BABINE PORPHYRY BELT PROJECT: BEDROCK GEOLOGY OF THE NAKINILERAK LAKE MAP SHEET (93M/8), BRITISH COLUMBIA

By Don MacIntyre

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

KEYWORDS: bedrock mapping, Nechako NATMAP, Nakinilerak Lake, Babine Porphyry Belt, Eocene extension, Babine Igneous Suite, Babine Intrusions, Ootsa Lake group, porphyry copper deposits, Nak, Trail Peak.

INTRODUCTION

The Nechako National Mapping Program (NATMAP) project, which began in 1995, is a joint mapping and geoscientific research project between the British Columbia Geological Survey Branch (BCGSB) and the Geological Survey of Canada (GSC) that also includes participation by universities and industry (McMillan and Struik, 1996; MacIntyre and Struik, 1997, MacIntyre and Struik (this volume). The co-coordinators of this project are Don MacIntyre (BCGSB) and Bert Struik (GSC). Work done by BCGSB field crews is funded wholly by the Energy and Minerals Division of the Ministry of Employment and Investment; GSC funding is from the Cordilleran division in Vancouver supplemented with additional funding from the National Mapping Program (NATMAP).

The Babine porphyry belt project, which is a multidisciplinary project with separate components for bedrock and surficial geology, till and silt geochemistry is part of the Nechako NATMAP project (Figure 2-1). The primary objectives of this project are to improve the geological database in the Babine Porphyry belt, to define new areas with potential for additional deposits and to attract new exploration expenditures in the district. To meet these objectives we will 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 2-1) and define areas of possible buried metallic mineral deposits using till, lake and silt geochemistry. This report summarizes the results of bedrock mapping completed in 1997 and builds on previous reports that describe the results of mapping done in the Fulton Lake (MacIntyre *et al.*, 1996) and Old Fort Mountain (MacIntyre *et al.*, 1997) map sheets.

PROJECT DESCRIPTION

The Babine porphyry belt is located in west-central British Columbia and is centered on the northern third of Babine Lake (Figure 2-1). The belt is approximately 80

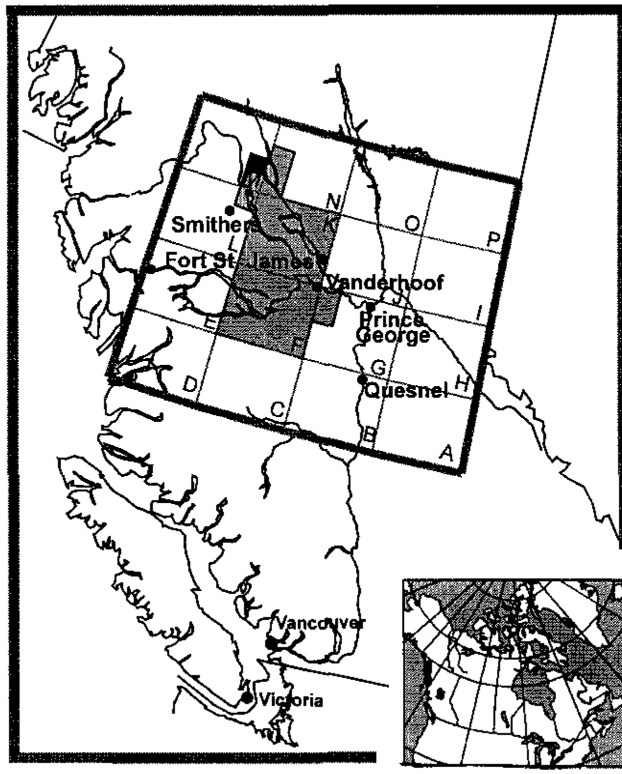

Figure 2-1. Location of the Nechako Natmap project, central British Columbia. Dark grey area was mapped in 1997 and is the subject of this report.

kilometres long and includes twelve significant porphyry copper deposits and prospects including the Bell and Granisle past producers. Previous work and access routes into the Babine Porphyry belt have been described in detail in previous reports (MacIntyre *et. al.*, 1995, 1996).

