margin of the Coast Plutonic Complex. Preliminary

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stratigraphic analyses suggest that the stratigraphy, composition, age and facies architecture of the Hazelton Group in this region strongly resemble strata that host the Eskay Creek VMS deposit in the northwestern portion of Stikinia (Diakow et al., 2001; Gordee et al., this volume). Hazelton Group strata in this area are the focus of an ongoing stratigraphic, geochemical and geochronological investigation by S.M. Gordee at the University of British Columbia. The following description is a synopsis, and detailed volcanostratigraphic descriptions of Hazelton Group strata in the region are provided by Gordee et al. (this volume).

One of the most significant results of the 2004 field season was the recognition that Hazelton Group strata are substantially more widespread in the area than suggested by earlier reconnaissance mapping (i.e., Woodsworth, 1980). Regionally, the Hazelton Group forms a gently east-

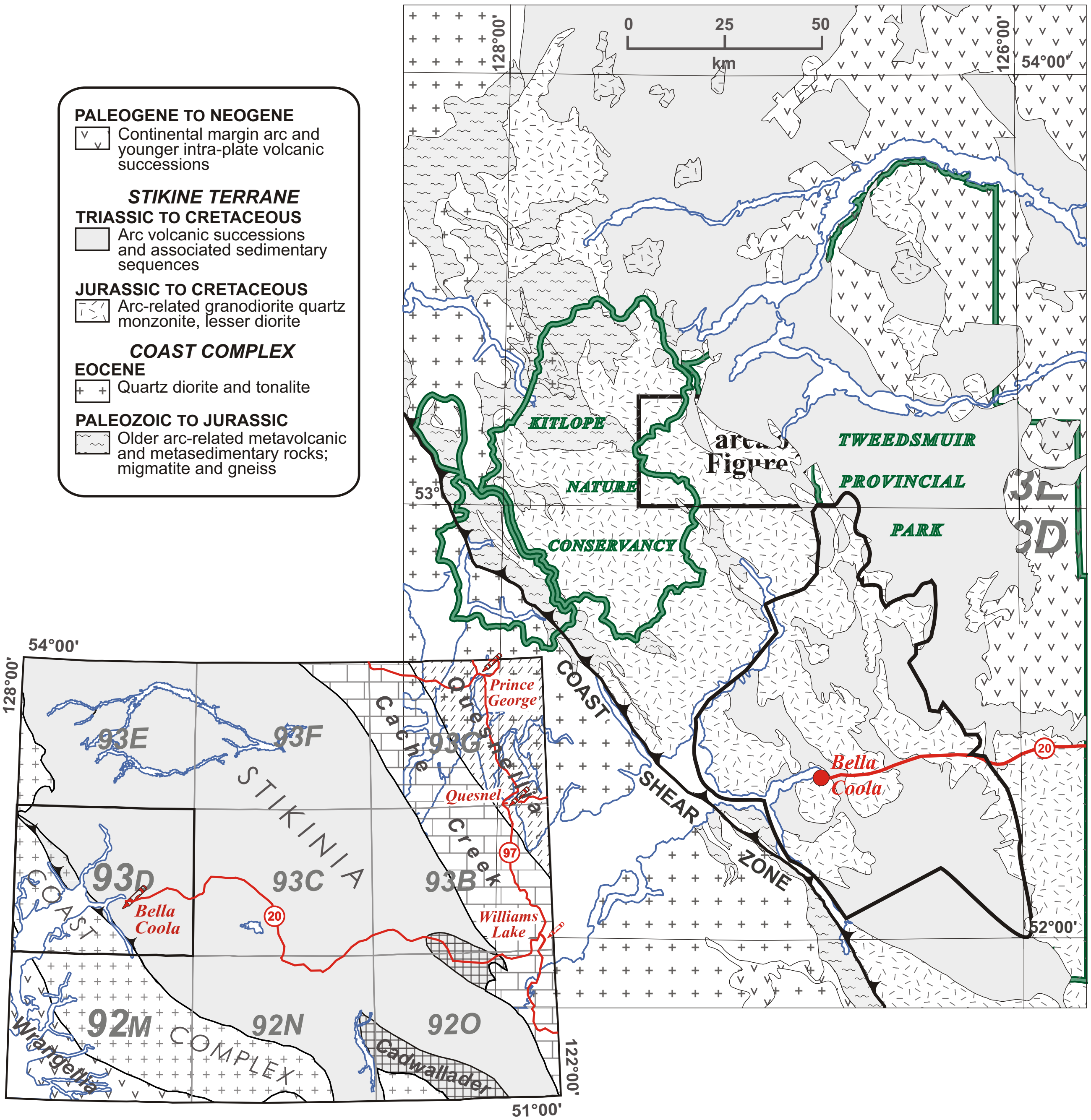

Figure 1. Schematic regional geological map of Bella Coola (NTS 093D), Whitesail Lake (NTS 093E) and adjoining map areas. The irregular polygon represents the area mapped during the TGI project (Haggart *et al*., 2004). Inset box shows current study area, including NTS 093E/02 and 03. Diagram modified from Diakow et al. (2003). Inset map shows morphogeological belts and tectonic terranes for the west-central Canadian Cordillera.

