REGIONAL AND ECONOMIC GEOLOGY OF THE TULSEQUAH RIVER AND GLACIER AREAS (104K/12 & 13)

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KEYWORDS: Regional geology, Stikine assemblage, Whitewater metamorphic suite, Boundary Ranges metamorphic suite, Stuhini, Laberge, Sloko, Llewellyn fault, Tulsequah Chief, Polaris-Taku, Big Bull, volcanogenic massive sulphide, skarn, copper, zinc, gold

INTRODUCTION

Geological mapping in 1993 expanded 1991 reconnaissance surveys of NTS map sheets 104K/12 and 13 (Smith and Mihalynuk, 1992; Figure 1). Mapping of both quadrangles was completed at 1:50 000 scale during a 2-week field season in 1992 and a 7-week field season in 1993, aided by compilation of previous industry work in 104K/12. Objectives of 1993 fieldwork included:

- Determination of the age(s), regional extent and stratigraphy of the Paleozoic northern Stikine assemblage, with identification and correlation of key mineralized intervals.
- Identification of a southern continuation of the Llewellyn gold province at the transition between Stikinian and metamorphosed rocks to the west.
- Determination of mesothermal gold potential in veins associated with metamorphosed tuff and ultramafic pods, analogous to the Polaris-Taku deposit, and of the age and nature of such mineralization.
- Investigation of associations between samples collected in 1991 yielding anomalous gold analyses and their apparent association with east-west cross-faults, age of motion on these faults, and identification of other examples elsewhere in the map area.
- Evaluation of the mineral potential of widespread Sloko Group volcanic strata and structures which may focus hydrothermal mineralization.

Maps produced during this study are designed to aid exploration, guide future land use and resource management decisions and address public questions. This paper focuses on: lithological packages not previously recognized or fully described, or which differ significantly from correlative strata elsewhere; structures that affect them; and their mineral potential.

Figure 1. A) Location of map area with respect to major geographic and geological features in northwest British Columbia and adjacent Alaska. B) location in NTS coordinate system.
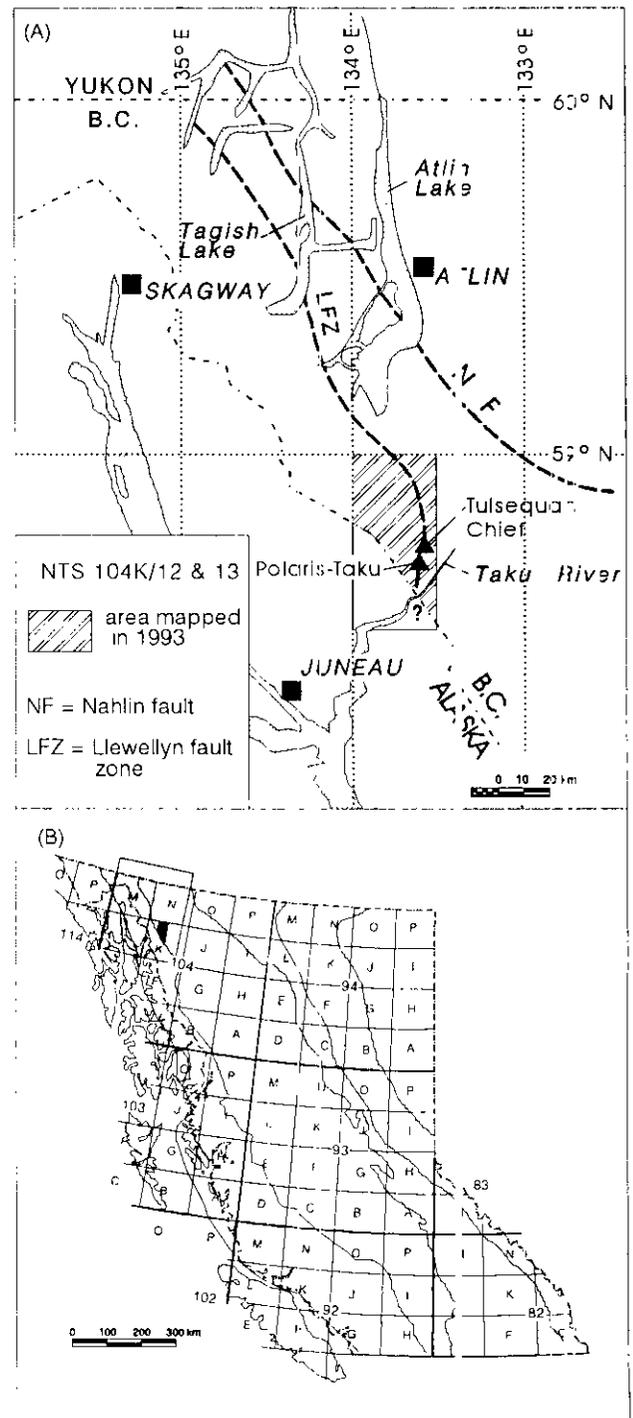
PREVIOUS WORK

Mineral exploration in the area dates back to at least 1924 with the discovery of the Tulsequah Chief deposit. However, systematic regional mapping was not begun until Kerr's investigations in 1930 and 1932 (Kerr, 1931a,b, 1948). In 1958 to 1960 Souther (1971) completed 1:250 000-scale mapping of the Tulsequah area. Geological mapping since that time has been primarily restricted to company reports with limited distribution. Maps produced by Cominco Ltd. (Payne and Sisson, 1988) cover a large part of 104K/12. This work was based in part on regional surveys by Anglo Canadian Mining Corporation (Payne *et al.*, 1981), a compiled version of which was published by Nelson and Payne (1984).

Recent advancements in understanding of the Stikine assemblage have arisen from regional mapping studies to the south, in the Tatsamenie Lake and Forest Kerr areas by Brown *et al.* (1991), Bradford and Brown (1993, and references therein) and Logan and Drobe (1993).
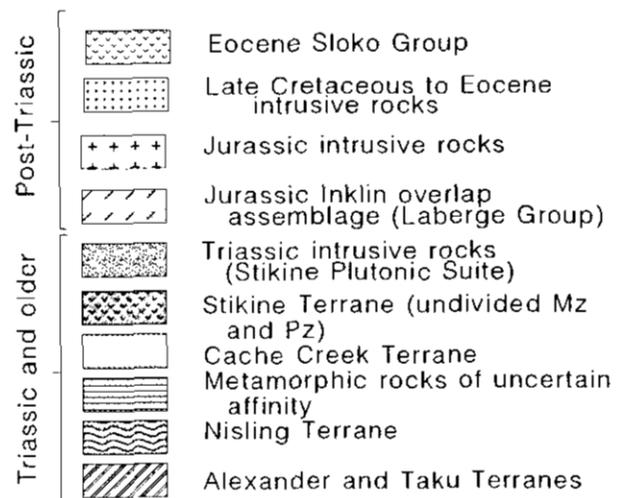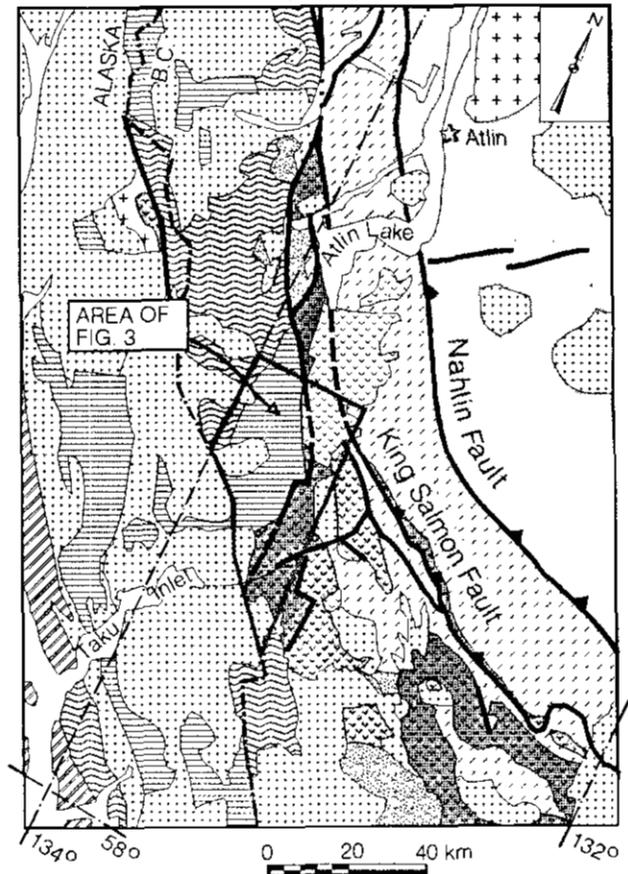
LOCATION, PHYSIOGRAPHY AND ACCESS

The Tulsequah River (104K/12) and Tulsequah Glacier (104K/13) map areas cover about 1300 square kilometres of the Coast Mountains, centred 90 kilometres east of Juneau, Alaska and 100 kilometres south-southwest of Atlin, British Columbia (Figure 1). The map area lies mainly north of the steep-sided Taku River valley. More gentle and drier Stikine Plateau uplands flank the area to the east. Most of the area is rock or forest, with roughly 5% outcrop in forested areas. Large covered areas are restricted to ice cover, river bottoms and swamp which collectively amount to about 30% of the area. Fieldwork in general is hampered by steep topography, snow and ice cover and poor weather, but the summer of 1993 was unusually hot and dry, resulting in a low snow pack and better exposure than usual.

Access is easiest by fixed-wing aircraft from Atlin or Juneau. Two airstrips are serviceable. A gravel strip is located northwest of the confluence of the Taku and Tulsequah rivers, and will accommodate a DC-3 or Caribou aircraft, but is subject to flooding two or more times each summer. A shorter strip at the Polaris-Taku minesite is less flood prone, but has a difficult approach and will accommodate only small aircraft. A few short road segments were built during development and production years of the Tulsequah Chief and Polaris-Taku mines, but all are at least in part washed out and overgrown, and none are linked to the provincial road network. Travel from the airstrips to other parts of the map area is by helicopter. Helicopters are intermittently based in the Tulsequah valley, but otherwise must be chartered from Atlin or Juneau.

Figure 2. Simplified geologic map of the Atlin and Tulsequah area after Wheeler *et al.* (1989), showing major faults and lithotectonic elements. The Tulsequah map area straddles parts of the Jurassic Inklin overlap assemblage, Stikine Terrane, and metamorphic rocks of mixed arc and siliciclastic affinity and uncertain (possibly Yukon-Tanana) terrane assignment.

GENERAL GEOLOGIC AND TECTONIC SETTING

The Tulsequah River and Tulsequah Glacier area is one of extreme geological diversity and structural complexity resulting from the juxtaposition and deformation of several Mesozoic to Paleozoic and older tectonostratigraphic terranes (Figure 2). Subsequent intrusion by Cretaceous-Tertiary Coast plutons and burial by Tertiary volcanic rocks complicate investigations into the nature of terranes and their plate tectonic contexts. In northwestern British Columbia and Yukon these studies are further hampered by a proliferation of nomenclature.
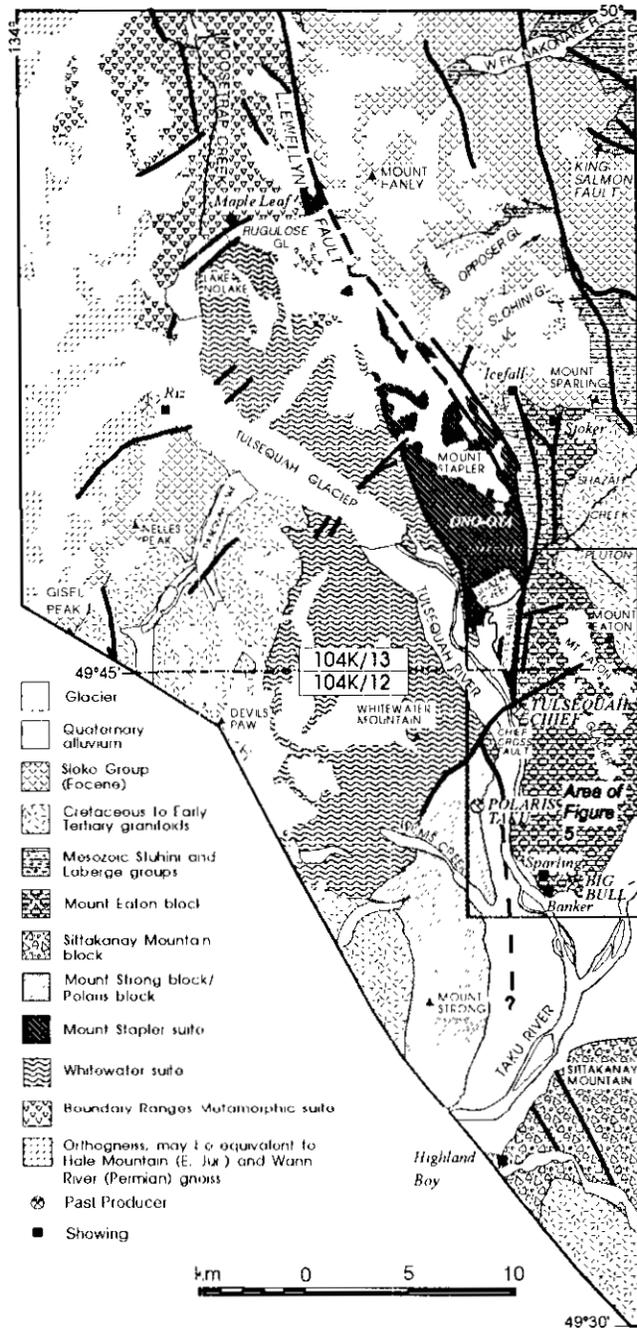

Post-Triassic	⠿ Eocene Sloko Group	
	⠿ Late Cretaceous to Eocene intrusive rocks	
	+ + + Jurassic intrusive rocks	
	⫽ Jurassic Inklin overlap assemblage (Laberge Group)	
Triassic and older	⠿ Triassic intrusive rocks (Stikine Plutonic Suite)	
	⬚ Stikine Terrane (undivided Mz and Pz)	
	▭ Cache Creek Terrane	
	▤ Metamorphic rocks of uncertain affinity	
	≋ Nisling Terrane	
	⫽ Alexander and Taku Terranes	

Figure 3. Simplified geological map of the Tulsequah area, showing major Mesozoic and Paleozoic lithotectonic assemblages, Late Cretaceous and Tertiary volcanic and intrusive rocks, faults (thick lines) and the locations of past-producing mines and significant showings. Geology simplified from 1993 British Columbia Geological Survey mapping, Nelson and Payne (1984), and Smith and Mihalynuk (1992).