One of the objectives of the current project is to stimulate additional exploration in the belt by providing an integrated package of geoscientific maps. Bedrock and surficial mapping in the belt is now complete. In addition there are completed lake geochemical and till geochemical surveys that cover the entire belt. Most of this data has now been released or is in preparation for release. The Quaternary geology and till and lake geochemical sampling completed in 1995, 1996 and 1997 are discussed in separate reports (Huntley *et al.*, 1996, Stumpf *et al.*, 1996, Levson *et al.* , 1997, Levson *et al.* (this volume) and Cook *et al.*, 1997, Jackaman *et al.* (this volume).

The 1997 bedrock mapping crew consisted of Don MacIntyre and student field assistants Ryanne Metcalf,

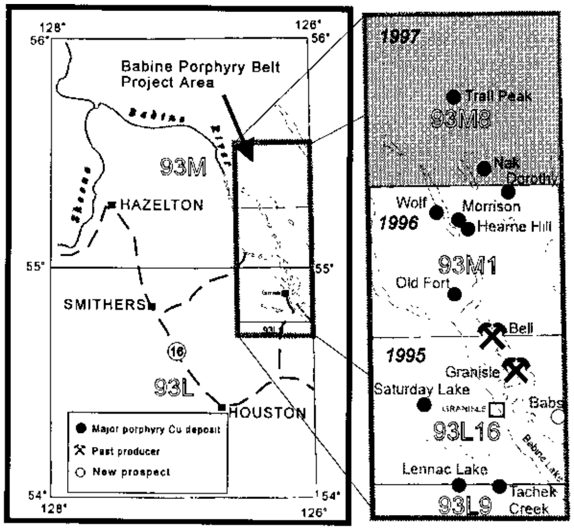

Figure 2-2. Location of the Babine Porphyry Belt project area and major porphyry copper deposits in the district. Shaded area is the Nakinilerak Lake map sheet (93M/8) which was mapped in 1997.

Stephan Munzar and Deanne Tackaberry. This crew spent approximately 4 weeks working in the Babine Porphyry Belt. Logging roads provided access to the east side of the Netalzul Mountain (93M/7) and southeast and southwest corners of the Nakinilerak Lake (93M/8) map sheets. The remaining part of the area was mapped using daily helicopter set-outs and pickups from a base camp located at Takla Narrows on Takla Lake. In addition, Mike Villeneuve and Nancy Grainger of the Geological Survey of Canada helped field crews collected samples for Ar-Ar and U-Pb radiometric dating. Randy Enkin and Judith Baker also visited the project area and did sampling for paleomagnetic studies.

ACCOMPLISHMENTS

Major geological accomplishments made during the 1997 field season are summarized below.

- revised the geology, stratigraphy and structure of the east side of the Netalzul Mountain (93M/7) and all of the Nakinilerak Lake (93M/8) map sheets.
- the Trail Peak and Nak porphyry copper deposits, which are the most important mineral properties in the 93M/8 map area, were examined and mapped.
- the belt of Lower to Middle Jurassic bimodal volcanic rocks first recognized in the area west of Granisle in 1995 was extended into the 93M/8 map sheet. However the unit appears to be thinning and contains less felsic volcanic rocks going northward. This coincides with a general change in the nature of Lower to Middle Jurassic sedimentary rocks from shallow to deep water facies.
- an area of rhyolitic ash flows and vesicular basalt belonging to the Eocene Ootsa Lake and Endako groups respectively was mapped in the low lying region west of Takla Lake in the 93M/8 map area and along the southern edge of the 93K/13 map sheet. These areas represent zones of Tertiary extension and volcanism and may have some epithermal potential. Two Ar-Ar isotopic age date samples were collected from the ash flow members of the Ootsa Lake group.
- Randy Enkin and Judith Baker collected core samples from three sites in the Upper Cretaceous sedimentary rocks of the Sustut Group for paleomagnetic studies. These samples may shed light on Tertiary displacements and rotations in the area near the Takla fault.

