BABINE PORPHYRY BELT PROJECT: BEDROCK GEOLOGY OF THE OLD FORT MOUNTAIN AREA (93M/1), BRITISH COLUMBIA

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(British Columbia Geological Survey Branch contribution to the Nechako NATMAP Project)

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INTRODUCTION

The Babine porphyry belt project is part of the Nechako National Mapping Program (NATMAP), a joint effort of the Geological Survey of Canada and the British Columbia Geological Survey Branch of the Ministry of Employment and Investment (McMillan and Struik, 1996; MacIntyre and Struik, 1997, this volume). This is a multidisciplinary project with separate components for bedrock and surficial geology, till and silt geochemistry. The primary objectives of the Babine Porphyry Belt project are to produce 1:50 000-scale bedrock and surficial geology maps of the Fulton Lake (93L/16), Old Fort Mountain (93M/1) and Nakinilerak Lake (93M/8) map sheets (Figure 1) and to define areas of possible buried metallic mineral deposits using till, lake and silt geochemistry. This report summarizes the results of bedrock mapping completed in 1996 and supplements a previous report on mapping done in the Fulton Lake map sheet in 1995 (MacIntyre *et al.*, 1996).

PROJECT DESCRIPTION

The Babine porphyry belt is located in west-central British Columbia and is centred on the northern third of Babine Lake (Figure 1). The belt is approximately 80 kilometres long and includes twelve significant porphyry copper deposits and prospects including the Bell and Granisle past producers. The mineral potential of the area was ranked the fourth highest of the 97 tracts evaluated in the Skeena-Nass mineral potential project (MacIntyre *et al.*, 1995). The estimated value of known in-ground mineral resources in the area is $1.96 billion and the value of past production is estimated at $1.13 billion (1986 dollars). In spite of the high mineral potential and obvious economic significance of the area, the most recent published geological mapping in the belt was by Carter (1973). Since then there has been extensive logging in the area, providing new access and better bedrock exposure, especially in areas of extensive drift cover. This, coupled with renewed interest in

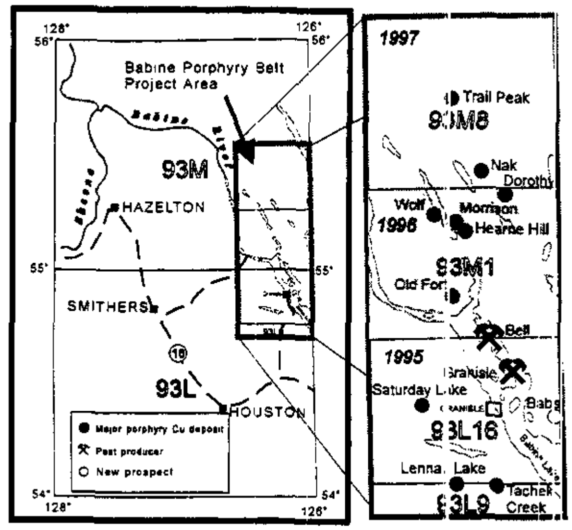

Figure 1. Location of the Babine Porphyry Belt project area, West-central British Columbia. Shaded area was mapped in 1996 and is the subject of this report.

porphyry copper deposits as an exploration target and the need for economic diversification in the economy of the area, make this project particularly timely. It is hoped that new bedrock and surficial mapping, together with regional till and lake geochemistry and airborne geophysical surveys, will stimulate additional exploration in the belt and lead to new discoveries. Drift prospecting, lake geochemistry and airborne geophysics will be especially important in defining new targets in drift-covered areas. The Quaternary geology and till and lake geochemical sampling completed in 1995 and 1996 are discussed in separate reports (Huntley *et al.*, 1996, Stumpf *et al.*, 1996, Levson *et al.* , 1997 (this volume) and Cook *et al.*, 1997 (this volume).

ACCOMPLISHMENTS

The 1996 bedrock mapping crew consisted of Don MacIntyre and Ian Webster accompanied by student field assistants Susan Hand and Joseph Schrank. Additional mapping support was provided by Pat Desjardins and Paul Wojdak. This crew completed 1:50

000-scale geological mapping of the Old Fort Mountain mapsheet (93M/1). In addition to regional bedrock mapping, major mineral deposits and new prospects in the area were mapped and sampled. Samples were also collected for radiometric dating in conjunction with Mike Villeneuve of the Geological Survey of Canada and this information will help to further refine the geology of the area. Major geological accomplishments made during the 1996 field season are summarized below.

- the belt of Lower to Middle Jurassic bimodal volcanics first recognized in the area west of Granisle in 1995 was extended as far northward as Hearne Hill. This volcanic package thickens and becomes more vent proximal northward suggesting a major eruptive center is located in this direction.
- a major ash flow unit of probable Lower to Middle Jurassic age was mapped on the south flank of Hearne Hill. This unit could be up to 1000 metres thick.
- collections were made from 18 fossil localities. Many of these occurrences are new and will provide important stratigraphic control in the map area.
- correlation of Lower Jurassic stratigraphy in the Old Fort Mountain area with the type area of the Telkwa Formation in the Telkwa Range. This suggests the Howson subaerial facies extends much further east than originally thought.
- zones of silicification and quartz veining associated with Eocene rhyolite domes were sampled and may prove to contain precious metal values.
- a Tertiary graben containing carbonaceous Cretaceous strata was located in the northeast corner of the map area. This area may have potential for coal.
- 24 mineral occurrences were located and sampled. Assay results will determine if any of these are significant.
- 16 Ar-Ar and 5 U-Pb radiometric age date samples were collected. These will be processed by Mike Villeneuve of the Geological Survey of Canada, Ottawa.

SUMMARY STATISTICS

A total of 235 person days was required to complete 1:50 000-scale mapping of Fulton Lake map sheet (93L/16). A total of 562 geologic stations were recorded in the 89 000 hectare map area.

FUTURE PLANS

Geoscientific studies are planned for the Babine Lake area in 1997 as part of the Nechako NATMAP program. The target for bedrock mapping in 1997 will be to complete 1:50 000-scale mapping of the Nakinilerak Lake map sheet (93M/8, Figure 1). The major porphyry copper deposits on this map sheet are Nak and Trail Peak, both of which should be active next summer.

PREVIOUS WORK

Geologic mapping and mineral property evaluations by the Geological Survey of Canada and the British Columbia Department of Mines (now Ministry of Employment and Investment) date back to the turn of the century. Earliest reports on the geology of west-central British Columbia are by G.M. Dawson (1881) who described porphyritic flows in the Francois Lake and Skeena River areas. Volcanic rocks in the Hazelton and Smithers area were first described by Leach (1910) who proposed a two-fold subdivision between Jurassic volcanics, which he called the Hazelton Group, and Cretaceous sedimentary strata which he named the Skeena series. Hanson (1925) further subdivided the Hazelton Group into a lower volcanic division, a middle sedimentary division and an upper volcanic division. This division remained unchanged for many years until Armstrong (1944a, 1944b) included the Skeena series with the Hazelton Group

In 1976, the Geological Survey of Canada published Tipper and Richards (1976a) bulletin *Jurassic Stratigraphy and History of North-central British Columbia*. This comprehensive publication included previously unpublished data on numerous fossil localities and measured stratigraphic sections, including several in the Babine Lake area. This bulletin complemented the release of an open file, 1:250 000-scale, geological map of the Smithers (Tipper and Richards, 1976b). The geology of the Hazelton map sheet (93M) was released as open files 720 (Richards, 1980) and 2322 (Richards, 1990).

Tipper and Richards subdivided the Hazelton Group into several different formations. They also resurrected the name Skeena Group for Early Cretaceous coal-bearing, overlap sedimentary strata that Armstrong (1944a, 1944b) originally placed in the Hazelton Group.

Carter mapped the Babine porphyry belt in detail between 1965 and 1972 as part of a British Columbia Ministry of Mines regional study of porphyry deposits in west-central British Columbia. This excellent work was released as Preliminary Map 12 (Carter, 1973) and remains the only published geological map of the belt. Because of improved access via logging roads, better bedrock exposure in clear-cuts and a better understanding of regional stratigraphic relationships, we were able to expand on this earlier mapping and place it in a modern stratigraphic framework.

The Babine porphyry belt is one of the most important mineral camps in British Columbia (Carter *et al.* 1995). Numerous reports have been published on individual deposits. Carson and Jambor (1974), Wilson *et al.* (1980) and Zaluski *et al.* (1994) have discussed hydrothermal alteration and fluid geochemistry in the district; Fahrni *et al.* (1976), Carson *et al.* (1976) and Dirom *et al.* (1995) have described the geology and mineralization at the Granisle and Bell mines; and Carson and Jambor (1976) and Ogryzlo *et al.* (1995) the Morrison and Hearne Hill deposits.

ACCESS

The main access to the area is from Highway 16, which follows the Bulkley River valley from the town of Houston through Telkwa and Smithers and north to Hazelton (Figure 1). Smithers, located approximately half way between Prince George and Prince Rupert, is the largest town in the area and is a major transportation centre with daily jet service to Vancouver, Terrace and Prince George.

There are two main routes into the study area from Highway 16. The Smithers Landing - Granisle connector route, which leaves Highway 16 south of Smithers and goes through McKendrick Pass on its way to Granisle, is 78 kilometres long and is mainly gravel. The Topley - Granisle road is paved; it leaves Highway 16 at Topley and terminates at Granisle, a distance of 48 kilometres. An extensive network of logging roads provides access to much of the map area, especially east of Babine Lake. The east side of the lake is accessible by private ferry between Mill Bay, just north of Topley Landing, and Nose Bay on the east side of the lake. Crossing time is approximately 20 minutes. The ferry is run by Northwood Lumber Co. based in Houston, and is free to the public with the acquisition of a permit. On the east side of the lake, the Morrison, Hagan, Jinx and Nose Bay haulage roads, which are radio controlled and heavily used by logging trucks, are the main access routes.

PHYSIOGRAPHY

The physiography of the Babine Lake area is characterized by rolling hills and extensive drift-covered areas of low relief. Bedrock exposure is found on the crests of hills and small glaciated knolls, in deeply incised creek valleys and along the shores of Babine and Fulton lakes. Clear-cut logging in the area has also exposed bedrock along road cuts and in areas subject to soil erosion. Huntley *et al.* (1996) discuss the physiography and Quaternary history of the study area.

TECTONIC HISTORY AND REGIONAL GEOLOGIC SETTING

The Babine Porphyry Belt is entirely within Stikinia, the largest terrane of the Intermontane tectonic belt. This terrane includes Lower Devonian to Middle Jurassic volcanic and sedimentary strata of theAsitka, Stuhini, Lewes River and Hazelton assemblages and related comagmatic plutonic rocks The oldest rocks are upper Paleozoic carbonates and island-arc volcanic and volcaniclastic rocks locally referred to as the Stikine assemblage (Monger, 1977, Brown *et al.*, 1991). Areas with this assemblage, which east of the Bowser Basin is called the Asitka Group, represent remnants of a tectonically dismembered, shallow-water, island-arc environment with carbonate buildups fringing emergent volcanic islands. Permian and possibly older rocks occur in the study area and these rocks are tentatively correlated with the Asitka Group.

The Paleozoic island-arc regime was followed by a depositional hiatus prior to development of a Late Triassic volcanic arc and eruption of the predominantly basaltic Stuhini Group. By Early Jurassic time the area was part of the regionally extensive Hazelton calcalkaline volcanic arc. The orientation of this arc and the polarity of related subduction zones is still much in debate. However, facies relationships suggest there was a central marine trough that was bounded by northwest-trending island-arcs. This apparent paleogeography is complicated by significant right-lateral displacement of the Hazelton rocks along northeast-trending transcurrent faults. A northeast-dipping subduction zone seems likely for the western part of the Hazelton arc. The basaltic to andesitic island-arc volcanics exposed in the study area can be correlated with the Stuhini and Hazelton groups on the basis of lithology and inferred stratigraphic position.