Nevertheless, recognition of terrane affiliation and context are important keys to understanding regional metallogenesis, and terrane assignments are made here.

A thorough treatment of the subject is, however, beyond the scope of this paper. Interested readers are referred to a pragmatic view of terranes in the Yukon by Mortensen (1992). Terranes shown on Figure 2 are modified from Wheeler *et al.* (1991) and Mortensen (1992).

The southern extension of the Llewellyn fault (known locally as the Chief fault), a major tectonic boundary in northern British Columbia, divides pre-Tertiary rocks in the map area into metamorphosed rocks of presumed Paleozoic and older age, which underlie the southern and western half of the area, and weakly metamorphosed upper Paleozoic and Mesozoic rocks, which underlie the eastern half (Figure 3). West of the fault, three suites of rocks are recognized divided on the basis of lithologic associations and degree of deformation (Figure 4). From west to east, corresponding with decreasing metamorphic grade and degree of deformation and variation from predominantly basinal to predominantly arc character, they are: the **Whitewater suite** (or metamorphic suite, informal) which refers to a distinctive package of amphibolite-grade quartz-rich graphitic schist, quartzite, metabasite and ultramafite, that may be correlative with parts of the Yukon-Tanana Terrane having continental margin affinity; the **Boundary Ranges suite** (or metamorphic suite; Mihalynuk and Rouse, 1988), consisting of schists of volcanic and sedimentary origin; and the **Mount Stapler suite**, a low-grade package which shares some characteristics with both the Whitewater and Boundary Ranges suites and locally can be demonstrated to be gradational into both.

East of the Llewellyn fault, Paleozoic rocks are assigned to the **Stikine assemblage** (Monger, 1977), a low-grade package of middle to upper Paleozoic volcanic arc rocks which form the basement to the Stikine arc and host the Tulsequah Chief and other volcanogenic massive sulphide deposits in the area (Figures 3 and 4). Building on the work of Nelson and Payne (1984), the Stikine assemblage is further divided into three structural-stratigraphic blocks. These are separated by large valleys (and known or suspected faults), but share important lithologic elements. **Mount Eaton block** lithologies are most clearly correlative with *bona fide* Stikine assemblage to the south (Brown *et al.*, 1991). More deformed, but obviously equivalent strata comprise the **Sittakanay block**. While Nelson and Payne did not include the rocks on Sittakanay Mountain with those in the Mount Eaton block, they did acknowledge their lithologic similarities; we believe them to be correlative on this basis. **Mount Strong block** rocks are of more questionable affinity. They are dominantly sedimentary in character and are here interpreted to be a distal equivalent of the other blocks, but with uncertainty as to the position of the Mount Strong block with respect to the trace of the Llewellyn fault, this correlation is tentative.

Mesozoic rocks include volcanic and volcanogenic rocks of the Upper Triassic Stuhini Group, an arc assemblage of the Stikine Terrane, and Lower to Middle Jurassic sedimentary rocks of the Laberge Group, an overlap assemblage that straddles the Stikine and other inboard terranes (Figures 2 and 3).
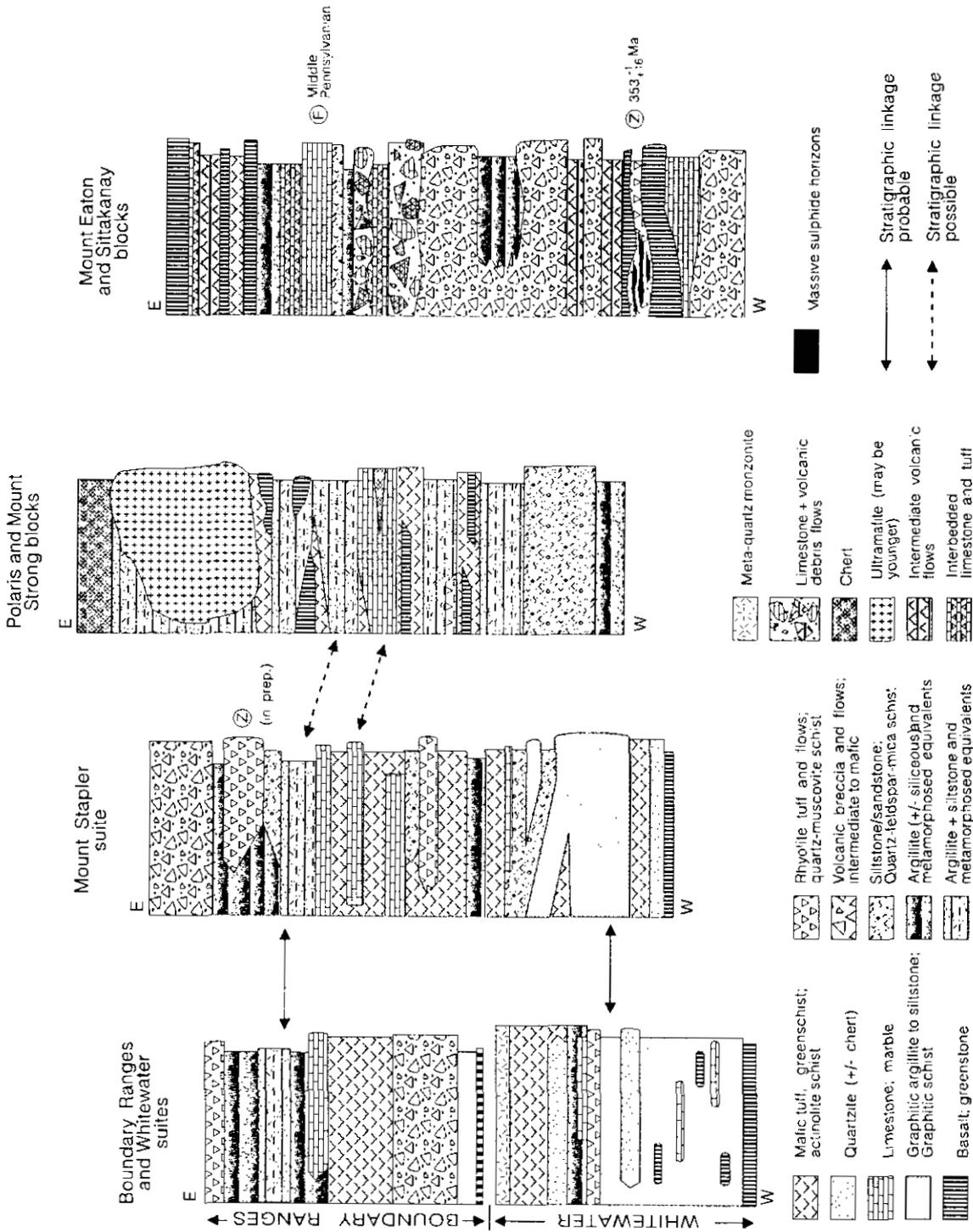
Figure 4. Pseudo-stratigraphic columns for the major Paleozoic lithologic suites in the Tulsequah area. With regard to columns 1-3, age and facing are uncertain and structural disruption and metamorphic recrystallization are significant, thus the columns are intended only to give the reader an estimate of the relative proportions of lithologic types. Column 4 (Mount Eaton formation) is a more accurate representation of the stratigraphic section. Section thicknesses are on the order of a few kilometres.

METAMORPHIC SUITES

Metamorphic suites described here grossly conform to a west to east progression from higher grade, lower structural and stratigraphic(?) position to structurally higher and lower grade rocks interpreted to be some of the youngest metamorphic units. Emphasis is placed on units that have not been described previously; detailed descriptions of the Boundary Ranges suite can be found in Mihalynuk *et al.* (1989).

WHITEWATER METAMORPHIC SUITE

The name "Whitewater suite" is given to a distinctive lithologic association formerly mapped by Souther (1971) as "undifferentiated schist and gneiss of pre-Triassic age". It consists of a belt of regionally metamorphosed rocks which extends from Rugulose glacier (104K/13) to Wilms Creek (104K/12), composed of quartz-rich graphitic schist with intercalated quartzite and metabasite, with minor marble, quartzofeldspathic schist (metarhyolite?), monzonitic orthogneiss and variably serpentinized ultramafite. The Whitewater suite is exposed in a north-plunging anticlinorium and generally increases in metamorphic grade and degree of recrystallization to the south. Regional metamorphism is overprinted by contact metamorphism near large plutons.

GRAPHITIC SCHIST

Most characteristic of the Whitewater suite is an extensive unit consisting of bright orange-weathering, quartz-rich graphitic schist. In most places the unit contains conspicuous, black spessartine garnet (manganiferous) porphyroblasts which display a pronounced {110} parting, and locally feldspar porphyroblasts, which may reach 2 to 3 centimetres in diameter. More than 60% of the rock is composed of ribbon quartz. Biotite and muscovite occur in subequal amounts up to 30% combined. Plagioclase and graphite are the remaining major components. Pyrrhotite is a significant accessory in quantities of 1 to 3%; sparse tourmaline prisms are also typical. At a few localities fibrolite has been tentatively identified in hand samples. Minor bands of dark grey to tan, banded carbonate are common, but rarely exceed 3 metres in thickness and comprise less than 1% of the section. These are associated with talc-tremolite schist and serpentinite (see below).

Widespread hornfelsing of the unit tends to destroy its schistose fabric, producing a finer grained, gneissic rock with a graphite component that is much less apparent.

METABASITE

Metabasite is second in abundance to graphitic schists within the Whitewater suite. It is generally gneissic to massive, dark green and commonly mottled
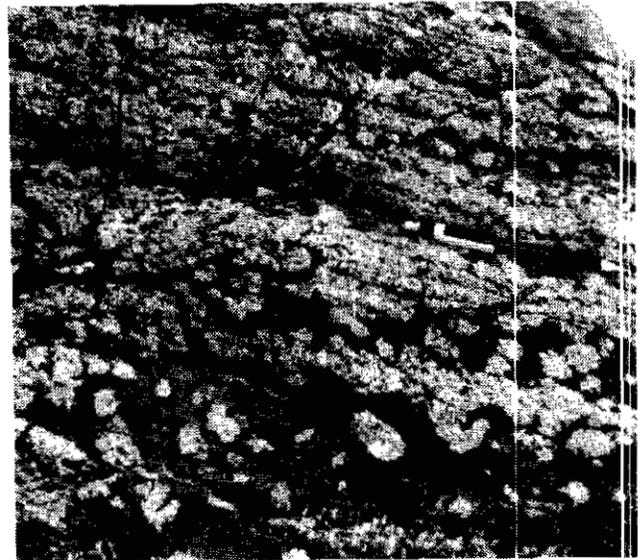

Plate 1. Conspicuous feldspar poikiloblasts developed in metabasite unit of the Whitewater suite.

with white-weathering plagioclase poikiloblasts up to 5 centimetres across (Plate 1). Metamorphism varies from transitional greenschist-amphibolite grade to amphibolite grade. Respective metamorphic mineral assemblages, in decreasing order of abundance are: actinolite-biotite±chlorite-feldspar-quartz-epidote±garnet and hornblende-biotite-plagioclase-quartz-diopside-garnet-epidote. Feromagnesian minerals comprise 40 to 60% of the rock. Except for feldspar poikiloblasts, these rocks are generally medium grained. Locally, contact metamorphism has resulted in coarsely recrystallized rocks with plumose actinolite commonly up to 10 centimetres long.

QUARTZITE TO QUARTZ-FELDSPAR-MUSCOVITE ±GARNET SCHIST

Quartzite and quartz-feldspar-muscovite-garnet schist and gneiss occur as bands up to 100 metres thick within the graphitic schist unit. Quartz content is typically greater than 90% with some layers of nearly pure, medium-grained quartz. Feldspar poikiloblasts may comprise over 10%, and in places they take the form of remnant granules or pebbles, but no unequivocal conglomeratic facies have been found. Muscovite is common in abundances of 5 to 10%; tourmaline and clear, red garnet are common accessories up to 1 centimetre in size. Most quartzite bands are discrete units, while others have gradational contacts with enclosing graphitic schist. In thin section the quartz and micas are highly strained, lacking any annealed texture. Garnets are xenoblastic and commonly fractured.

Quartzite layers are most abundant near the contact with the metabasite division, suggesting some common genesis. Gradational contacts with graphitic schist point to remnant depositional contacts. Relict feldspathic "granules" and consistent occurrence of tourmaline, probably as recrystallized detrital grains, points to a clastic protolith with a quartz-rich provenance.

TALC-TREMOLITE-MAGNESITE(?) SCHIST AND SERPENTINIZED ULTRAMAFITE

Bright green and white-weathering talc-tremolite±magnesite schist and associated, variably serpentinized, dark green and red-weathering ultramafite are conspicuous, but relatively minor components of the Whitewater suite. Together they comprise less than 0.1% of the suite, normally as lenses and pods less than a metre thick, although rarely to 20 metres thick, within the graphitic schist unit. Bright green tremolite-actinolite commonly occurs as very coarse intergrown prisms randomly aligned within foliation planes. Talc and minor magnesite(?) comprise the matrix of the rock, commonly with sparse, but well-crystallized chromium mica.

Podiform serpentinite bodies occur in zones of intense structural disruption within the graphitic schist unit. They pinch and swell, attaining mappable thicknesses of over 20 metres, and are semicontinuous for a kilometre or more. Generally, few primary igneous textures have survived. In a few localities serpentinization appears to have been at the expense of pyroxenite, but thin section analysis reveals a hornfels texture in which quartz flooding has produced very dark clinozoisite porphyroblasts, poikiloblastic feldspar-garnet and finely intergrown actinolite. All of these minerals have grown statically on a remnant "lizard skin" texture outlined by dustings of fine mafic grains. The serpentinite protolith remains in question.