FUTURE PLANS

Bedrock mapping in the Babine Porphyry Belt has now been completed. Any additional work in 1998 will focus on mineral deposits in the belt and on areas where more fill-in mapping or sampling is needed.

REGIONAL GEOLOGIC SETTING

The Babine Porphyry Belt is entirely within Stikinia, the largest terrane of the Intermontane tectonic belt. This terrane includes Early Devonian to Middle Jurassic volcanic and sedimentary strata of the Asitka, Stuhini, Takla, Lewes River and Hazelton assemblages and related comagmatic plutonic rocks. East and in fault contact with Stikina are Paleozoic and Mesozoic oceanic rocks of the Cache Creek terrane; to the west are the Mesozoic and Cenozoic plutonic and metamorphic rocks of the Coast Belt.

LITHOLOGIC UNITS

The geology of the study area, based on mapping completed in 1997 and the earlier mapping of Carter (1973), Tipper and Richards (1976) and Richards (1980; 1990), is shown in Figure 2-3. Figure 2-4 illustrates our current understanding of the stratigraphic relationships between the different map units.

The physiography of the Babine Lake area reflects the effects of Tertiary extension. A northwest trending range in the center of the Nakinilerak Lake map sheet is an uplifted, tilted and folded block of Jurassic volcanic and sedimentary rocks. The uplift forms a broad, fault bounded syncline with an axial fault that cuts Middle Jurassic sedimentary rocks of the Nilkitkwa and Ashman formations in its core. These rocks overlie Lower Jurassic volcanic rocks of the Telkwa Formation which are exposed on the east and west limbs of the syncline. To the west and east of this uplift are low lying, downdropped areas that are underlain by Cretaceous and Tertiary sedimentary and volcanic rocks of the Skeena, Sustut, Ootsa Lake and Endako groups and their comagmatic intrusive equivalents. These grabens, are truncated and offset by northeast and northwest-trending high angle faults of Eocene or younger age.

Lower to Middle Jurassic Hazelton Group

The oldest rocks in the Nakinilerak Lake map area are part of the Hazelton Group. The Hazelton Group (Leach, 1910) is a calcalkaline island-arc assemblage that evolved in Early to Middle Jurassic time. In the Babine Lake area, and McConnell Creek map area to the north (94D), it sits unconformably to disconformably on volcanic and sedimentary strata of the Upper Triassic Takla Group (MacIntyre *et al.*, 1996).

Tipper and Richards (1976) divided the Hazelton Group into the Telkwa, Nilkitkwa and Smithers Formations based on lithology, fossil assemblages and stratigraphic position. The Lower Jurassic Telkwa Formation is comprised of subaerial to submarine, predominantly calcalkaline volcanic rocks, the Lower Jurassic Nilkitkwa Formation is mainly marine sedimentary and volcanic rocks and the Middle Jurassic Smithers Formation is mainly shallow water, marine sedimentary rocks. In the Babine lake area there is also a Lower to Middle Jurassic, marine to subaerial volcanic succession which Richards called the Saddle Hill volcanics. In the Nakinilerak Lake area the lower part of the Hazelton succession is not well-exposed and the predominant formations are the Saddle Hill volcanics and the Smithers Formation (Figure 2-4).

Lower Jurassic Telkwa Formation

The best exposures of the Telkwa Formation crop out along the crest and east facing slopes of a north trending ridge that extends from Sinta Creek to Frypan Peak (Figure 2-2) The pedominant lithology, which is typical of the upper part of the Telkwa Formation, is amygdaloidal basalt with areas of strong flow top brecciation. Interbedded with the flows are maroon lapilli and crystal tuffs, volcanic wacke and volcanic conglomerate. The volcanic members are overlain, apparently conformably, by well-bedded siltstones, wackes and pebble conglomerates of the Nilkitkwa Formation. To the east, the Telkwa volcanic rocks are in fault contact with a downdropped area of Tertiary volcanic rocks.