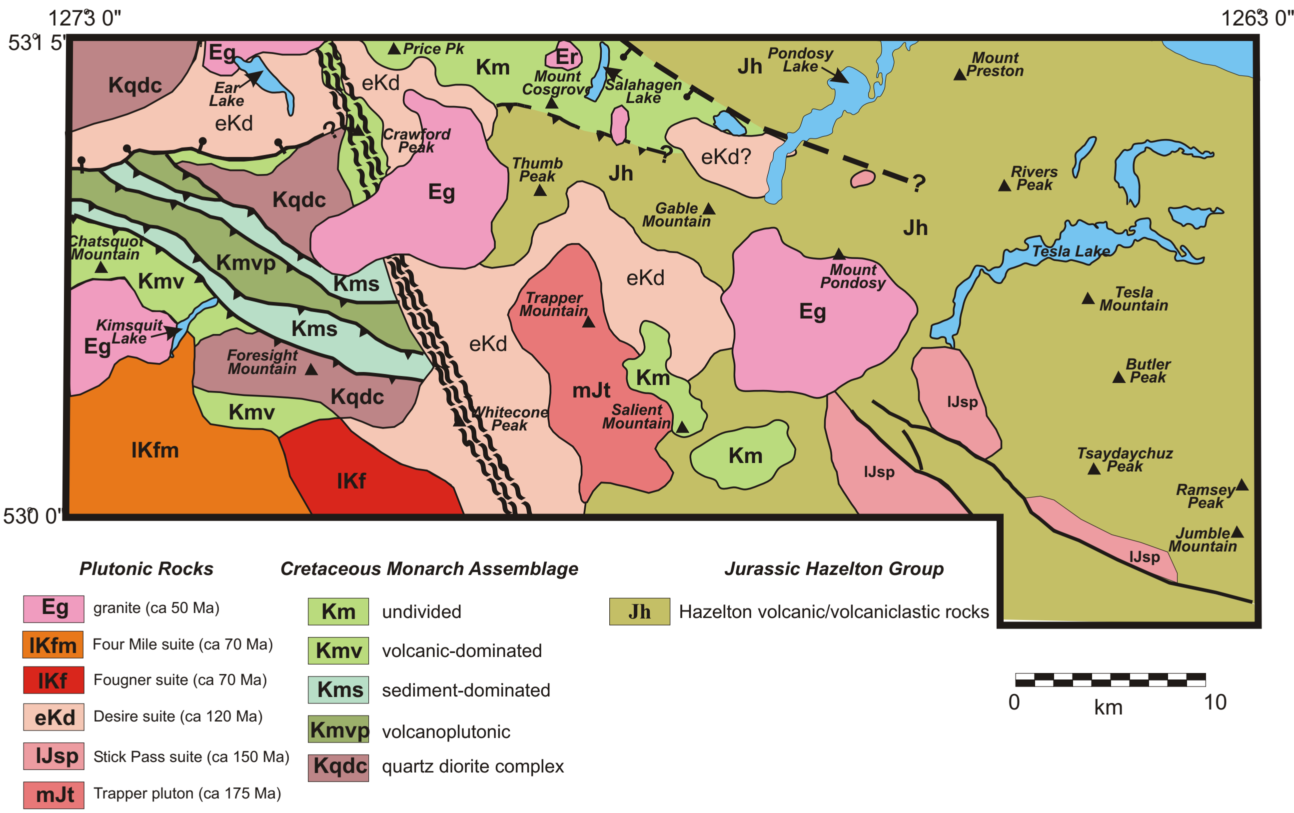

Figure 2. Generalized geology of the northeastern Bella Coola – southeastern Whitesail Lake map area, showing major lithological units, structures and physiographic features referred to in the text.

northeast-dipping homocline that can be crudely subdivided into two stratigraphic packages. The basal package consists of a thick succession (>2000 m) of intermediate to mafic volcanic flows, tuff-breccias, lapilli tuffs and associated medium to coarse-grained volcaniclastic sedimentary rocks that form the jagged massifs of the Tsaydaychuz Peak – western Jumble Mountain area (Fig. 2). Hypabyssal intrusions are common, and much of the area consists of complexly intercalated basalt and basaltic andesite flows, dikes and sills, and associated tuffaceous strata intruded by abundant gabbroic to dioritic hypabyssal intrusions.

