Middle Jurassic Stratigraphy Hosting Volcanogenic Massive Sulphide Mineralization in Eastern Bella Coola Map Area (NTS 093/D), Southwest British Columbia

By L.J. Diakow[1], J.B. Mahoney[2], T.G. Gleeson[3], M.G. Hrudey[4], L.C. Struik[5] and A.D. Johnson[2]

KEYWORDS: *Regional Mapping, Bella Coola, Middle Jurassic, Hazelton Group, Volcanogenic Massive Sulphide, Nifty.*

INTRODUCTION

Eastern Bella Coola map area (NTS 93D) is considered highly prospective for metallic minerals because arc volcanic-sedimentary assemblages of both Middle Jurassic and Early Cretaceous age occur in the area. These rocks are potentially correlative with coeval strata known elsewhere to host important volcanogenic massive sulphide deposits, including the Jurassic Eskay Creek deposit to the north and the Early Cretaceous Britannia deposit to the south.

This work is a part of the Bella Coola Targeted Geoscience Initiative (TGI) whose primary objective is to improve understanding of the geology underlying the eastern half of the Bella Coola map area in order to evaluate the potential of arc-related volcano-sedimentary rocks for volcanogenic massive sulphide deposits. An additional goal is to place the geology of the eastern Bella Coola region into a regional context; for example, to evaluate potential linkages between this area and Late Cretaceous and Eocene porphyry belts found in the Whitesail Lake map area (NTS 93E) to the north.

This paper emphasizes results of the Bella Coola TGI related to Middle Jurassic volcano-sedimentary stratigraphy of the Hazelton Group. Regionally, the Middle Jurassic Hazelton Group in Stikinia locally hosts stratabound and stratiform massive sulphides deposited synchronously with submarine silica-bimodal volcanic rocks and sedimentary rocks. Our aim is to examine the internal character of volcanic sequences and contained mineral deposits to improve our understanding of the metallogenesis and history of Mesozoic arc generated magmatism along the western margin of the Stikine terrane in southwest and central British Columbia.

[1] *British Columbia Ministry of Energy and Mines*
[2] *University of Wisconsin*
[3] *Simon Fraser University*
[4] *University of Calgary*
[5] *Geological Survey of Canada*

ACCESS AND PHYSIOGRAPHY

The study area straddles a physiographic transition from mountainous terrain of the Kitimat Ranges in the west, sculpted by numerous active alpine glaciers, eastward to comparatively subdued forested topography of the Chilcotin Plateau. The majority of the Bella Coola area is rugged with steep-sided mountains covered at lower elevation by thick, nearly impenetrable coastal vegetation. Helicopter assistance is essential to gathering geological information efficiently during a relatively narrow window of suitable weather lasting from July into early September.

Highway 22 traverses the study area and provides an all-weather surface to Williams Lake, about 430 kilometres east. Relatively few logging roads extend from the highway up some of the major river valleys. Ground access to the historically most active exploration play in the area, the Nifty property, and a number of other nearby prospects is a challenging endeavor. The first part is via a good logging road that extends northward from the highway up Noosegulch River valley. The road ends at a bridge washout and beyond this point it is an arduous hike across steep talus slopes and through difficult bush to the Nifty property.

PREVIOUS AND PRESENT WORK

Systematic mapping of the Bella Coola map sheet by the Geological Survey of Canada was conducted between 1962 and 1965 as part of the Coast Mountain Project, an umbrella program involving several simultaneous mapping studies that collectively established the geological framework of remote mountainous coastal terrain stretching nearly 700 kilometres from Vancouver to Prince Rupert. This program, completed in the mid-1970s, generated a number of 1:250 000-scale geological maps and accompanying reports, including one for the Bella Coola map area (Baer, 1973). Since completion of the Coast Mountain Project, selected areas between Bella Coola and Prince Rupert have been the subject of more detailed geologic and tectonic analyses (*e.g.* Stowell and McClelland, 2000 and references therein).

The impetus for new bedrock mapping aimed at producing a modern geological map and mineral potential reassessment of the eastern half of Bella Coola map area stems from a number of factors. These include:

1) Existence of tracts of high mineral potential geology identified by reinterpretation of the geology and mineral potential of the Bella Coola area, as part of the British Columbia Mineral Potential Initiative-Mid-Coast Project (Bellefontaine and Alldrick, 1994, 1995);

2) Recognition of the importance and regional potential of Jurassic arc-volcanic rocks as host for significant volcanogenic massive sulphides of the Eskay Creek type (Massey *et al.,* 1999);

3) Recent work focused on the mineral occurrences in the eastern Bella Coola area. (Ray *et al*., 1998) characterized physical and chemical features of the Nifty occurrence, the principal stratiform sulphide occurrence in the region. This work yielded fundamental information useful for comparison to other potential exploration targets.

The Bella Coola Targeted Geoscience Initiative (TGI) is a new, two-year bedrock mapping program. Coordinated by the Geological Survey of Canada, it is implemented by scientists from both the federal and provincial geological surveys and the universities of British Columbia, and Wisconsin - Eau Claire. This program will examine a large region of volcanic strata underlying the eastern Bella Coola map area viewed as the most prospective for volcanic-hosted massive sulphide mineralization. In addition, the probability of southward extensions of Late Cretaceous or Eocene arc-magmatic suites associated with copper-molybdenum porphyry style deposits in the Whitesail Lake and Smithers map areas (Carter, 1981) will be examined. A regional stream sediment survey to quantify metal contents in watersheds of Bella Coola (NTS 93D) and adjoining parts of Laredo Sound (NTS 103A) map sheet is the focus of a joint Canada-Provincial geochemical survey that was conducted simultaneously with the bedrock programs in 2001 (Jackaman *et al.*, 2002; this volume).

In 2001, the Bella Coola TGI involved 1:50 000-scale bedrock mapping, encompassing roughly 2000 square kilometres situated between the Dean to Bella Coola rivers, and between Dean Channel and the boundary of Tweedsmuir Provincial Park. This region was arbitrarily subdivided into contiguous eastern and western study areas (Figure 1). Mapping data was digitally captured during more than 160 traverses in these areas. Geological results from the western study area are presented in a series of thematic geological reports that address Early Cretaceous stratigraphy (Struik *et al*., 2002), plutonic rock suites (Hrudey *et al*., 2002) and structural geology (Mahoney *et al*., 2002). This report focuses on the eastern study area, underlain mainly by Jurassic volcanic and sedimentary rocks that crop out to the east of the broad, deformed belt of Early Cretaceous rocks. We present a preliminary account of the lithological character,

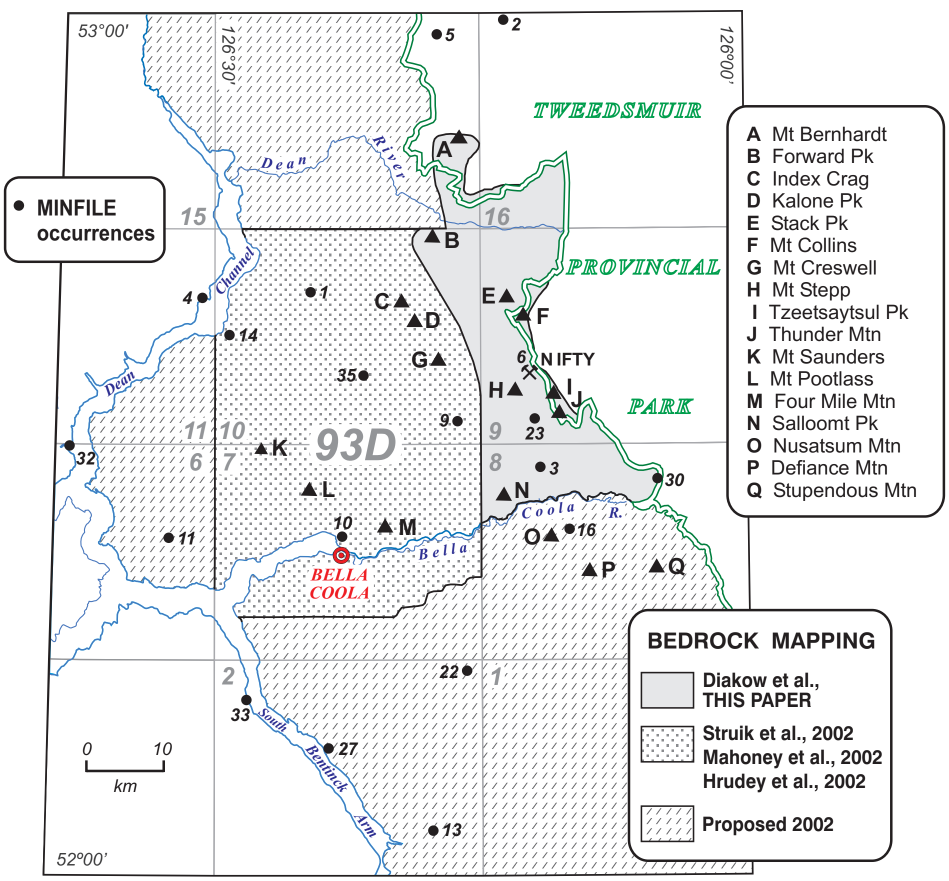

Figure 1. Geographic location map of eastern Bella Coola map area (93D), showing prominent peaks and major drainages. Field mapping during the 2001 field season was concentrated between the Bella Coola and Dean Rivers, in the area east of Dean Channel and west of Tweedsmuir Park. Letters refer to prominent peaks in the area, and dots correspond to MINFILE occurrences. Note location of Nifty prospect.

internal stratigraphic arrangement of various lithofacies and the relative position and setting of known mineral occurrences within this stratigraphy. A supplementary mapping project conducted in southern Tweedsmuir Provincial Park focused on structural and stratigraphic aspects of the Atnarko Complex (Isreal and Kennedy, 2002).

REGIONAL SETTING

The Bella Coola map area (93D) straddles the boundary between the Intermontane and Insular superterranes in west-central British Columbia. Intrusive and metamorphic rocks of the Coast Plutonic Complex dominate the western portion of the region, and separate rocks of Stikinia (Intermontane superterrane) from those of Wrangellia and possibly Alexander Terrane (Insular superterrane; Figure 2 inset). Metamorphic pendants of the Burke Channel Assemblage, a belt of supracrustal rocks exposed along the western margin of Stikinia, are exposed within the Coast Plutonic Complex east of the Coast Shear Zone (Figure 2; Boghossian and Gehrels, 2000). These rocks include quartzite, marble, biotite schist (metapelite) and lesser amphibolite (mafic volcanic rocks) and quartzite-cobble conglomerate. These rocks are lithologically and isotopically similar to continental margin assemblages to the north within the Coast Plutonic Complex (Boghossian and Gehrels, 2000).