METARHYOLITE

White-weathering metarhyolite is best exposed on the ridges a few kilometres east of the Devil's Paw (Figure 3). It is well foliated and composed of alternating centimetre to decimetre-thick feldspar and quartz-rich layers. On this basis it is easily distinguished from the metaquartzite unit. It also lacks tourmaline, garnet and muscovite±biotite±chlorite layers, contains much less quartz, and has sharp contacts with the graphitic schist unit.

FELSIC ORTHOGNEISS

Pinkish grey, slabby weathering, medium-grained orthogneiss underlies a few square kilometres west of Whitewater Mountain. It mainly occurs as part of a single, large tabular body, with several nearby smaller, related(?) bodies. At one locality protolith textures are preserved, but generally the rock is strongly foliated, commonly presenting a second fabric. Composition varies from place to place with an average of quartz monzonite. Pink to yellowish grey feldspar comprises 55%, ribboned quartz 35%, muscovite 6%, and biotite 2%.

BOUNDARY RANGES METAMORPHIC SUITE

Rocks assigned to the Boundary Ranges metamorphic suite (Mihalynuk and Rouse, 1988) primarily underlie the northwestern part of 104K/13 near Moosetrap Creek (Figure 3). They consist of schists of variable composition, reflecting a wide variety of protolith types, cut by several phases of igneous rocks. Based on a Late Mississippian U-Pb age on crosscutting intrusive rocks 100 kilometres to the north (Currie, 1992), some or all of the Boundary Ranges metamorphic suite in the Tulsequah area may be early Paleozoic or older. The suite appears to be gradational to the southeast into the Mount Stapler suite, where probable protoliths are similar but metamorphic grade and degree of recrystallization are lower.

SCHISTOSE ROCKS

Interlayered schists of highly variable composition are characteristic of the Boundary Ranges metamorphic suite (BRM). They are interlayered on a scale ranging from decimetres to several tens or rarely hundreds of metres. Medium-grained, schistose to gneissic amphibole-chlorite-plagioclase schist and gneiss (metabasalt, diorite or gabbro) is volumetrically the most significant unit. It ranges from dark green actinolite or hornblende schist to gneissic rocks with equal parts actinolite (or hornblende) and plagioclase. This lithology dominates the western and central Moosetrap Creek area, where it ranges from layers more than 100 metres thick to interlayered with other units on a metre scale. Light green chlorite and muscovite-rich schist and phyllite (metatuff of intermediate composition?), typically displaying a strong second foliation and tight crenulations, is the most important lithologic element in the eastern Moosetrap Creek area, and appears to be gradational into the Mount Stapler assemblage. Quartz-biotite-muscovite-feldspar±garnet schist (metapelite and related metasedimentary rocks) is present throughout the section. It is characterized by the presence of garnets that range from nearly fresh to completely replaced by chlorite, suggesting a retrograde low greenschist facies overprint of formerly high greenschist to low amphibolite facies rocks. This effect is more pronounced east of Moosetrap Creek, and less pronounced west of the creek, where amphibolite facies rocks are still locally preserved. Quartzofeldspathic schist (metamorphosed clastic sediments), and quartz-rich schist or quartzite (metarhyolite or metaquartzite) are minor but significant constituents of the BRM. They are typically white to tan or brown weathering and form lenses rarely more than several metres thick. They are particularly abundant in the area immediately northeast of Lake Nolake, where they are interlayered with minor impure marble and biotite schist. Dark grey graphitic schist forms thin (generally <2 m) layers within schists of metasedimentary protolith.

GNEISSIC ROCKS OF IGNEOUS ORIGIN

Two orthogneiss units of regional extent and significance, and numerous units of restricted extent,

occur within, or along the margin of the Boundary Ranges metamorphic suite.

Orthogneiss of intrusive and possible extrusive origin underlies parts of the extreme western 104K/13 map area (Figure 3). It is banded on a centimetre to metre scale with coarse, sill-like quartz-feldspar segregations. Individual bands consist of interlayered hornblende and plagioclase; biotite, hornblende and plagioclase; and biotite, plagioclase and quartz. Bands are medium grained and poorly foliated. There are similarities between this unit and the Permian Wann River Gneiss (Currie, 1992).

immediately west of the north end of Lake Nolake. The other units are poorly foliated and barely metamorphosed, suggesting a relatively young age.

MOUNT STAPLER/POLARIS STRUCTURAL SUITES

Variable arc lithologies, probably reflecting original rapid facies changes, are preserved within the Mount Stapler suite (Figure 4). It includes metavolcanic and

Plate 2. Large, east-trending kink folds in the rhyolite tuff unit of the Mount Stapler suite.

A unit of strongly to weakly foliated hornblende quartz diorite to granodiorite intrudes the banded gneiss. An identical unit was previously described in the Tagish Lake area where it is mapped as the Hale Mountain granodiorite (Mihalynuk and Mountjoy, 1990; Mihalynuk *et al.*, 1990). It is correlated region-wide with the Aishihik magmatic episode, which forms an intrusive belt extending from the map area to west-central Yukon. The suite is distinguished from similar protoliths by the common occurrence of plagioclase porphyroblasts and epidote (Johnston, 1993). Recent U-Pb dating (Currie, 1992; Johnston, 1993) suggests a crystallization age of approximately 186 Ma.

Of limited regional extent are variably foliated and lineated pink potassium feldspar megacrystic granodiorite and granite, gabbro, and pyroxenite, which form layers and lenses rarely exceeding a few tens of metres in thickness. The former is an augen gneiss that is strongly deformed, metamorphosed to greenschist facies and interlayered with marble and greenstone

metasedimentary rocks that lie immediately west of the northern extension of the Llewellyn fault system north of Shazah Creek, and east of the Whitewater suite. Pronounced strain gradients over areas o several metres to several tens of metres are characteristic, resulting in juxtaposition of rocks with strained, but recognizable protolith textures with phyllite and semischist. Original thicknesses of most of the units are thus unknown. Fine-grained actinolite in greenstone samples suggests low greenschist facies metamorphic conditions. Biotite in metagreywacke from near the contact with the Boundary Ranges metamorphic suite suggests conditions of at least middle greenschist facies. The age of this sequence is unknown, but presumed to be in part middle or late Paleozoic. The age is presently under investigation using U-Pb isotopic techniques (Sherlock *et al*, 1994, this volume).

Major protolith types in the Mount Stapler suite include: rhyolite, limestone, siliciclastic rocks, intermediate to mafic tuff, and augite-phyric volcanic

rocks. The first three units are typically interlayered with the fourth on a scale of several to tens of metres; the latter two units tend to form sections up to several hundred metres thick.

RHYOLITE FLOWS AND TUFF

Metarhyolite and metarhyolite tuff are white to tan weathering, and range from quartz-feldspar-muscovite schist to meta-lapilli and ash tuff (Plate 2) and flows with relict lapilli, bedding, flow banding, and feldspar and quartz phenocrysts. Rhyolitic rocks forms lenses rarely more than 30 metres thick, and make up approximately 5% of the total section.

LIMESTONE

Limestone is recrystallized, light grey to white, massive to banded, isoclinally folded, and forms lenses up to a few kilometres long but rarely more than 20 metres thick. Several limestone lenses, interbedded with siliciclastic rocks, chert, and andesitic and rhyolitic tuff, are exposed northwest of Shazah Creek, west of the Chief fault. One limestone layer in this interval hosts a metre-thick exhalative massive sulphide horizon (Ono-Oya showing; Figure 3).

SILICICLASTIC ROCKS

Quartz-rich siliciclastic rocks can be subdivided on the basis of the predominance of various platy minerals or relict sedimentary structures. These include dark grey graphitic to quartz-rich phyllite and medium grey muscovite schist; brown to medium to dark grey, thin-bedded siliceous metasiltstone; greenish brown, thin to medium-bedded metagreywacke with thin slate interbeds (volcanogenic turbidites?); meta-argillite; dark to light grey metachert; and rare lithic conglomerate with clasts derived from all protoliths represented in the Mount Stapler suite. All sedimentary rock types are interlayered with metarhyolite flows and tuff, meta-andesite tuff, and limestone, on scales ranging from centimetres to several metres. On the lower part of the ridge separating the Tulsequah River from Shazah Creek, a section composed mainly of dark grey siliceous to graphitic argillite and phyllite is gradational westward into quartz-rich graphitic schist of the Whitewater suite.

INTERMEDIATE TO MAFIC METATUFFS

Intermediate to mafic metatuffs are volumetrically the most significant unit in the Mount Stapler assemblage. They range from metamorphosed light to dark green ash to lapilli tuff and rare breccia with flattened clasts, to greenstone with millimetre-scale light and dark green compositional layers or spaced chloritic partings, to crenulated chlorite phyllite and rare schist. A thick section is exposed west of the summit of Mount Stapler, with rare interbeds of rhyolite and metasedimentary rocks.

BASALT

An eastern unit up to 1 kilometre thick of augite-phyric, amygdaloidal basalt with relict pillows and breccia fragments is only tentatively assigned to the Mount Stapler suite. It is largely in fault contact with the other units in the suite across a strand of the Llewellyn fault, is less deformed than most of the rest of the suite, and strongly resembles parts of the Stuhini Group, to which it may be related. However, this unit is also occasionally found interlayered on a metre scale with other rock types of the Mount Stapler suite.

Along the northern edge of the Rugulose Glacier, interbedded greywacke, argillite, phyllite, rhyolite and andesitic tuff of the Mount Stapler suite grade westward with no apparent major breaks into chlorite-actinolite schist and garnet metapelite of the Boundary Ranges metamorphic suite. A boundary is roughly drawn between the two where protolith textures are no longer visible and garnet grade rocks are in evidence.

POLARIS BLOCK STRATIGRAPHY

A suite dominated by weakly to strongly foliated green basaltic lapilli and ash tuff hosts the Polaris-Taku deposit. Subordinate lithologies include gabbro, marble, altered ultramafite and rare intermediate to felsic lapilli tuff layers. Serpentinite and gabbro intrusive bodies mapped along north-trending faults in the north part of the block are similar to the geology hosting the Polaris-Taku deposit in the southern part of the block. Metamorphic grade is lower to middle greenschist and stratigraphic relationships are complicated by tight folding with extreme limb attenuation producing rootless hinges (J. Moors, personal communication, 1993). Resultant strain partitioning is similar to that seen in the Mount Eaton block, but more severe.

Rocks most resembling those of the Polaris block are unmetamorphosed strata of the Mount Eaton block, an association suggested by Souther (1971; at that time both were believed to be part of the Upper Triassic Stuhini Group). So far, our attempts to date this package have been unsuccessful as all samples collected for conodont separates have been barren.

STRATIGRAPHY WITH WELL-PRESERVED PROTOLITH TEXTURES

Lithologic packages of Paleozoic age in which pristine protolith textures are commonly preserved and the maximum metamorphic grade is lower greenschist, include the Mount Eaton and Sittakanay blocks. Both rock packages are typical of the Stikine assemblage, the upper Paleozoic basement to the Mesozoic Stikine arc. Mesozoic strata are dominated by Upper Triassic Stuhini Group arc rocks and Lower Jurassic fore-arc(?) and successor basin strata of the Laberge Group. Conventional wisdom places the former in the Stikine Terrane and the latter as part of an overlap assemblage

(Wheeler *et al.*, 1991).

STIKINE TERRANE

Distribution of the Stikine Terrane has historically been considered coextensive with regionally correlated Upper Triassic and Lower Jurassic volcanic successions of probable arc origin. These arcs were, in turn, built upon Paleozoic arc and sedimentary successions collectively known as the Stikine assemblage (Monger, 1977). Gross aspects of a stratigraphy originally thought restricted to Permian and locally late Mississippian in age, can be correlated from place to place, but details differ greatly. Oldest Stikine assemblage rocks are now known to predate Late Devonian intrusions (Logan *et al.*, 1993). Thick limestones, at one time lumped by default with "Permian limestone", then considered the Stikine assemblage hallmark, are now known to span ages ranging from Devonian to Permian (Brown *et al.* 1991). Similarly, Stikine assemblage strata in the Tulsequah area are known to range in age from early Mississippian (Sherlock *et al.*, 1994, this volume) to middle Pennsylvanian (Nelson and Payne, 1984), and are suspected to range in age from Devonian to Permian. New fossil collections and samples for isotopic age determination now being processed will help to further constrain ages. Meanwhile, the stratigraphic interpretation here remains necessarily simplistic, with treatment of physiographic "blocks" and only preliminary correlations within and between them.

PALEOZOIC MOUNT EATON BLOCK

The Mount Eaton block is bounded on the north and south by Shazah Creek and Taku River, and on the east and west by a Tertiary pluton and the Tulsequah River, respectively (Figure 5). South and north of the Mount Eaton block, similar rocks also underlie the eastern part of Sittakanay block and the southern part of Mount Sparling (Figure 3).

Paleozoic strata of the Mount Eaton block, referred to by previous workers as the Mount Eaton group (informal; Payne and Sisson, 1988), display radical lateral facies changes, intraformational unconformities and synsedimentary deformation. In the absence of detailed age control, the group is tentatively subdivided here into lower, middle and upper divisions. The **lower division** is distinguished by the relatively common occurrence of felsic tuff, and near the Tulsequah Chief deposit has been informally subdivided into the hangingwall, footwall and mine series (McGuigan *et al.*, 1993). They are at least in part early Mississippian in age on the basis of U-Pb zircon dating (Sherlock *et al.*, 1994, this volume).

Overlying hangingwall series rocks are here subdivided into a **middle division** of massive pyroxene-phyric volcanic tuff, agglomerate and volcanogenic turbidite, succeeded by a sediment-dominated **upper division** which marks the influx of bioclastic limestone. Middle division rocks are undated, whereas upper

division rocks at one locality have returned middle Pennsylvanian fossils (Nelson and Payne, 984).

Lower Division (Early Mississippian to Late Devonian?)

Stratigraphically and structurally lowest recognized strata within the Mount Eaton block are mafic volcanics overlain by bimodal volcanic and sedimentary rocks which host the Tulsequah Chief and Big Bull deposits (Figures 4, 5). Based on correlation of an enveloping limestone marker bed, the rocks probably extend to the north and south ends of the Mount Eaton block. In the vicinity of the orebodies these rocks have been subdivided into more than three dozen units, but on a regional scale they can be represented by only a few (for a more detailed description of Tulsequah Chief and Big Bull stratigraphy, readers are referred Sherlock *et al.*, 1994, this volume).