The best exposure of Telkwa Formation volcanic rocks is in the vicinity of Frypan Peak. Here, a moderately west dipping section of basaltic flows and lapilli tuffs is overlain by well-bedded siltstones and mudstones of the Nilkitkwa Formation. The contact runs across the top of Frypan Peak. Correlation of the volcanic strata with the Telkwa Formation is based on a fossil locality east of Frypan Peak (GSC locality C-90981) which is reported to be Late Sinemurian in age.

Lower Jurassic Nilkitkwa Formation

Tipper and Richards (1976) assigned thick sections of Pliensbachian to Toarcian shale, greywacke, red tuff, breccia and minor limestone to the Nilkitkwa Formation. This succession is well exposed in the Nilkitkwa and Bait ranges, the type area, which is just north of the map area. Here, the formation is as much as 1000 metres thick. Limestone and chert beds in the lower part of the section help distinguish Nilkitkwa rocks from younger, lithologically similar formations. Shallow-water, fossiliferous limestone, with interbedded pebble conglomerate and feldspathic sandstone, is a particularly common sequence where Nilkitkwa sedimentary rocks onlap Telkwa volcanic rocks.

The best exposure of the Nilkitkwa Formation in the current study area occurs on the west side of Frypan Peak. Here, moderately west dipping, well bedded, siltstone, mudstone, cherty argillite, and calcarenite with minor volcanic pebble conglomerate and occasional tuff beds conformably overlie Telkwa volcanic rocks. Both the volcanic and sedimentary rocks are intruded by a number of fine-grained, greenish grey diorite sills. Further south, similar, well-bedded sedimentary rocks are exposed in near continuous outcrop (1500 metres) in Sinta Creek. Unlike exposures of Nilkitkwa sedimentary rocks in the Old Fort Mountain map sheet (93M/1) to the south, which are typically shallow water, fossiliferous beds, those in the Nakinilerak Lake map area are fossil poor and appear to represent a deeper, water, finer-grained marine facies. The only known fossil localities in the Nilkitkwa Formation in the current study area are on a ridge 3 kilometres northwest of Frypan Peak where dark grey siltstones interbedded with amygdaloidal, chloritized submarine basaltic flows are reported to contain Middle Toarcian macrofossils (GSC fossil localities C90984, C90949). These volcanic rocks, which are characterized by the presence of submarine basaltic flows and flow top breccias, were mapped previously as the Ankwell Member of the Nilkitkwa Formation (Richards, 1990).

Lower to Middle Jurassic Saddle Hill volcanics

The Saddle Hill volcanics, as defined by Richards (1990), consist of Early to Middle Jurassic, interbedded, reddish, subaerial tuffaceous mudstone, basalt to rhyolitic flows, ash-flows, ash and lapilli tuff, breccia, lahar and minor volcaniclastic sedimentary rocks. In the type area, at Saddle Hill, which is located in the Old Fort Mountain map sheet south of the current study area (MacIntyre *et al.*, 1996), the volcanic rocks overlie Nilkitkwa Formation and are overlain by Aalenian to Bajocian sedimentary rocks of the Smithers Formation. Zircons extracted from rhyolitic ash flows interbedded with basalts west of the town of Granisle gave a 184.5 Ma U-Pb isotopic age. The Saddle Hill volcanics are therefore Toarcian in age based on stratigraphic position and limited age dating.