The 'lower' mafic assemblage is gradationally overlain by a very thick succession (>3000 m) of laterally extensive dacitic to rhyolitic tuff, lapilli tuff, tuff-breccia and associated volcaniclastic sediments (Fig. 3). This 'upper' felsic package makes up over 80% of the Hazelton Group in the area. The rocks are very well bedded, and individual beds can be traced for hundreds of metres along strike. The package is dominated by maroon to red, thin to medium-bedded, rhyolitic welded to unwelded tuff and lapilli tuff, pebble to cobble conglomerate, volcanic lithic arenite and wacke; and mudstone interbedded with medium to thick-bedded lapilli tuff, tuff-breccia and conglomerate. The entire sequence fines upward, with thin-bedded mudstone, siltstone and sandstone dominating in the northern and eastern portions of the map area.

In the Rivers Peak – Mount Preston area, an impressive sequence of aphanitic rhyolite flow domes intrudes thin to medium-bedded volcaniclastic strata, and follows the trace of a down-to-the-south, apparently synvolcanic extensional fault. Both the fault zone and rhyolite domes are extensively sericitized and oxidized, forming a very distinct red-stained gossan zone immediately south of Mount Preston.

The age of the Hazelton Group in the southern Whitesail Lake area is constrained by a combination of fossil ages and U-Pb geochronology. The age of the base of the Hazelton Group section to the west of Tsaydaychuz Peak is poorly constrained by the combination of a 191 ±?12 Ma U-Pb age from dacitic tuff underlying the major mafic interval, and by an intrusive contact between Hazelton Group strata and the ca. 177 Ma Trapper Peak pluton (P. van der Heyden and G. Woodsworth, unpublished data). Up section, in the Jumble Mountain area, fine to coarse-grained feldspathic lithic arenite and wacke have yielded a diverse assemblage of bilvalves, gastropods, belemnoids and ammonites that constrain the strata to Late Toarcian to Early Aalenian age (T.P. Poulton, personal communication, 2003). This age designation is supported by a U-Pb zircon age of 176.6 ±?0.7 Ma, derived from overlying rhyolitic lapilli tuff (R.M. Friedman, personal communication, 2003). The Jumble Mountain area straddles the contact between the 'lower' mafic and 'upper' felsic stratigraphic packages, suggesting that the transition from effusive basaltic volcanism to explosive rhyolitic volcanism is roughly Aalenian in age. The correlation between rhyolitic strata in the Jumble Mountain area and those of the Mount Preston area is provided by U-Pb ages of 176.3 3.3 Ma and 175.4 0.9 Ma, derived from rhyolitic lapilli tuff from the base and top of the Mount Preston section, respectively (S.M. Gordee, work in progress). The youngest Hazelton Group strata in the region are found to the east of the map area, where a Late Bathonian to Early Callovian fauna has been identified near Oppy Lake (H. Frebold, unpublished data).

Monarch Assemblage

The Lower Cretaceous Monarch assemblage is exposed in a series of northwest-trending structural panels in the western and northern portions of the map area, and as erosional remnants near Salient Mountain in the southern portion of the map area (Fig. 2). These exposures represent a continuation of the outcrop pattern in the Bella Coola area to the south, where volcanic strata of the Monarch assemblage are exposed in a series of imbricate structural panels developed to the west of the main Hazelton Group outcrop belt.

The base of the Monarch assemblage in the southern Whitesail Lake map area is represented by a prominent angular unconformity between rocks of the Hazelton Group and basaltic andesite and andesite of the Monarch assemblage. The contact is visible on the south and east flanks of Salient Mountain, where volcanic rocks of the Monarch assemblage forming the steep massif of Salient Mountain overlie steeply dipping felsic strata typical of the upper Hazelton Group. The underlying felsic strata are intruded by the ca. 177 Ma Trapper Mountain pluton on the south side of Salient Mountain, thus verifying assignment to the Hazelton Group. This is the first locality where an unconformable contact has been identified between the Monarch assemblage and the Hazelton Group. To the south, the Monarch assemblage erosionally overlies both ca. 155 Ma and ca. 134 Ma plutonic rocks, but the contact between the Monarch assemblage and older volcanic rocks in the eastern Bella Coola map area is equivocal (Haggart *et al*., 2004).