Collision of Stikinia with the Cache Creek Terrane in Middle Jurassic time resulted in uplift of the Skeena Arch and formation of the Bowser Basin. From Late Jurassic to Early Cretaceous time, continued uplift and erosion of the Skeena Arch and Omineca crystalline belt resulted in deposition of thick molasse deposits in the Bowser Basin, which lies northwest of the study area. Contraction and development of the Skeena Fold Belt began in the latest Jurassic or earliest Cretaceous, accompanied by uplift and magmatism within the Coast Belt and supracrustal shortening in the Bowser Basin (Evenchick, 1990). In the Albian, rocks of the Skeena Group were deposited in a broad, shallow-water basin that may have covered much of West Central British Columbia including the current study area.

A major plate collision in middle Cretaceous time resulted in further uplift of the Coast Mountains and extensive folding and thrust faulting of rocks to the east. Debris from rising metamorphic-plutonic complexes and the evolving Skeena Fold Belt was shed eastward and deposited in the Sustut basin. This was followed by the growth of north-trending, eastward-migrating Andean-type volcanic arcs in late Cretaceous to Eocene time. These arcs are believed to be the result of oblique, eastward subduction of oceanic crust under the leading edge of the North American plate, with volcanic centres localized along zones of extension within a transtensional tectonic regime. Throughout the North American Cordillera this volcano-tectonic event is known as the Laramide orogeny. In West Central British Columbia, calcalkaline volcanic rocks of the

Upper Cretaceous Kasalka Group and Eocene Ootsa Lake Group are the remnants of these arcs which were built on uplifted, folded and eroded blocks of Stikinia and its Upper Jurassic to Lower Cretaceous overlap assemblages. In the Tahtsa lake area late Cretaceous and Eocene volcanics sit with angular discordance on folded early Cretaceous (Albian) sediments of the Skeena group. The unconformity is overlain by an erosional conglomerate suggesting uplift and erosion prior to the onset of continental arc volcanism in late Cretaceous time. In the study area, Eocene porphyritic flows and breccias of the Newman volcanics are correlated with the Ootsa Lake Group; the Kasalka Group is not well represented, being restricted to one small outlier.

The Middle to Late Cretaceous Bulkley intrusions and the Eocene Babine intrusions (Carter, 1981) are the plutonic roots of these younger continental volcanic arcs. Mineral deposits in the study area are associated with emplacement of these intrusions. The most economically important exploration targets are porphyry copper and molybdenum deposits and related mesothermal precious metal veins. Post Eocene (post Laramide) crustal extension and block faulting produced a basin and range geomorphology through the development of grabens and horsts. This complex fault pattern, superimposed on an earlier mid Cretaceous contractional event controls the bedrock map pattern of the area. Locally within the Interior plateau, late Tertiary extension was accompanied by the development of metamorphic core complexes and extensive bimodal volcanism. No metamorphic core complexes are recognized in the northern Babine lake area and there is not an extensive cover of post Eocene volcanics as there is to the south in the Interior plateau. The Babine porphyry belt appears to lie near the northern limit of late Tertiary extension and volcanism.

Extension in the Babine lake area appears to have been accompanied by northeast displacement along right-lateral transcurrent faults and tilting of fault blocks to the southeast. This right-lateral displacement offset earlier northwest-trending grabens and horsts containing Eocene and younger volcanic and sedimentary strata (MacIntyre *et al.*, 1989). Extension of the crust in Miocene time was accompanied by extensive outpouring of continental lava flows of the Endako and Chilcotin groups which now cover large parts of the Interior Plateau to the south.

An important objective of the current project is to reconstruct the paleogeography of the Eocene magmatic arc and associated porphyry copper deposits prior to disruption by late Tertiary block faulting and right lateral transcurrent fault movements. This is important to exploration because many of the porphyry deposits have probably been rotated, tilted and possibly segmented by the late Tertiary tectonism. Such offsets have been documented at the former Bell mine (Carson *et al.*, 1976), and at the Morrison and Hearne Hill deposits (Ogryzlo *et al.*, 1995). The latter may be part of the same volcano-plutonic center, with the Morrison deposit displaced downward and northeastward into the Morrison graben (Ogryzlo *et al.*, 1995). Understanding these movements is critical to mounting successful exploration programs at both known deposits, and in the search for new deposits that may not be exposed at surface.

LITHOLOGIC UNITS

The geology of the study area, based on mapping completed in 1996 and the earlier mapping of Carter (1973), Tipper and Richards (1976) and Richards (1980; 1990), is shown in Figure 2. Figure 3 illustrates our current understanding of the stratigraphic relationships between the different map units; Figure 4 is a cross section across the map area.

The geologic framework of the study area consists of a series of uplifted, tilted and folded fault blocks containing rocks ranging from Triassic to Eocene in age. North-trending grabens centred on Hatchery arm of Babine Lake, Morrison Lake and the Hautête valley are defined by a series of inward dipping, progressively down-dropped fault blocks. Eocene and possibly younger volcanic and intrusive rocks are preserved in these grabens. The grabens are truncated and offset by northeast and northwest-trending dextral shear zones of post Eocene age.

PERMO-TRIASSIC ROCKS

Limestone and mafic volcanics that have previously been mapped as Permian and Triassic in age (Tipper and Richards, 1980) crop out along the southern margin of the map sheet, west of Babine Lake. A series of cliffs along the shore of Babine lake offer the best exposure. Here, limestone is interbedded with mafic volcanics. Bedding attitudes are disrupted by fault imbrications suggesting proximity to a fault zone. These rocks are tentatively correlated with the Western Takla Group based on lithology and apparent age.

LATE TRIASSIC TO EARLY JURASSIC TOPLEY INTRUSIONS (LTrJT)

The Topley intrusions, as defined by Carter (1981), include quartz diorite to quartz monzonite of Late Triassic to Early Jurassic age. Earlier reports (Carr, 1965; Kimura *et al.*, 1976) used the term Topley intrusions for granite, quartz monzonite, granodiorite, quartz diorite, diorite and gabbro intrusions of probable Jurassic age that intrude Triassic volcanic rocks from Babine Lake to Quesnel. Included in this Topley suite were high-potassium intrusions associated with the Endako porphyry molybdenum deposit. However, subsequent K-Ar isotopic dating showed that most of these intrusions were Late Jurassic to Early Cretaceous in age. Consequently, the intrusions around Endako were renamed the Francois Lake intrusions to distinguish them from the older Topley suite.

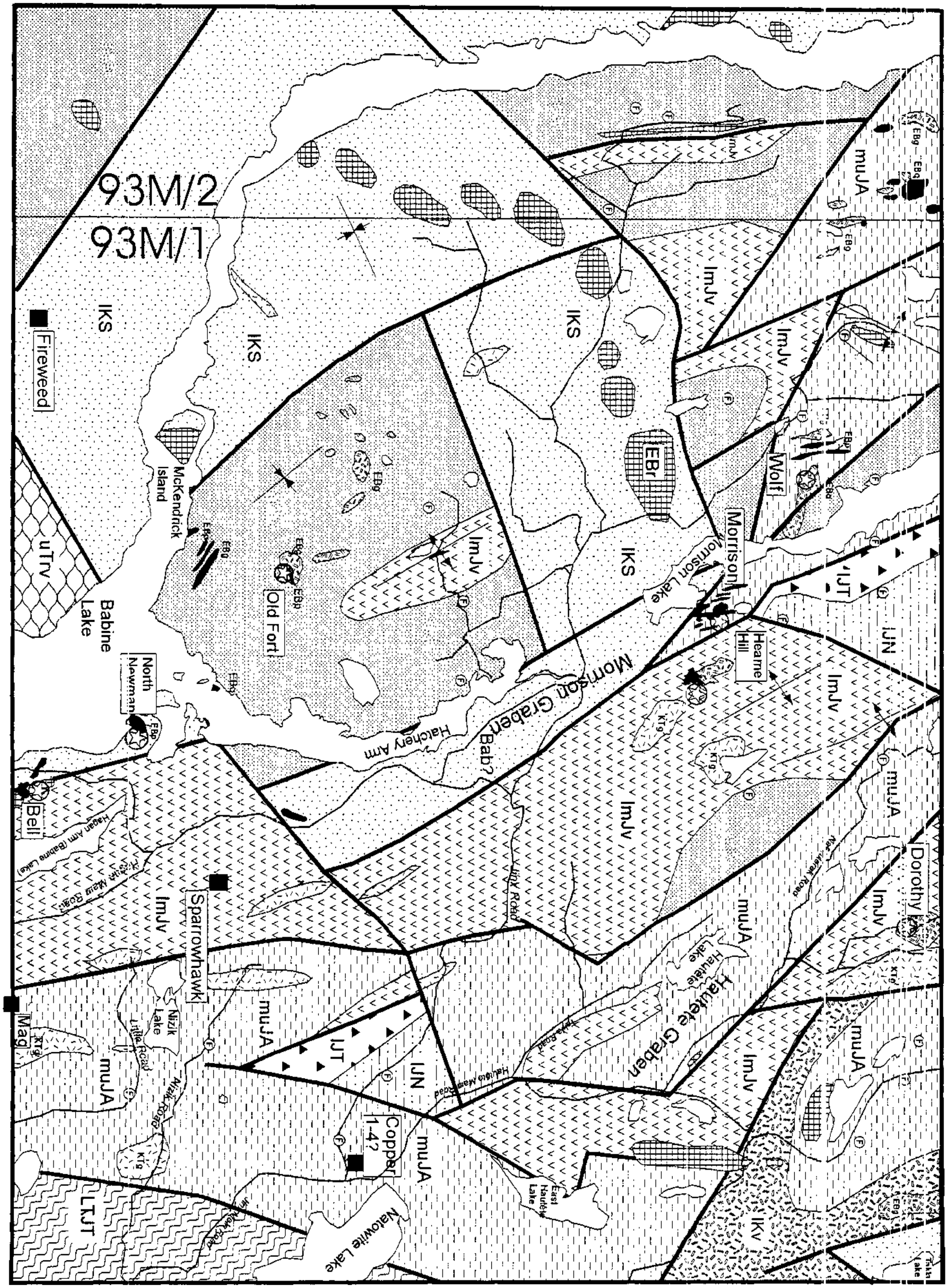

Figure 2. Generalized bedrock geology of the Old Fort Mountain map sheet, 93M/1. See Figure 3 for legend. Stars and solid squares are known occurrences discussed in this report.

Potassium-argon isotopic dates for the Topley intrusions, as defined by Carter (1981), would include ages as young as 178 Ma, but most are between 199 and 210 Ma (Early Jurassic) using the old decay constants. Most of these dates are from large plutons in the Topley area and southwest of Babine Lake. In the current study we restrict the term Topley intrusions to typically pink, potassium feldspar-rich granite and quartz monzonite of apparent Late Triassic to Early Jurassic age. We consider the type area to be the southeast corner of the Fulton Lake map sheet where a large, multiphase intrusive body, the Tachek stock, is well exposed in clear-cuts and along the shores of Babine Lake. The high-potassium composition of these rocks distinguishes them from older and younger plutonic suites that are mainly granodiorite to quartz diorite. Phases of the Topley intrusions, as defined in this study, intrude rocks believed to be correlative with the Permian Asitka and Late Triassic Stuhini groups. The only locality where a Topley intrusion has been observed cutting Telkwa Formation rocks is in a creek exposure 3 kilometres west of Lennac Lake. Here, a fine-grained, pink aplitic dike, typical of the youngest phase of the Topley suite, cuts maroon lapilli tuffs.