At the latitude of Bella Coola, rocks of the Insular superterrane are restricted to the western side of the Coast Mountain Shear Zone (Figure 2). This structure is a 1200-kilometre long, northeast-side-up shear zone active mainly between approximately 65 and 55 Ma (Rusmore *et al*., 2000, and references therein). Andronicos *et al*. (1999) suggest this shear zone is a potentially major translational structure that may have accommodated 1000s of kilometres of displacement.

East of the Coast Mountain Shear Zone, granitic and metamorphic rocks of the Coast Plutonic Complex comprise the western boundary of Jurassic and Cretaceous arc-related volcano-sedimentary sequences spatially associated with a diverse suite(s) of syn- and post volcanic plutons. These two contrasting lithostratigraphic groups are exposed in parallel northwest-trending belts that include from east to west, 1) bimodal volcanic strata and related volcanogenic sedimentary rocks of the Hazelton Group (Baer, 1973); and 2) the informally named Monarch volcanics (van der Heyden, 1990, 1991; Rusmore *et al.*, 2000), a thick succession of Early Cretaceous volcanic and sedimentary rocks. Plutons of probable Jurassic to Tertiary age intrude both belts, but are volumetrically more abundant in the western belt (Baer, 1973).

Although this report focuses on the stratigraphy of the Hazelton Group, a summary of the Monarch volcanics, plutonic assemblages and the structural setting of the adjoining western belt, described in detail in companion papers (Struik *et al*., 2002; Hrudey *et al.*, 2002; Mahoney *et al*., 2002), is presented below.

The informally named Monarch sequence forms a thick succession of andesitic flows, fragmental rocks, volcaniclastic sandstone, tuffs and slates underlying a broad region west of Noosgulch River and Kalone Creek (Struik *et al.*, 2002). Olive green dacite to andesite flows and associated tuff breccias dominate the succession, although intercalated sediments form continuous stratigraphic sections up to several hundred metres in thickness. Stratigraphy within this sequence is complicated by abrupt lateral facies changes and structural deformation. The base of the section is exposed in one locality north of Salloomt Peak, where polymictic conglomerate with plutonic and volcanic clasts gradationally overlie a quartz diorite pluton which yields a 134 ± 0.3 Ma U-Pb zircon age (van der Heyden, 1991). The contact between the Monarch volcanics and the Hazelton Group has not been found in the map area.

Probable Jurassic to Tertiary, on average intermediate composition, intrusive rocks form volumetrically significant plutons cutting both the Monarch sequence and the Hazelton Group to the east (Hrudey *et al*., 2002). These plutons range from very fine to medium-grained diorite and microdiorite associated with the Hazelton Group to fine to coarse-grained hornblende and pyroxene-bearing quartz diorite, diorite, granodiorite and gabbro, hornblende and biotite-bearing granodiorite and tonalite, and hornblende-biotite granite. These plutons are generally massive, and magmatic and structural foliations are evident locally. The oldest known intrusive rocks, inferred to be subvolcanic plutons associated with the Middle Jurassic Hazelton Group, consist of diorite and microdiorite that appears to have been intruded prior to deposition of the Early Cretaceous Monarch sequence

Rocks in the eastern Bella Coola map area have been affected by several distinct deformational events recording episodic extensional, contractional, and transpressional tectonism in the region (Mahoney *et al*., 2002; Isreal and Kennedy, 2002). The timing is equivocal; the contractional and transpressional events are relatively well constrained by crosscutting relations, whereas the timing of the extensional events is less clear. The widespread occurrence of north-trending basalt to andesite dikes and dike swarms spatially associated with both the Hazelton Group and the Monarch sequence suggests that east-west extensional events may have been an important factor in arc development during both Middle Jurassic and Early Cretaceous time.

A well developed system of northwest-trending, northeast-vergent folds and subordinate thrust faults is associated with the Monarch sequence in the central portion of the map area. Structures vary from outcrop-scale, close to tight, locally isoclinal, asymmetric to map-scale recumbent shallowly to steeply plunging folds. The northeast-vergent fold system is inferred to be Late Cretaceous based on the age of folded strata and regional correlation with the eastern Waddington thrust belt (Rusmore and Woodsworth, 1994). Although rocks of the Hazelton Group in the eastern Bella Coola map area are tilted and locally openly folded, it is unclear if these structures are the same age as the Cretaceous (?) folds to the west. Hazelton Group may underlie a sub-Lower Cretaceous rock decollement surface, like some of the sub-Monarch volcanic plutonic suites to the west.

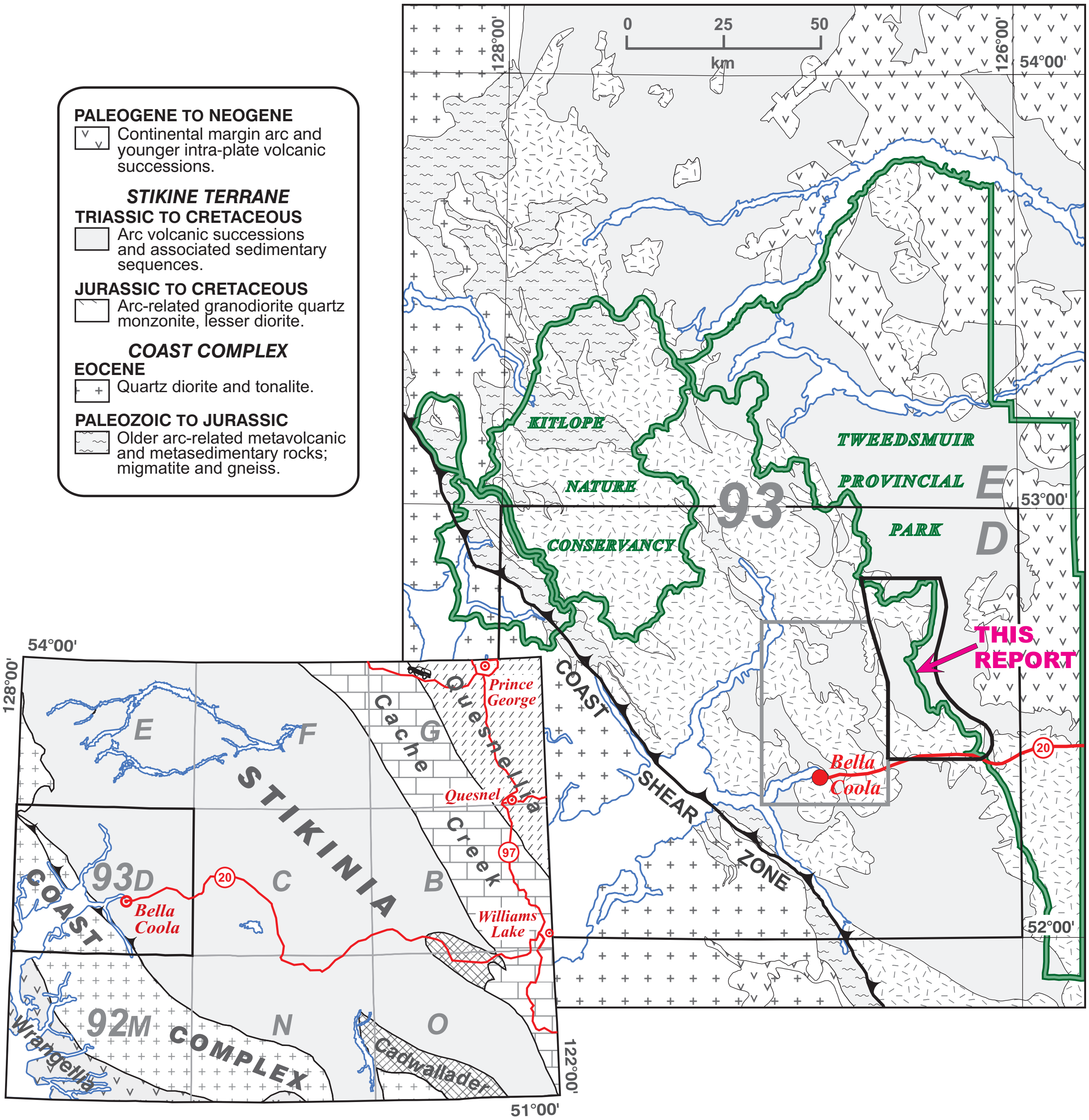

Figure 2. Schematic regional geologic map of Bella Coola (93D) and Whitesail Lake (93E) map areas and adjoining areas. Boxed areas indicate contiguous areas mapped during the 2001 field season. Inset map shows morphogeologic belts and terranes of the west-central Canadian Cordillera.

The contractional event is superceded by the development of a series of northwest-trending, steeply dipping ductile protomylonitic to mylonitic transpressional shear zones (10-1300 m wide), which affect most rocks in the western portion of the mapped area. These shear zones increase in concentration from east to west, although a similar deformational style is concentrated in the Atnarko Complex to the southeast (Israel and Kennedy, 2002). The shear system involves several different phases of Jurassic (?) to Cretaceous plutonic rocks and the Early Cretaceous Monarch sequence, and is itself cut by various probable Tertiary plutons. Shear sense indicators are equivocal; the shear zone apparently records extensive transpressional multi-directional flow. The high-angle shear zones are restricted to the western map area, and do not involve rocks of the Hazelton Group.

LITHOSTRATIGRAPHY

EARLY AND MIDDLE JURASSIC HAZELTON GROUP

The Hazelton Group is one of the most widely distributed Mesozoic arc-magmatic successions in the Canadian Cordillera, strung out along the entire length and breadth of the Stikine terrane. It is associated with significant mineral deposits, including Eskay Creek type volcanic-hosted massive sulphides (Roth *et al.*, 1999), epithermal gold, and associated copper-gold porphyry deposits in subvolcanic granitoids (Diakow *et al*., 1991; MacDonald *et al*., 1996). Over the past three decades, the Hazelton Group has attracted the attention of both the explorationist and geological surveys which resulted in considerable new and revised stratigraphic nomenclature that builds upon a Jurassic stratigraphic foundation established by Tipper and Richards (1976) in central British Columbia.