The Monarch assemblage is dominated by olive green, locally amygdaloidal basalt, basaltic andesite and dacite flows and associated breccias and tuff-breccias, intercalated with distinctive intervals of argillite, siltstone and volcanic lithic arenite to wacke. The sedimentary intervals locally amalgamate to sections hundreds of metres thick, and contain thin to medium-bedded lapilli tuff, volcanic pebble conglomerate, medium to coarse-grained feldspathic lithic sandstone, and thin-bedded tuff, siltstone and rare limestone interbeds. Sedimentary interbeds are tabular and laterally continuous, and locally may represent amalgamated partial bottom-cut-out turbidite beds. The lateral continuity, partial turbidite sequences and presence of limestone and fossiliferous intervals indicate, at least in part, a sub-wavebase marine depositional environment. Stratigraphy within the assemblage is complex, however, a result of abrupt lateral facies changes complicated by structural deformation. The Monarch assemblage is differentiated from the Hazelton Group by its higher percentage of mafic amygdaloidal flows, lower amount of rhyolite, overall green chloritic color (contrasting with the predominantly reddish-purple cast of the Hazelton) and the presence of laterally continuous thin-bedded argillite, siltstone and sandstone intervals that form distinct marker horizons between massive mafic flow packages.

In the western portion of the map area, the Monarch assemblage is exposed within a series of structural panels that are interpreted to represent an imbrication of several different stratigraphic-structural levels within a single volcanoplutonic arc assemblage (Fig. 4). From the lowest structural level upward, these panels include 1) a foliated to nonfoliated hornblende quartz diorite complex with metavolcanic xenoliths (10–20%) and abundant mafic dikes trending roughly east-west; 2) metavolcanic and metasedimentary screens (40–50%) within a 'matrix' of texturally and compositionally complex, locally magmatically foliated biotite-hornblende, pyroxene-hornblende and hornblende diorite to quartz diorite (Fig. 5); 3) massive basalt, basaltic andesite and andesite flows, associated tuff-breccia and other fragmental rocks; and 4) volcaniclastic sedimentary strata and associated pyroclastic rocks. These structural panels are interpreted to

Figure 3. Thick succession of rhyolitic tuff, lapilli tuff, and associated volcaniclastic sedimentary rocks on the south end of Gable Mountain. Note abundant gossan associated with strata and associated structures.

Figure 4. Imbricate thrust stack within Monarch assemblage and subjacent intrusive rocks, northeast of Chatsquot Mountain.

represent 'slices' of a single volcanoplutonic-arc assemblage, from the subvolcanic plutonic roots, through the plutonic-volcanic intrusive contact, to the surficial volcanic flows and associated volcanogenic sedimentary rocks (Fig. 2). In this succession, the rheologically weak sedimentary intervals tend to form décollement surfaces, whereas the massive flow units tend to be structurally resistant.

One of the structurally resistant structural panels is exposed on Chatsquot Mountain and the ridges immediately to the southeast and northwest of the main massif, which harbour spectacular exposures of a mineralized layered mafic intrusion (LMI; Fig. 2). Compositional banding in the LMI is typically defined by variable proportions of olivine, pyroxene, plagioclase and magnetite, and ranges in composition from ultramafic magnetite-olivine websterite to anorthositic gabbro. The prominent foliation in the rock parallels the compositional layering and results in a distinctly layered appearance visible from several kilometres away. Typical compositional layers are less than 1 m thick, with clinopyroxene (cpx)-rich gabbro (80% cpx) alternating with more plagioclase-rich layers that distinctly weather to a lighter colour (Fig. 6). Subordinate ultramafic layers include magnetite and olivine-rich rocks (apparent cumulate layers), which weather to a distinctive rusty brown, knobby surface. Along the ridge northeast of Chatsquot Mountain, the LMI is cut by numerous mafic and intermediate porphyry dikes, which occasionally exceed the LMI in volume and form intrusion breccias.