The extreme southeast corner of the Old Fort Mountain map sheet is the only area where typical Topley rocks crop out. These rocks are believed to be in fault contact with younger Jurassic volcanics and sediments to the northwest. Exposure is poor and the exact nature of the contact and possible kinematics are not known. The bounding fault is believed to be a southerly extension of the Takla right lateral transcurrent fault system which juxtaposes Jurassic and Cretaceous volcanic and sedimentary strata against older Triassic rocks to the east. Significant displacement along this fault system has been demonstrated to the north; the magnitude of right lateral displacement, if any, is unknown in the Babine Lake area.

Prior to the current study, only two localities in the study area where the Topley intrusions had been dated (Nos 40 and 33, Table 1). A 210 ±9 Ma age (revised) was determined on hornblende extracted from coarse-grained porphyritic monzonite exposed on a small island 8 kilometres north of Topley Landing (Wanless, 1974); a 178 ±7 Ma age (revised) was determined on biotite from a hornblende-biotite-quartz-feldspar porphyry dike at the Tachek porphyry copper prospect (Carter, 1981).

Two new U-Pb age determinations have been done on zircon extracted from rocks collected at two different localites within the Tachek stock (nos. 33 and 41, Table 1). These gave ages of 178.7 ± 0.5 Ma and 215-230 Ma respectively. Unfortunately both of the U-Pb determinations have problems and their reliability is suspect. In addition, Ar-Ar ages were determined on a porphyritic hornblende diorite stock located east of the Tachek stock near Toncha lake (No. 32, Table 1), biotite granodiorite within the Tachek stock (No 36, Table 1) and a hornblende-feldspar porphyry dike cutting suspected Triassic rocks north of Granisle (No. 37, Table 1) These gave ages of 175.7±1.7 Ma, 191.1±1.9 Ma and 193.7±1.9 Ma respectively, all within the previously determined age ranges for the Topley intrusive suite. These new age determinations combined with previous dating suggest that there are two main magmatic events, one in the 191 to possibly as old as 230 Ma time period, and another more tightly constrained episode around 176 to 179 Ma. Clearly, more work will be needed to confirm the apparent range of ages within the Tachek stock and for other intrusive bodies considered to be part of the Topley suite.

LOWER TO MIDDLE JURASSIC HAZELTON GROUP

The Hazelton Group (Leach, 1910) is a calcalkaline island-arc assemblage that evolved in Early to Middle Jurassic time. Tipper and Richards (1976a) divided the group into three major formations. These are, from oldest to youngest, the subaerial to submarine, predominantly calcalkaline volcanic Telkwa Formation, the marine sedimentary and volcanic Nilkitkwa Formation and the shallow water, marine transgressive Smithers Formation. In the Babine lake area there is also a lower to middle volcanic formation which Richards called the Saddle Hill volcanics. On the Old Fort Mountain map sheet the lower part of the Hazelton succession is not well exposed and the predominant formations are the lower to middle Jurassic Saddle Hill volcanics and the middle Jurassic Smithers and middle to upper Jurassic Ashman formations.

LOWER JURASSIC TELKWA FORMATION (lJT)

The type area for the Telkwa Formation is in the Telkwa Range, where a thick section of Early Jurassic volcanic rocks is well exposed. Regionally, the formation varies from marine to nonmarine and ranges from Sinemurian to early Pliensbachian in age. In the type area the predominant lithologies are air-fall tuffs, volcanic breccias and amygdaloidal basalt flows; these rocks constitute the Howson subaerial facies of the formation (Tipper and Richards, 1976a).

Previous mapping in the type area (MacIntyre *et al.*, 1989) suggests the Telkwa Formation is divisible into three members, each representing a distinct cycle of arc volcanism. These members are characterized by their predominant lithologies, although internal facies variations are common. In ascending stratigraphic order they are: (1) an andesitic pyroclastic member comprised of thick-bedded, massive, maroon andesitic lapilli, crystal and ash tuffs with minor interbeds of siliceous-banded ash flows and grey, welded lapilli tuffs; (2) a basaltic flow member which is predominantly dark green to maroon, amygdaloidal to aphyric basalt; and (3) a felsic pyroclastic member that includes interbedded ash-flow tuff, felsic lapilli and crystal tuff, flow-banded spherulitic rhyolite, volcanic breccia and related epiclastic rocks.

The Telkwa Formation is not well exposed in the Old Fort Mountain map sheet, occurring in only two

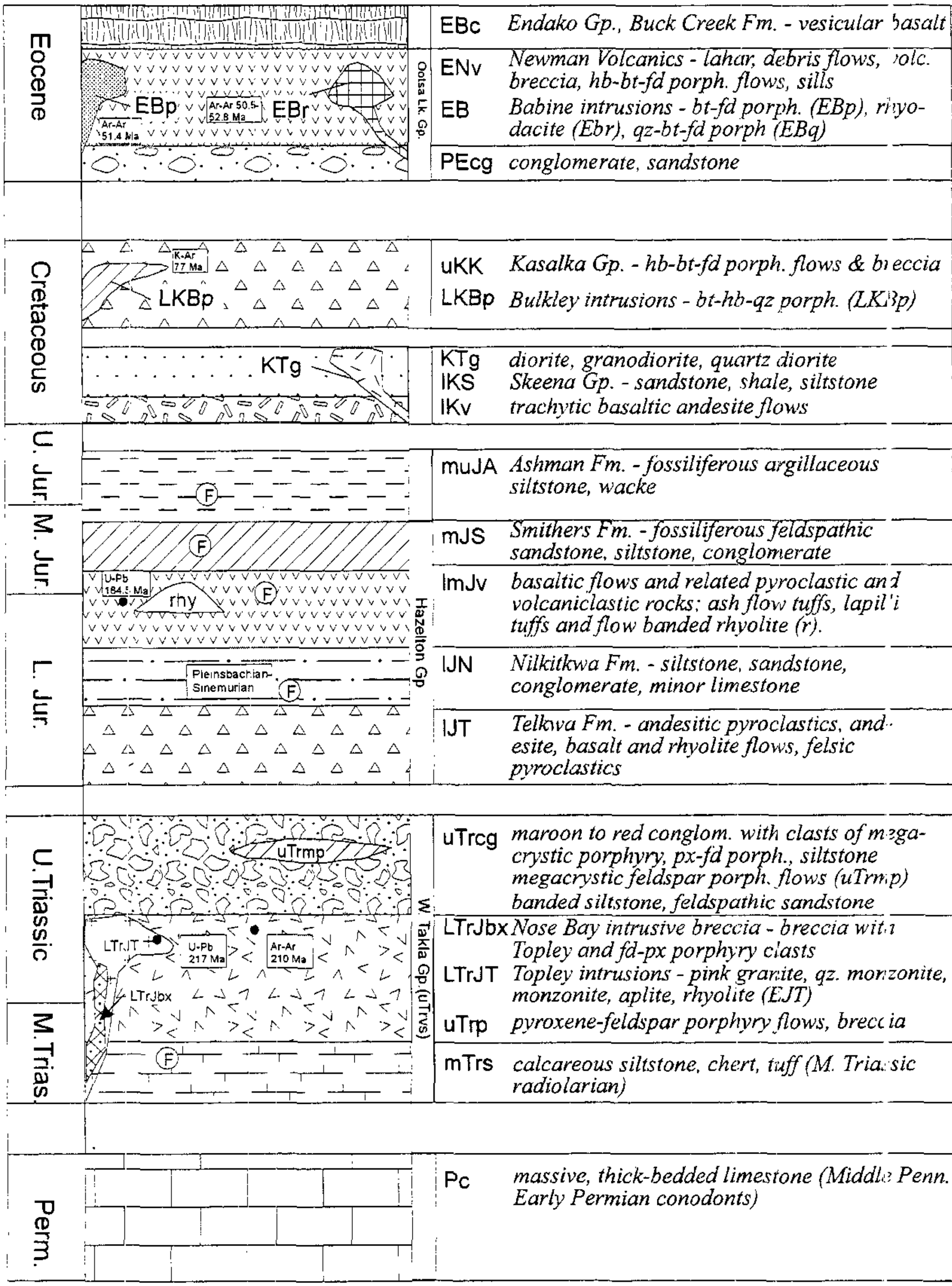

Figure 3. Diagrammatic section showing relationships between map units in the Old Fort Mountain map area (93M/1).

isolated fault blocks, one east of Morrison lake and one northeast of Nizik lake. In both areas only the upper members or the formation are exposed and these rocks, which are typically amygdaloidal basalt flows, are overlain by shallow water marine sedimentary rocks of the Late Sinemurian - Early Pliensbachian Nilkitkwa formation.

LOWER JURASSIC NILKITKWA FORMATION (lJN)

Tipper and Richards (1976a) assigned thick sections of Pliensbachian to Toarcian shale, greywacke, tuff, breccia and minor limestone, that are well exposed in the Nilkitkwa and Bait ranges, to the Nilkitkwa Formation. In the type area the formation is as much as 1000 metres thick. Limestone and chert beds occur in the lower part of the section and help distinguish Nilkitkwa rocks from younger, lithologically similar formations. Shallow-water fossiliferous limestone, interbedded with pebble conglomerate and feldspathic sandstone, is particularly common where Nilkitkwa sediments onlap Telkwa volcanics.

The only known exposures of the Nilkitkwa Formation in the current study area are east of Morrison lake and northeast of Nizik lake along the old Jinx haulage road. In both localities, northeast dipping beds of feldspathic sandstone, siltstone and pebble conglomerate conformably overlie amygdaloidal basalt and maroon lapilli tuff of the Telkwa Formation. Coarse, poorly sorted conglomerate beds often contain subangular pebbles and boulders of amygdaloidal basalt in a limy, sandy matrix. The coarse clastics grade up section into deeper water, finer-grained, more thinly bedded feldspathic sandstones and siltstones. Fossils from these beds include well preserved *Weyla*, a diagnostic Lower Jurassic bivalve commonly found in the lower part of the Nilkitkwa formation. Similar shallow water sediments containing late Sinemurian to early Pliensbachian fossils occur in the Telkwa Range (MacIntyre *et al.*, 1989) and at two localities in the Fulton Lake map sheet (MacIntyre *et al.*, 1996), one on a small island just south of Sterrett Island which is Late Sinemurian (H.W. Tipper, personal communication, 1995) and the other at Broughton Creek which is late Pliensbachian (H.W. Tipper, personal communication, 1995).

LOWER TO MIDDLE JURASSIC SADDLE HILL VOLCANICS (lmJv)

The Old Fort Mountain map sheet is underlain by up to 2000 metres of bimodal, predominantly subaerial, volcanics that are Lower to Middle Jurassic in age. Richards (1990) was the first to recognize volcanics of this age in the Hazelton map area and he named these rocks the Saddle Hill volcanics. Saddle Hill, which is located west of Morrison lake in the current study area, is underlain by maroon to green feldspar rich crystal and lapilli tuffs that are overlain by shallow marine sediments of the Smithers formation. The latter contain ammonites and bivalves of Bajocian age. The volcanic rocks, which underlie the central and northwest corners of the Old Fort Mountain map sheet, are believed to conformably overlie Lower Jurassic marine sedimentary strata of the Nilkitkwa formation although this contact is not well exposed. The Saddle Hill volcanics are therefore lower to middle Jurassic in age based on stratigraphic position.

Rocks lithologically similar to the Saddle hill volcanics crop out in the area west of Granisle and on the Newman Peninsula. The Granisle section was previously mapped as Triassic Takla Group, and the Newman Peninsula section as Lower Jurassic Telkwa Formation. In a previous report (MacIntyre, *et al.* 1996), we suggested the Newman section was probably not Telkwa Formation, based on lithologic differences, and that both the Newman and Granisle sections were probably Triassic, assuming the age shown on previous open file maps for the rocks west of Granisle was correct. However, zircons extracted from a quartz-bearing lapilli tuff bed within the Granisle section subsequently yielded a Jurassic, 184.7$\pm$0.5 Ma U-Pb isotopic age (M. Villeneuve, personal communication) (No. 35, Table 1). This Toarcian age suggests the rocks west of Granisle (and therefore, lithologically similar rocks on the Newman Peninsula) are correlative with the Saddle Hill volcanics, a conclusion supported by lithologic similarities and apparent isotopic age.