Rocks of the Hazelton Group consist of an island-arc volcano-sedimentary assemblage that broadly ranges in age from Early to Middle Jurassic (Hettangian to Bajocian). In general terms, the earliest record of arc constructional events in west-central Stikinia were subaerial and by Middle Jurassic time volcanism had waned. However, it still provided significant episodic input into a broad, shallow marine back-arc (?) or intra-arc (?) trough established to the east-southeast of the older, eroded subaerial centres.

Baer's (1973) work, coupled with fossil collections from pioneering reconnaissance exploration in central British Columbia (G.M. Dawson, 1878), show that Jurassic strata extend to the eastern boundary of the Bella Coola map sheet, well within Tweedsmuir Park. In that location, they are unconformably overlain by remnants of a moderately dissected peralkaline shield volcano forming the Rainbow Range (Bevier, 1981). The Rainbow Range is one of a number of Neogene volcanic centers and related alkaline plutons comprising the Anahim Volcanic Belt (Souther, 1977, 1986). Volcanic loci in this belt are scattered along a linear east-west tract at about 52° latitude, extending for 300 kilometres from the coast into the Chilcotin Plateau to the east (Souther and Yorath, 1992).

Jurassic rocks documented in the Bella Coola area by Baer (1973) were presumed to overlie an even more widely distributed greenstone assemblage of possible Triassic age. Recent findings of the Bella Coola TGI program reveal that the oldest Mesozoic rocks in the area include the Jurassic Hazelton Group, found mainly to the east (this report). These rocks pass farther west into a younger, Early Cretaceous volcano-sedimentary succession (Struik *et al.*, 2002). No Triassic or older strata have been found in the study area. An unconformable contact between Jurassic and Cretaceous sequences is suspected but has not yet been mapped. The Talcheazoone fault, inferred as steeply dipping, projects north northwesterly from east of Sallompt Peak and along much of its strike length separates folded and thrust faulted Cretaceous strata from tilted Hazelton Group strata. A belt dominated by dioritic intrusive complexes lies east of the Talcheazoone fault, although elements of these same intrusive complexes can be found in other parts of eastern Bella Coola map area (Figure 3; Hrudey *et al*., 2002).

Separation of Jurassic Hazelton Group from Early Cretaceous Monarch volcanics is sometimes equivocal in absence of interlayered fossil-bearing clastic rocks. However, in this study the differentiating field criteria included:

1) The Jurassic succession is dominated by crudely bedded, dark green, sometimes oxidized purplish flows of basalt to andesite composition containing plagioclase and augite phenocrysts. Rhyolitic pyroclastic rocks and less common aphanitic flows form areally restricted deposits bound by the more mafic rocks. These contrast with the Cretaceous volcanics in which fragmental rocks are generally more widespread than flows and have the bulk composition of andesite. These rocks are typically olive to light green-grey and exhibit aphanitic and plagiophryic textures, but also appear to contain notable hornblende phenocrysts.

2) Jurassic sedimentary rocks exhibit an intimate relationship with arc magmatism, manifest in volcanic interbeds and the high proportion of angular feldspar with or without quartz and volcanic lithic fragments in arkose, greywacke and volcanic lithic-bearing clastic rocks derived from nearby volcanic and/or plutonic sources. Tuffaceous argillite containing fossils are rare within the Jurassic succession. By contrast, Early Cretaceous strata include more prominent and regionally mapable black slate beds. These are interlayered with siltstone and sandstone that form discrete rusty weathered intervals 10s of metres thick within the volcanic rocks. Fossils including ammonites and other shelly fauna are abundant locally (Struik *et al.*, 2002).

In this study, the volcanic and sedimentary rocks comprising the Hazelton Group are subdivided into various lithofacies on the basis of continuity in overall lithologic characteristics and their original textures and structures. The distribution of these rocks is shown in figure 3. These lithofacies are described in order of decreasing relative prominence in which order of description makes no inference of superposition. Regionally, these rocks are in the sub-greenschist facies as the mafic rocks contain an assemblage of secondary chlorite, epidote and albite. The original

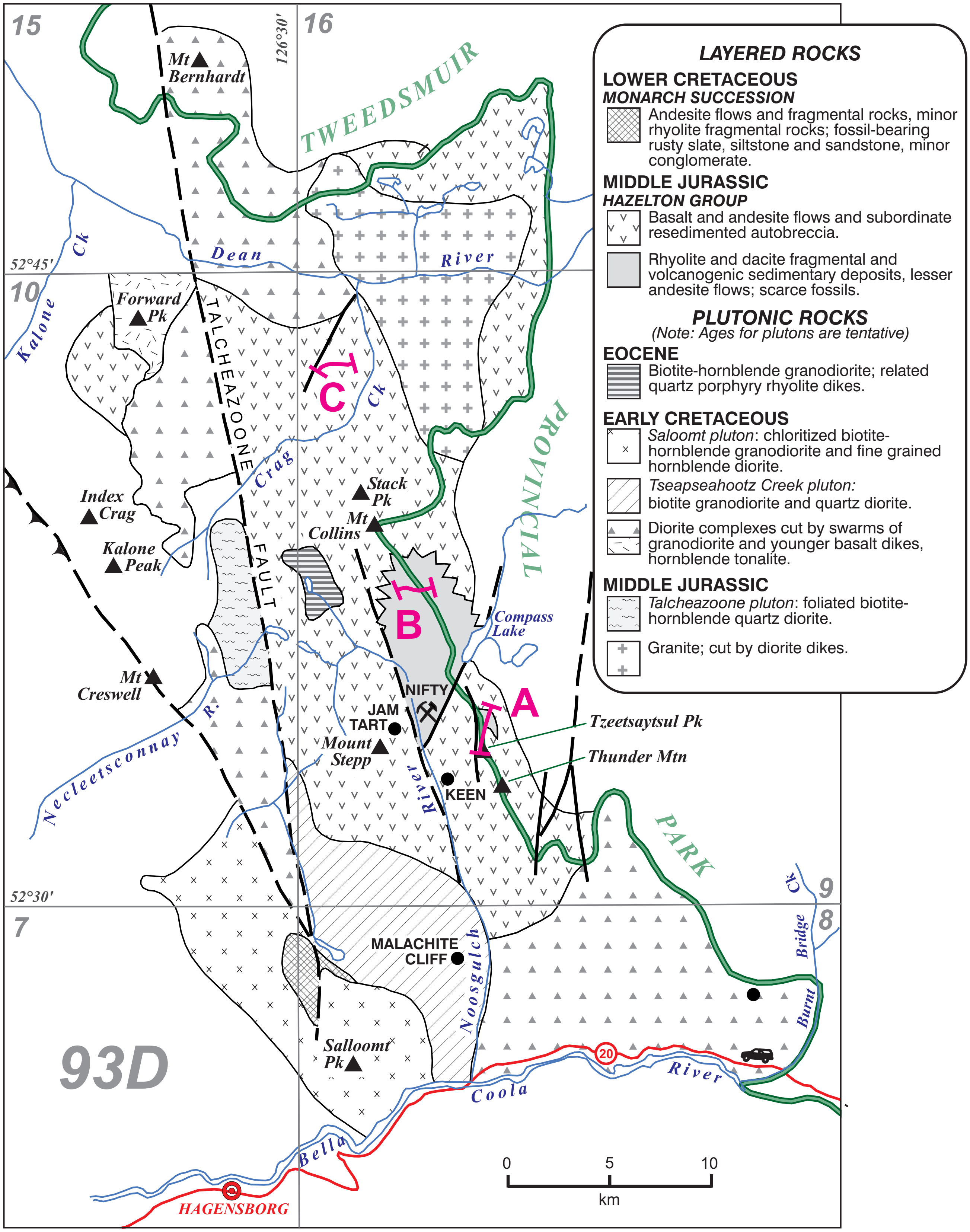

Figure 3. Schematic geology map of the eastern portion of the Bella Coola map sheet, bordering Tweedsmuir Provincial Park. Letters refer to stratigraphic columns (Figures 4,5 and 6) discussed in the text. Dots are MINFILE occurrences.

textures and fabrics within this mixed volcano-sedimentary succession are generally well preserved.

Bimodal Mafic-Intermediate and Lesser Rhyolitic Volcanic Rocks

Volumetrically, subaerial mafic to intermediate lava flows and associated breccias dominate probable Jurassic successions in the study area. Thick mafic volcanic sections are particularly well exposed at Tzeetsaytsul Peak and Thunder Mountain in the southeast. Thick accumulations of mafic to intermediate rocks crop out again farther northwest in the region between Mount Collins and Stack Peak, then across Crag Creek towards Forward Mountain. Locally these mafic volcanic rocks are interlayered with or faulted against felsic volcanic rocks. Representative stratigraphic sections described below are shown in figure 3 and detailed sections are presented in figures 4, 5 and 6. Composite diorite bodies cut by intermediate and mafic dike swarms, crop out immediately adjacent to the mafic volcanic unit in at least three areas leading us to speculate that they may be comagmatic. An alternate hypothesis is that such complexes may be Early Cretaceous (Hrudey *et al*., 2002) and related to extrusive rocks of the Monarch succession (Struik *et al.,* 2002); however, at this early stage of the program there is no compelling geochemical or geochronological data to verify either genetic association.

Tzeetsaytzul Peak and Thunder Mountain Area

At Thunder and Tzeetsaytzul mountains, more than 1100 metres of crudely layered volcanic strata dip between 25 and 40 degrees southwest toward the Noosgulch River valley. The volcanic rocks are dominated by basalt to andesite lava flows in excess of 750 metres thick, interlayered with related breccias. Dacite to rhyolite flows and tuffs have an aggregate thickness of about 250 metres. On the north side of Tzeetsaytzul Peak, these felsic rocks dominate the lower 200 metres of the section, and form a distinct interval within more mafic rocks approximately 120 metres down from the summit (Figure 4; Section A in Figure 3). A relatively short distance northwest of Tzeetsaytzul Peak, a high-angle fault trending northeast through Compass Lake truncates and juxtaposes the mafic succession against a dominantly felsic, shallow marine lithofacies.

The basalt and andesite flow and fragmental rocks have a massive character that at a distance, are discernable as a series of uniformly weathered, very thick planar beds. Oxidized reddish flow tops accompanied by autoclastic breccia have been observed only at one locality. The flows are typically dark grey-green to purplish green and exhibit amygdaloidal, porphyritic and aphanitic textures.