In the Bella Coola map area (NTS 093D), the Monarch assemblage is interpreted to be Valanginian in age, based on sparse ammonite collections from several localities (Struik *et al*., 2002). In the Whitesail Lake map area, this interpretation is supported by a 124 4 Ma K-Ar age on hornblende from the top of George Peak, and by an imprecise 128–136 Ma U-Pb age from the summit of Salient Mountain (P. van der Heyden and G. Woodsworth, unpublished data; Fig. 2). However, Albian ages have been reported from strata lithologically identical to the Monarch assemblage from the Bella Coola area (Haggart *et al*., 2004). Fieldwork in the type area of the Monarch assemblage on the south side of the Monarch Icefield, south of the Bella Coola (NTS 093D) map area, during 2004 yielded fossils of Albian age, indicating that the Monarch assemblage most likely ranges from Valanginian to Albian in age. It is unclear if this age range encompasses a single stratigraphic succession or two (or more?) unconformity-bound successions. Fossils collected east of Price Peak have been submitted for identification, and U-Pb geochronology samples from rhyolitic lapilli tuff within the Monarch assemblage east of Chatsquot Peak are being analyzed.

Figure 5. Clasts of metavolcanic rocks from the basal Monarch assemblage within hornblende diorite to quartz diorite. Intrusive rocks are presumed to be subvolcanic equivalent of Monarch assemblage. Rock hammer for scale.

PLUTONIC ASSEMBLAGES

The central portion of the southern Whitesail Lake map area (NTS 093E/02, 03) is characterized by a westerly-increasing volume of plutonic rocks of Middle Jurassic to Eocene age. The spatial and temporal magmatic pattern in the southern Whitesail Lake map area mimics that of the Bella Coola area to the south, which is characterized by a northwest-trending belt of plutonic rocks that is subdivided into intrusive suites on the basis of lithological characteristics, crosscutting field relationships, mineralogy, alteration assemblages, geochemical attributes and age (Gordee *et al*., 2003). Plutonic rocks in the study area have been subdivided on the basis of crosscutting relations and lithology, with limited geochronology. Geochemical, geochronological and isotopic analyses are in progress.

Early Jurassic(?) Plutons

Crosscutting relations along the margins of the Middle Jurassic Trapper Peak pluton (*see* below) indicate that the oldest plutonic rocks in the southern Whitesail Lake map area consist of a texturally and compositionally complex suite of hornblende diorite and quartz diorite. The unit displays a wide textural variation from fine grained holocrystalline to locally pegmatitic. It is variably foliated, ranging from unfoliated to complexly magmatically foliated, and displays a strong tectonic foliation adjacent to the shear zone west of Whitecone Peak. Metavolcanic mafic xenoliths are common, ranging from pebble to boulder size, but generally constitute less than 20% of the unit. To the south, in the Bella Coola map area, rocks lithologically similar to those intruded by the Trapper Peak pluton are referred to as the Howe Lake suite, and yield U-Pb crystallization ages of ca. 180–185 Ma.

Middle Jurassic Plutons

The oldest dated plutonic rock in the southern Whitesail Lake map area is the Trapper Peak pluton, which is a medium to coarse-grained, locally K-feldspar porphyritic hornblende-biotite granite. The rock is relatively fresh, with weak chloritization of hornblende and weak sericitization of plagioclase feldspar. The unit is unfoliated, and appears relatively homogeneous on a regional scale. The Trapper Peak pluton clearly intrudes andesitic volcanic rocks of the Hazelton Group along its southeast margin, and intrudes texturally complex, locally foliated hornblende diorite along its southern and northeastern margins. Contact relations with plutons on the northwestern and western sides are ambiguous. The Trapper Peak pluton yielded a 177.4 0.7 Ma U-Pb zircon age (P. van der Heyden and G. Woodsworth, unpublished data). This age is only slightly younger than U-Pb ages obtained from rhyolitic tuffs in the Hazelton Group, and overlaps paleontological ages from the upper portion of the Hazelton Group stratigraphy. The coeval nature of the pluton and its spatial association with thousands of metres of rhyolitic pyroclastic rocks and associated rhyolite domes strongly suggest this pluton may represent the source magma chamber for rhyolitic volcanism in the upper Hazelton Group.

Late Jurassic (?) Plutons

Plutonic rocks of apparent Late Jurassic age form a northwest-trending belt between Tsaydaychuz Peak and Salient Mountain. These rocks are characterized by fine to medium-grained biotite hornblende granodiorite to quartz diorite. Aplite dikes are common, and small (<4–5 cm), strongly recrystallized mafic xenoliths are locally abundant. The unit is heavily fractured. Hornblende is commonly glomerocrystic and chloritized, and with widespread interstitial pink K-feldspar imparts a distinct green and pink tint to the rock. The unit clearly intrudes mafic volcanic rocks of the Hazelton Group, and is intruded on its northern end by rhyolite porphyry associated with the Eocene (?) Mount Pondosy pluton. These rocks form the northern continuation of a northwest-trending belt of lithologically similar rocks in the Bella Coola map area assigned to the Stick Pass suite, which is constrained to be 148–156 Ma (Gordee *et al*., 2003; Haggart *et al*., 2004).