Bounding the mine succession to the west is a **massive limestone** unit, consisting of a north-trending series of limestone lenses that separate the mine series (see below) to the east from the augite-phyric, chlorite-quartz amygdaloidal unit to the west (Figure 5). This limestone is light grey on weathered and fresh surfaces, fine grained (to coarse grained where horn felsed by the Shazah Creek pluton) and massive to banded. It is not clear whether the limestone is in stratigraphic contact with the mine succession, or part of a fault panel that is juxtaposed against the mine succession.

In the valley bottom east of the massive limestone unit is a dark green to black, **indurated augite-phyric, chlorite-quartz amygdaloidal basalt breccia** and lesser flows and fine-grained sediments. It forms the eastern bank of the Tulsequah River immediately south of the Tulsequah Chief deposit where it is known as the **footwall series**. Finely disseminated sulphides, including chalcopyrite, are common. Near the mine site, pervasive silicification and pyritization of this unit produce totally bleached, rusty and white-weathering outcrops such that contacts with overlying felsic units are difficult to distinguish.

Dacitic to andesitic tuffs overlie the basalt breccia and are best developed, and probably coarsest where they host the Tulsequah Chief deposit. Fine-grained felsic tuff at the Big Bull deposit and intervening dacitic tuff and flows may be distal equivalents, but the possibility of a distinct felsic package has not been ruled out. They are typically white weathering, locally epidotized, sericitic or spherulitic. Similar rocks also occur within the Sittakanay block.

Middle Division (Mississippian to Pennsylvanian)

Interfingering, fine mafic and felsic tuffaceous and sedimentary strata form a diffuse contact between the lower division and distinctive, **pyroxene±plagioclase-phyric volcanic breccia and agglomerate of the middle division. This is the single most abundant lithology within the upper Mount Eaton block, but is locally subordinate to volcanogenic turbidite and waterlain ash tuff. From a distance, this cliff-forming unit is massive and dark green, but in detail it is bright green, with dark green to black, xenomorphic, medium-grained pyroxene phenocrysts and 1 to 5-millimetre chlorite amygdales.

Figure 5. Geological map of the Mount Eaton area, showing major units, faults and folds. Simplified from 1993 British Columbia Geological Survey mapping, Payne *et al.* (1981) and Dawson *et al.*, 1993.

LEGEND

MOUNT EATON SUITE; Devonian to Permian arc succession of the STIKINE ASSEMBLAGE

Pennsylvanian to Permian

PEsc	Medium-bedded, creamy white, tan, light grey or greenish chert. Commonly interbedded with tan limestone or fusilinid packstone; Rarely black and rusty weathering; Permian?
PEse	Sedimentary exhalitive horizon. Siliceous, with disseminated to semimassive fine-grained pyrite; minor quartz-sericite schist.
PEst	Tuffaceous shale to siltstone. Tan and dark grey weathering, laminated to medium bedded; AE turbidites, locally with cross-stratified ACE.
PEsd	Debris flow - fossiliferous carbonate> volcanic fragments and tuffaceous shale. Matrix green volcanic sandstone to (rarely) limestone. Clasts up to several metres in diameter.
PEsl	Brown bioclastic packstone. Tuffaceous; well bedded; interbeds of shale, greywacke, massive limestone.
PEvt	Finely laminated maroon lapilli-ash tuff; locally massive tuff breccia, some green fragments: intervals of tan, siliceous tuff.
PEvb	Dark green, abundantly vesicular and sparsely K-feldspar megacrystic pillow basalt and breccia.
PEvd	Subophitic dike and sill complex. Dark green, medium to fine crystalline with chilled margins, massive, dioritic to gabbroic.
PEvc	Volcanogenic conglomerate. Light to medium green weathering, epidotized, massive to crudely bedded, rare sand intervals.
PEstm	Tuffaceous mudstone/greywacke. Distinctive white to pea-green weathering unit is thin to thick bedded, with locally common bioclastic limestone/debris flows and purple weathering massive limestone intervals; Characteristic red and white striped appearance where hornfelsed; may also weather dark green to maroon.

Mississippian or Pennsylvanian

MPEva	Agglomerate. Pyroxene > feldspar porphyritic, mainly monomict, commonly strongly epidotized, light to medium green weathering, some clasts weather maroon.
MPEv	Undifferentiated andesite to basalt flows, breccia, and minor lapilli and ash tuff. Dark green, generally pyroxene phyric, chlorite amygdaloidal, tuff typically well bedded. As mapped, does not represent a single stratigraphic interval.
MPEvt	Finely laminated maroon lapilli-ash tuff; locally massive tuff breccia, some green fragments; intervals of tan, siliceous tuff.
MPEvlt	Medium to dark green lapilli tuff. As mapped, includes intervals of ash tuff and breccia.
MPEvb	Mainly dark green pillow basalt and massive basalt. Pyroxene phyric.
MPEst	Tuffaceous shale to siltstone. Tan and dark grey weathering, laminated to medium bedded; AE turbidites, locally with cross-stratified ACE.
MPEstm	Tuffaceous mudstone/greywacke. White to pea-green weathering; dark grey to dark green fresh; thin to thick-bedded.
MPEsm	Massive marble/limestone. Hackley, light grey weathering; recrystallized; may be sparsely fossiliferous at margins.
MPEvbb	Massive basaltic tuff breccia and lesser flows. Dark green to maroon, massive; relatively undeformed; generally pyroxene > tabular feldspar porphyritic.

Early Mississippian

eMEm	Massive limestone or marble. Light grey to white; banded; fine to medium grained.
eMEms	Massive sulphide mineralization. Most commonly pyrite±gypsum or sphalerite>galena> chalcopyrite>tetrahedrite. Adjacent rocks sericitized.
eMEr	Rhyolite breccia; minor flows. Light grey to light green; may include bleached quartz amygdaloidal basalt in part.
eMEd	Dacite to andesite tuff, breccia and flows; light grey to mauve. Tuff may be foliated and sericitic; flows may be spherulitic.
eMEb	Basalt breccia. Quartz and chlorite vesicular; pyroxene and lesser feldspar-phyric; well indurated; traces of chalcopyrite in the matrix; black to dark green weathering.
eMEv	Undifferentiated andesite to basalt flows, breccia, and minor lapilli and ash tuff. Dark green, generally pyroxene phyric, ± chlorite vesicular, tuff typically well bedded. As mapped, does not represent a single stratigraphic interval.

Pyroxene is commonly subequal or subordinate to medium or coarse tabular plagioclase phenocrysts. Clasts are round to subangular and most may have formed as pillow breccia, particularly where enclosing sparse pillowed flows. Associated sediments including mafic ash tuff and pyroxene-feldspar crystal tuff, tuffite and green to grey turbidite occur throughout the succession. Overlying polymictic debris-flows and conglomerate mark a transition to the upper division.

Upper Division (Middle Pennsylvanian to ?Permian)

Upper division rocks of known Permo-Pennsylvanian age are the structurally highest and youngest dated unit in the Mount Eaton block. They outline a large east-verging, north-northwest-plunging anticline, with the axis near the west side of the Mount Eaton Glacier (Figure 5) and are distinguished by the presence of interbedded brown-weathering bioclastic rudite debris flows. Calcarenite, micrite, shale, siltstone, chert, variegated tuff and sparse pillow basalt flows locally dominate parts of the section.

Conspicuous bioclastic rudite debris flow lenses, generally less than 2 metres thick, characterize the division. Fossil debris is silicified and often very well preserved, and consists of a diverse assemblage of solitary and colonial corals, brachiopods, bryozoans, crinoid stems, pelecypods and fusilinids of middle Pennsylvanian age (Nelson and Payne, 1984). All are resedimented and thus fossil ages reflect the maximum age of the rock. Bedding ranges from laminated in the shale and micrite intervals to medium and thick bedded in the coarser lithologies. Sedimentary features, including grading, crossbedding and flame structures, are spectacularly displayed. A slight tuffaceous component may impart a pink or greenish tinge to these rocks which are normally light brown to tan or white.

A polymictic, mainly volcanic conglomerate and sandstone unit marks the base of the upper division; it is particularly well developed north of Roger Lake where it is over 500 metres thick. These rocks are green, and massive to rarely bedded. Beds are medium to thick, with rare grading and thin-bedded intervals. Clasts are subangular to rounded pebbles to boulders up to 2 metres in diameter, of dark to light green, aphanitic to feldspar or augite-phyric volcanics, lesser limestone, siliciclastics, felsic tuff and rare pyritic tuff with copper staining.

Thick sheet to lens-like coarse debris flow deposits are exposed at the base of the bioclastic limestone unit in many locations. They consist principally of clasts of fossiliferous to massive limestone and intermediate to mafic volcanic breccia fragments in a matrix ranging
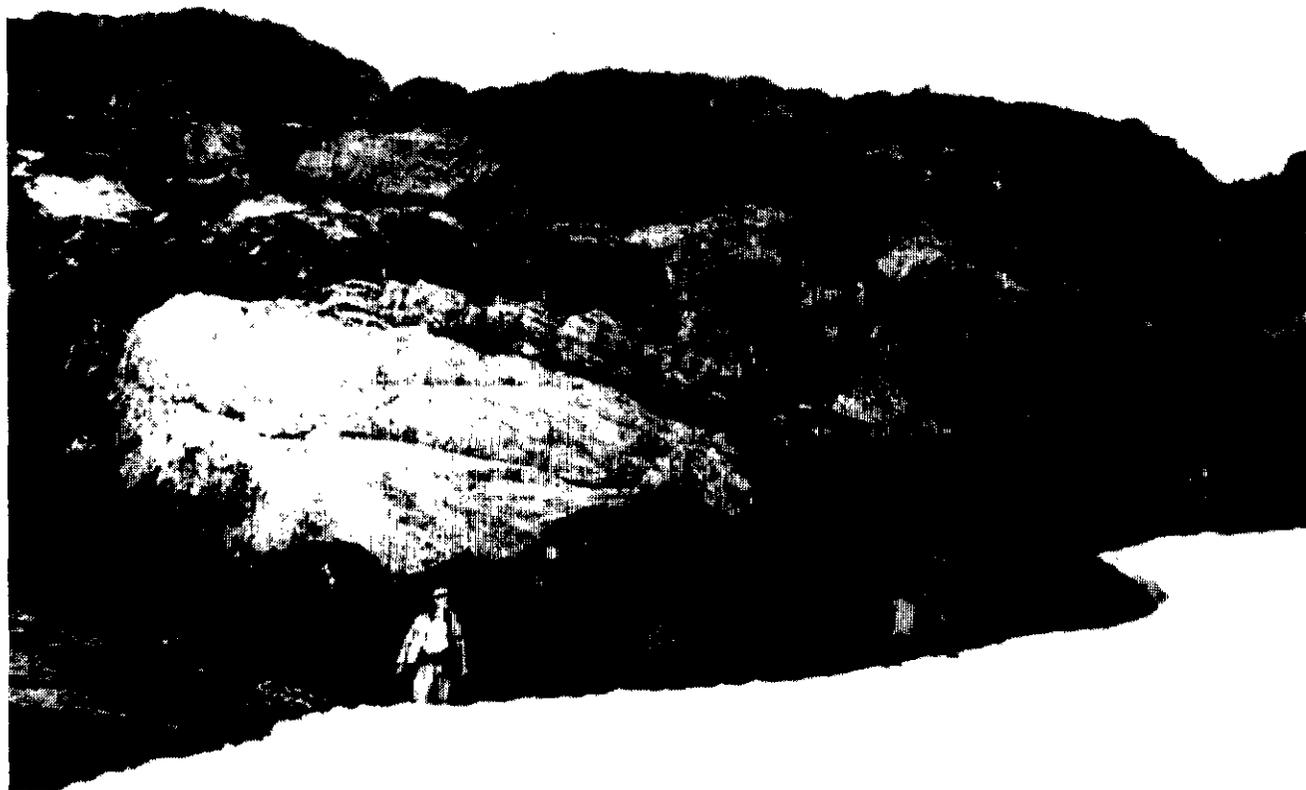

Plate 3. Outcrop in the limestone debris flow unit. Note extremely poor sorting, blocks up to several metres in diameter, and dark volcanogenic matrix.
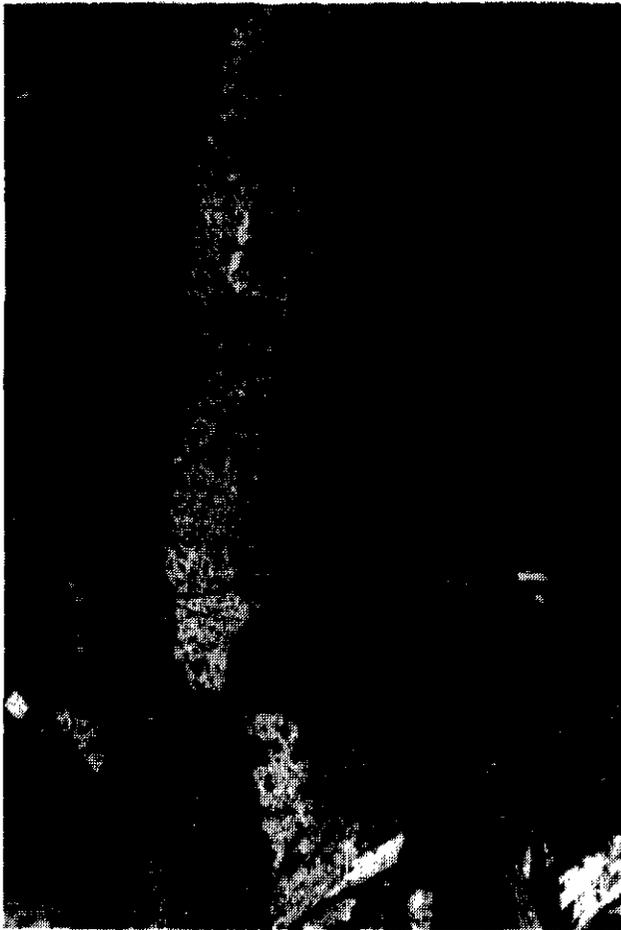
Plate 4. Hyaloclastite unit in the Mount Eaton sequence. Note angular volcanic fragments and boundary between cooling units (white layer).

from limestone to fine-grained volcanic material. Lenses are massive and poorly sorted, with clasts ranging from granule to house-size, (Plate 3) and may be up to 50 metres thick. Some limestone blocks appear to have been subjected to subaerial weathering or karsting.