Amygdaloidal flow varieties are very common in the upper part of the section at Thunder and Tzeetsaytsul mountains. They contain rounded, irregular, and stretched amygdules ranging from several millimetres up to 30 millimetres in diameter, which are infilled with either quartz or chlorite or a combination of these minerals, with or without epidote. Quartz is generally clear and crystalline, growing inwards from an outer concentric shell composed of chlorite; however, in a few places it is a translucent variety of chalcedony. The porphyritic texture in the flows is imparted by randomly oriented blocky plagioclase phenocrysts 1-4 mm in amounts rarely more than 20 to 25%. Rare andesitic lavas may contain plagioclase laths between 6 and 13 millimetres. In addition to plagioclase, augite phenocrysts are ubiquitous, present as grains ranging from 1 to 3 millimetres in amounts commonly up to 7%. Rare hornblende phenocrysts accompany augite in some andesites. In thin section, the hornblende is corroded, surrounded typically by an opacite rim.

Autoclastic rocks forming irregular deposits between lava flows are relatively common in the vicinity of Tzeetsaytzul Peak. These deposits characteristically contain basaltic monomict porphyry fragments composed of fine-grained, crowded, plagioclase and lesser augite phenocrysts. They are poorly sorted and unstructured containing subangular to subrounded blocks that are fragment supported and matrix poor or in similar matrix composed of finer granulated fragments. Some of the fragments exceed one metre in diameter. These deposits may represent variably reworked and redeposited autobreccia, although, in general, the flow succession lacks in-situ fragmented and oxidized tops and bottoms common in subaerially erupted lavas.

Felsic rocks observed in two intervals on the north slope of Tzeetsaytzul Peak appear to be stratigraphically bound by mafic volcanic rocks. The lower section consists of as much as 200 metres of dacite to rhyolite lava flows having a somewhat bulbous cross section. Adjacent rocks are mafic breccias and the upper contact, which was not mapped, is assumed to be with massive mafic flows. Except for relict flow laminae and spherulitic texture, these flows are aphanitic and massive in appearance. Rare, volcanic breccia containing subangular blocks of laminated rhyolite is spatially associated with the more massive flows. The upper felsic interval, about 50 to 70 metres thick, is located near the top of Tzeetsaytsul Peak. It comprises mainly light green lapilli tuffs characterized by white weathering angular rhyolitic fragments. Welded texture is observed in several thin intervals within this otherwise massive nonwelded deposit.

Mount Collins to Forward Mountain Area

Mount Collins and connected ridges to the north and east are underlain by a large volume of mafic and intermediate flows lithologically similar to those at Thunder and Tzeetsaytsul mountains (Figure 3). East of Mount Collins coarse breccias identical to those described at Tzeetsaytsul Peak are prominent within the mafic sequence. Mainly porphyritic flows with plagioclase and lesser augite phenocrysts form the ridges across a drainage divide immediately west of Mount Collins. These flows are associated with volcanic breccia, finer bedded tuffs and thin lenticular interbeds of locally welded rhyolitic tuff.

The volcanic sequence west of Mount Collins area has a chlorite-rich aureole surrounding a biotite-hornblende granodiorite stock. Quartz-feldspar porphyry dikes ranging up to 20 metres wide appear to project outward from the stock cutting adjacent country rocks. Such felsic hypabyssal

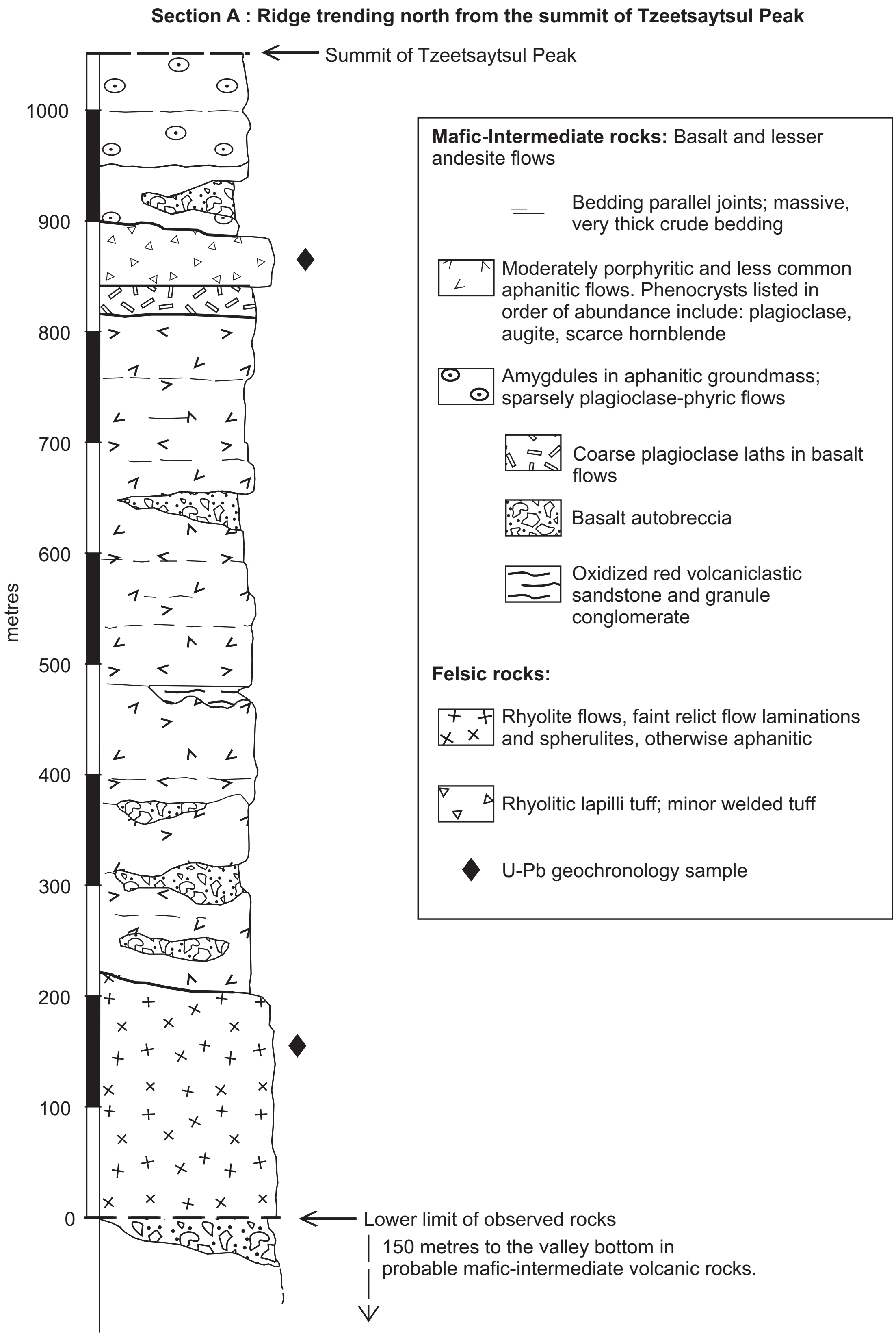

Figure 4. Stratigraphic section of the mafic volcanic facies exposed on the north flank of Tzeetsaytsul Peak. Base of section not exposed; upper limit is the modern erosion surface. Note the bimodal nature of the succession.

rocks are prominent mainly in the area between Stack Peak and Mount Collins where interestingly, they are also spatially associated with rhyolitic rocks that comprise a well-bedded subaqueous volcaniclastic succession.

Presently, the northern extent of the mafic volcanic sequence is in the vicinity of Forward Peak, occupying an area west of the inferred Talcheazoone fault. Aphanitic and lesser porphyritic basalts, similar to those found elsewhere, predominate. Additionally, there are significant lapilli tuffs, some with white felsic fragments, quartz-feldspar crystal tuffs and in a few places substantial rhyolite sills (?). A moderate foliation is developed in tuffs and is particularly noticeable in those containing stretched felsic fragments.

West of Crag Creek a sequence of mafic lavas having lithologic features similar to those near Mount Collins appear to unconformably overlie a distinctive sequence of sedimentary rocks (Figure 5; Section C in Figure 3). Because the lower contact of the sedimentary rocks was not observed, it is unclear whether these sediments are underlain by more mafic flows similar to those stratigraphically above, or are in fact an older unit. However, Baer (page 30, 1973) describes geology underlying a ridge south of the junction between Crag Creek and Dean River that is presumed to be an along strike extension immediately north of Section C. In this section a fossil-bearing thin carbonate unit, thought to be correlative with belemnite-bearing tuffaceous mudstones in Section C, appears to occupy a relatively thin interval in a mafic volcanic sequence.

In section C, the lower contact of the overlying mafic sequence is sharp, marked by a change in bedding that is inclined at a high angle relative to the underlying sedimentary rocks. In the west this sequence is truncated by a high angle fault that places it against quartz-bearing rhyolite lapilli tuffs. The lava flows are relatively thin and separated by clastic rocks derived from the flows. The clastic rocks consist of granule and pebble conglomerates and well-layered feldspar-rich sandstones. The clasts are composed of abundant angular pyroxene grains and, monomict basalt that are subrounded and tightly packed. The clasts commonly weather positively where the carbonate cement has been dissolved.

Fossil-bearing Sedimentary Rocks West of Crag Creek

Sedimentary rocks underlying mafic rocks in section C comprise about 75 metres of thinly bedded volcanogenic mudstone, siltstone and sandstone. Tuffaceous mudstone dominates the lower 25 metres of exposure. The sedimentary rocks exhibit distinctive parallel banding due to thinly bedded off-white ash tuff layers alternating with black mudstone. These are interbedded with feldspathic siltstone, sandstone, and minor granule conglomerate, which become more prevalent upsection. Welded tuff containing chloritic fiamme and an andesite flow or sill crop out in the middle of the section and attest to the volcanogenic origin of the interbedded sedimentary rocks. Fossils from wackes collected by Baer (1973) at this site were recently re-examined and reported to contain a diverse collection of bivalves and some belemnoids all of which are non diagnostic Jurassic forms (pers. comm. T.P. Poulton; Report No. J4-2001-TPP).