The volcanic rocks exposed on Saddle Hill probably represent only the upper part of the total Lower to Middle Jurassic volcanic succession. The lower and middle parts, which include beds of amygdaloidal and aphyric to feldspar-phyric basalt and felsic pyroclastic rocks, crop out as a series of ridges in the clearcut area west of Saddle Hill. However, the best and most continuous exposures of rocks correlated with the Saddle Hill volcanics occur along the north trending ridge that extends from the Newman Peninsula to Hearne Hill. This volcanic sequence, which appears to be thickening northward toward Hearne Hill, includes a lower unit of rhyolitic ash flows and ignimbrites and lesser lapill tuff , a middle unit of greenish grey basaltic flows interbedded with related epiclastic and pyroclastic rocks and an upper unit of maroon feldspathic tuffs, volcanic conglomerates, cherts and epiclastics that grade into fossiliferous, shallow marine sediments of the Smithers Formation.

White-weathering, flow-banded rhyolite and medium to thick-bedded, weakly to intensely welded ash-flow tuff and ignimbrite occur near the bottom of the Saddle Hill volcanic sequence. The ash flow member is well-exposed in the clear cut south of Hearne Hill where it may be up to 1000 metres thick. This section includes light grey to white-weathering, well bedded lapilli tuffs, ash-flow tuffs and volcanic debris-flows. The ash-flow tuffs are unwelded to strongly welded to un-welded and contain light coloured, lapilli-sized clasts that include aphanitic rhyolite, flow-banded rhyolite and scoriaceous tuff in a fine-grained, greyish green, feldspar-phyric matrix. A sample of ash flow from the Hearne Hill section was collected in 1996 and has been submitted for age dating. Debris flows in the section contain clasts of the ash-flow tuffs and are probably locally derived.

The Hearne Hill section is intruded by northwest-trending, vertical, strongly epidotized basaltic dikes that probably feed flows higher up in the section. Younger, Eocene, northeast trending-flow banded, rhyolite dikes cut both the ash-flows and basalt dikes. Flow banding is defined by cream and maroon bands, approximately 1 to 2 millimetres wide. Some of the bands are comprised almost entirely of white spherulites. Elsewhere within the Saddle Hill succession, flow banded rhyolites occur as light grey weathering, discontinuous, lensoidal to dome-like bodies that intrude basaltic flows in the upper part of the Saddle Hill succession. It is not certain whether these rhyolites, which are clearly intrusive, are part of the Lower to Middle Jurassic volcanic sequence or are much younger, the Eocene Babine Intrusive Suite.

A distinctive lithology within the Saddle Hill succession is a heterolithic, clast-supported volcanic breccia or agglomerate that contains white-weathering, subrounded, 25-centimetre to 1-metre bombs of flow-banded rhyolite. The bombs have deep reaction rims indicating that they were hot at the time of lithification. The breccia was probably the result of a phreatic explosion. The fact that the breccia contains flow banded rhyolite clasts suggests the rhyolites are part of the Lower to Middle Jurassic volcanic suite.

Near the top of the lower member is a section consisting of interbedded medium to coarse-grained volcanic wacke, aquagene tuff and autobrecciated, amygdaloidal basalt flows.

The middle member of the Saddle Hill volcanics is comprised of volcanic breccia, aquagene tuff and autobrecciated basaltic flows, interbedded with lapilli tuff, volcanic conglomerate and sandstone. Hyaloclastite is locally present and the massive volcanics typically contain magnetite and specularite. A strong aeromagnetic high is associated with this unit and has been used to map the extent of these volcanics below areas of heavy overburden. The volcanic rocks weather a distinctive orange-tan colour and have a dark green chloritic matrix. The volcanic wackes have poorly defined cross and graded bedding and locally contain poorly preserved bivalves, ammonites and corals (J. Palfy, personal communication) indicating a marine depositional environment. Irregular bodies of light grey, recessive, lime mud are also associated with the fossil bearing beds.

The most distinctive lithology within the middle to upper part of the Saddle Hill succession is a greenish grey to slightly maroon volcanic breccia. The breccia is poorly-sorted and contains lapilli to block-sized, rounded to subrounded volcanic clasts in a greenish grey feldspathic matrix. The clasts vary from light grey to dark green in colour and from dense, aphanitic to feldspar phyric and amygdaloidal. Medium to strong epidote alteration, often with quartz, occurs either pervasively or as veins and clots. Overlying the breccias are basalt flows. The flows are typically amygdaloidal and locally autobrecciated. Intense epidote alteration and veining is common. The flows weather a light brown colour and vary from maroon to greenish grey on fresh surfaces. They appear to be mostly subaerial in origin.

A sequence of greenish grey weathering, autobrecciated basaltic flows and aquagene tuffs occur near the top of the Lower to Middle Jurassic section. The flows vary from aphanitic to intensely amygdaloidal and are locally porphyritic with 35-40%, 5 to 8 millimetre feldspar phenocrysts. Epidote alteration and veining is locally intense. In one locality, an aphanitic flow has a bulbous weathering pattern that is suggestive of pillows.

Feldspar rich maroon to green, medium to thick-bedded volcanic sandstones, debris flows and tuffs occur near the top of the Saddle Hill volcanic section and grade into fossiliferous green to dark grey beds of the Smithers formation. In general there is a change from maroon to green colour up section, suggesting a change from subaerial to submarine conditions.

A minor amount of marine sediment also occurs in the upper half of the section and contains poorly preserved bivalves, ammonites and possible corals. Attitudes are measured from thin tuffaceous sandstone, feldspar crystal tuff and ash tuff beds that are intercalated with the more massive volcanic rocks.

MIDDLE JURASSIC SMITHERS FORMATION (mJS)

The Lower to Middle Jurassic Saddle Hill volcanics are conformably overlain by an interbedded sequence of shallow water, green to maroon feldspathic volcanic sandstone, wacke, siltstone shale, crystal tuff and minor granule to pebble conglomerate of the Smithers Formation. These rocks are very fossiliferous and contain abundant bivalves, ammonites and belemnites that indicate an Early Bajocian age (H. Tipper, personal communication). Several of these localities contain well-preserved *Trigonia*. The Smithers Formation sediments typically contain 25-45 percent feldspar detritus suggesting they are derived from a volcanic source area. Some of the feldspar may be of an air-fall origin. A distinctive dark green colour is also common due to presence of glauconite. Carbonaceous wood impressions and concretions are also common.

The best exposures of the Smithers Formation in the current study area east of the northwest arm of Babine Lake, on a low knoll and in the clear cut areas west of Hatchery Arm, on Old Fort Mountain and along the west side of the Hautête graben (Figure 2).

UPPER JURASSIC TO LOWER CRETACEOUS BOWSER LAKE GROUP

The Smithers Formation grades up section into deeper water, finer-grained siltstones and wackes of the

Table 1. Isotopic Age Dates, Babine Porphyry Belt

No.	Sample #	NTS	Zon	Easting	Northing	Location	Unit	System	in	Age (Ma)		Error	Rock Description	Source
1	GSC 73-43	93L/16	9	677314	6091091	Bear island	Babine intrusions	K-Ar	Bi	45.1	±	2	bt-fd porphyry	Wanless et al., 1974
2	GSC 73-37	93L/16	9	665878	6094217	Turkey Mtn.	Newman volcanics	K-Ar	Bi	46.8	±	2.7	hb-fd porphyry flow	Wanless et al., 1974
3	NC-68-10	93M/ 8	9	668795	6144179	Trail Peak	Babine intrusions	K-Ar	Bi	49.8	±	1.5	bt-fd porphyry	Carter, 1974, 1981;
4	DMA95-200	93L/16	9	679350	6090650	Newman Pen.	Newman volcanics	Ar/Ar	Hb	49.9	±	0.6	hb-fd porphyry with rare bt	this study
5	NC-67-1	93M/ 1	9	670285	6105244	Old Fort Mtn.	Babine intrusions	K-Ar	Bi	50.0	±	2	bt-fd porphyry	Carter, 1974
6	GSC 73-39	93L/16	9	662856	6089781	Saturday Lk.	Newman volcanics	K-Ar	Hb	50.2	±	3	hb-bt-fd porphyry, flow or neck	Wanless et al., 1974
7	GSC 73-40	93L/16	9	662856	6089781	Saturday Lk.	Newman volcanics	K-Ar	Bt	50.2	±	3	hb-bt-fd porphyry, flow or neck	Wanless et al., 1974
8	NC-67-22	93L/16	9	677036	6096223	Bell mine	Babine intrusions	K-Ar	Bi	50.7	±	2.1	bt-fd porphyry, weakly mineralized	Carter, 1974
9	NC-69-8	93L/16	9	682022	6091781	Granisle mine	vein	K-Ar	Bi	51.0	±	2.1	qtz-cpy-bn-apatite-biotite vein	Carter, 1974
10	DDH70-11	93L/16	9	682000	6092000	Granisle mine	Babine intrusions	Ar/Ar	Bi	51.2	±	0.6	medium-grained hb-bt-fd porphyry	this study
11	KBE95-43	93L/16	9	666136	6094717	Turkey Mtn.	Newman volcanics	Ar/Ar	Hb	51.2	±	0.5	hb-bt-fd porphyry	this study
12	DMA95-177	93L/16	9	680526	6092845	Newman Peninsula	Newman volcanics	Ar/Ar	Hb	51.3	±	0.6	hb-bt-fd porphyry	this study
13	DMA95-106	93L/16	9	663556	6086574	Saturday Lk.	Newman volcanics	Ar/Ar	Bi	51.5	±	0.5	hb-bt-fd porphyry, flow or neck	this study
14	NC-67-23	93L/16	9	677036	6096223	Bell mine	Babine intrusions	K-Ar	Bi	51.5	±	3	bt-fd porphyry, mineralized	Carter, 1974
15	NC-68-1	93L/16	9	682022	6091781	Granisle mine	Babine intrusions	K-Ar	Bi	51.5	±	2	bt-fd porphyry, late dyke	Carter, 1974
16	NC-67-5	93L/16	9	682022	6091781	Granisle mine	Babine intrusions	K-Ar	Bi	51.6	+	2	bt-fd porphyry, late dyke, unmineralized	Carter, 1971
17	N95-1-152	93M8	9	675100	6130050	NAK property	Babine intrusions	Ar/Ar	Bi	51.7	±	0.5	hb-bt-fd porphyry	this study
18	DMA95-106	93L/16	9	663556	6086574	Saturday Lk.	Babine intrusions	Ar/Ar	Hb	51.9	±	0.7	hb-bt-fd porphyry, flow or neck	this study
19	73-10-318	93L/16	9	668000	6084750	Saturday Lk.	Babine intrusions	Ar/Ar	Hb	52.3	±	0.6	hb-fd porphyry	this study
20	DMA-95-24	93L/16	9	666318	6121851	Wolf property	Babine intrusions	Ar/Ar	Bi	52.4	±	0.5	granodiorite	this study
21	NC-67-43	93L/16	9	679391	6090746	Newman Peninsula	Newman volcanics	K-Ar	Hb	52.4	±	1.9	hb-fd porphyry	Carter, 1974
22	DMA95-270	93L/16	9	663750	6090750	Turkey Mtn.	Newman volcanics	Ar/Ar	Hb	52.6	±	0.6	medium to fine-grained hb-bt-fd porphyry	this study
23	IWE95-275	93L/16	9	668900	6096950	Turkey Mtn.	Newman volcanics	Ar/Ar	W	52.7	±	0.6	augite phyric basalt plug	this study
24	NC-67-2	93M/ 1	9	670356	6103390	S. of Old Fort	Babine intrusions, sill	K-Ar	Bi	53.0	±	2	bt qz monzonite	Carter, 1974
25	NC-67-40	93M/ 1	9	669718	6120076	Morrison	Babine intrusions	K-Ar	Bi	53.0	±	2.1	bt-fd porphyry	Carter, 1974
26	NC-67-4	93L/16	9	682022	6091781	Granisle mine	Babine intrusions	K-Ar	Bi	55.8	±	3	bt-fd porphyry, mineralized	Carter, 1974
27	NC-72-1	93L/ 9	9	671768	6066311	Lennac Lake	Bulkley intrusions	K-Ar	Bi	78.3	±	2.5	qz-hb-bt-fd porphyry, mineralized	Carter, 1974
28	DMA95-134	93L/16	9	671530	6070262	Lennac Lake	Bulkley intrusions	Ar/Ar	Bi	78.3	±	0.8	coarse grained bt-plagioclase porphyry	this study
29	NC-69-1	93M/ 8	9	668795	6144179	Trail Peak	Bulkley intrusions?	K-Ar	Bi	105	±	4	qz diorite, granodiorite	Carter, 1974
30	DMA95-181	93L/16	9			Newman Peninsula	Rocky Ridge volc.?	U/Pb	Zr	107.8	±	0.5	plag-K-spar porphyritic dacite	this study
31	MAC-CORE	93K/13	10			MAC property	Francois intrusions	Ar/Ar	Bi	142.5	±	1.4	bt-hb porphyry stock	this study
32	KBE95-161	93K/13	10	311900	6085500	Toncha Lk.	Topley intrusions?	Ar/Ar	Hb	175.7	±	1.7	porphyritic hb-fd diorite to monzonite	this study
33	NC-69-4	93L/16	9	681279	6070396	Tachek Crk.	Topley intrusions?	K-Ar	Bi	178	±	7	hb-bt-qz fd porphyry, mineralized	Carter, 1974
34	KBE95-145	93L/16	9			E. of Babine Lk.	Topley intrusions	U/Pb	Zr	178.7	±	0.5	granite, bt monzogranite	this study
35	IWE95-111	93L/16	9			W. of Granisle	Hazelton Group	U/Pb	Zr	184.7	±	0.5	fd-qz phyric rhyolitic lapilli tuff	this study
36	KBE95-71	93L/16	9	687749	6087797	E. of Babine Lk.	Topley intrusions	Ar/Ar	Bi	191.1	±	1.9	granodiorite	this study
37	DMA95-275	93L/16	9	673700	6089950	N. of Granisle	Topley intrusions	Ar/Ar	Hb	193.7	±	1.9	bt-hb-fd porphyry	this study
38	GSC 73-44	93L/ 9	9	681368	6056103	Mahtzehtzel Mt.	Topley intrusions	K-Ar	Bi	199	±	8	qz monzonite	Wanless et al., 1974
39	DMA 95-146	93L/16	9	669421	6080872	N. of Fulton Lk.	W. Takla Group	Ar/Ar	Hb	208	±	2	pyroxene hb-fd porphyry flow	this study
40	GSC 73-45	93L/16	9	683883	6082888	Babine Lake	Topley intrusions	K-Ar	Hb	210	±	9	monzonite, slightly foliated	Wanless et al., 1974
41	DMA95-180	93L/16	9			W. of Babine Lk.	Topley intrusions	U/Pb	Zr	215-230		???	K-spar-bt granite, weakly foliated	this study
42	KBE95-11	93K13	10	309600	6093500	W. of Toncha Lk.	??	Ar/Ar	Hb	219	±	2	foliated hb diorite	this study