Brightly coloured, **green and maroon lapilli ash tuff** is a very distinctive unit within the upper division (Plate 4). It is mainly comprised of lapilli and ash, but blocks are not uncommon. Fragment composition is fairly consistently intermediate and ranges from aphanitic to fine feldspar and pyroxene porphyritic. Ash and dust matrix is commonly calcareous. Individual beds may show grading and are typically less than a metre thick forming sets ten or more metres thick. They are interlayered with bioclastic debris flows and turbiditic units, but are mainly concentrated in two or three parts of the section.

Pea-green volcanogenic turbidites (Plate 5) are thin to medium bedded and well graded. Coarse bases are mainly composed of volcanic lithic grains, feldspar crystals and sparse bioclasts grading upward into dark grey argillite. Scours, and synsedimentary flame and slump structures are common. Locally the unit is intimately interbedded with thin micrite, bioclastic limestone, grey-black turbidites and debris-flow layers on

a centimetre to metre scale; however, sets of green volcanogenic turbidite beds several metres up to tens of metres thick are typical.

Intervals of black (shale/argillite) and tan-weathering (sandstone) AE (± D) **turbidites** are most commonly interlayered with volcanic breccia and conglomerate. Most beds are thinly laminated to medium bedded, but rare thick beds are observed. Thicker intervals of the turbidite unit exceed 250 metres. Thinner intervals lie within and interfinger with the bioclastic limestone unit. The unit differs from the volcanogenic turbidites in its colour, composition and commonly associated lithologies. Like the volcanogenic turbidites, however, it is locally interlayered with most other lithologies in the upper division, including pea-green volcanogenic turbidites.

Beautifully pillowed units of dark green, highly vesicular, **potassium feldspar megacrystic basalt** are exposed in the Mount Manville area. Potassium feldspar megacrysts are white to pink, iron oxide stained and commonly up to 4 centimetres in diameter (Plate 6). Megacrysts and vesicles form concentric layers mimicking the shape of pillows. Distribution of this unit

Plate 5. Well-preserved, thin to medium-bedded intermediate ash tuffs in the Mount Eaton sequence near Mount Manville. These rocks are interbedded with massive to pillowed basalt.

is limited to two areas separated by several kilometres, providing a distinctive marker. It is uncertain whether these flows are related to much more common basalt flows that lack potassium feldspar megacrysts.

Intermediate to mafic volcanic breccia and flows are dark green to black, grey or purplish, and poorly bedded. Angular lapilli are mainly finely feldspar porphyritic. This unit is best developed in the Mount Manville area on the far eastern limb of the Mount Eaton antiform, and thus is one of the structurally highest and

possibly youngest units in the area.

Subophitic hypabyssal sills are relatively abundant locally within the upper division, particularly in volcanogenic turbidites of the Mount Manville area. Sills are grey to dark green and range from aphanitic, particularly near sill margins, to medium grained in the cores. Peperite textures and fluid escape features in overlying strata are locally well developed and point to injection penecontemporaneous with sedimentation, probably coincident with pillow basalt outpourings. One sill more than 300 metres thick crops out on both sides of the Mount Eaton glacier near its terminus, although most are only decimetres thick.

An accumulation of light brown, tan and white-weathering bioclastic rudite, micrite and sets of thin calcareous turbidite layers marks the top of the division. One mappable unit within this package is a **massive bioclastic limestone** unit 90 metres or more thick.

On the north end of Mount Eaton, a distinctive medium **interbedded limestone and chert** unit crops out to the southeast of the massive limestone described above. Composition ranges from medium-bedded chert to massive limestone which are both light grey to buff weathering, rarely darker. At least two fusilinid packstone marker beds are present within the section. Another distinctive bed of siliceous pyritic, exhalative black chert and minor sericite schist is continuous for at least 200 metres within this sequence. The chert-limestone unit is exposed in a series of tight, complex folds, and it grades from limestone breccia into andesitic to basaltic lapilli tuff and minor flows and thin to medium-bedded tuff and siltstone, perhaps correlative with the middle division. To the north of these outcrops, there is a very thick section of massive limestone. It is interbedded with andesitic ash to lapilli tuff and tuffite to the north and siliceous mudstone to the south. Both margins are fossiliferous, which may help to tightly constrain the age.

SITTAKANAY BLOCK

Rocks on the west ridge of Sittakanay Mountain, in the extreme southern part of 104K/12 (Figure 3) are here called the Sittakanay Mountain block. Many rock types in the Mount Eaton block are represented in the Sittakanay Mountain block, and the rocks are interpreted as correlative. However, the overall degree of ductile deformation of the Sittakanay Mountain block, particularly the western half, is more pronounced. Rock types represented in the eastern half of the block include (from most to least abundant) andesitic lapilli tuff, breccia and ash tuff; brown to grey-weathering, thin to medium-bedded turbiditic shale, siltstone, sandstone and rare conglomerate; augite-phyric flows; limestone, ranging from massive grey to brown bioclastic; chert and siliceous argillite; maroon hyaloclastite and lapilli tuff; felsic tuff, and dioritic to gabbroic hypabyssal intrusive bodies. The western part of the ridge may be a more deformed and recrystallized equivalent of the units to the east. It consists primarily of alternating panels of quartz-

Plate 6. Potassium feldspar megacryst in vesicular pillow basalt. This distinctive unit crops out at several locations in the upper Mount Eaton sequence.

rich phyllite and semischist (shale, argillite, siltstone and sandstone), and chlorite phyllite and greenstone (tuff and flows of intermediate composition) with rare quartz-rich intervals (felsic tuff or clastics).

MOUNT STRONG BLOCK

The Mount Strong block underlies the area bounded on the east by the Tulsequah and Taku rivers, on the west by a large granitic pluton, and on the north is separated from the Polaris block by Wilms Creek (Figure 3). Six lithologic units or associations are mapped in the block. In order of decreasing volumetric significance they are: siliceous greywacke, siltstone and shale; basaltic tuff and flows; limestone; pyroxenite; argillaceous chert; and andesitic(?) tuff. South and west of Mount Strong, rocks are strongly foliated but barely recrystallized and show effects of later hornfelsing, but to the north, protolith textures are still preserved.

SILICICLASTIC ROCKS

Most of the Mount Strong block is underlain by metamorphosed siliceous argillite, siltstone, sandstone, and phyllite. Siltstone and sandstone are quartz rich, light to dark brown or grey with compositional bands that

resemble thin beds and laminations. Thick sections are present on the south ridge of Mount Strong, alternating with sections of dark grey phyllite and siliceous argillite. Where protolith textures are preserved north of Mount Strong, siltstone and sandstone are medium to thin bedded and rarely graded.

MARBLE

A single, large body of light grey to white, medium to coarse-grained, banded to massive, foliated marble crops out on the upper slopes of Mount Strong. It is phyllitic along the margins and contains layers of cherty argillite, mafic tuff and phyllite. It pinches out to the south and splits into two distinct bands to the north, suggesting that it may represent a very attenuated, rootless isoclinal fold. The layer is over 300 metres thick (perhaps representing a double thickness if the fold interpretation is correct), but its original depositional thickness may have been substantially greater.

BASALT

Basalt flows and tuffs are locally interlayered with argillite and siltstone units described above, primarily along the east flank of the north-trending ridge north of Mount Strong. The unit is characteristically featureless, only rarely displaying ghosts of a primary fabric. Relict lapilli and stretched white feldspar phenocrysts and amygdules distinguish these volcanic rocks from the argillites. Near Mount Strong, rocks are dark green to black and very fine grained due to hornfelsing.

ULTRAMAFITE

A nearly circular, polyphase pyroxenite to hornblendite ultramafite body approximately 2 kilometres in diameter is exposed 1.5 kilometres south of the confluence of Wilms and Bacon creeks. Pyroxenite is dark green to black, fine to coarse grained, weakly foliated, and dominantly composed of pyroxene with minor biotite (or phlogopite? up to 7%), opaque spinel (up to 10%) and secondary serpentine and carbonate. Hornblendite to gabbro is very coarse with crystals up to 10 centimetres long with interstitial feldspar, locally partly altered to epidote. Contacts with the enclosing sedimentary rocks are sheared and, where best exposed, the ultramafite is thoroughly serpentinized, thus contact relations and relative age are uncertain.

ANDESITIC TUFF

Metatuff of probable intermediate composition is exposed 1 kilometre southwest of the summit of Mount Strong, where a section approximately 50 metres thick is interlayered with younger intrusive rocks and hornfelsed basalt and siltstone. It is light to medium green, locally phyllitic, and fine grained, with compositional bands suggestive of thin beds and laminations.

STUHINI GROUP

Regionally extensive, arc and arc-derived rocks of the Upper Triassic Stuhini Group underlie much of the Stikine Terrane. Region-wide, it consists largely of green, augite-phyric pillowed flows, breccia, tuff, hyaloclastite, feldspar-phyric flows and massive Norian limestone, with other minor sedimentary rocks. The Stuhini Group was originally thought to underlie much of the map area (Souther, 1971). However, more recent workers (Nelson and Payne, 1984; J. Mortensen, personal communication, 1992) established that much of the section mapped as Stuhini Group belongs to the upper Paleozoic Stikine assemblage which it strongly resembles. Stuhini rocks are also difficult to distinguish in some areas from intermediate volcanics of the Sloko Group. In the map area, rocks definitely identified as Stuhini Group are only slightly deformed, contain a sub-greenschist or low greenschist facies mineral assemblage, and consist mainly of breccias and sedimentary rocks. A relatively extensive unit of penetratively deformed augite-phyric flows that bounds the east side of the Llewellyn-Chief fault system in many areas may belong either to the Stuhini Group or one of the Paleozoic units.

In general, the units here can be correlated with units at the southern end of Atlin Lake where they have been described in detail (Bultman, 1979; Mihalynuk and Mountjoy, 1990).

A **basal conglomerate** mapped immediately east of the Llewellyn fault in the extreme northern part of 104K/13 includes mainly clasts of Mount Stapler-type lithologies and intrusive cobbles (from a body dated c. 220 Ma). Immediately overlying(?) strata are indurated, poorly bedded, black, cherty and pyritic argillite. However, contact relationships are obscured by intense brittle deformation along the Llewellyn fault which is well exposed at this locality.

Volcanic lithologies dominate the succession. They include: maroon and green feldspar-phyric breccia, **heterolithic lapilli tuff** and derived volcaniclastics; variegated, locally quartz-bearing intermediate tuff; **augite-phyric tuff and flows**, hyaloclastite(?) breccia and pillowed flows; and bright green, picritic, augite-phyric, hyaloclastite(?) breccia.

Carbonate near the top of the succession forms discontinuous layers, pods and olistoliths. It is tentatively correlated with the upper Norian Sinwa Formation which is best exposed several kilometres outside the eastern edge of the map area, at Sinwa Mountain. Within the map area the Sinwa Formation is mainly covered, eroded away or faulted out of the section. Exposed remnants are strongly veining and brecciated. The unit may grade laterally into pyroxene-phyric tuffs with a matrix of carbonate.

A succession of fine-grained, dark grey to black, thin-bedded to laminated **graphitic shale and argillite** is exposed several kilometres north of Mount Sparling. It is tentatively assigned to the Stuhini Group on the basis of preliminary identification of *Halobia* of Late Triassic age, and the presence of layers of similar lithologies several metres thick, interbedded with conglomerates and

breccias of the Stuhini Group immediately to the south. The section is several tens of metres thick, and is overlain by coarse, medium to thick-bedded feldspathic wackes.

Cobble to boulder conglomerate and sandstone are exposed below the Sloko unconformity along both sides of the lower Opposer Glacier and the unnamed glacier to the southeast. It is generally light green to white or salmon-pink weathering, massive to rarely crudely bedded, and epidotized. It contains rare thin to medium-bedded, green sandstone and siltstone intervals. Clasts are subangular to well rounded, and typically composed of augite or feldspar-phyric to aphanitic light green (epidotized) volcanics. At its easternmost mapped occurrence, the conglomerate is interlayered with green to maroon volcanic breccias assigned to the Stuhini Group, and is thus correlated. Similar rocks in northwest 104K/13 are, however, suspected to be of late Pliensbachian age based on association with finer grained sediments of that age, and are correlated with the Laberge Group.

LABERGE GROUP

Marine turbidites and fan deposits of the Laberge Group are best exposed in the northeasternmost part of 104K/13. Mapping of deep glacial valleys incising the Sloko Group reveals several occurrences of Laberge Group, extending its known distribution much farther to the west. Several new macrofossil localities discovered at new and previously known Laberge Group localities should help to further constrain the age of these rocks.

Laberge Group lithologies in the Tulsequah area include indurated, finely bedded siliciclastics: dark, fissile argillite; coarse feldspathic wacke; intrusive cobble conglomerate; and tuffite. With the exception of the tuffite and the enormous thickness of some conglomerate lenses, the lithologies present in the Tulsequah area are much the same as those near Atlin Lake to the north where the Laberge Group has been thoroughly described (Bultman, 1979; Mihalynuk *et al.*, 1989; Johannson, 1993).

Siliciclastics are grey-brown to red-brown, fine turbiditic greywacke and siliceous shale. Beds are thin to thick, AE to nearly complete Bouma sequences. A slight cleavage is locally developed in fine-grained layers.

Distinctive cobble to boulder conglomerate forms the southeasternmost Laberge Group exposures. It is characterized by the presence of very well rounded, high sphericity granitic clasts, which make up 20 to 30% of the total clast population. Clasts which are more abundant include: fine-grained green-grey intermediate volcanic; grey feldspar porphyry; maroon ash tuff; and silt and sandstone. Intrusive cobbles are predominantly orange-yellow, biotite granite with euhedral potassium feldspars, and white granodiorite with pink potassium feldspars, hornblende and subordinate biotite. Clasts of lesser abundance include: green lapilli tuff, coarse pyroxene porphyry, rare white chert or rhyolite, and very rare hornblende-feldspar gneiss. In two locations this

unit appears to directly overlie volcanic breccias of the Stuhini Group. Thus, it may represent the basal unit in the Laberge Group in the Tulsequah area.