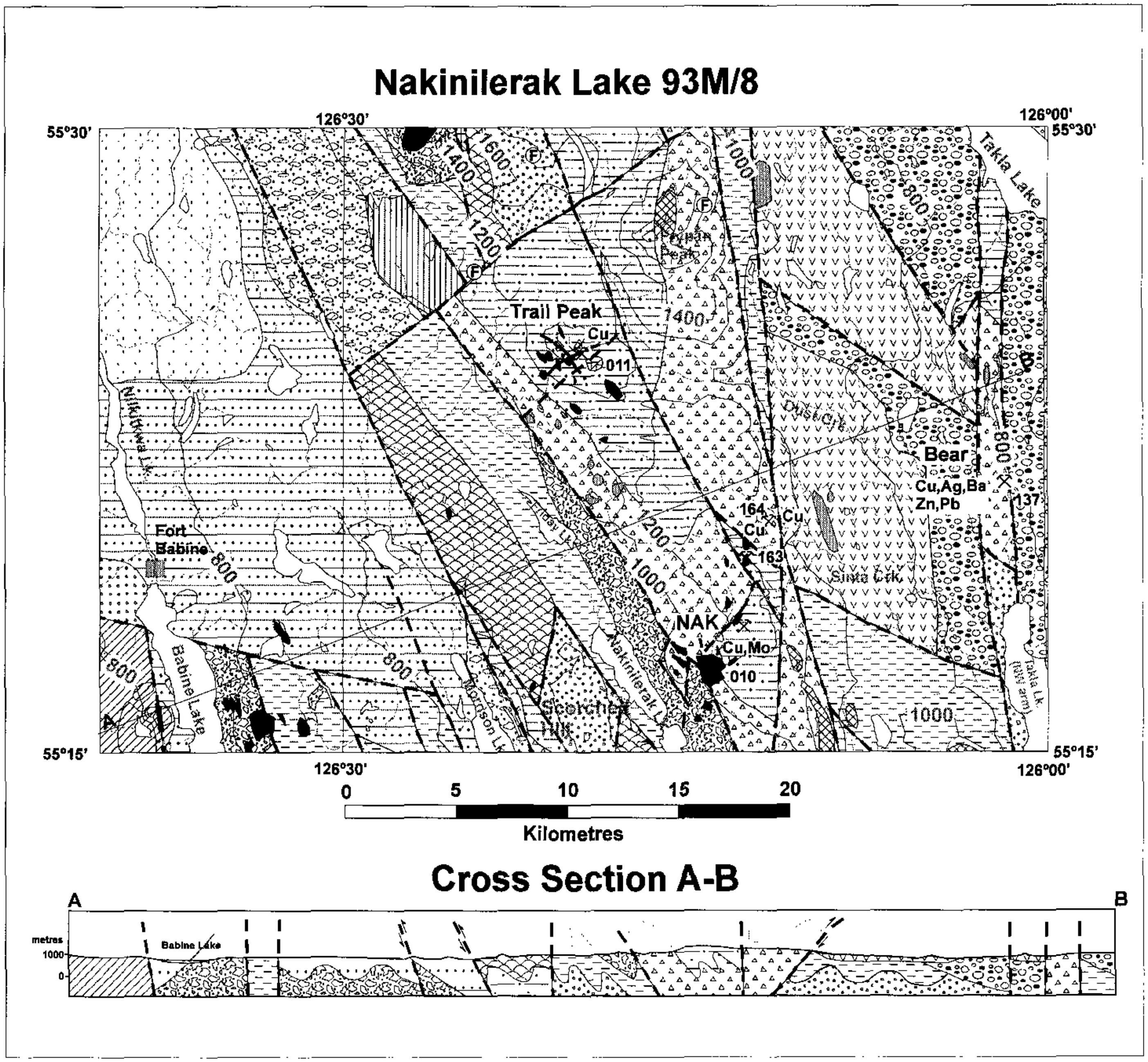

Figure 2-3. Generalized geology of the Nakinilerak Lake map area (93M/8)

In the current study area, rocks lithologically similar to the Saddle Hill volcanics are well-exposed near the southern end of the Bait Range. Here, massive flows of chloritized basalt and basalt breccia with calcareous siltstone interbeds form the core of an anticline. The anticline is assymetrical with a moderately east dipping eastern limb and a nearly vertical to slightly overturned western limb. On the east side of the ridge well-bedded siltstones, mudstones and shales conformably overlie the volcanic rocks. Numerous feldspar porphyry dikes and sills cut the sedimentary section. According to GSC records, Early Bajocian fossils occur at GSC locality C-91067 which is up section and to the east of the volcanic-sedimentary contact. Therefore, based on the occurrence of these fossils, the sedimentary rocks are mapped as Smithers Formation. Richards (1990) previously mapped the volcanic rocks as the Ankwell member of the Nilkitkwa Formation which is predominantly subaqueous basalt of Middle Toarcian age. Based on apparent age, stratigraphic position and lithology we correlate these volcanic rocks with the Saddle Hill volcanics. Overall, there appears to be a