Rhyolitic Pyroclastic and Resedimented Pyroclastic Deposits

Mount Collins South to the Nifty Mineral Occurrence

Ridges south of Mount Collins are underlain by a thick succession of rhyolitic pyroclastic and resedimented pyroclastic strata that contrast markedly with the dominantly mafic character of the Hazelton Group to the north and south. This felsic succession seems to form an areally restricted lense enclosed by more mafic components of the Hazelton Group. Over 1000 metres of rhyolitic volcaniclastic rocks are well exposed in an east-dipping homocline south of Mount Collins (Figure 6; Section B in Figure 3). The base of the section is interpreted to gradationally overlie andesitic breccias and subordinate flows cut by hypabyssal sills and dikes. Near the top of the felsic succession interbeds of mafic volcaniclastic strata suggest a gradational or lateral interfingering relationship with mafic volcanogenic sedimentary rocks lying to the east and north.

The rhyolitic succession comprising section B (Figure 6) may be subdivided into two distinct lithofacies. These include a lower dominantly coarse tuff facies that passes gradationally upwards into thick planar bedded, volcanogenic sedimentary deposits.

Rhyolite Tuff Lithofacies

The lower ~420 metres of strata is characterized by diffusely bedded to massive rhyolitic lapilli tuff and tuff breccia, intercalated locally with resedimented pyroclastic debris. Individual beds are up to 5 metres thick, and are typically composed of poorly sorted, angular, pebble to cobble-sized clasts of aphanitic felsic volcanic rock floating in a coarse-grained volcaniclastic matrix. Rounded clasts and crude laminations are locally evident, suggesting reworking of volcaniclastic debris. Thick (>4 m) lenticular beds of clast-supported volcanic boulder conglomerate are locally evident. Quartz-phyric rhyolite dikes, sills and rare welded lapilli tuff occur sporadically throughout the sequence. Thin basaltic flows form a minor, yet genetically important, portion of the sequence. Units are distinctly lenticular, and the sequence is characterized by rapid lateral facies changes.

Resedimented Syn-eruptive Volcaniclastic Lithofacies

The rhyolite tuff lithofacies is sharply overlain by more than 600 metres of well-bedded volcaniclastic conglomerate, sandstone, siltstone and subordinate primary volcanic deposits comprised of welded and nonwelded lapilli tuff and rare accretionary lapilli tuff. The lowermost beds consist of a 20 to 30 metre section of tuffaceous black mudstone interbedded with dark gray, parallel and locally cross laminated, feldspathic sandstone and siltstone. White ash-tuff laminae in black mudstones mark the base, and closely resemble those found at the bottom of lithologically similar mudstones and feldspathic sandstone occupying the lower part of Section C, west of Crag Creek (*see* Figure 5 for details). This sequence is gradationally overlain by 100s of metres of thickly bedded to massive, coarse-grained feldspathic arenite and intercalated matrix-supported volca-

Section C : Ridge west of Crag Creek (starting point at treeline); 6.8 kilometres at 343° azimuth from the summit of Mount Collins (UTM 09 670287E, 5843542N)

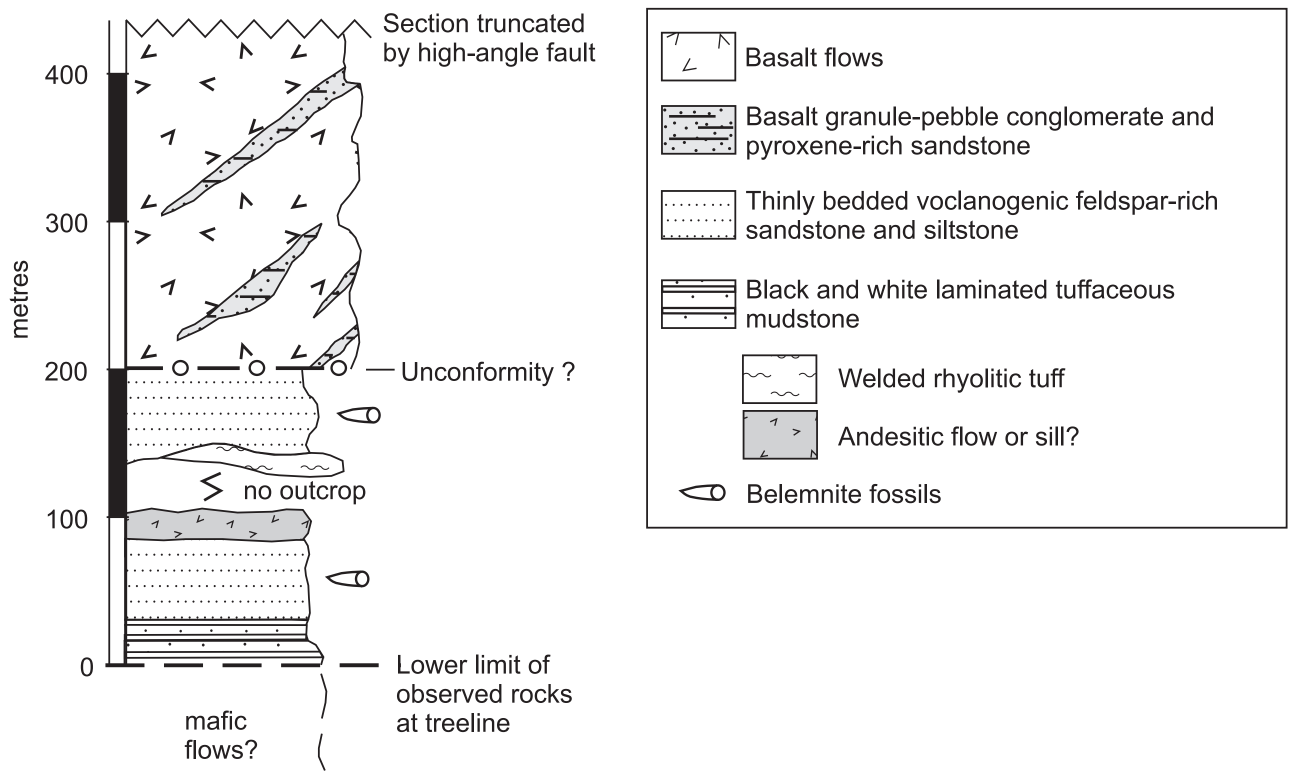

Figure 5. Stratigraphic section of the mafic volcanic facies and underlying volcanogenic sedimentary facies exposed on an east-facing slope west of Crag Creek. Base of the section is not exposed; upper limit is the modern erosion surface.

nic pebble conglomerate. Graded bedding and convolute laminations are common; most units appear tabular and laterally continuous. Rare welded quartz-bearing rhyolite ash-flow tuff occupies intervals up to 25 metres thick interbedded with quartz-rich sandstone and volcanic sharpstone conglomerate. Felsic fiamme define a pronounced eutaxitic texture in several intervals of the welded rhyolites. Quartz and feldspar arenite sandstones interlayered with lesser rhyolite granule and pebble conglomerates dominate massive beds in the upper portion of the section. Polycrystalline quartz, probably derived from a plutonic source, is found in some of these arenites. Laminated and massive ash tuffs up to 40 metres thick and a rare, accretionary lapilli tuff bed several metres thick are interlayered with these clastic rocks and attest to syn-sedimentary explosive volcanic eruptions.

Near the top of the exposed section light colored resedimented rhyolitic volcaniclastic rocks are gradationally overlain by 30 metres of dark green and purple basalt pebble conglomerate and coarse-grained sandstone. These conglomerates and sandstones are characterized by an abundance of coarse sand to granule-sized volcanic lithic clasts of finely amygdaloidal and vesicular basalt. A thin basaltic andesite sill or flow occurs within these mafic clastic rocks. These mafic conglomerates exhibit distinctive differential weathering in which tightly packed basalt clasts are separated by voids that evidently result from the dissolution of carbonate cement. A similar feature was also noted in nearly identical mafic conglomerates and sandstones found as lenticular beds within mafic flows directly overlying tuffaceous mudstone and feldspathic sandstone west of Crag Creek (*see* Figure 5 for details). In turn these mafic deposits are sharply overlain by reddish oxidized siltstone with oscillation ripples in the topmost bed of section B.

Felsic volcanogenic sedimentary rocks comprising most of section B dip moderately southeast, below topographically lower terrain west of Compass Lake. Felsic strata then continue to the southwest where they comprise part of the hangingwall succession for the stratiform mineralization at Nifty. Farther east-southeast of Nifty, the felsic volcanic succession is cut off by a northeast striking fault whose trace projects through Compass Lake. Across this structure the felsic sequence is juxtaposed against the mafic volcanic succession underlying Tzeetsaytsul and Thunder mountains.

On the north side of an east-west trending valley, occupied in part by Compass Lake, white weathered rhyolite forms a series of scattered low lying knolls. These rocks are aphanitic and locally display diffuse flow laminae. Although interpreted as lava flows, their uniform texture, ab-

Section B : Centred 3.1 kilometres at 149° azimuth from the summit of Mount Collins
(UTM 09 674000E, 5834370N)