Intervals of buff-weathering greywacke and granule conglomerate are enclosed by argillite. The greywackes are quartz and feldspar rich; clasts in the conglomerate are much like those in the lower conglomerate unit including volcanic (pyroxene and hornblende feldspar porphyries, feldspar porphyries, aphanitic mafic to felsic); sedimentary (light and dark grey, rarely fossiliferous carbonates with lesser wackes and argillite); and intrusive (syenites through leucogranites) rocks. The rocks are generally medium to thick bedded with thin silty interbeds. this unit includes lithologies mapped by Souther (1971) as "Takwahoni Formation".

Green tuffite, bisected by the interpreted northern extension of the King Salmon fault, underlies the Sloko unconformity in the extreme northeast corner of 104K/13 (Figure 3). East of the fault, it consists of alternating layers of thin-bedded green to maroon and chocolate-brown tuffaceous siltstone and shale, thin to thick-bedded sandstone and massive conglomerate lenses. Sandstone and conglomerate clasts are almost wholly volcanic in composition. This unit appears to grade northeastward into tan-weathering, thick-bedded sandstone, then brown to grey, thin-bedded siltstone and shale typical of the Laberge Group. The contact area is poorly exposed and contains numerous small faults. Ammonites collected from this unit are probably upper Pliensbachian, thus correlation with the Laberge Group seems likely. Strata west of the King Salmon fault consist of massive, green, volcanogenic sandstone intervals up to 100 metres thick interlayered with intervals of fossiliferous, black, graphitic argillite and siltstone 2 to 5 metres thick. Although very similar in nature to the Upper Triassic section, these rocks also contain upper Pliensbachian ammonites.

SLOKO GROUP

Mafic to felsic Sloko Group volcanic strata rest with profound and irregular unconformity above Mesozoic and older strata. Sloko Group rocks were originally mapped as covering most of the northeast part of the map area and many of the higher peaks in the western part of the map area. This distribution is borne out by our mapping, but with important exceptions. Several windows through the Sloko expose Mesozoic strata, diminishing the expansive blanket of Sloko Group rocks.

Numerous volcanic centres, rapid facies changes, and synvolcanic high-angle faulting characterize the Sloko Group, yet it is easily subdivided into regionally mappable volcanic units. On the basis of 1993 fieldwork, the group is divided into six map units not previously reported in the area: basal conglomerate; massive, well-indurated, black pyroclastics (Opposer formation); massive, tan-weathering breccias (Mount Haney formation); distinctive interlayered flows and volcaniclastic rocks (Nakonake formation); rhyolite

domes and tuffs, and trachyte flow succession(s).

BASAL CONGLOMERATE

Sloko Group strata were deposited on a paleosurface of considerable relief, as evidenced by irregular, sloping contacts, slump deposits and a wide variety of volcanic types overlying the unconformity. In some areas, a basal conglomerate is developed over the erosional surface. It is characterized by subangular to well-rounded, poorly sorted, crudely bedded polymictic cobble conglomerate, composed of intraformational clasts (porphyritic andesite, rhyolite) and clasts derived from underlying rocks (schist, gneiss, argillite, granitoid rocks). The basal conglomerate is generally poorly indurated, and may grade laterally and/or up-section into volcanic breccia and tuff. Deposition of the conglomerate is clearly diachronous.

OPPOSER FORMATION (INFORMAL)

Very well indurated, cliff-forming vitrophyric tuff and flows of the Opposer formation are characteristically massive, dark green to dark grey or black. On outcrop scale, Opposer rocks typically consist of sparse breccia fragments ranging from a few centimetres to about 20 centimetres across in a massive, black, fine-grained matrix. Matrix material often exhibits conchoidal fracture, suggesting relatively high silica content. Breccia fragments are light grey to green, often epidote altered with diffuse margins. Fragments of granitoid rocks are not uncommon. Opposer formation underlying Nelles Peak and many of the other high peaks in the region is nearly 2000 metres thick. In at least three locations (Nelles Peak, the Devil's Paw, and an unnamed peak southeast of Mount Haney), the Opposer formation is intruded by granitic plutons, suggesting that its distribution coincides with regional magmatic centres.

MOUNT HANEY FORMATION (INFORMAL)

Poorly indurated, epidote or clay-altered, tan to light green weathering Mount Haney formation is massively bedded, dacitic to andesitic volcanic breccia and lapilli tuff up to several hundred metres thick. Breccia fragments range from a few centimetres in diameter to house sized, but are typically 10 to 20 centimetres across; they are feldspar porphyritic and maroon to green in relatively unaltered sections. Vent facies are recognized locally, and in several localities pyroclastic dikes of the same composition are proof of a pyroclastic origin. Elsewhere, laharic facies predominate, and in at least one locality growth faults and highly chaotic layering indicate infill of a collapse feature.

NAKONAKE FORMATION (INFORMAL)

Alternating recessive volcaniclastic and resistant flows create the distinctive light and dark ribbed appearance of the Nakonake formation (Plate 7).

Volcaniclastic layers are poorly consolidated, tan weathering lahar, breccia and tuff in layers from metres to tens of metres thick. Maroon to dark brown-weathering, white feldspar porphyritic flows, range from 5 to over 50 metres in thickness. Nakonake formation both grades laterally into and overlies the proximal facies Opposer and Mount Haney formations, and probably represents both distal facies and the waning, more quiescent phases of Sloko volcanism. This is well illustrated in the north-central part of 104K/13, where Opposer formation rocks that underlie Mount Haney grade laterally eastward into the Nakonake formation, and southeast of Mount Haney, where the Nakonake formation overlies the Opposer formation.
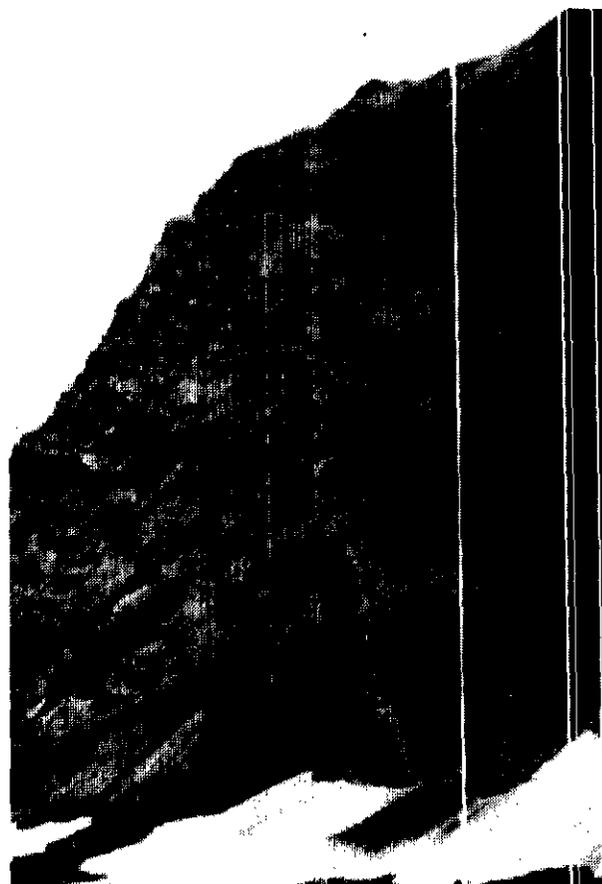

Plate 7. Volcanic rocks of the Nakonake formation of the Sloko Group. Approximately 300 metres of section are illustrated in this photo.

RHYOLITE

Mappable units of rhyolitic flows and tuff crop out in a few localities, typically near or at the base of the section. Tuff is generally well indurated, light green to grey weathering, and characterized by lapilli sized fragments of feldspar±quartz-phyric rhyolite in an ash matrix. A basal rhyolite tuff and breccia unit is exposed south and west of Mount Sparling for several kilometres along strike. Rhyolite flow-domes are mapped in a few localities within the Mount Haney formation. They are irregular lenses of flow-banded, aphanitic to sparsely

feldspar and quartz-phyric rhyolite and welded rhyolite tuff. Flow banding is often steeply inclined.

TRACHYTE FLOW SUCCESSION

Thick, locally columnar jointed trachyte flow successions can be mapped in northeastern 104K/13. Here they are in gradational contact with Mount Haney formation laharic strata near the toe of the "Slohini Glacier" (informal name) and are deposited with angular discordance on the Nakonake formation north of the "Opposer Glacier" terminus. Immediately underlying Mount Haney formation strata are somewhat distinctive in that they contain up to 3% pebble-sized rusty weathering and strongly pyritized clasts of uncertain protolith.

Trachyte flows may be flow banded and form cooling units up to several tens of metres thick. They weather bluish or greenish grey to tan or brown, containing 10% pinkish, glomeroporphyritic sanidine(?) and plagioclase partly altered to chlorite. Rarely fine-grained quartz phenocrysts are present. Chlorite and calcite-filled vesicles are locally common, perhaps outlining the tops of individual cooling units. Matrix material is very fine grained to aphanitic.

DIKE AND SILL SWARMS

Dikes believed to be coeval with Sloko volcanism are of four types: white, flow-banded rhyolite, grey to maroon banded trachyte, green to grey aphanitic to hornblende-phyric and pyroclastic Mount Haney formation feeders.

White rhyolite dikes are most conspicuous and are thus the best mapped of Sloko dikes. They attain thicknesses of metres to tens of metres and commonly follow or form topographic linears which, in at least some cases, are related to zones of structural weakness. Such relationships are well documented at the Tulsequah Chief deposit (G. Dawson, personal communication, 1993). Trachyte dikes are conspicuous where they cut darker volcanic strata of the Nakonake formation, but have generally not been mapped on an individual basis. Pyroclastic dikes are recognized in only a couple localities, but are clearly related to the Sloko volcanic episode. Darker coloured dikes are at least as common as rhyolitic lithologies, although they lack the contrasting colour which enables the former to be mapped from a distance.

Dikes form swarms with two predominant orientations: north and northeast; although individual dikes are observed with almost any orientation. Rhyolite dikes following linears in the Mount Eaton block are invariably oriented north-south.

PLUTONIC ROCKS

With the possible exception of the early Jurassic Hale Mountain intrusion correlation described under **Gneissic Rocks of Igneous Origin** above, no Mesozoic

plutons have yet been clearly documented in the area. One intrusion near Sittakanay Mountain is interpreted to be Late Cretaceous based solely on its relatively high degree of alteration. Elsewhere in the map area, deeply incised valleys have exposed the roofs of several discrete plutons which vary compositionally from granodiorite to monzodiorite. Most are undeformed and cut Sloko volcanics with which they are probably comagmatic, and on this basis are assigned an Eocene age. A similar relationship is displayed near Tutshi Lake to the north. Here good age control dates both the volcanics and crosscutting intrusion as 55 Ma (M.G. Mihalynuk, unpublished data).

LATE CRETACEOUS?

A medium-grained, epidote-chlorite-altered hornblende and lesser biotite granodiorite to quartz diorite forms the northwestern ridge of Mount Sittakanay. From a distance it appears black and massive with irregular jointing. Local foliation is probably igneous in origin. A Cretaceous age assignment will be tested using K-Ar isotopic dating techniques.

EOCENE

Plutons of known Sloko or younger age underlie Shazah Creek, and the unnamed ridge southeast of Mount Haney, Devil's Paw, east Gisel Peak, and the north cirque of Nelles Peak (Figure 3). They generally range in composition from hornblende-biotite quartz monzonite to biotite granite, and are medium crystalline, homogeneous, light weathering, and exhibit pronounced exfoliation features and/or one or more prominent joint sets.

On the basis of these features, a granite pluton with granodioritic margins centred on Bacon Creek is also suspected to be of Eocene age. Contacts with country rocks are generally sharp and relatively unaltered, with the exception of the southwest contact of the Shazah Creek pluton, which has a very irregular contact and a wide contact aureole with associated brecciation of the country rocks up to 2 kilometres from the contact. The plutons are generally fresh and unaltered, but one body near Tulsequah Lake is cut by a myriad of chlorite-lined fractures. A cataclasite is produced where fracture density is greatest, but no sense of offset has been ascertained.

Sparse pea sized blebs of molybdenum and traces of disseminated chalcopyrite and pyrite occur in otherwise unaltered granite east of Gisel Peak.

DEFORMATION

All Mesozoic and older rocks in the map area were affected to various degrees by post-Early Jurassic, north to northwest-trending, polyphase folding, faulting and metamorphism. The degree of ductile deformation and

metamorphism generally increases westward from relatively undeformed Mesozoic strata to amphibolite grade gneisses of the Boundary Ranges and Whitewater suites. Possibly long-lived northwest-trending faults have been reactivated into the Early Tertiary. Late easterly to northeasterly crossfaults and crenulation cleavage are locally developed. Deformational styles differ between lithotectonic suites. These are described briefly below, grouped where appropriate.

MESOZOIC ROCKS

Deformation in the Stuhini and Laberge Groups is characterized by open to tight, mainly upright, north-northwest-trending, gently plunging folds. Rocks only locally possess a weak cleavage, typically in fold hinges in fine-grained strata. Volcanic rocks contain the assemblage chlorite+epidote+albite+quartz, indicative of subgreenschist facies metamorphism. Several small, northwest-striking, northeast-dipping thrust faults imbricate the section. The largest of these, apparently a continuation of the King Salmon thrust mapped by Souther (1971) to the east, is marked by a breccia zone up to a few metres wide and a zone of reddish alteration up to 50 metres wide. Rocks on both sides appear to be the same age and lithology (see above under lithologic descriptions), so total motion is probably not great. Movement on the King Salmon fault is thought to be Bajocian (Middle Jurassic) in age, related to emplacement of the Cache Creek Terrane over the Stikine Terrane (Thorstad and Gabrielse, 1986).

STIKINE ASSEMBLAGE

The Mount Eaton block and the more strongly deformed Sittakanay and Mount Strong blocks that make up the Stikine Terrane in the Tulsequah area are characterized by a single dominant phase of folding, sub-greenschist to middle greenschist facies deformation, weakly to locally strongly developed penetrative foliation and lineation, and steeply dipping, north-trending structural grain. This is overprinted locally by a non-pervasive second phase of east-trending folds that generally have wavelengths of less than 1 kilometre.