Middle to Upper Jurassic Ashman Formation. The Ashman Formation has been included by previous workers as part of the Bowser Lake Group, based on an apparent disconformity as indicated by a gap in the fossil record. In the current study area, the Ashman Formation, like the Smithers Formation, is locally very fossiliferous with abundant bivalves, ammonites and belemnites. The formation varies. The lower part is coarse-grained, poorly sorted shallow water marine granule and pebble conglomerate interbedded with maroon and greenish grey sandstone and siltstone and containing abundant bivalves, ammonites, belemnites and fossilized wood debris. It changes to deeper water, well-bedded, sparsely fossiliferous shaly argillaceous siltstones and greywackes. The finer-grained, presumably deeper water rocks are well-exposed in road cuts north and south of Nizik Lake. Small, carbonaceous bivalves collected in 1995 from a road cut southeast of Nizik Lake were identified by the Geological Survey of Canada as *Vaugonia doroschini* (Eichwald)(?) and *Plagiostoma*(?) sp. indicating a Late Bathonian or Callovian through to Early Oxfordian age (Paleontology Subdivision, Calgary, collection number C-211602). In 1996, ammonites and bivalves were collected from several new localities, including outcrops in a clear cut northwest of Saddle Hill, a road cut northeast of Nizik Lake, road cuts along the west side of the Hautête graben and outcrops in clear cuts north of MacDougall Creek in the northeast corner of the map area (Figure 2). Preliminary examination of these fossil collections by Jozsef Palfy suggests an age range for the Ashman Formation from as old as Late Bajocian or Bathonian, for beds directly overlying Smithers Formation along the Nakinilerak Lake road, to as young as Oxfordian for beds exposed along road cuts north of MacDougall Creek. The latter are shallow water sediments with abundant wood and volcanic debris, suggesting a facies change from deeper water fine-grained basinal sediments to coarse-grained, shallow water near shore sediments going from Nizik lake in the south central part of the map area to the northeast corner.

LOWER CRETACEOUS SKEENA GROUP (lKS)

The Skeena Group (Leach, 1910) is characterized by well-bedded, quartz, feldspar and muscovite-bearing, marine sedimentary rocks that overlap Jurassic and older rocks along the southern margin of the Bowser Basin. The main Skeena lithologies are dark grey shaly siltstone, greywacke, carbonaceous mudstone and chert-pebble conglomerate These sediments were deposited in a fluviodeltaic, near-shore to shallow marine environment (Basset, 1991). Although fossils are rare, the Skeena Group appears to be range from Hauterivian to late Albian or early Cenomanian in age. The Skeena rocks were folded, uplifted and eroded during a mid to late Cretaceous contractional event related to evolution of the Skeena Fold Belt.

Richards (1990) subdivides Skeena Group rocks in the Hazelton map area (93M) into six formations or mappable units. These are from oldest to youngest the Kitsuns Creek Formation, Kitsumkalum shale, Hanawald conglomerate, unnamed subaqueous volcanics and volcaniclastics, Rocky Ridge Formation and Red Rose Formation. Skeena Group sedimentary rocks in the Old Fort Mountain map sheet have previously been correlated with the Kitsuns Creek Formation or mapped as undivided Skeena Group. A small area in the northeast corner of the map area, around Wedge Mountain has been mapped as Rocky Ridge Formation. In the Hazelton map area the Kitsuns Creek Formation includes feldspathic and volcanic sandstone, siltstone, shale, polymictic, volcaniclastic conglomerate, coal and carbonaceous sediments; the Rocky Ridge Formation includes subaerial, alkaline basaltic-andesitic augite-feldspar porphyry flows, tuff, breccia, lahar and intercalated volcaniclastic sediments (Richards, 1990).

In the current study area, Skeena Group sedimentary rocks are generally poorly exposed because they are only preserved in downdropped fault blocks or grabens which tend to be low-lying areas with extensive cover. Areas where Skeena Group rocks are exposed or have been intersected in drilling, include the northwest shores of the Newman Peninsula, the low lying area between Turkey and Old Fort mountains, the low lying area north of Old Fort Mountain, the area along the east shore of Hatchery Arm and the southeast end of Morrison Lake, and in road cuts in a new clear cut east of Wedge Mountain in the northeast corner of the map area. The main Skeena Group lithologies are medium to coarse-grained, grey quartzo-feldspathic sandstone, dark grey siltstone and dark grey to black carbonaceous mudstone. These rocks are folded and have a moderate to steep dip especially near intrusive bodies.

LATE CRETACEOUS BULKLEY INTRUSIONS (LKBp)

The term Bulkley Intrusions was first used by Kindle (1954) for granitic rocks near Hazelton. This suite is Late Cretaceous in age and includes large porphyritic and equigranular stocks of quartz monzonite, granodiorite and quartz diorite and smaller plutons and dikes of feldspar porphyry, hornblende-biotite-quartz-feldspar porphyry and quartz porphyry. Potassium argon isotopic ages range from 70 to 84 Ma (Carter, 1976). The plutons define a north-trending belt that extends from north of the Babine River south to the Eutsuk Lake area. They are believed to be the roots of an eastward-migrating magmatic arc that formed during a major transtensional tectonic event in Middle to Late Cretaceous time. The only intrusions in the Babine Lake area that are known to be part of this suite are exposed at the Lennac Lake porphyry copper prospect (MacIntyre *et al.*, 1996). One of these intrusions was dated using the laser Ar-Ar technique and gave a 78.3 ± 0.8 Ma age date(No 28, Table 1), identical to a previous 78.3 ± 2.5 K-Ar age date determined by Carter (1973). There are no known occurrences of Bulkley Intrusions in the Old Fort Mountain map area.

CRETACEOUS-TERTIARY INTRUSIONS (KTg)

Correlation of these intrusions with the Babine Intrusions is based on a spatial association and should be considered tentative; none of these bodies has yet been dated. These intrusions could be older and unrelated to the Babine intrusions. In places the stocks are very coarse-grained with 3 to 4 centimetre long, crudely aligned, hornblende phenocrysts.

Numerous stocks of medium to coarse-grained greenish grey hornblende diorite, quartz diorite and gabbro crop out in the map area. The best exposures occur along the ridge east of the Morrison Graben, especially between Hearne Hill and south of Nizik Lake, where northerly elongate bodies cut Lower to Middle Jurassic volcanics and younger sedimentary rocks of the Ashman Formation. They range from dikes less than 10 metres wide to stocks 2 to 3 kilometres long and 0.5 to 1 kilometres wide. For the most part the intrusions have been emplaced passively with little disruption of regionally bedding attitudes. Zones of biotite hornfels are locally present, especially around larger bodies. In places the diorite has a porphyritic texture with hornblende needles and laths up to 3 or 4 centimetres in length. Generally the diorite is weakly to moderately chloritized and in places has poorly developed mineral lineation. Compositionally these intrusions range from gabbro to granodiorite, but most are probably true diorites.

The age of diorite intrusions in the map area is uncertain. They are found cutting rocks ranging from Lower Jurassic through to Lower Cretaceous in age. Therefore, assuming there is only one episode of dioritic magmatism, these intrusions must be Lower Cretaceous or younger. The only radiometric date on any of these intrusions is consistent with this conclusion, giving a K-Ar of 105±4 Ma (no.29, Table 1). on biotite from a quartz diorite or granodiorite at Trail Peak. It is possible, however, that some of the diorite intrusions are Eocene, and represent the earliest, least differentiated phases of the Babine Intrusions.

EOCENE BABINE IGNEOUS SUITE

The Babine Igneous Suite includes 3 major units all of which are believed to be early Eocene in age. These units are: the porphyritic to equigranular diorite to granodiorite Babine intrusions (Carter, 1976; 1981); the extrusive equivalent of these intrusions, the Newman volcanics; and a series of flow-banded rhyolite domes and dikes which may or may not be related to the two previous units.