Early Cretaceous (?) Plutons

One of the most abundant plutonic suites in the southern Whitesail Lake map area is a texturally and compositionally complex assemblage of fine to medium-grained, hornblende to biotite hornblende granodiorite, quartz diorite and tonalite that is primarily exposed in the

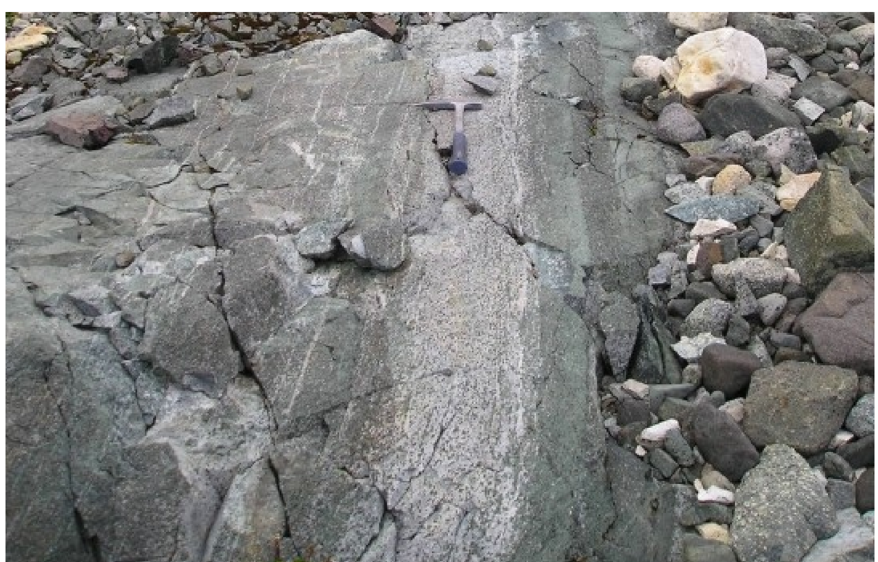

Figure 6. Typical compositional layering of plagioclase-rich (lighter) bands and pyroxene-rich (darker) bands within the layered mafic intrusion on Chatsquot Mountain. Rock hammer for scale

northwestern portion of the map area (Fig. 2). Compositional variations are complex, with abundant gradational variations in the percentage of hornblende, biotite, plagioclase and quartz. The alteration character also varies, ranging from fresh and unaltered mineral assemblages to rocks containing pervasively chloritized hornblende and sericitized plagioclase. The unit is variably foliated, with a locally strong magmatic foliation, particularly in xenolith-rich phases, and a distinct tectonic foliation associated with crosscutting shear zones, particularly east of Crawford Peak. Metavolcanic xenoliths are abundant, particularly near the contact with adjacent Monarch assemblage volcanic rocks. The xenolith density varies considerably, from relatively uncommon to locally dense enough to form an intrusion breccia (Fig. 5). Crosscutting andesite dikes are common.

These plutonic rocks are spatially associated with exposures of the Monarch assemblage, and clearly intrude the Monarch assemblage on Crawford Peak and south of Price Peak (Fig. 2). Lithologically similar rocks are incorporated into an imbricate stack of thrust panels exposed northeast of Chatsquot Mountain, where they are interpreted to form the subvolcanic plutonic root of the Monarch assemblage. Similar rock types and crosscutting relations exist to the south, along the western side of the eastern Bella Coola map area (Gordee *et al*., 2003; Haggart *et al*., 2004), where these rocks are assigned to the Desire suite. The Desire suite is assumed to be comagmatic with the Monarch assemblage, and is constrained to be ca. 118–122 Ma.

Late Cretaceous to Paleocene(?) Plutons

Rocks of presumed Late Cretaceous to Paleocene age are restricted to the southwestern portion of the Foresight Mountain map area (NTS 093E/03). The plutons form distinct, massive, homogeneous intrusive bodies that display steep vertical walls and well-developed exfoliation joint patterns. Mineral assemblages are very fresh, xenoliths are rare, and crosscutting dikes are relatively uncommon. These plutons can be compositionally subdivided into two distinct intrusive rock types. The first is a medium-grained, equigranular to plagioclase porphyritic, hornblende-biotite tonalite to granodiorite with fine-grained, conspicuous honey brown sphene (1–3%). Fresh books of euhedral biotite and elongate hornblende crystals, together with fresh euhedral to subhedral plagioclase and anhedral vitreous quartz give the unit a distinctive 'salt and pepper' appearance. This rock is compositionally and texturally similar to the Fougner suite of the Bella Coola map area, which is constrained to be approximately 70 Ma (Gordee *et al*., 2003; Haggart *et al*., 2004).