Deformation in the Mount Strong block is characterized by upright, tight to isoclinal, north or south-trending, gently plunging folds on a scale of centimetres to metres. In an otherwise monotonous sequence, panels of consistently west or east-vergent folds, as well as an apparently duplicated marble layer, suggest the presence of isoclinal folding on a kilometre scale. Rocks range from intensely flattened and strongly lineated parallel to fold axes south of Mount Strong to relatively undeformed several kilometres north of Mount Strong.

A similar structural style is exhibited by rocks in the western Sittakanay block (Plate 8). Although folds are not abundant on an outcrop scale, repetitions of strata suggest that the section my be folded on a kilometre

scale. Rocks are phyllitic and generally lack primary depositional features.

Rocks in the eastern part of the Sittakanay block are openly to tightly folded on a metre to kilometre (locally centimetre) scale. Folds are generally upright, north trending and gently plunging. Rocks show primary depositional features but (with the exception of massive flow rocks) display a pronounced flattening fabric, stretching lineation parallel to fold axes, and locally, a second, subparallel axial planar fabric.

Plate 8. Tight folds in thin bedded tuffs of the Sittakanay Mountain block showing intense deformation of units that still retain protolith textures. Note refolded isocline, upper right of ice axe head.

Rocks in the Mount Eaton block are only weakly penetratively deformed, except in the cores of appressed folds where intense and chaotic folding produces a phyllitic fabric. Several large, open to appressed folds with sheared axial regions divide the Mount Eaton block into eastern, central and western structural panels (Figure 5). The eastern panel includes rocks east of the Mount Eaton glacier (Mount Manville area) which strike north-northwest, are steeply dipping to overturned, mainly east facing, and represent the eastern limb of a large, north-plunging anticline (Mount Eaton anticline). Minor folds are most commonly gently plunging and parallel to the strike direction.

The central panel exhibits the most complex deformation and includes the hinge and immediate western limb of the Mount Eaton anticline. It covers the area west of the Mount Eaton glacier to the vicinity of Roger and Wendy lakes, and extends along strike to the north and south. The hinge zone is mostly ice covered, but in at least two locations, where outlined by relatively competent massive volcanic breccia (e.g., northeast of Roger Lake), it is ruptured with shortening accommodated by several faults. Exact lithologic correlations cannot be made across the hinge zone, suggesting either significant facies changes or significant

motion on faults within the hinge. A northward continuation of the anticlinal hinge is represented by a very complex series of refolded anticlines and synclines at the northwest end of the Mount Eaton glacier.

Abundant east-verging folds on the immediate western limb of the Mount Eaton anticline are outlined well by the bioclastic unit, and to a lesser extent units below it, which are tightly folded around north trending fold axes, (Plate 9). Near Wendy Lake, folds axes trend southwest and axial planes dip northwest. Rocks are locally phyllitic and coarse tuff units have a pronounced flattening fabric. Locally an orthogonal set of folds produces a steep, second fabric oriented southwest to west. These folds have been clearly outlined through detailed mapping by Dawson *et al.* (1993) in the vicinity of the Big Bull mine. A north-trending zone of relatively intense ductile deformation, well developed west of Wendy Lake (the "Wendy Lake shear zone") separates the central and western structural panels.

The western structural panel includes rocks on the eastern bank of the Tulsequah River. Structural trends in this area are difficult to decipher due to thick vegetative cover, massiveness and rapid facies changes in the dominantly volcanic section. On a regional scale, bedding is steep and north to northwest trending, possibly representing another large fold. Minor folds also trend in the same direction. A set of fairly tight, north-plunging folds which are cut by numerous north-

imparted compositional layering, layer-parallel foliation and intrafolial isoclinal folds of variable orientation (Plate 10). It is locally difficult to recognize because it is largely coaxial to second phase deformation. The latter is characterized by greenschist to amphibolite facies metamorphism, schistose to phyllitic foliation with regional north-northwest strike and moderate to steep east dip, and millimetre to possibly regional scale appressed to isoclinal folds with axes that plunge gently and trend roughly 015°. Fold styles are highly variable, with competent units displaying metre-scale cylindrical to disharmonic folds and nearby phyllitic units tightly crenulated, sheared and refolded (Plate 10). Peak metamorphism of middle amphibolite grade is associated with second phase deformation. It is thought to be mid-Jurassic, as evidence by an ^{40}Ar/^{39}Ar-sericite plateau age of 172 Ma in the Moosetrap Creek area (Smith and Mihalynuk, 1992) and by reference to mapping and geochronology in other areas to the north (*e.g.* Currie, 1992). Foliated orthogneiss units do not reach amphibolite grade and may be late synkinematic with respect to second phase deformation.

Manifestations of third phase deformation include millimetre to decimetre-scale kink and crenulation folds with steep axial planes (locally forming a strong cleavage), and open to tight chevron folds, developed on a metre to kilometre scale. Cleavage and axial planes in both types strike 050° to 090° with steep dips, similar to

Plate 9. East-verging chevron folds in the bioclastic limestone unit west of Mount Eaton. View to the northwest.

trending high-angle faults, has been well delineated by drilling at the Tulsequah Chief mine (G. Dawson and T. Chandler, personal communication, 1993).

BOUNDARY RANGES AND MOUNT STAPLER SUITES

At least three phases of deformation are evident in the Boundary Ranges metamorphic suite. Phase 1

the second fabric developed in the Mount Eaton block. The effects of third phase deformation are variable, locally quite strong, and are accompanied by a retrograde, greenschist (chlorite grade) facies metamorphic overprint.

Deformation in the Mount Stapler suite is similar, but apparently represents higher crustal levels than the BRM. The highest grade rocks of this suite are middle greenschist facies.

POLARIS BLOCK

Variably developed foliation in the Polaris block probably corresponds to structural position whereby more intensely foliated rocks occur in the cores of tight north-trending folds. The eastern limbs of these folds are attenuated and locally cut off, at one locality sinistral offset is indicated. En echelon repetition of such structures on the outcrop scale produces a distribution of units with hook-like outlines (J. Moors, personal communication, 1993).

WHITEWATER SUITE, FOLIATED ORTHOGNEISS UNITS

Rocks of the Whitewater suite are relatively coarsely recrystallized upper greenschist to amphibolite facies rocks. Rocks tend to possess a relatively weak schistosity and strong gneissic compositional banding. As in the Boundary Ranges suite, first phase intrafolial isoclines are locally well developed and manifest by folded compositional bands. Second phase effects include open to tight folds, developed on a metre to kilometre scale in competent units (Plate 11), to tight folds and a crenulation or transposition fabric in graphitic schist. Latest folding produces the dominant structural style

Plate 10. Detail of outcrop in the western Boundary Ranges metamorphic suite, showing various generations and styles of folding. Photo illustrates: an early, first phase, intrafolial isoclinal fold (left centre of photo); a tight, upright, second phase fold, with both cylindrical (top) and kink (bottom) fold characteristics; and a late synkinematic quartz vein. Long dimension of photo represents about 0.6 m.

where minor folds with amplitudes of metres to tens of metres cascade down the limbs of folds with kilometre-scale wavelengths. Faults associated with fold limbs are common. In contrast to the Boundary Ranges suite, retrograde effects are generally not in evidence, except near plutons.

The banded gneiss unit (Wann River gneiss?) has a weak foliation and strong compositional banding, which generally strikes northeast and dips gently to moderately southeast. Folds are uncommon. The younger orthogneiss unit (Hale Mountain granodiorite?) is only weakly foliated.

FAULTS

NORTH TO NORTHWEST-TRENDING FAULTS

North to northwest-trending high-angle faults with complex movement histories are common in the map area. The largest is the regionally significant Llewellyn fault, which is mapped as far north as the southern Yukon, where it merges with the Tally Ho shear zone (Doherty and Hart, 1988), and continues southward into the map area, where it merges with the Chief fault (Payne and Sisson, 1988) south of Shazah Creek (Figure 2). Early movement on the Llewellyn fault zone is manifested by zones of ductile sinistral shear, which to the north, are largely pre-180 Ma. Sinistral shear zones, generally less than a few metres wide, are present in the Mount Stapler, Boundary Ranges and Mount Strong units up to several kilometres west of the main strand of the Llewellyn fault zone (Plate 12). Small dextral shear zones are relatively common throughout the map area, particularly in the vicinity of the Llewellyn fault; to the north these zones postdate sinistral motion on the fault (Mihalynuk and Mountjoy, 1990). The main strand of the Llewellyn fault is a ductile to brittle mylonite zone up to several metres wide, which is well exposed in the extreme northern part of 104K/13 and the adjoining map sheet to the north (104N/4; unpublished BCGS mapping, 1991; Plate 13) and north of Shazah creek. In both locations, the fault zone contains sheared and comminuted intrusive rocks ranging from granodiorite to leucogabbro in composition. In some areas, the intrusive rocks form flower structures - west-vergent thrust flaps that root to the east in the near-vertical main fault. Brittle faulting postdates ductile shear, but largely predates Sloko volcanism, and may be coeval with middle Jurassic movement on other regionally significant thrust faults to the east (Nahlin and King Salmon faults). Minor Eocene reactivation of the fault is indicated by areas where the Sloko Group is offset by up to several hundred metres.

A few kilometres north of Shazah Creek, the fault bends southwestward and splays into several strands. It is offset by the Chief crossfault (see below and Figures 4 and 5) to west of the Tulsequah River. The trace of the Llewellyn-Chief fault south of the Polaris-Taku mine is uncertain. The dramatic contrast in metamorphic grade

Plate 11. Outcrop-scale tight fold in interlayered quartz-rich and graphitic schist of the Whitewater suite. View to the northwest. Fold verges southwest. Thick resistant layer to right is amphibolite gneiss.

across the fault zone to the north is not present in the vicinity of Mount Strong and Sittakanay Mountain, where the westward increase in metamorphic grade and deformation is relatively gradual. This may be explained by several alternatives: distributed shear along numerous small fault strands; as yet unrecognized overthrusting of the fault by higher grade rocks from the west; or gradual southward dying out of the Llewellyn fault zone . Existing data do not permit evaluation of these alternatives.

Other north to northwest-trending brittle faults and ductile shear zones are common in the map area. Most are minor and located in fold hinge areas or bounding units of differing competency. West of the Tulsequah River, several such faults contain sheared serpentinite. Two relatively significant faults include the Whitewater fault, which separates the Whitewater suite from the Polaris suite, and an unnamed brittle fault in the northeastern corner of the map sheet that, to the south, down-drops Sloko Group breccias against Mesozoic rocks, perhaps representing at least a few kilometres of syn-Sloko movement. This fault crosscuts a section of Laberge and Stuhini rocks imbricated along older northwest-trending faults.

Thrust faults are recognized in the Mount Eaton block (Plate 14) where offset is thought to be relatively

minor, but the true extent and significance of this type of faulting is largely unknown.

EAST TO NORTHEAST-TRENDING CROSSFAULTS

East to northeast-trending, high-angle, brittle crossfaults with limited displacement are common in the map area. Faults with offsets significant on a 1:50,000 scale are spaced every few kilometres, and may be even more common. Both dextral and sinistral offsets are displayed. Assay samples taken in 1991 from quartz veins close to these faults returned gold values well above background values (Smith and Mihalynuk, 1992). Additional examples were not positively identified in 1993.

The most significant crossfault in the Tulsequah area is the Chief crossfault, a structure that is interpreted to offset the Llewellyn-Chief fault system about 2 kilometres in a dextral sense (Figure 5). The fault is located immediately north of the Tulsequah Chief mine, and cuts off the mine sequence to the north (Plate 15). It is well displayed in the bioclastic limestone unit more than 1000 metres above the mine, where it is marked by a steeply north-dipping zone of brecciation and ductile deformation. On the west bank of the Tulsequah River it

juxtaposes virtually undeformed augite porphyry, tuff and breccia with graphitic schist of the Whitewater suite. The Chief crossfault is important for two reasons. It increases the width of the Mount Eaton block and the area prospective for volcanogenic massive sulphide deposits by several kilometres and determination of the amount of motion on this fault may help to constrain the location of the northern continuation of the Tulsequah Chief orebody, if one exists.
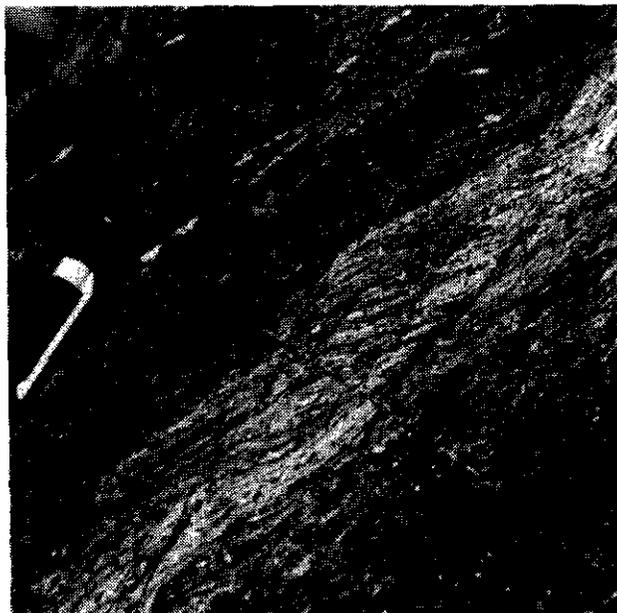

Plate 12. Shear fabric in siliceous argillite, south of the summit of Mount Strong. This fabric is indicative of sinistral shear. View to the north.

MINERAL DEPOSITS AND REGIONAL POTENTIAL

Within the Tulsequah map area are three significant past-producing mines: the Tulsequah Chief and Big Bull volcanogenic massive sulphide accumulations, and the Polaris Taku mesothermal vein-hosted gold deposit. Several prospects, including the Banker and Sparling, are located near these mines and have been included in property-scale geophysical surveys and mapping, but have not been explored in detail in recent years. Other showings that have been the target of exploration activity in the last few years include the Maple Leaf, Riz, and Highland Girl. British Columbia Geological Survey crews investigated the Maple Leaf showing in 1991 (Smith and Mihalynuk, 1992). The Riz and Highland Girl, prospects, visited in 1993, are described below, as are newly discovered showings of potential economic significance. These new showings, named the Stoker and Icefall, are located several kilometres north and west of Shazah Creek.

Plate 14. Small thrust faults (dashed) in the Mount Eaton block. Note hangingwall cut-offs (highlighted by solid lines).