LEGEND FOR FIGURE 2-3

EOCENE

Ootsa Lake Group

- rhyodacite, andesite and basalt flows, tuffs &, volcaniclastics
- vesicular basalt, bladed porphyry, breccia, volcaniclastics
- bt-hb phyric rhyodacite domes

Babine Igneous Suite

- Newman volcanics: porphyritic andesite, breccia
- Babine Intrusions: bt±hb-fd porphyry, qz-fd porphyry, bt-hb qz. diorite

PALEOCENE-EOCENE

- siltstone, shale, mudstone, conglomerate

UPPER CRETACEOUS

Kasalka Group

- porphyritic andesite

Sustut Group

- Tango Crk. Fm.: chert pebble conglomerate, sandstone

Skeena Group

- Red Rose Fm.: sandstone, siltstone, conglomerate
- Hanawald conglomerate: chert pebble conglomerate, sandstone
- Rocky Ridge volcanics: alkaline basalt, tuff, rhyolite
- Kitsuns Creek Fm.: siltstone, mudstone, conglomerate, coal

MIDDLE CRETACEOUS

- biotite hornblende granodiorite, hornblende diorite

MIDDLE to UPPER JURASSIC

Bowser Lake Group

- Trout Creek Fm.: heterolithic conglomerate, sandstone
- Ashman Fm: siltstone, argillite, shale (Callovian-Oxfordian)

LOWER to MIDDLE JURASSIC

Hazelton Group

- Smithers Fm: feldspathic sandstone, siltstone (Aalenian-Bajocian)
- Saddle Hill volcanics: basalt, breccia, limy siltstone (Toarcian)
- Nilkitkwa Fm: wacke, siltstone, argillite, basalt (Pliensbachian)
- Telkwa Fm: basalt, andesite, maroon tuff, volcaniclastics (Sinemurian)

F — Fossil locality

Fault trace

Cu,Mo 010 — Minfile showing

trend from a thick bimodal, partly subaerial section near the type area in the 93M/1 map sheet, to a thinner, predominantly submarine basalt section in the Bait Range to the north.

Smithers Formation

The Lower to Middle Jurassic Saddle Hill volcanics are conformably overlain by green to dark grey, marine sedimentary rocks of the Smithers Formation. In the 93M/1 map sheet, the Smithers Formation is very fossiliferous and contains abundant bivalves, ammonites and belemnites that indicate an Early Bajocian age. In the current study area, the best exposures of this formation occur on Scorched Hill, west of Nakinilerak lake and at the south end of the Bait Range (Figure 2-3). Bajocian age fossils have been collected from both areas. In general, the Smithers Formation appears to become finer-grained and more deep water going northward towards the Bowser Basin. Fine-grained, well-bedded siltstones and shales at the south end of the Bait Range were mapped by Tipper and Richards (1976) as the Bait member to distinguish them from more shallow water, fossiliferous, coarser-grained and poorly bedded members of the Smithers Formation.

Upper Jurassic to Lower Cretaceous Bowser Lake Group

The Bowser Lake Group, as defined by Tipper and Richards (1976), includes marine sedimentary rocks and minor volcanic rocks ranging in age from Late Bajocian to Kimmeridigian. The group is thickest and most continuous in the Bowser basin located northwest of the current study area. Within the Bowser Basin fine-grained clastic rocks of Late Bajocian to Early Oxfordian age are mapped as Ashman Formation (Tipper and Richards, 1976). Along the southern margin of the basin Late Oxfordian conglomerates overlie Ashman Formation and are mapped as the Trout Creek Formation.