BABINE INTRUSIONS (EBp, EBq, EBg)

The Babine Intrusions include small plugs and dikes of crowded biotite±hornblende feldspar porphyry (EBp), quartz±biotite feldspar porphyry (EBq) and equigranular hornblende-biotite granodiorite to quartz diorite (EBg) that occur as multi-phase intrusive centres in a north-trending belt that extends from Fulton Lake to Trail Peak (Figure 1). Also included with the Babine Intrusions but not restricted to being a phase within major intrusive complexes are domes and dikes of flow-banded to aphanitic rhyolite (EBr). Potassium-argon isotopic ages biotite and hornblende phyric phases range from 49 to 55 Ma (50.2 to 55.8 using new decay constants, see Table 1) indicating the intrusions are early Eocene in age. The intrusions, which are believed to be the subvolcanic roots of a calcalkaline magmatic arc, cut volcanic and sedimentary strata ranging in age from Triassic to Early Cretaceous. The Newman volcanics are the extrusive equivalents of the intrusions, and these rocks are preserved close to intrusive centres on the Newman Peninsula and at Saturday Lake. The fact that the volcanic edifices have not been completely removed by erosion is further evidence that the Babine intrusions and associated porphyry copper deposits, such as Bell and Granisle, are exposed at a subvolcanic level.

Compositionally, the Babine intrusions and Newman volcanics are very similar to the older Bulkley intrusions and Kasalka volcanics found further to the west. This suggests similar, transtensional, volcanic environments prevailed during the Late Cretaceous and, Eocene, with the locus of volcanism moving progressively eastward with time.

Biotite-hornblende quartz diorite to granodiorite (EBg)

Stocks of medium-grained, equigranular to sub-porphyritic biotite-hornblende quartz diorite to granodiorite are exposed on Old Fort Mountain, north of Saddle Hill on the Wolf property, north of Hearne Hill, and at the Dorothy property (Figure 2). The stocks are typically cut by dike-like bodies of biotite-feldspar porphyry which have associated porphyry copper mineralization. Zones of biotite hornfels and disseminated and fracture controlled pyrite up to several hundred metres in width enclose the equigranular stocks, particularly on Old Fort Mountain and at the Wolf Property. The Old Fort Mountain stock also has a very strong aeromagnetic response. Although the equigranular phase of the Babine intrusions can host low-grade copper mineralization, better grades are typically associated with younger porphyritic phases. The absence of any significant amount of the early equigranular phase at properties such as Morrison, Bell and Granisle is interpreted to reflect a shallower level of exposure at these properties. It is assumed that these bodies exist at depth according to the model shown in Figure 3.

Biotite-feldspar porphyry (EBp)

The most abundant rock type of the Babine intrusive suite is a crowded, dark grey biotite-feldspar porphyry that typically occurs as small plugs and dikes. This rock type contains 40 to 60%, 2 to 3-millimetre phenocrysts of biotite, plagioclase and rarely hornblende and quartz, in a finer grained groundmass of plagioclase, quartz, biotite and minor potassium feldspar. The porphyries are quartz diorite to granodiorite in composition and are typical of plutonic rocks found in a continental calcalkaline magmatic arc environment.

Quartz-biotite-feldspar porphyry and quartz feldspar porphyry (EBq)

Quartz-phyric intrusions with or without biotite post-date the main phase of stockwork mineralization at the Bell mine and apparently cut the earlier biotite-feldspar porphyry phase (Dirom *et al.*, 1995). The quartz-phyric rocks are weakly mineralized relative to the biotite-feldspar porphyry phase and contain partially resorbed quartz phenocrysts. This intrusive phase is most common around the Bell pit but also occurs as small stocks and dikes in the northwest corner of the map area (Figure 2). One north trending dike is 10 to 20 metres thick and can be traced for up to 3 kilometres.

Rhyolite dikes and domes (EBr)

White to cream weathering, locally flow-banded, aphanitic to feldspar phyric rhyolitic dikes and domes are common in the map area. These siliceous rocks are resistant and tend to form topographic highs. The largest bodies are located north of Old Fort Mountain, where the rhyolite occurs as an arcuate belt of resistant knolls rising from a relatively flat plateau. The knolls are comprised of rusty weathering, white to cream weathering aphanitic to flow-banded rhyolite that is intrusive into Cretaceous Skeena Group sedimentary rocks. Both the flow banding in the rhyolite domes and bedding in the surrounding sedimentary strata have a shallow to moderate south to southeasterly dip suggesting the emplacement of the rhyolite might have been controlled in part by bedding in the sedimentary succession. The rhyolite domes may also have been emplaced along an inward dipping ring dike structure centered on Old Fort Mountain. As mentioned earlier numerous intrusions are exposed on Old Fort Mountain suggesting the presence of a major volcano-plutonic center.

Northerly elongate rhyolite intrusions also occur in the northeast corner of the map area, in the vicinity of McDougall Creek. These domes are at the southern end of a long, narrow chain of rhyolite domes that extends northward into the 93M/8 map sheet.

The rhyolite domes in the Babine Lake area were probably formed when silica rich fluids escaped from partially crystallized magma reservoirs. Emplacement of the highly viscous magma was controlled by faults in the surrounding country rock. Formation of rhyolite domes may have been accompanied by collapse of underlying magma chambers and formation of caldera like structures.

EOCENE OOTSA LAKE GROUP

The Ootsa Lake Group, as defined by Duffell (1959), is a succession of continental calcalkaline volcanic rocks with minor nonmarine sedimentary interbeds. In the type area around Ootsa Lake, the volcanic members are differentiated andesites, dacites and rhyolites. The dacites and rhyolites occur both as flows and flow-breccia dome complexes of limited areal extent; the andesites and tuffs are more extensively distributed. Several dates determined in the Whitesail Lake area indicate that the Ootsa Lake volcanics erupted 50 million years ago for a period as short as 1 million years (Diakow and Mihalynuk, 1987). In the study area, hornblende-biotite-phyric andesite flows, breccias and lahars of the Newman volcanics yield similar ages and are therefore mapped as part of the Ootsa Lake Group.

NEWMAN VOLCANICS (ENv)

In the Babine Lake area, calc-alkaline, hornblende-biotite-feldspar porphyry flows, breccias and lahars sit with angular discordance on folded Triassic, Jurassic and Lower Cretaceous volcanic and sedimentary rocks. These volcanic rocks were given the name Newman volcanics by Tipper and Richards (1976a) because they are well exposed on both sides of the Newman Peninsula. Similar rocks crop out sporadically along the western shore of Babine Lake and on Bear Island. Here the Newman Volcanics are restricted to the north trending Granisle graben which is centered on Babine Lake. The volcanics within the graben are in fault contact with older rocks indicating formation of the graben post-dates volcanism. The Newman Volcanics also occur as a subcircular volcanic plateau southeast of the current map area. This plateau, which is locally known as Turkey Mountain, may be the eroded remains of a large volcanic cone (MacIntyre *et al.*, 1996).

In the Old Fort Mountain map sheet, outcrops of Newman volcanics are restricted to the north end of the Newman Peninsula. Scattered outcrops of hornblende-biotite-feldspar porphyry do occur within the Morrison graben but most of these are probably resistant knolls representing volcanic necks or dikes that intrude recessive Lower Cretaceous Skeena Group sedimentary strata. The Newman volcanics have probably been removed by erosion within the Morrison graben.

The Newman volcanics are Early Eocene based on previous K-Ar dating which ranges from 44.3±2 to 51.5±1.9 Ma (45.1 to 52.4 using new decay constants, Table 1). These ages overlap those determined for lithologically identical porphyries of the Babine Intrusions and the volcanics are, therefore, considered to be the extrusive equivalent of these rocks (Villeneuve and MacIntyre, 1997).

The Newman volcanics can be subdivided into three units or members. The lowest member is mainly columnar to sheet-jointed hornblende-biotite-feldspar porphyry flows and/or sills that are lithologically similar to biotite-feldspar porphyries of the Babine intrusions. These rocks are overlain by a middle member which is mainly volcanic breccia composed of angular clasts identical to the underlying porphyries. Towards the top of the section lahars, debris flows and volcanic-pebble conglomerate predominate. A gently east dipping, heterolithic conglomerate exposed in Tachek Creek, and sitting with angular discordance on Triassic volcanic rocks, may be the basal member of the Newman volcanics.

STRUCTURE

The structure of the Babine Lake area reflects the effects of at least four major tectonic events. The oldest took place in mid to late Jurassic time when rocks of the Hazelton and Takla Groups were folded and uplifted. This was followed in mid Cretaceous time by a contractional event that produced northwest-trending folds and northeast directed thrust faults. Rocks as young as Albian were involved in this folding whereas the Late Cretaceous volcanics of the Kasalka Group were not. Crustal extension and development of north trending grabens and horsts took place in Late Eocene or younger time as both the Babine intrusions and Newman volcanics have been truncated and displaced by movement on faults bounding the grabens. The latest event which may be as young as Miocene involved tilting of fault blocks to the southeast along northeast trending faults. In general, because of the Eocene and younger movement of fault blocks younger rocks typically occur at lower elevations within north trending valleys while older rocks are found at higher elevations on the ridges bounding the valleys.

MINERAL OCCURRENCES

The most important mineral occurrences in the Babine Lake area are porphyry copper deposits associated with the Eocene Babine intrusions and Late Cretaceous Bulkley intrusions (Carter, 1981; Carter *et al.*, 1995). The Bell past producer and the Morrison, Hearne Hill, Dorothy, Old Fort and Wolf (Double R) are the main porphyry copper prospects in the 1996 study area (Table 2). In addition, the Fireweed epithermal prospect occurs near the southern boundary of the map area.

BELL (MINFILE 93M 001)

The Bell porphyry copper deposit is located on the Newman Peninsula and straddles the boundary between the 93L/16 and 93M/1 mapsheets (Figure 2). The geology and production history of the Bell deposit, which was a producing mine from 1972 to 1992, has recently been reviewed by Dirom *et al.*, 1995 and in a previous report by Carson *et al.*, 1976. Zaluski (1992), and Zaluski *et al.* (1994) have recently described the results of stable isotope studies at Bell and other deposits in the district which indicate the presence of both magmatic and mixed magmatic-meteoric fluid sources.

The Bell ore body is associated with a multi-phase intrusive complex, covering an area of approximately 1200 metres by 600 metres, that includes from oldest to youngest biotite-feldspar porphyry, rhyolite to rhyodacite, quartz-feldspar porphyry and explosion breccia. Several small, elongate stocks of biotite-feldspar porphyry and rhyolite occur around the main intrusive complex. The intrusions, which are probably the subvolcanic roots of a stratovolcano, are believed to have been emplaced along zones of dilation associated with extensional faulting during the early stages of formation of the Granisle graben. The intrusive complex is located along the north-trending Newman fault, which is located along the eastern boundary of the Granisle Graben. To the east of the fault the Bell intrusions cut volcanics believed to be correlative with the Lower to Middle Jurassic Saddle Hill volcanics; to the west of the fault they cut sedimentary strata of the Lower Cretaceous Skeena Group. Another fault occurs 1000 metres west of the Newman fault and juxtaposes Skeena Group rocks against Eocene Newman Volcanics. The Newman volcanics, which are the extrusive equivalents of the porphyry intrusions, are

Table 2. Mineral Occurrences

No.	Property Name	Status	Metals	Hosts	Type
001	Bell	PAPR	Cu,Ag,Au	EBp,EBqEBr,lKS, lmJv	Porph
002	Mag	SHOW	Pb,Zn,Cu	muJA	Vein
003	Snoopy	SHOW	Cu	lmJv	?
004	Old Fort	SHOW	Cu	EBg,mJS	Porph
005	Jake	SHOW	Cu	lmJv	?
006	Kofit, Hearne Hill	DEPR	Cu,Au,Ag	lmJv, EBp, EBg	Porph
007	Morrison	DEPR	Cu,Au	EBp, muJA	Porph
008	Wolf	PROS	Cu,Mo	EBg, EBp	Porph
009	Dorothy	DEPR	Cu,	EBg, EBp	Porph
121	Mast	SHOW	Cu	KTd,lmJv	Porph
127	Bab	SHOW	Cu	EBp	Shear
144	Fort	SHOW	Cu	mJS, EBp	Porph
151	Fireweed	DEPR	Ag,Pb,Zn	lKS	Epith.
159	Newman North	SHOW	Cu	EBp, lKs	Porph
160	Sparrow-hawk	SHOW	Cu	lmJv	Vein
162	Copper 1-4	SHOW	Cu	muJA	Vein

PAPR - past producer; DEPR - developed prospect; PROS - prospect; SHOW - showing well exposed southwest of the deposit. The close proximity of these extrusive rocks to the Bell intrusive complex suggests the intrusive complex is exposed at a subvolcanic level.