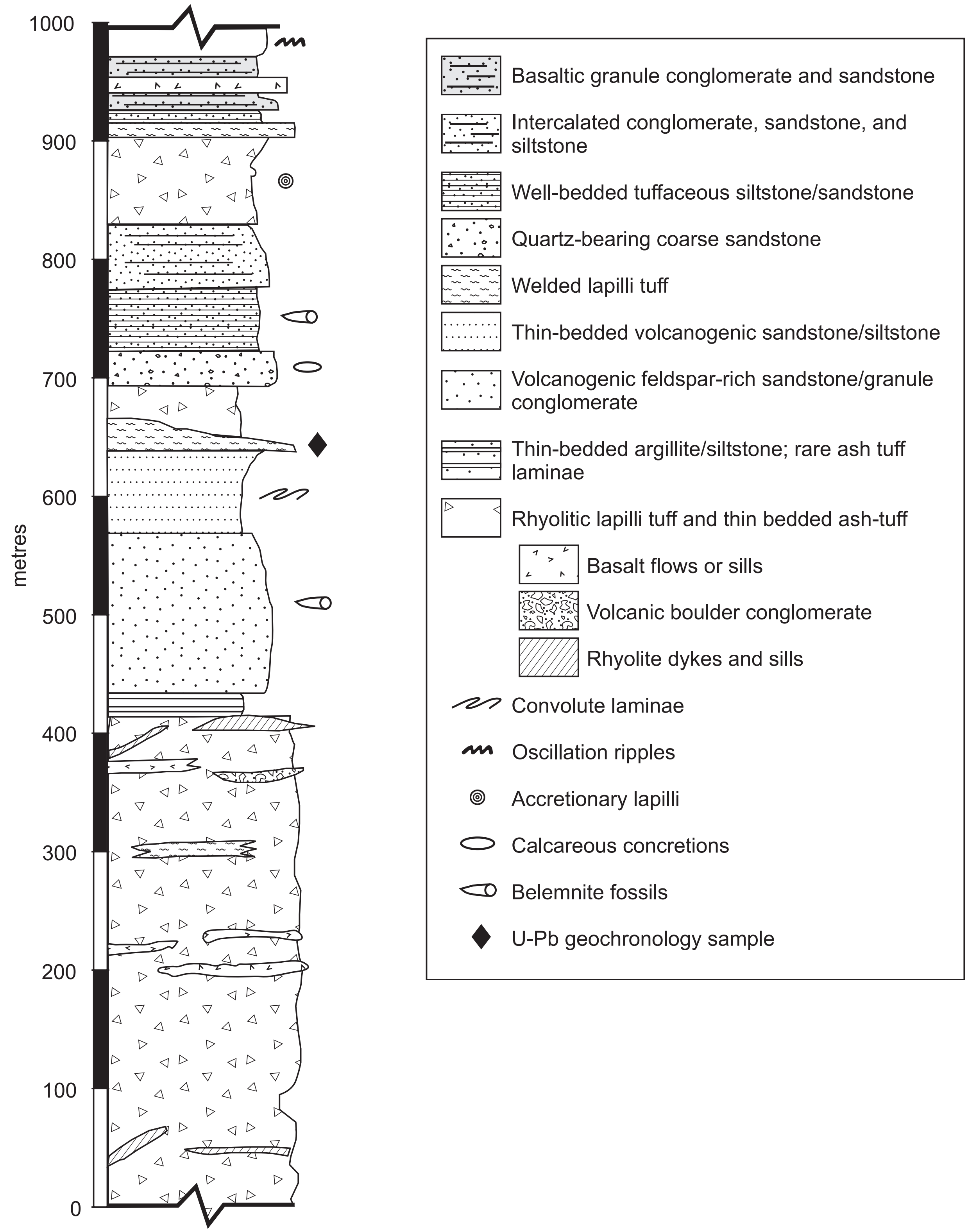

Figure 6. Stratigraphic section of the rhyolitic facies exposed on the west-facing slope of an unnamed mountain south of Mount Collins. Base of section is not exposed; upper limit is the modern erosion surface.

sence of related autoclastic rocks and common occurrence of finely disseminated pyrite suggests they might be part of a subvolcanic intrusive dome. South of the east-west trending valley, near the Nifty occurrence, aphanitic rhyolite is found, but accompanied by lesser lapilli tuffs. The fragments consist mainly of subangular aphanitic white rhyolite and fewer, fine-grained plagioclase porphyries. Quartz is often present in the matrix as grains several millimeters in diameter.

Volcanic strata hosting stratiform sulphides and barite at the Nifty occurrence were re-examined in some detail by Ray *et al.* (1998), who synthesized published geology and provided new information on the geochemistry of the host rocks and mineralization. Rocks immediately overlying the mineralized interval at Nifty have been disrupted by faults, which rotate the layered sequence from subvertical to gentler dips. In turn, strata have been cut by several generations of northeast to east trending steeply dipping post-mineralization dikes composed of andesite and quartz porphyry rhyolite.

Above the sulphide and capping barite mineralization near the adit, the stratigraphy consists of alternating orange and white weathering ash tuffs containing subordinate lapilli tuffs. Fragments invariably consist of aphanitic white rhyolite lapilli set in a finer aggregate of volcanic lithics, plagioclase and a few quartz crystals. These felsic tuffs are sharply overlain by a conformable sequence of dark green aphanitic rocks, which near the base comprise thin parallel-layered ash-tuff or volcanic siltstone and mudstone. In turn these rocks grade imperceptibly upwards into other dark green massive rocks with aphanitic texture, interpreted as lava flows.

Ray *et al.* (1998) shows that in the vicinity of Nifty the hangingwall stratigraphy is dominated by tholeiitic and calcalkaline basalt and andesite, interbedded with volumetrically lesser calcalkaline rhyodacite tuff and minor devitrified lava flows. Footwall strata were not examined during this study; however, Ray *et al*. (1998) documented pervasive bleaching accompanied by the addition of silica and pyrite to the tuffs and flows of probable dacite and andesite composition.

Mixed Mafic-felsic Clastic Lithofacies

Mafic clastic rocks near the top of section B are believed to grade upwards into a dominantly mafic volcanogenic sedimentary succession widely exposed at lower elevation immediately to the east and north of section B. Currently, little is known about these deposits other than that they consist of medium to thick bedded mafic volcaniclastic sandstone, siltstone and lesser conglomerate, estimated to be in the order of several hundred metres thick. These clastic rocks contain diagnostic quartz grains, angular black mudstone and basaltic debris, which suggests rapid dissection of a lithologically varied provenance region or mixing of detritus derived from both felsic and mafic sources. The exact nature of the transition with resedimented felsic volcaniclastic rocks dominant to the west in section B is unclear. The felsic and basaltic sedimentary successions may interfinger over a few 100 metres, or the contact may represent a buttress unconformity or fault.

DEPOSITIONAL ENVIRONMENT

Volcanic rocks in the study area are broadly divided into two compositional clans - a regionally prominent, mainly basalt flow sequence containing subordinate rhyolitic tuffs and scarce interflow sedimentary rocks, and an adjacent succession composed mainly of rhyolitic volcanogenic sedimentary rocks interspersed with rhyolitic pyroclastic deposits. These felsic pyroclastic rocks appear to change laterally into a more massive rhyolite flow-tuff facies that has a distinctly bimodal character and is associated with stratiform sulphide-barite mineralization and crosscutting felsic to intermediate dikes. The temporal relationship of these two contrasting packages is presently poorly constrained. They appear to interfinger laterally and are in part coeval volcanic sequences that evolved relatively close to one another. Although geochemical analysis for the volcanic rocks discussed are not yet available, geochemistry of country and hypabyssal rocks in the vicinity of Nifty suggest the rhyolites and basalts are volcanic arc related (Ray *et al*., 1998).

Tzeetsaytsul Peak-Thunder Mountain, Mount Collins and Stack Peak all composed of thick, crudely layered sequences of dark green and purplish basalt and lesser andesite flows. Individual flows, several 10s of metres thick, grade imperceptibly through combinations of aphanitic, plagiophyric and amygdaloidal textures. Very rarely is an actual flow contact observed, indicated by red oxidation accompanied by flow breccia. Interflow deposits of monomictic basalt breccia debris, that in places exhibit rounded clasts, are interpreted as redeposited autoclastic products derived possibly from flow breccias. Because the lava sequences are typically massive, uniformly layered and homogeneous, lacking pillows, hyaloclastites and well stratified waterlain tuffs; they probably reflect high volume and high effusion rate eruptions in a subaerial setting close to their source vent(s). Comparatively minor subaerial felsic flows and fragmental rocks evidently coalesce with the mafic rocks and indicate the bimodal nature of magmatism.

An abrupt change from mafic to felsic dominant successions corresponds with several steeply dipping faults which trend northwest, parallel to Noosgulch River, and an intersecting northeast fault passing through Compass Lake. These faults delimit rhyolitic rocks generally deposited in a shallow marine depocentre.

Topographically lowest and perhaps oldest rhyolitic rocks crop out south west of Compass Lake and consist of aphanitic rhyolites believed to be devitrified flows, and subordinate lapilli tuff and minor well-layered waterlain ash tuffs. To the north, the rhyolitic succession detailed at Section B, in the area south of Mount Collins, represents both subaerial and submarine deposition. The coarse pyroclastic lithofacies at the base of the section contains primary lapilli tuff, matrix-supported reworked pyroclastic debris, channelized clast-supported conglomerate, rare, thin, non-pillowed basalt flows and associated breccias and small rhyolitic flow domes. This assemblage suggests deposition on the relatively steep flanks of a rhyolitic eruptive centre adjacent to the distal reaches of a basaltic volcanic edifice. An abrupt change from underlying coarse pyroclastic lithofacies into overlying resedimented rhyolitic volcaniclastic lithofacies records a change towards sequential rhyolitic eruptive events punctuated by transport of large volumes of ash, crystals and lithic fragments in shallow water.

More than 600 metres of thick, uniformly bedded resedimented volcaniclastic rocks composed exclusively of rhyolitic fragments, crystals and ash, alternate with subordinate primary pyroclastic deposits in an overall shallowing upward sequence. The base of the sequence is composed of thin to medium-bedded, laterally continuous fine-grained rocks. These beds generally coarsen upward into thickly bedded coarse-grained sandstones with substantial pebble conglomerate. Sedimentary structures are abundant, and include graded bedding, parallel laminations, basal scour features, convolute laminations and matrix-supported pebble conglomerate. These features, together with distinctive thin to medium bedded couplets consisting of a basal structureless to parallel laminated sandstone overlain by a parallel to convolute laminated siltstone representing top-cut-out turbidite (AB) packets indicate submarine deposition by mass sediment gravity flow.

Submarine deposition is supported by the presence of belemnites and *Cruiziana* trace fossils. Water depth is equivocal, as these rocks could represent submarine fan deposition below normal wave base, or shallow marine deposition in a deltaic environment characterized by high sediment influx. Several measurements from convolute beds suggest sediment failure and transport on a northwest-southeast striking paleoslope that dipped west-southwest. The shallow water depositional setting is further supported by the presence of welded lapilli tuff and associated tuffaceous conglomerate and sandstone. An overall shallowing upward sequence is indicated by the increasing presence of primary volcanic rocks upsection including welded-tuff and lapilli tuff. Accretionary lapilli found immediately above a welded tuff record a brief interval of subaerial deposition and is followed by resumption in shallow water deposition marked by development of oscillatory wave ripples in siltstones occupying the upper portion of the lithofacies.

The rhyolitic succession interfingers with more mafic sediments in the upper 50 metres of the section. Oscillation ripples above and accretionary lapilli below these mafic strata indicate this interfingering occurred in a shallow marine depositional environment. Although the interfingering sediments appear compositionally distinct in outcrop, thin section petrography indicates sandstone beds are locally well mixed; containing a heterogeneous bimodal assemblage of basaltic tuff clasts intermixed with quartz and sanidine grains.