The second rock type is a yellow-weathering, medium to coarse-grained, crudely equigranular two-mica granite characterized by large (0.5–1 cm) euhedral books of muscovite and biotite and large (0.25–0.5 cm) anhedral blebs of quartz that locally displays a grey or bluish tint. The muscovite:biotite ratio varies throughout the unit, but its low, rounded weathering profile, pervasive yellow weathering and presence of well-developed exfoliation joints makes the unit distinctive in the field. This two-mica granite is lithologically similar to the two-mica granite of the Four Mile suite to the south, which yields U-Pb ages of 62–73 Ma. The close spatial association between the 'salt and pepper' hornblende-biotite tonalite to granodiorite and the two-mica granite in the southern Whitesail Lake map area mimics the close spatial association of the lithologically similar Fougner and Four Mile suites in the Bella Coola map area to the south (Gordee *et al*., 2003; Haggart *et al*., 2004).

Eocene (?) plutons

The map area contains several large, roughly circular bodies of biotite granite, K-feldspar pophyryitic granite and rhyolite porphyry that extend in a crudely northwest direction from Mount Pondosy. Similar bodies were reported by Woodsworth (1980) to the east and northeast of Tesla Lake, but these bodies were not examined during this investigation. These rocks are characteristically medium to coarse-grained, equigranular, locally K-feldspar porphyritic biotite granite with clean, fresh books of biotite, white to pink K-feldspar, euhedral white plagioclase and large, anhedral quartz blebs. Associated rhyolite porphyry is generally pink, with distinct coarse-grained plagioclase phenocrysts and finer grained phenocrysts of biotite and quartz. Xenoliths are present but rare, and crosscutting andesite dikes are locally evident. The plutons are relatively homogeneous, and tend to have sharp, unaltered contacts with adjacent country rocks. These bodies are the source of abundant white, locally quartz-phyric rhyolite dikes that cut a variety of rock units in the vicinity of the plutons.

STRUCTURAL GEOLOGY

The southern Whitesail Lake map area displays three distinct types of structural deformation, each indicative of a specific stress regime operating at different times in the geological evolution of the region. These deformational regimes are discussed sequentially, from oldest to youngest:

Mt. Waddington Fold and Thrust System

The western portion of the map area is underlain by an imbricate stack of northeast-vergent thrust sheets that complexly interdigitates various structural levels within the Monarch volcanoplutonic assemblage (Fig. 4). The primary décollement horizons are within sediment-dominated intervals, with the massive mafic volcanic units acting as structural buttresses. The northern edge of the thrust system appears to juxtapose Monarch assemblage volcanic rocks over Hazelton Group stratigraphy, similar to inferred structural relations to the south. The maximum age of the system is constrained by the age of the deformed Monarch assemblage, which is believed to be Valanginian to Albian. The system is truncated on its eastern side by a high-angle dextral shear zone (discussed below) that runs between Whitecone Peak and Crawford Peak. This shear zone is cut by a biotite granite of presumed Eocene age, providing a minimum age for the contractional deformation. Regional analysis suggests this thrust system is continuous with the

Late Cretaceous Mt. Waddington fold and thrust system, exposed in the Bella Coola map area to the south (Haggart *et al*., 2003, 2004).

High-Angle Dextral Shear System

A prominent north-northwest-trending, high-angle shear zone extends through the western side of the map area. It extends north from the northern end of Dean Channel, through Whitcone Peak and the eastern flank of Crawford Peak and continues north out of the area. This shear zone continues south into the Bella Coola map area, where it connects into the Pootlass shear zone (Haggart *et al*., 2004). The shear zone is recognized in plutonic rocks by the presence of pervasive near-vertical fracture planes and locally intense foliation development, manifested by mineral realignment and the stretching and reorientation of xenoliths and metamorphic screens. On the eastern flank of Crawford Peak, graphitic phyllite, chloritic schist, clastic metasedimentary rocks and metavolcanic rocks are incorporated in the shear zone. Well-developed kink bands, isoclinal folds with moderately plunging (30–35°) fold axes clearly indicate dextral transpression. Offset of the previously described Mt. Waddington fold and thrust system, which reappears on the east side of the shear zone south of the Dean River, suggests an offset of approximately 20–25 km. The southern continuation of this shear zone, the Pootlass shear zone, is truncated by the ca. 70 Ma Four Mile plutonic suite, providing a maximum age of transpressional deformation (Haggart *et al*., 2004).