TULSEQUAH CHIEF AND BIG BULL

Redfern Resources Ltd. conducted an aggressive exploration program on its significant claim holdings which include the Tulsequah Chief and Big Bull deposits as well as all intervening ground. A comprehensive
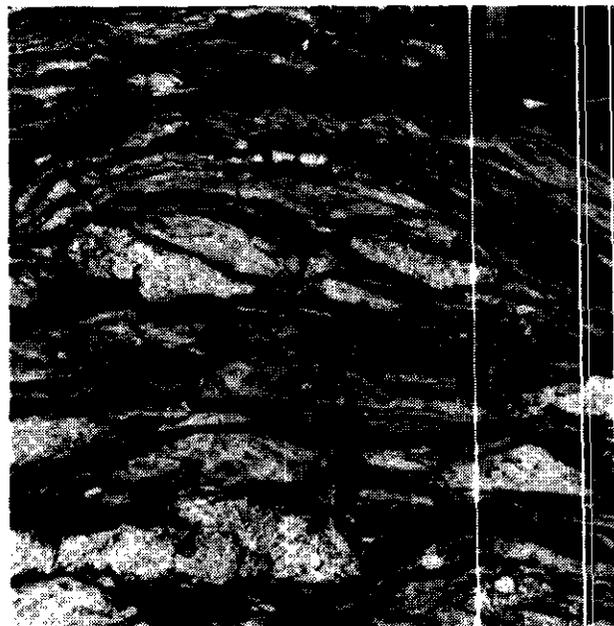

Plate 13. Sheared volcanic breccia along the Llewellyn fault zone.

geophysical survey helped to guide exploration drilling. In all, 32 holes totaling 11,200 metres were drilled on the property. At the Tulsequah Chief deposit, six surface and fourteen underground fill-in and exploration holes were drilled. Successes include more detailed delineation of the main AB zones and increased grade and tonnage of the G zone.

At the Big Bull deposit, twelve drill holes helped to greatly extend the known dimensions of the alteration zone. Base metal sulphides were intersected at depth, but new zones of economic accumulations remain elusive. Redfern plans to continue exploration on both the Tulsequah Chief and Big Bull deposits in 1994.
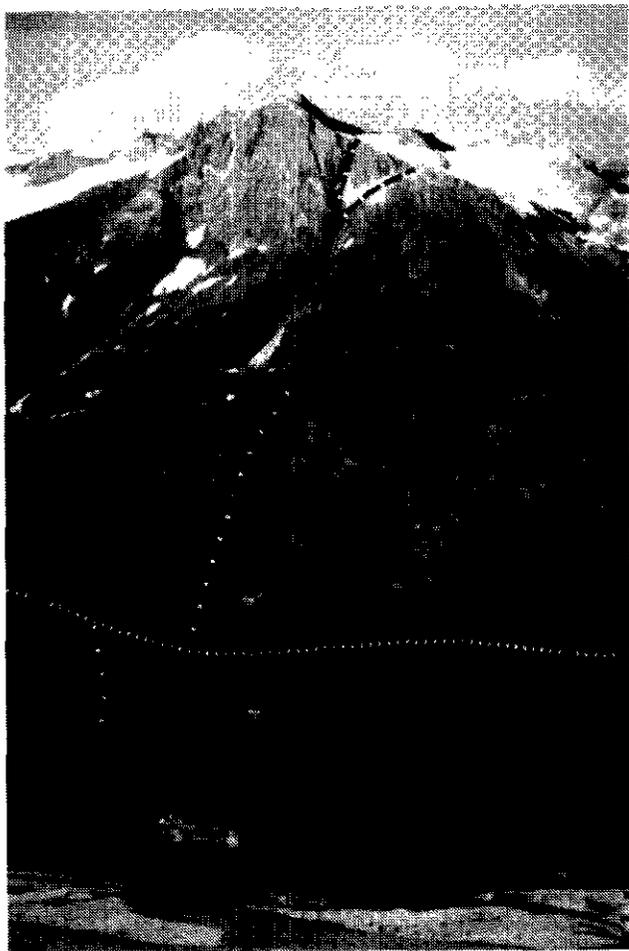

Plate 15. Aerial view to the northeast showing: the Tulsequah Chief mine portals at the 5200 (near river level), 5400 (camp level), 5900, 6300 and 6500 levels; trace of the Chief crossfault where known (solid) and suspected (dash); and the 4400 fault (fine dash). Gross stratigraphy on southern Mount Eaton is shown with felsic units beneath the heavily treed lower slopes; dark, mafic volcanics underlying the higher, sparsely vegetated slopes; and light-coloured bioclastic limestone capping the peak in the centre of the photo.

STOKER AND ICEFALL SHOWINGS

Two showings of potential economic significance were discovered approximately 8 kilometres north of the Tulsequah Chief deposit in the course of 1993 mapping.

The Stoker showing is located west of the head of a south-flowing creek, and the Icefall showing is approximately 2 kilometres to the west-northwest in steep, red-weathering cirque walls on both sides of an icefall.

The Stoker showing displays two styles of mineralization. Massive chalcopyrite and minor sphalerite and galena occur as bands up to 40 centimetres thick on the margin of a deformed limestone body several metres thick. Limy tuffaceous(?) strata topographically below the first occurrence host a zone about 60 metres by 10 metres minimum dimensions in which disseminated sphalerite and galena comprise up to 15% combined, but generally less than 1% of the rock. Nearby, greasy grey chalcedonic quartz cements brecciated country rocks.

The Icefall prospect consists of two mineralized areas separated by an inaccessible icefall, which, on the basis of mineralized float, probably masks continuity between the two showings. On the west side of the icefall mineralization consists of pyrite±quartz veins hosted by argillites of the Laberge or Stuhini Group. This style of mineralization grades eastward into a zone of green to white (bleached) weathering rocks, apparently of volcanic origin. Float from this relatively inaccessible area contains abundant disseminated sulphides, primarily pyrite, and several zones of copper staining were observed in the cliff face. Boulder trains on the glacier approximately 1 kilometre south of the cliff contain abundant mineralized detritus, including bleached lapilli tuff, felsic intrusive, quartz-eye porphyry and rocks of uncertain protolith, containing disseminated and semimassive pyrite and sphalerite, with minor galena and chalcopyrite. A regional stream sediment sampling program reported anomalous lead and zinc values from creeks draining both the Icefall and Stoker showings (Matysek *et al.*, 1988).

The lithologies and styles of mineralization are suggestive of a high-level porphyry system involving rocks of Sloko age, or possible remobilization of a deeper volcanogenic massive sulphide accumulation. Lead isotope data might help to further constrain the source of mineralization.

RIZ SHOWING

The Riz showing, discovered and prospected by American Bullion Minerals, Limited in 1990 (American Bullion Minerals Limited, 1990), is located where the north-facing Nelles Peak cirque intersects the Tulsequah Glacier. It was visited in 1991 as part of our reconnaissance survey. It consists of a red-weathering, ice-cored medial moraine or landslide deposit consisting of boulders of relatively fine grained quartz monzonite that hosts sulphide mineralization, both disseminated and in veinlets. Primary sulphide minerals include pyrite, pyrrhotite, sphalerite and minor galena. Most of the Nelles Peak cirque is underlain by the Opposer formation, except for minor gneissic rocks. These are intruded by quartz monzonite stocks that are the probable source of the mineralized boulders. The source has not

been pinpointed; however, an east-trending high-angle fault with altered wallrocks cuts through the cirque. Adjacent gneissic rocks contain up to several percent disseminated pyrrhotite, and are possible targets for further investigation.

HIGHLAND BOY

The Highland Boy mineral showing is located on the north side of the Sittakanay River 3.5 kilometres east of its confluence with the Taku River (Figure 3). Gold, silver, lead and arsenic mineralization is hosted by fine-grained quartz-mica schist and dark grey to black, strongly folded, slates and phyllites. Foliation in rocks around the showing trends 345° and most commonly dips moderately to the east The rocks contain abundant, barren, 5 to 6 centimetre wide, concordant quartz sweats. Mineralization occurs within a discontinuous, vertical, mineralized shear over a metre in width and trending 035°. It cuts a quartz pod 60 metres long and up to 10 metres wide (oriented 210°/37°W).

Galena, pyrite and arsenopyrite mineralization is reported over a 60-metre strike length and has been tested by an adit 23 metres long, a shaft 4 to 6 metres deep and six old hand trenches (Aspinall, 1991). Our assay data were not available as this paper went to press. However, Aspinall reports on analysis of samples from a trench and from the shaft. They returned 8.05 and 10.4 grams per tonne gold, 475.2 and 35.3 grams per tonne silver, 6.88% and 0.10% lead and 24.27% and 22.69% arsenic respectively.

OTHER OCCURRENCES

One new occurrence found in the Mount Sittakanay area remains unnamed. At this locality hornfelsed boulders up to 4 metres in diameter are mineralized with several percent pyrrhotite, about 1% chalcopyrite and minor sphalerite. The boulders are in moraine which was derived from the cirque wall less than 1.5 kilometres away.

Near the east end of Wendy Lake a pyrite-sericite alteration zone was discovered in a synclinal keel at the contact between dominantly sedimentary and volcanic packages. It is on strike with, and about 3 kilometres north of the Big Bull deposit. Mapping indicates that this horizon trends down towards the Big Bull open pit (K. Curtis, personal communication, 1993). Intervening rocks at the same stratigraphic level together with those along trend to the north, warrant further investigation.

REGIONAL MINERAL POTENTIAL

The Tulsequah region is prospective for several types of mineral deposits, including volcanogenic massive sulphides, vein and shear-hosted gold deposits, porphyry copper-gold-molybdenum deposits, and skarns.

Significant **Kuroko-type volcanogenic massive**

sulphide deposits in the Mount Eaton block include the Tulsequah Chief and Big Bull orebodies. Exhalite mineralization is also recognized in the chert and limestone sequence on the north end of Mount Eaton, and perhaps in the Sittakanay Mountain block. On the basis of these known occurrences, regional potential for additional deposits of this type is high. The presence of other showings of this type in the Stikine assemblage north of Telegraph Creek underscores the need for additional mapping and exploration in intervening areas underlain by known and suspected Stikine assemblage rocks.

The massive sulphide potential of the Mount Stapler and Boundary Ranges suites may also be significant Unusual mineralization at the Ono and Oya showings north of Shazah Creek includes several layers of massive sphalerite-galena-pyrite-arsenopyrite up to 30 centimetres thick and 30 metres long (Nelson, 1981). They are hosted in limestone, and according to Nelson (1981), in chert exhalite(?) and rhyolite. To the north, at the Maple Leaf showing, mineralized marginal boulders with semimassive pyrite, sphalerite and galena associated with areas of quartz-sericite-pyrite-altered schist may also be primary and exhalative in origin. Sediment from streams that drain the area yield regionally anomalous lead, zinc and copper values (Matysek *et al.*, 1988).

The area adjacent to the Llewellyn fault zone north of the map area contains numerous small shear-related **quartz veins** with anomalous precious, base metal and arsenic concentrations. The fault zone as a whole corresponds with pronounced regional geochemical anomalies. A similar style of mineralization apparently continues into the Tulsequah area, where numerous shear-related quartz-sulphide veins are in evidence, including the Banker, Sparling and Highland Girl showings, as well as several others in the Mount Sittakanay area. The Polaris-Taku mesothermal gold vein system may be genetically related to these smaller occurrences. Younger crossfaults also host quartz veins with minor sulphides and anomalous gold values (Smith and Mihalynuk, 1992).

Skarn, porphyry and other intrusive-related deposit types have not been previously identified in the Tulsequah River or Glacier map areas, despite the abundance of intrusive rocks and the presence of porphyry copper and molybdenum showings in the Mount Ogden area to the south. A possible candidate for this type of mineralization is the combined Stoker-Icefall showing area, where chalcedonic quartz veins, skarn and porphyry-style(?) mineralization are all present. Pea-sized blebs of molybdenum and chalcopyrite in granites near Gisel Peak point to additional potential for porphyry-style mineralization, albeit in a restricted and inaccessible area.

SUMMARY AND DISCUSSION

The Tulsequah region is underlain by Jurassic rocks of the Inklin overlap sequence (Laberge Group), the upper Paleozoic Stikine assemblage (Mount Eaton and

Sittakanay blocks) and Upper Triassic Stuhini Group of the Stikine Terrane, metamorphic rocks of dominantly volcanic affinity (Polaris block, Boundary Ranges and Mount Stapler suites) and dominantly sedimentary affinity (Mount Strong block and Whitewater suite). Low grade Mesozoic and Paleozoic rocks are separated from high grade rocks along the Llewellyn fault and its southern continuation, the Chief fault.

A tentative geological/metallogenic evolution of the Tulsequah area is as follows:

- **Early to Late Paleozoic:** deposition of the Boundary Ranges and Mount Stapler suites, perhaps in part coeval with and/or overlying the Whitewater suite. Felsic to mafic volcanism and the abundance of associated sedimentary rocks suggests an arc-flank environment.
- **Pre-Pennsylvanian(?):** first phase deformation and development of intrafolial isoclinal folds in units west of the Llewellyn fault.
- **Devonian to Permian:** Stikine assemblage arc volcanism in the Late Devonian(?) to Mississippian, waning by late Pennsylvanian time. The Boundary Ranges and Mount Stapler suites may be in part lateral facies equivalents or basement to the lower part of the Stikine assemblage. Early Mississippian felsic volcanism and associated volcanogenic massive sulphide deposition.
- **Late Triassic:** Construction of the Stuhini arc over Stikine assemblage basement.
- **Early Jurassic:** deposition of the Inklin overlap assemblage above the Stuhini Group. Magmatism possibly correlative with the Hale Mountain granodiorite to the north. Major, mainly sinistral, offset on the Llewellyn fault
- **Early to Middle Jurassic.** Deformation and metamorphism of all older units; imbrication of units along west-directed thrust faults and the Llewellyn fault. Possible timing of precious metal mineralization along the dominantly dextral Llewellyn fault.
- **Late Cretaceous:** emplacement of scattered plutons.
- **Early Tertiary:** a major magmatic event producing the Sloko Group and formation of caldera complexes cored by high-level plutons. Easterly trending cross-faulting and associated base and precious metal vein mineralization. Porphyry-style and related skarn mineralization associated with some intrusions.

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