AGE OF VOLCANO-SEDIMENTARY ROCKS AND CORRELATION

The Middle Jurassic depositional ages for volcanic and sedimentary rocks of the Hazelton Group rocks of eastern Bella Coola map area are based on several isotopic dates from igneous rocks in the vicinity of the Nifty mineral prospect and inferred from ammonite fauna identified in sedimentary rocks lying outside the study area in the northeastern corner of the Bella Coola area.

Felsic volcaniclastic rocks exposed near Mount Collins are thought to be temporally equivalent to silica bimodal volcanic rocks that host the Nifty occurrence. In order to test this hypothesis, and to determine the timing of felsic volcanism locally associated with stratiform sulphide mineralization in the region, several samples have been collected for uranium-lead dating. A white weathered rhyolite north of Nifty (UTM Zone 09 675 208E, 5830012N) yields a range of provisional Middle Jurassic ages, and requires additional zircon fractions to obtain a more precise date (pers. comm., Mike Villeneuve, 2001). Ray *et al.* (1998) report a U-Pb date on zircon of 164.2+1.2/-0.9 Ma from a quartz rhyolite dike (UTM location: Zone 09 675150E, 5828850N). This dike is one in a swarm of northeast trending hypabyssal intrusives near the Nifty occurrence, where they cut volcanic strata hosting the sulphide-barite mineralization. This date, therefore, provides a minimum age for bimodal volcanism and syngenetic sulphide-barite mineralization in the Hazelton succession in the Bella Coola map area.

South of Mount Collins a welded ash-flow tuff about 25 metres thick, conformable with bounding subaqueous volcanogenic clastic rocks, is currently being processed for a U-Pb date (*see* Figure 6 for approximate position in section C; UTM location: Zone 09 673912E, 5834551N). The tuff contains fiamme up to 120 millimetres long in a white siliceous groundmass that contains sparse quartz phenocrysts and microscopic sanidine grains. This date will provide information on the contemporaneity of rhyolitic deposits near Mount Collins with those closer to Nifty.

Comparison of depositional ages for the felsic volcaniclastic facies and mafic flow facies will be achieved by dating two samples of felsic rocks occupying intervals within depositionally conformable mafic volcanic rocks at Tzeetsaytzul Peak. These age determinations will partly bracket the timing of mafic volcanism and provide a temporal relationship with bimodal volcanic rocks associated with massive sulphides at Nifty. The lower of the two sites is from the upper portion of approximately 250 metres of aphanitic rhyolite interpreted as a flow dome; and, the second sample is from a thin, welded zone in a rhyolite lapilli tuff succession near the top of Tzeetsaytzul Peak (*see* Figure 4 for approximate positions in section A; respective UTM locations Zone 09 677545E, 5828855N and 677417E, 5827245N).

Volcanic derived feldspar and quartz-bearing sedimentary rocks intercalated with primary volcanic rocks south of Mount Collins contain sparsely distributed, non-diagnostic belemnoids and *Cruiziana* trace fossils. However, at another locality close to Mount Collins a collection of bivalves have been previously identified by Dr. J.A. Jeletsky as Callovian to Early Oxfordian in age. At a new fossil locality, one and one half kilometres southeast of Mount Collins, ammonites occur within rare limey lenses in a twenty five metre thick interval of thinly bedded black siltstone and sandstone that occurs stratigraphically beneath coarse mafic sandstones that lay to the east and north of strata comprising Section B (GSC location C-306159; Zone 09 673800E, 583625N). Poor preservation of these ammonites prevents positive identification (pers. comm. J. Haggart; Report No. 2001-7), however, further examination of this locality is planned.

Recent re-examination of the Geological Survey of Canada's archived fossil collections from the Bella Coola area by Dr. T.P. Poulton include several collections made from a ridge south of the confluence of Crag Creek and Dean Rivers (GSC Locations 65045 and 65046). These collections, reported in Baer (1973, pages 32 and 33), are from a feldspathic wacke associated with limestone situated between massive basaltic lavas. Sedimentary strata in this section are believed to continue immediately south, correlating with a gently dipping sequence of volcanogenic sandstones and tuffaceous mudstones forming the lower part of Section C (Figure 5). Scarce belemnites were found in these shallow marine rocks in Section C and comparable strata to the north contain abundant shelly fauna, although non diagnostic, they are presumed to be of Jurassic age (pers. comm. T.P. Poulton, Report No. J4-2001-TPP). Argillites and greywackes believed to be correlative with volcanogenic sedimentary interbeds occur sporadically in widely separated areas near the eastern margin of the Bella Coola map area. Locally, they contain the Early Bajocian ammonite, *Stephanoceras*, associated with a variety of bivalves (Baer, 1973; pers. comm. T.P. Poulton, Report No. J4-2001-TPP).

Lithologically similar sedimentary rocks of Bajocian age, also containing *Stephanoceras* or other abundant shelly fauna, extend northward into Whitesail Lake map area (NTS 93E), thence eastward into the southern Nechako River map area (NTS 93F). A lithologic feature common in all areas is the presence of felsic volcanic interbeds manifest as ash tuff and coarser fragmental interbeds and, ubiquitous beds rich in angular feldspar grains and volcanic lithic clasts in wackes. These components indicate contemporaneous explosive felsic volcanic activity adjacent to or within a shallow marine depositional basin. If the rocks in the study area are proven to be Bajocian in age (Middle Jurassic) they are then most comparable to strata comprising the Naglico formation in the southern Nechako area (Diakow *et al.* 1997a) where time stratigraphic rocks are dominated by basalt and andesite flows containing local accumulations of fossil-bearing feldspathic and lithic arenites. However, the distinctive volcanogenic character of Bajocian strata is not unique to this specific time interval in the southern Nechako River and Whitesail Lake map areas. Fossil-bearing mudstones, feldspathic and lithic arenites containing significant components of felsic volcanic material have also been recognized in Middle Jurassic Aalenian, down into Early Jurassic Toarcian strata in these areas (Diakow and Levson, 1997b; Poulton and Tipper, 1991; Woodsworth, 1980). Therefore, the possibility exists that some of volcano-sedimentary sections exposed in the study area may well be older than fossiliferous Early Bajocian strata known in eastern Bella Coola map area.

MINERAL POTENTIAL OF JURASSIC VOLCANO-SEDIMENTARY ROCKS

The Jurassic Hazelton magmatic arc in Stikinia is an important metallotect for a variety of mineral deposits including copper-gold porphyries associated with subvolcanic plutons, epithermal gold-silver deposits in subaerial rocks and less common, but significant, stratiform massive sulphide in subaqueous volcano-sedimentary sequences. Evaluation of submarine volcanic-sedimentary sequences in British Columbia as potential hosts for massive sulphide accumulations reveals that remnants of the Hazelton arc are primary targets for exploration (Massey *et al.*, 1999).

The Eskay Creek deposit, in northwest British Columbia, is the premier example of massive sulphides hosted by strata of the Hazelton Group. The Eskay Creek mine, currently in its 6th year of operation, has reserves as of January 2001 of 705 200 tonnes of direct shipping ore containing 65.5 g/t gold and 3036 g/t silver and 761 800 tonnes of mill ore grading 25.8 g/t gold and 1092 g/t silver (Wojdak, 2001). At Eskay Creek, stratiform massive sulphide mineralization occurs in a carbonaceous mudstone interval deposited in a submarine environment during Aalenian to Bajocian (Middle Jurassic) time (Roth *et. al.*, 1999). Mineralized mudstone is depositionally bound by subaqueous bimodal tholeiitic volcanic rocks composed of rhyolite in the upper footwall unit and massive and pillowed basalts stratigraphically lower in the hangingwall unit where they may be locally interlayered with mudstone. Roth and co-workers (1999) envisage that the Eskay Creek deposit formed during waning Hazelton arc volcanism that coincided in space and time with extensional rift tectonism localizing basin development, which consequently focused volcanic and subvolcanic intrusive rocks and metalliferous hydrothermal fluids. The Eskay Creek deposit exhibits many characteristics typical of massive sulphide deposits. However, unusually elevated antimony, mercury and arsenic, accompanying extremely high gold and silver contents are mineralogic features more commonly associated with epithermal mineralization. Such precious metal enriched massive sulphide deposits have been termed Eskay Creek-type or subaqueous hot spring gold-silver in British Columbia (Alldrick, 1995).

In the Bella Coola area, investigation of the Nifty prospect, a significant volcanic- associated stratiform sulphide-barite prospect, indicates that it possesses features that suggest metal deposition may be related to relatively low temperature hydrothermal fluids vented in a shallow water environment (Ray *et al.* 1998). The Nifty mineralization is positioned beneath a hanging wall succession composed of waterlain felsic tuffs overlain by basaltic tuffs and probable flows. Overall this succession has transitional tholeiitic to calcalkaline chemistry. Stratiform barite forms a series of discontinuous stratabound lenticles above lenticular pods containing galena, sphalerite and pyrite. The mineralization is weakly enriched in Ag, As, Sb and Hg suggesting a lower temperature fluid that reflects a more epithermal character; however, gold values are negligible (Ray, *et al.*, 1998). Below the mineralized zone, primary intermediate volcanic rocks comprising the footwall are extensively bleached and enriched in potassium, sodium and magnesium, and associated with ubiquitous disseminated pyrite. Late post-mineral dikes, of both felsic and mafic compositions, and calcalkaline affinity cut the hangingwall-footwall successions along a preferred east-northeast trend.

Within the area mapped, a rhyolitic unit of probable Aalenian to Bajocian age is believed to be the most prospective host rocks for volcanic-related massive sulphide mineralization. This assemblage consists of more than 1000 metres of resedimented syn-erupted fragmental and subordinate primary volcanic rocks showing evidence of subaqueous and periodic subaerial deposition. The Nifty occurrence is situated adjacent to several intersecting high-angle faults that form the southern margin of a distinctive rhyolitic assemblage. These structures evidently post date deposition of the rhyolite unit; and, they may have caused an unknown portion of this rhyolitic facies to be uplifted and subsequently eroded. Unlike other parts of this rhyolitic unit, however, semi-concordant alteration and sulphide-barite mineralization are evident only in the vicinity of Nifty. Elsewhere, scant mineralization is limited to disseminated pyrite associated with massive aphanitic rhyolites interpreted either as flows or subvolcanic intrusives.