Mineralization at Bell is typical of high level porphyry copper systems. Pyrite, chalcopyrite, minor bornite and trace molybdenite occur as disseminations, fracture coatings and in quartz veinlet stockworks within all phases of the intrusive complex. Gold occurs as electrum associated with copper mineralization. One of the unusual features at Bell was a zone of chalcocite supergene enrichment which originally capped the deposit and extended to depths of 70 metres.

Extensive zones of hydrothermal alteration are associated with the porphyry copper mineralization at Bell. The earliest alteration, which was produced by high temperature magmatic fluids according to the stable isotope studies of Zaluski *et al.* (1994), produced a core zone of potassic alteration comprised of secondary biotite, magnetite and minor K-feldspar centered on the intrusive complex and an outer zone of propylitic alteration comprised of chlorite and carbonate. Influx of meteoric water during the later stages of alteration resulted in overprinting of feldspar destructive sericite-carbonate-quartz alteration on the earlier potassic and propylitic alteration zones (Zaluski *et al.*, 1994)

Initial ore reserves at Bell were 116 million tonnes averaging 0.48 percent copper. Production from the Bell mine totalled 77.2 million tonnes averaging 0.47 percent copper with an average waste to ore ratio of 0.98:1. Total recovered metals were 303 277 tonnes copper, 12 794 kilograms gold and 27 813 kilograms of silver (Dirom *et al.*, 1996).

MAG (MINFILE 93M 002)

The MAG showing is located near the northern limit of the Red property, which is 6 kilometres north of the Granisle mine-site in an area of very limited outcrop. Granby Mining Company Limited first explored the property in the mid 1960's followed in 1966 by Bethex Explorations Ltd. Bethex drilled nine holes in 1967. Canadian Superior Exploration Limited and Quintana Minerals Corporation completed induced polarization and geochemical surveys in 1972. The property was restaked by Gerard Auger in 1984 and he subsequently optioned it to Anglo Canadian Mining Corporation. Anglo in turn optioned the property to Equity Silver Mines Limited. In 1987; Equity completed 963 metres of diamond drilling in seven inclined holes. An additional 914 metres was drilled in six holes in 1989.

The MAG showing is the only mineral occurrence exposed on surface. It is a 0.3 metre wide quartz-carbonate vein with galena, sphalerite and chalcopyrite, in sheared, rusty sedimentary rocks near the northwest corner of the property. Elsewhere on the property, the main target is a pyrite-pyrrhotite zone that produces a strong geophysical conductor. The zone has been drill-tested over a strike length of 220 metres. Drill intersections with core lengths of between 30 and 50 metres have contained massive and stringer sulphides with elevated copper, zinc, lead, silver and gold values (N.C. Carter, personal communication, 1995). Host rocks are Middle to Upper Jurassic Ashman Formation argillaceous siltstones and greywackes with interbedded felsic and intermediate volcanic rocks. One outcrop of the sedimentary rocks occurs in a south-flowing creek gully on the west side of the property. Here, the beds strike north and dip moderately to the west. A Cretaceous to Teritiary diorite stock crops out in the large clear-cut on the north end of the property.

SNOOPY (MINFILE 93M 003)

The Snoopy copper showing is reported to be located 1.6 kilometres northwest of Nizik Lake and 7.5 kilometres northeast of the Bell mine. It is apparently associated with a Cretaceous to Tertiary dioritic intrusion. The exact location of the showing is uncertain.

OLD FORT (MINFILE 93M 004)

The Old Fort showing is located on the southeast slope of Old Fort Mountain, in an area of heavy tree cover. The property was staked in 1965 following a soil sampling program. In 1966, Falconbridge Nickel Mines Limited built a tractor road from Hatchery Arm to the property, completed geologic mapping, and drilled 17 holes totalling 1113 metres (3652 feet). Falconbridge in conjunction with several joint venture partners did additional exploration, including trenching, magnetics, induced polarization and electromagnetic surveys between 1966 and 1976. Additional work was done by Pearl Resources in 1982 and 1983. The main target of interest on the property is an elliptical stock of hornblende-biotite quartz diorite approximately 1000 metres in diameter that is cut by a northeast trending body of biotite quartz monzonite and dikes of biotite-hornblende-feldspar porphyry. Carter (1974) reports that biotite collected from one of these dikes gave a K-Ar isotopic age of 49 Ma (50.0 ± 2 Ma using revised decay constants) (No. 5, Table 1). The quartz diorite intrudes marine sediments of probable Middle Jurassic age. A broad zone, up to 1000 metres wide, of hard, dense, rusty weathering, biotite-hornfels with variable amounts of disseminated pyrite and pyrrhotite surrounds the stock. Chalcopyrite and minor bornite occur with magnetite as disseminations and fracture coatings in both the quartz diorite and hornblende-biotite-feldspar porphyry dikes. Molybdenite occurs in some fractures associated with K-feldspar veinlets.

JAKE (MINFILE 93M 005)

The Jake copper showing is reported to be located 5 kilometres northeast of the north end of Hatchery Arm. The showing is described as minor pyrite, chalcopyrite and malachite in stratified andesitic and rhyolitic volcanic rocks of the Lower to Middle Jurassic Saddle Hill volcanics. The showing was not located during the current mapping program and its location can not be verified.

HEARNE HILL (KOFIT) (MINFILE 93M 006)

The geology and exploration history of the Hearne Hill property has recently been reviewed by Ogyzlo *et al.* (1995). The Hearne Hill showing was first explored by Trojan Consolidated Mines and Buttle Lake Mining in 1967. In 1968, Texas Gulf Sulphur Company optioned the property and drilled 12 holes totalling 1942 metres. This work defined the presence of low grade (0.2 percent copper) porphyry copper deposit associated with a multi-phase intrusive body similar to other porphyry prospects in the district. The property was optioned to Canadian Superior Exploration who did diamond drilling and percussion drilling in 1968 and 1969 respectively. Discouraged by low grades, the option was dropped and the property was not explored again until 1989 when in was acquired by Dave Chapman. Chapman did some trenching on the property and located the Chapman breccia zone in an area where high grade breccia boulders had originally been found back in 1967. Noranda subsequently optioned the property in 1989 and drilled 6 holes totalling 468 metres in an attempt to define the geometry of the breccia zone. The best intersection from this drilling was 42.5 metres averaging 3.61 percent copper. In 1990, Noranda further explored the Chapman breccia by drilling 5 vertical NQ holes, totalling 856 metres. These drill holes intersected both the well mineralized breccia and younger, post mineral quartz-feldspar porphyry dikes which resulted in lower overall grades. In 1991, the owner, Dave Chapman, drilled 7 more holes totalling 550 metres into the breccia body, with the best intersection being 50 metres assaying 2.3 percent copper, including a 3 metre section assaying 0.401 oz/tonne gold. Booker Gold optioned the property in 1992 and did diamond drilling in 1994, 1995 and 1996. This work resulted in the discovery of the Peter Bland breccia zone, northeast and up slope from the Chapman breccia body. To date, Booker has competed over 70 drill holes on the property, most of these targeting the Chapman and Peter Bland breccia zones. In addition, a detailed till geochemical program was done on the property in 1996 and follow-up work based on the results of this survey are in progress at the present time.

There are two distinctive styles of copper mineralization at Hearne Hill. The earliest and most widespread is typical of porphyry copper deposits in the district and is comprised of fracture controlled and disseminated pyrite, chalcopyrite, minor bornite and molybdenite. This mineralization occurs in hornfelsed volcanics, equigranular biotite quartz diorite and dikes of biotite-feldspar porphyry. Late syn and post mineral dikes cut the mineralized zone and have diluted the overall grade of the deposit. In general higher copper grades occur in hornfelsed rocks of the Lower to Middle Jurassic Saddle Hill volcanic succession.

The second style of mineralization at Hearne Hill, and the one which has been the focus of recent exploration by Booker Gold, is comprised of northeast elongate, steeply southeast dipping ellipsoidal breccia bodies that contain high grade copper and associated gold and silver values. To date, two breccia bodies, the original Chapman zone, which is 68 metres long and up to 26 metres wide, and the more recently discovered Peter Bland zone which is of similar size, are known and appear to be on strike along the same northeast-trending structure that cuts through the Hearne Hill porphyry system. The breccias are clast-supported with angular clasts showing a preferred orientation parallel to the current erosion surface. The mineral concentration within these breccias, which has characteristics of low temperature epithermal systems, occurs as coarse, nearly massive chalcopyrite, pyrite and marcasite cement in the interstices between clasts. Superimposed on the sulphides is a younger cement of calcite, dolomite and chalcedony. Open cavities are still common within the breccias, which are believed to have formed by collapsed of wallrock into porous zones created by intense hydrothermal leaching of silicates. The collapse breccias grade outward into intensely fractured wall rock which can also contain significant copper mineralization as fracture fillings.

The fluid inclusion geothermometry studies of Ogryzlo (1994) suggest the breccias at Hearne Hill formed from low temperature, low salinity meteoric fluids at a minimum depth of less than 100 metres. The stockwork porphyry system, on the other hand, apparently formed from higher temperature, higher salinity magmatic fluids at a minimum depth of 4 kilometres plus or minus 1 kilometre. The magmatic stockwork mineralization, which occurs within both the porphyry intrusions and surrounding volcanics, is characterized by the occurrence of disseminated and fracture controlled chalcopyrite and minor bornite with associated very fine-grained secondary biotite and K-feldspar. Argillic alteration, which is common within the breccias, has been superimposed on these potassically altered rocks, and is probably related to a lower temperature epithermal event during the waning stages of hydrothermal alteration. Some supergene replacement of sulphides by limonite is observed in surface exposures. Booker Gold has estimated that the high grade core centered on the breccia bodies contains up to 28 million tonnes of potentially ore grade rock (Sampson and Weary, 1996)

MORRISON (MINFILE 93M 007)

The Morrison deposit, like Hearne Hill was discovered in 1962 when Noranda's Norpex Group did a follow-up on anomalous silt samples. The deposit, which has been described by Carter (1967), Carson and Jambor (1976) and Oryzlo *et al.* (1996), occurs on the east side of the north-trending Morrison graben which underlies Morrison Lake and Hatchery Arm (Figure 2). Although outcrop within the graben is limited, rocks near the deposit are more resistant due to hornfelsing and silicification and tend to crop out as small north trending ridges that are surrounded by low-lying areas covered by thick glacio-lacustrine deposits.

Subsequent drilling by Noranda at Morrison resulted in delineation of a porphyry copper deposit which is estimated to contain 190 million tonnes grading 0.40 percent copper and 0.2 grams per tonne gold using a cutoff grade of 0.30 percent copper (Ogryzlo *et al.*, 1995). Noranda still owns the Morrison deposit.