Ashman Formation

The Ashman Formation is the basal member of the Bowser Lake group and was deposited during an extensive mid to late Jurassic marine transgression that ultimately covered all of west central British Columbia including the Skeena Arch. The formation, which ranges in age from Late Bajocian to Early Oxfordian, consists predominantly of fine-grained dark grey to black shale, with lesser feldspathic to quartzose siltstone and greywacke. On Ashman Ridge, the type area for the Ashman Formation, it sits conformably on the Smithers Formation. South of Ashman Ridge and along the southern margin of the Skeena Arch the Ashman Formation is as old as Late Bajocian and is a more fossiliferous, coarser clastic shallow water facies. The Ashman formation is overlain by Late Jurassic to Early Cretaceous, westward prograding, non-marine clastic sedimentary rocks that were derived from rising landmasses north, east and southeast of the Bowser Basin.

In the current study area, the Ashman Formation, which is predominantly dark grey, fine-grained siltstone, is sporadically exposed in the core of a northwest trending, uplifted syncline that extends from the Bait Range to the southern limit of the Nakinilerak lake map sheet. Early Callovian to Early Oxfordian fossils have been collected at three localities, two east of Scorched Hill (C-89593, C89648) and the other just north of Trail Peak (C90816). These ages are similar to those obtained in the 93M/1 map sheet. Like the Smithers and Nilkitkwa formations, the Ashman Formation appears to become finer-grained and more deep water moving northward toward the Bowser Basin.

Trout Creek Formation

The Trout Creek Formation includes coarse sandstone and conglomerate beds containing mid to late Oxfordian bivalves that overlie fine-grained clastics of the Ashman Formation (Tipper and Richards , 1976). These rocks represent a period of marine regression in mid Oxfordian time and a coincident shedding of coarse volcanic detritus northward into the Bowser Basin. Lithologies include marine and non-marine thick-bedded conglomerate, sandstone, siltstone, shale and coal. The conglomerates contain predominantly volcanic clasts mixed with chert but locally contain granitic clasts as well. Cross-bedding and channel cut and fill structures are common and characterize deltaic sequences. The Trout Creek rocks are overlain and in part interbedded with Upper Jurassic basalt and andesite of the subaerial Netalzul volcanics.

In the current study area, good exposures of conglomerates that occur on a ridge immediately east of Friday Lake were previously mapped by Richards (1990) as Trout Creek Formation. Here, thick beds of heterolithic conglomerate containing feldspar phyric volcanic and chert clasts up to 20 centimetres in diameter are exposed at the top of the ridge. The conglomerate beds, which are locally cross-bedded and fill channels in finer-grained beds, dip around 60 degrees to the northeast. The stratigraphic position of these beds is uncertain due to lack of outcrop away from the ridge. Presumably they are underlain by Ashman Formation to the west and are in fault contact with older Telkwa Formation volcanic rocks to the east. Alternatively, they may be younger and correlative with Lower Cretaceous Skeena Group conglomerates.

Lower Cretaceous Skeena Group

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 sedimentary rocks were deposited in a fluviodeltaic, near-shore to shallow