CONCLUSIONS

The Hazelton Group in the Bella Coola area is composed of bimodal volcano-sedimentary rocks that represent deposition in both submarine and subaerial environments. Subaqueous rhyolite volcanic facies host the Nifty prospect, a key stratiform sulphide-barite occurrence, and is presumed to be the most prospective unit in the study area. Regionally, the bimodal volcanic rocks and interbedded fossiliferous sediments are tentatively Bajocian in age, but possibly as old as Toarcian. We believe this volcano-sedimentary succession has good potential for the discovery of other VMS prospects in the region. Despite the difficulties associated with of exploring in steep forested coastal terrain as in the Bella Coola region, the new mapping supplemented by regional stream sediment geochemistry programs jointly conducted by the federal and provincial surveys will better focus prospecting and exploration in the area.

ACKNOWLEDGMENTS

Mapping contributions by Sarah Gordee, Heather Sparks, Sara White, Edna Kaiser and Lori Snyder are greatly appreciated. We thank Terry Poulton and Jim Haggart of the Geological Survey of Canada for identifying new fossil collections and re-examining archived collections from the Bella Coola area. Gerry Ray has been an advocate for further mapping in the Bella Coola area and is acknowledged for sharing his views on mineral occurrences in the study area. Richard Lapointe and Rob Skelley of West Coast Helicopters provided safe, reliable air support for the mapping program. Gaylene Binns and David Flegel of the B.C. Ministry of Forests, and Dawn and Kim Meiers helped out with operational logistics. Editorial comments by Brian Grant and figures prepared by Verna Vilkos and Alexandra Shaw improved the paper.

REFERENCES

Alldrick, D.J. (1995): Shallow Subaqueous Hot Spring Au-Ag; *in* Selected British Columbia Mineral Deposit Profiles, Volume 1, D.V. Lefebure and G.E. Ray, Editors, *British Columbia Ministry of Energy and Mines*, Open File 1995-20. pages 55-57.

Andronicos, C., Hollister, L.S., Davidson, C. and Chardon, D. (1999): Kinematics and Tectonic Significance of Transpressive Structures Within the Coast Plutonic Complex, British Columbia; *Journal of Structural Geology*, Volume 21, pages 229-243.

Baer, A.J. (1973): Bella Coola-Laredo Sound Map-Areas, British Columbia; *Geological Survey of Canada*, Memoir 372, 122 pages.

Bellefontaine, K.A. and Alldrick, D.J. (1994): Mineral Potential of the Mid-Coast Area; *B.C. Ministry of Energy and Mines*, Open File 1994-17, 1:250 000 scale.

Bellefontaine, K.A. and Alldrick, D.J. (1995): Highlights of the Mid-Coast Mineral Potential Project (92F,G,H,J,L,M,N,N, 93D, 102P, 103A); *in* Geological Fieldwork 1994, *B.C. Ministry of Energy and Mines*, Paper 1995-1, pages 449-458.

Bevier, M.L. (1981): The Rainbow Range, British Columbia: a Miocene Peralkaline Shield Volcano; *Journal of Volcanology and Geothermal Research*, Volume 11, pages 225-251.

Boghossian, N.D. and Gehrels, G.E. (2000): Nd Isotopic Signature of Metasedimentary Pendants in the Coast Mountains Between Prince Rupert and Bella Coola, British Columbia; *in* Tectonics of the Coast Mountains, southeastern Alaska and British Columbia; H.H. Stowell and W.C. McClelland, Editors, *Geological Society of America*, Special Paper 343, pages 77-88.

Carter, N.C. (1981): Porphyry Copper and Molybdenum Deposits of West-Central British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Bulletin 64, 150 pages.

Dawson, G.M. (1878): Explorations in British Columbia, Chiefly in the Basins of the Blackwater, Salmon, and Nechako Rivers, and on Francois Lake; *Geological Survey of Canada*, Report on Progress 1876-77, pages 17-94.

Diakow, L.J., Panteleyev, A. and Schroeter, T.G. (1991): Jurassic Epithermal Deposits in the Toodoggone River Area, Northern British Columbia: Examples of Well-Preserved, Volcanic-Hosted, Precious Metal Mineralization; *Economic Geology*, Volume 86, Number 3, pages 529-554.

Diakow, L.J., Webster, I.C.L, Richards, T.A. and Tipper, H.W. (1997a): Geology of the Fawnie and Nechako Ranges, Southern Nechako Plateau, Central British Columbia (93F/2,3,6,7); *in* Interior Plateau Geoscience Project: Summary of Geological, Geochemical and Geophysical Studies, L.J Diakow, P. Metcalfe and J.M. Newell, Editors, *British Columbia Ministry of Energy and Mines*, Paper 1997-2, pages 7-30.

Diakow, L.J. and Levson, V.M. (1997b): Bedrock and Surficial Geology of the Southern Nechako Plateau, Central British Columbia (NTS 93F/2,3,6,7); *British Columbia Ministry of Energy and Mines*, Geoscience Map 1997-2, 1:100 000 scale.

Hrudey, M.G., Struik, L.C., Diakow, L.J., Mahoney, J.B., Woodsworth, G.J., Sparks, H.A., Kaiser, E.A. and Gleeson, T.P. (2002): Plutonic Rocks of the Eastern Bella Coola Map Area, Southwest British Columbia; *Geological Survey of Canada*, Current Research 2002-A.

Israel, S. and Kennedy, L. (2002): Reconnaissance of Structural Geology of the Atnarko Complex, Southern Tweedsmuir Park, British Columbia; *Geological Survey of Canada*, Current Research 2002-A.

Jackaman, W., Lett, R. and Fiske, P. (2002): National Geochemical Reconnaissance Surveys in the B.C. Cordillera to Target and Attract Mineral Exploration; Geological Fieldwork 2001, *B.C. Ministry of Energy and Mines,* Paper 2002-1, this volume.

MacDonald, A.J., Lewis, P.D., Thompson, J.F.H., Nadaraju, G., Bartsch, R.D., Bridge, D.J., Rhys, D.A., Roth, T., Kaip, A., Godwin, C.I. and Sinclair, A.J. (1996): Metallogeny of an Early to Middle Jurassic Arc, Iskut River Area, Northwestern British Columbia; *Economic Geology*, Volume 91, pages 1098-1114.

Mahoney, J.B., Struik, L.C., Diakow, L.J., Hrudey, M.G. and Woodsworth, G.J. (2002): Structural Geology of the Eastern Bella Coola Map Area, British Columbia; *Geological Survey of Canada*, Current Research 2002-A.

Massey, N.W.D., Alldrick, D.J. and Lefebure, D.V. (1999): Potential for Subaqueous Hot-spring (Eskay Creek) Deposits in British Columbia; *British Columbia Ministry of Energy and Mines*, Open File 1999-14, 1:2 000 000 scale.

Poulton, T.P. and Tipper, H.W. (1991): Aalenian Ammonites and Strata of Western Canada; *Geological Survey of Canada*, Bulletin 411, 71 pages.

Ray, G.E., Brown, J.A., Friedman, R.M. and Cornelius, S.B. (1998): Geology of the Nifty Zn-Pb-Ba Prospect, Bella Coola District, British Columbia; *in* Geological Fieldwork 1997, *B.C. Ministry of Energy and Mines*, Paper 1998-1, pages 20-1 to 20-28.

Roth, T., Thompson, J.F.H. and Barrett, T.J. (1999): The Precious Metal-Rich Eskay Creek Deposit, Northwestern British Columbia; *in* Volcanic-Associated Massive Sulphide Deposits: Processes and Examples in Modern and Ancient Settings, C.T. Barrie and M.D. Hannington, Editors, *Reviews in Economic Geology*, Volume 8, pages 357-373.

Rusmore, M.E. and Woodsworth, G.J. (1994): Evolution of the Eastern Waddington Thrust Belt and its Relation to the Mid-Cretaceous Coast Mountains Arc, Western British Columbia; *Tectonics*, Volume 13, pages 1052-1067.

Rusmore, M.E., Woodsworth, G.J. and Gehrels, G.E. (2000): Late Cretaceous Evolution of the Eastern Coast Mountains, Bella Coola, British Columbia; *in* Tectonics of the Coast Mountains, southeastern Alaska and British Columbia; H.H. Stowell and W.C. McClelland, Editors, *Geological Society of America*, Special Paper 343, pages 89-106.

Souther, J.G. (1977): Volcanism and Tectonic Environments in the Canadian Cordillera-A Second Look; *in* Volcanic Regimes in Canada, W.R.A. Barager, L.C. Coleman and J.M. Hall, Editors, *Geological Association of Canada*, Special Paper 16, pages 3-24.

Souther , J,G. (1986): The Western Anahim Belt, Rootzone of a Peralkaline Magma System; *Canadian Journal of Earth Sciences*, Volume 23, pages 895-908.

Souther, J.G. and Yorath, C.J. (1991): Neogene Assemblages, Chapter 10; *in* Geology of the Cordilleran Orogen in Canada, H. Gabrielse and C.J. Yorath, Editors, *Geological Survey of Canada*, Geology of Canada, Number 4, pages 373-401.

Stowell, H.H. and McClelland, W.C. (2000): Tectonics of the Coast Mountains, Southeastern Alaska and British Columbia; *Geological Society of America*, Special Paper 343, 289 pages.

Struik, L.C., Mahoney, J.B., Hrudey, M.G., Diakow, L.J., Woodsworth, G.J., Sparks, H.A. and Kaiser, E.A., Haggart, J. and Poulton, T. (2002): Early Cretaceous Stratigraphy and Tectonics of Eastern Bella Coola Map Area, Southwest British Columbia; *Geological Survey of Canada*, Current Research 2002-A.

Tipper, H.W. and Richards, T.A. (1976): Jurassic Stratigraphy and History of North-Central British Columbia; *Geological Survey of Canada*, Bulletin 270, 73 pages.

van der Heyden, P. (1990): Eastern Margin of the Coast Belt in West-central British Columbia; *Geological Survey of Canada*, Current Research, Part E, Paper 90-1E, pages171-182.

van der Heyden, P. (1991): Preliminary U-Pb Dates and Field Observations from the Eastern Coast Belt near 52°N, British Columbia; *Geological Survey of Canada*, Current Research, Part A, Paper 91-1A, pages 79-84.

Wojdak, P. (2001): Northwest Region; Exploration and Mining in British Columbia - 2000; *British Columbia Ministry of Energy and Mines*, pages 1-8.

Woodsworth, G.J. (1980): Geology of the Whitesail Lake (93E) Map Area, British Columbia; *Geological Survey of Canada*, Open File 708, 1:250 000 scale.