High-Angle Normal Faults

Several major northwest to west-trending normal faults juxtapose rocks of all ages in the southern Whitesail Lake map area. The most prominent high-angle fault in the area trends northwest from Tesla Mountain toward Salahagen Lake (Fig. 2). At its north end, this structure clearly drops Monarch assemblage volcanic rocks down to the south relative to Hazelton Group strata to the north (Fig. 2). This offset changes to the southeast, where it places Hazelton Group on Hazelton Group in the vicinity of Tesla Mountain. In the Tesla Mountain area, the type and magnitude of offset are not constrained, although there appears to be a significant counterclockwise rotation across the structure (Gordee *et al*., this volume).

A second major normal fault occurs on the west side of the previously discussed shear zone, where a west-trending normal fault truncates the northern end of the Mt. Waddington fold and thrust belt. The age of normal faulting in the region is poorly constrained, but must be Late Cretaceous or younger, based on the presumed age of truncated structures.

ECONOMIC POTENTIAL

The primary focus of this investigation was to assess the economic mineral potential of Mesozoic volcanogenic assemblages and Jurassic to Tertiary plutonic rocks in the southern Whitesail Lake map area. Preliminary analysis of bedrock geological mapping suggests that there are three potential targets of economic importance:

Volcanogenic Massive Sulphide Deposits within the Hazelton Group

Mapping described herein has substantially expanded the known areal extent of Hazelton Group stratigraphy in this region. Rocks previously mapped as Cretaceous Kasalka or Gambier groups by Woodsworth (1980) have been reassigned to the Middle Jurassic Hazelton Group. Preliminary facies analysis, geochronology and geochemistry from this area and the Bella Coola area to the south (Diakow *et al*., 2003) indicate that these rocks are age equivalent to hostrocks for the Eskay Creek VMS deposit, and are characterized by predominantly shallow-water deposition, probably in a rifted arc setting. The similarities between these strata and those in the Eskay Creek area suggest that the Hazelton Group in the southern Whitesail Lake area is highly prospective for VMS mineralization. Volcanogenic massive sulphide mineralization has been documented at the Nifty property to the south, and the occurrence of extensive rhyolitic stratigraphy, rhyolite domes, and potentially synvolcanic extensional faults suggest that Hazelton Group stratigraphy in the southern Whitesail Lake map area may represent an important new economic target. Details of this stratigraphy and economic potential are provided in a companion paper (Gordee *et al*., this volume)

Monarch assemblage mineralization

Rocks of the Early Cretaceous Monarch assemblage are widespread to the south of the Whitesail Lake map area, where they are clearly imbricated within the Late Cretaceous Mt. Waddington fold and thrust system. These strata are apparently offset to the north into NTS 093E/03 by dextral translation associated with the Pootlass shear zone, a strand of the Coast Shear Zone. In this area, imbricate thrust panels of the Monarch assemblage host the Smaby deposit, which is interpreted to be a Noranda/Kuroko-type VMS deposit (Massey *et al*., 1999). Paleontological, geochronological and geochemical analyses will test this correlation. If correct, this would represent the first significant mineralization within the Monarch assemblage, suggesting that economic potential may exist within large areas to the northwest and southeast that are underlain by coeval strata.

Layered mafic intrusions

The large layered mafic intrusion (LMI; described above) within the Monarch assemblage appears to have strong potential for significant Cu-Ni sulphide and PGE mineralization. Some pyroxene-rich compositional layers (clinopyroxene gabbro) near the southwestern contact have substantial chalcopyrite (or Cu-Ni sulphide) mineralization, both as disseminated sulphides and as sulphide veins. In addition, the southwestern margin of the LMI is intruded by a K-feldspar megacrystic biotite granite of Paleogene (Eocene?) age, and the LMI near the contact displays weak hydrothermal alteration and significant Cu-Ni sulphide mineralization. Conversely, the granite has very little hydrothermal alteration, although there is minor sericitization of feldspars, and it displays only weak Cu mineralization, primarily as malachite and azurite coating fracture surfaces within a few tens of metres of contact. The contact zone between the LMI and the granite is well exposed in a zone of glacial scour in the saddle between Chatsquot Mountain and the ridge to the southeast, where the contact is a breccia zone 50–100 m wide with clasts of both LMI and granite in a matrix of open stockwork quartz veins. The stockwork in the LMI consists of quartz, pyrite and molybdenite veins with substantial molybdenite mineralization (MoS > FeS_2). The LMI and the associated rocks along its contact may prove to be an interesting target for more detailed study.

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