At Morrison, as at other deposits in the district, chalcopyrite, pyrite and minor amounts of bornite and molybdenite occur as fracture coatings, disseminations and quartz veinlet stockworks within and peripheral to a small, northwest elongate, multi-phase stock of biotite-hornblende-feldspar porphyry, typical of the Babine intrusions. Carter (1974) reports that biotite from this intrusion gave a K-Ar isotopic age of 52.1 ± 2.1 Ma (53.0 ± 2.1 Ma using revised decay constants, No.25, Table 1). The stock, which is 900 metres long and up to 300 metres wide, and a series of peripheral north-trending dikes of similar composition intrude Middle to Upper Jurassic argillites and siltstones of the Ashman Formation. A small amount of well-sorted conglomerate cut by dacite sills, unconformably overlies the Ashman Formation and may be Cretaceous or Eocene in age. Near the main stock, the sediments are typically hornfelsed and contain disseminated and fracture controlled pyrite and chalcopyrite.

Alteration at Morrison is arranged in annular zones about the main stock. The main zone of copper mineralization occurs within a central zone of intense secondary biotite and magnetite which defines the potassic zone. Stable isotope studies indicate this alteration is predominantly of a magmatic origin (Zaluski *et al.*, 1994). Enclosing the potassic zone is a zone of propylitic alteration characterized by the presence of chlorite and carbonate. Unlike Bell and Granisle, there is no extensive overprinting of early magmatic alteration with phyllic and argillic alteration although this type of alteration does occur in some of the biotite-hornblende feldspar porphyry dikes.

The Morrison deposit has been affected by Eocene or younger extension and dextral shearing. To the east of the deposit is the Morrison fault which forms the eastern boundary of the Morrison graben. This fault may be dipping westward and, if so, the Morrison Deposit may be the downwardly displaced upper part of the Hearne Hill porphyry system, an idea put forth by Ogyzlo (1992). A north-trending, post-mineral shear zone with up to 330 metres of dextral offset cuts and displaces the main stock and zone of copper mineralization. This shear zone, which typically has intense clay-carbonate alteration and local breccia development, is also mineralized with marcasite, sphalerite and arsenopyrite occurring in quartz-carbonate veinlets and vugs.

Another northwest trending dextral shear zone truncates the southern part of the Morrison intrusive center. Intrusions on the Wolf property, some 4.5 kilometres to the northwest, may be the displaced southern part of the Morrison intrusive system.

WOLF (MINFILE 93M 008)

The Wolf prospect is located north of Saddle Hill and west of Morrison Lake. This area was first staked and explored by Kerr Addison who located an EM conductor and low grade copper in granodiorite along the west shore of Morrison Lake. Tro-Buttle Exploration and Canadian Superior Exploration explored the property in 1967 and 1968 and complete 5 diamond drill holes totalling 182 metres in the vicinity of the EM conductor. It was concluded this conductor was due to the presence of graphitic siltstone. Cities Services optioned the property in 1976 and did 19 kilometres of IP survey. This was followed by Noranda in 1979 who drilled a single 152 metre hole, again near Morrison Lake. Noranda did a small soil sampling program on the property in 1988 and in 1989 the claims were allowed to lapse. In 1992, R. McMillan staked the property as the Double R and in 1993 Phelps Dodge completed six diamond drill holes totalling 781 metres on the northeast slope of a small ridge on the west side of the property. This drilling, which was on 200 metre centers, was done to test a coincident soil and magnetic anomaly. The drill holes intersected low grade copper mineralization associated with biotite-feldspar porphyry dikes that cut a biotite granodiorite stock. Chalcopyrite and pyrite occur as disseminations and fracture coatings and locally as stockwork veinlets. The best drill intersection was 16 metres of 0.25 percent copper.

The biotite granodiorite stock at Wolf intrudes and has hornfelsed siltstones of the Middle to Upper Jurassic Ashman Formation. The contact zone, which is strongly pyritic is exposed near the crest of a north trending ridge. Biotite extracted from the granodiorite gave an Ar-Ar isotopic age of 52.4 ± 0.5 Ma confirming these intrusions are part of the Babine suite (No. 20, Table 1). The granodiorite stock underlies the area northeast of the ridge and, near Morrison Lake, is truncated and offset by a dextral shear zone that is probably a splay of the Morrison fault. Movement on this shear zone is clearly Eocene or younger. The same shear zone truncates the Morrison intrusive complex several kilometres to the east and the granodiorite on the Wolf property may be an offset and uplifted portion of the Morrison system. Outcrops of rhyolite and basalt occur northeast of the shear zone and these rocks are near the top of the Lower to Middle Jurassic Saddle Hill volcanic succession.

DOROTHY (MINFILE 93M 009)

The Dorothy property, which is located northeast of Hautête Lake, was first staked in 1965. After completion of induced polarization, magnetometer, electromagnetic and geochemical surveys in 1970, the property was tested by diamond drilling in 1971. This work defined an inferred resource of 45 million tonnes averaging 0.25 percent copper and 0.01 percent molybdenum. Little work has been done on this property since 1971. However, a new logging road (the Highland Main) now cuts through the deposit and low grade copper mineralization in the form of disseminated and fracture-controlled pyrite and chalcopyrite is exposed in road cuts over a distance of 1800 metres. Examination of these exposures reveals that the mineralization occurs in a multi-phase stock comprised of crowded biotite-feldspar porphyry and equigranular to subporphyritic granodiorite or quartz diorite. Some of the biotite-feldspar porphyry is dark grey due to abundant secondary biotite alteration. Elsewhere the porphyry has moderate to intense quartz-sericite-pyrite alteration. The latter appears to be overprinting the earlier biotite alteration. Although the Dorothy stock has not been dated it is almost certainly part of the Babine Igneous Suite.

East of the Dorothy stock is a large, north trending body of hornblende diorite which may or may not be part of the Babine suite. Contact relationships are not clear but it appears the Dorothy stock intrudes the diorite. To the west the stock intrudes volcanics of probable Lower to Middle Jurassic age.

MAST (MINFILE 93M 121)

The Mast copper showing is apparently located southeast of the Dorothy porphyry copper deposit. The exact location of the showing is uncertain and consequently it was not examined during the 1996 field program. The showing is described as disseminated pyrite and minor chalcopyrite in silicified andesitic volcanic rocks and diorite of probable Late Cretaceous to Tertiary age. The deposit is classified as a porphyry deposit.

BAB (MINFILE 93M 127)

The Bab showing is described as being located 2 kilometres east of the north end of Babine Lake. A number of hornblende-biotite-feldspar porphyry intrusions of the Babine suite are reported to occur in this area. These intrusions cut Lower to Middle Jurassic volcanics of the Saddle Hill succession. Mineralization in the form of pyrite and chalcopyrite with sericite and secondary biotite occurs in a narrow, northwest-trending shear zone that cuts relatively fresh porphyry. The location of the Bab showing is uncertain and it was not visited during the 1996 field program.

FORT (MINFILE 93M 144)

The Fort showing is on the west side of Old Fort Mountain. It is described as pyrite and minor chalcopyrite occurring within and adjacent to a small plug of biotite-feldspar porphyry. The showing was not examined in 1996.

FIREWEED (MINFILE 93M 151)

The Fireweed property is a relatively recent discovery in the Babine Porphyry Belt and is an example of the type of epithermal mineralization that is associated with the Babine Igneous Suite. The geology of the property has been described in a recent report by Mallott (1992).

The Fireweed property, which was staked in 1987 after float with anomalous gold was found by prospectors, is located in a low-lying clear cut area southeast of Smithers Landing. Follow-up work discovered two mineralized outcrops in an area covered by up to 40 metres of glacio-lacustrine clay. In 1988, Canadian United Minerals drilled 32 holes to test geophysical targets. This worked showed that the property is underlain by a northeast trending graben that contains moderate to steeply northwest and southeast dipping beds of the Lower Cretaceous Skeena Group. The graben is bounded by Jurassic and possibly Triassic volcanic rocks.

The main showings on the property are the Mn, Sphalerite and West Zone (Mallott, 1992). These occur in the Lower Cretaceous Skeena Group, which here is mainly interbedded carbonaceous sandstone, siltstone and mudstone. There are three types of mineralization observed in drill core and limited bedrock exposure. These include: breccia zones healed with fine to coarse-grained massive pyrite-pyrrhotite and lesser amounts of sphalerite, chalcopyrite; fine to very fine-grained disseminated pyrite, marcasite, sphalerite, galena and minor tertrahedrite interstitial to sand grains in manganiferous coarse sandstones; and fine-grained, banded, massive sulphides that contain rounded quartz-eyes and sedimentary clasts. The massive sulphides are comprised of alternating beds of pyrite-pyrrhotite and sphalerite-galena. The best grades of mineralization occur in the coarser-grained, more permeable sandstone beds within the carbonaceous sandstone-siltstone-mudstone succession. The best drill intersection was 7.9 metres averaging 635.3 grams per tonne silver, 2.26 percent lead and 3.02 percent zinc (Mallott, 1992). Although intrusive rocks are not exposed on surface, several drill holes have cut sills and dikes of strongly altered feldspar porphyry and latite that are probably part of the Eocene Babine Igneous Suite.

The style and tenor of mineralization on the Fireweed property suggests a near surface epithermal environment of formation. Circulation of hydrothermal fluids through the permeable Skeena beds produced near massive sulphide mineralization in places. Heat for the hydrothermal system was probably supplied by

Eocene dikes and sills which cut the sedimentary succession.

Other areas underlain by Skeena Group rocks and cut by Eocene intrusions should also be considered prospective for epithermal deposits similar to the Fireweed. These areas, which are typically recessive and lack outcrop, occur north of Old Fort Mountain and in the Morrison Graben (Figure 2). In 1996, Booker Gold drilled two holes into the Morrison Graben, southwest of the Hearne Hill deposit. These holes intersected carbonaceous Skeena Group sediments that are cut by numerous biotite-feldspar porphyry dikes. Bands of fine-grained massive pyrite and possibly marcasite often associated with strongly carbonaceous sediments were observed in the drill core. This mineralization may also be epithermal in origin and suggests there may be potential for deposits similar to the Fireweed within the Morrison Graben.

NEWMAN NORTH (MINFILE 93M 159)

The Newman North showing is located on a point at the northwest tip of the Newman Peninsula, approximately 4 kilometres northwest of the Bell mine. A small stock of biotite-feldspar porphyry intrudes steeply dipping Skeena Group sediments just west of the Newman Fault. The showing was discovered and drilled at the same time as the Bell deposit. The showing is comprised of disseminated and fracture-controlled pyrite and minor chalcopyrite. A strong aeromagnetic anomaly is associated with the intrusion which may be larger at depth.

SPARROWHAWK (MINFILE 93M 160)

The Sparrowhawk showing is located 7 kilometres north of the Bell mine and 3.5 kilometres northeast of Hagan Arm. The showing was discovered in 1989 during a regional reconnaissance program initiated by Noranda. Examination of exposures along road cuts and trenches on the property indicate the host rocks are part of a westward dipping succession of Lower to Middle Jurassic Saddle Hill volcanics. A north trending zone of bleaching, pyritization and carbonate alteration appears to be centered on a fault zone that parallels the east side of the Morrison Graben. Showings on the property include minor chalcopyrite associated with magnetite veins in altered vesicular basalt and chalcopyrite and bornite in a 10 centimetre wide quartz vein that cuts rhyolite. These showings appear unrelated to alteration along the fault zone and may be of a volcanogenic origin.

COPPER 1-4 (MINFILE 93M 162)

This showing, which was discovered in 1986, is reported to be located 2.5 kilometres west of Natowite Lake, in a gravel pit. Galena and sphalerite are present as pods, veinlets and stringers within a 10 to 20 centimetre wide, east-northeast trending shear zone that cuts argillaceous sediments of the Middle to Upper Jurassic Ashman Formation. The best assay reported by Canyon City Resources Inc. in their 1987 prospectus was 713.7 grams per tonne silver, 23 percent lead, and 13.5 percent zinc across 10 centimetres of vein and 5 centimetres of wall rock.

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