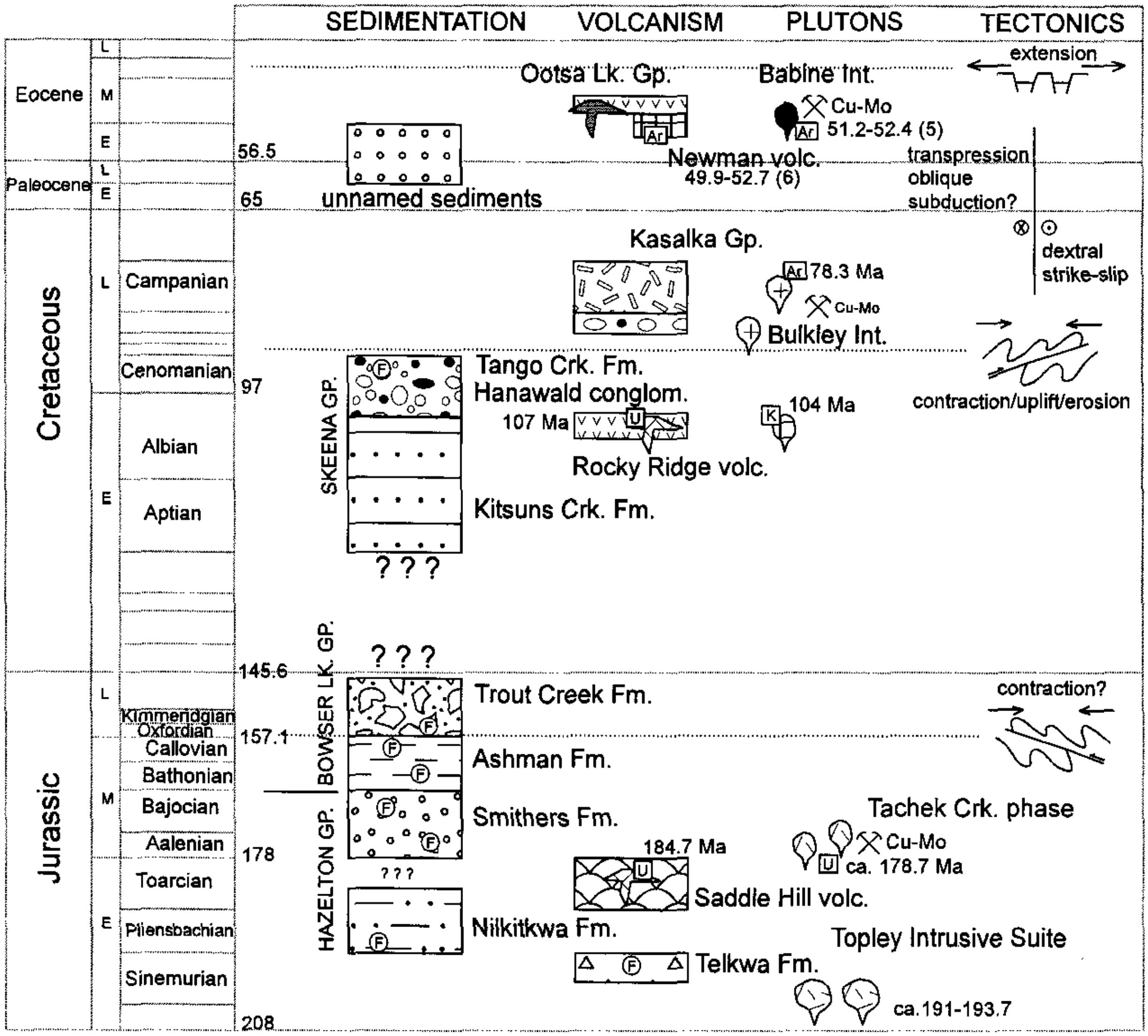

Figure 2-4. Generalized stratigraphy for the Nakinilerak Lake map area, 93M/8. See Figure 2-3 for legend.

marine environment (Basset, 1991). Although fossils are rare, the Skeena Group appears to range from Hauterivian to late Albian or early Cenomanian in age. Paleocurrent measurements indicate south, east and northeast sediment transport with the source area located in the Omineca belt. Bassett and Kleinspehn (1996) suggest that this belt was the main axis of a mid-Cretaceous continental arc and that the Skeena Group is a forearc succession. 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, the Kitsumkalum shale, the Hanawald conglomerate, an unnamed unit of subaqueous volcanic and volcaniclastic rocks, the Rocky Ridge Formation and the Red Rose Formation. In a recent paper Bassett and Kleinspehn (1996) propose a new stratigraphic nomenclature based on lithofacies. These are the fluvial to deltaic Rocher Deboule Formation which would include both the Red Rose Formation and Hanawald conglomerate, the volcanic arc Rocky Ridge Formation, the deltaic Bulkley Canyon Formation which includes the fluvial Kitsuns Creek Member and the subtidal, turbiditic Couture Formation. Table 2-1 attempts to rationalize this new stratigraphic nomenclature with that of Richards (1990).

Table 2-1. Skeena Group facies and comparison of stratigraphic divisions used by Richards (1990) and Bassett & Kleinspehn (1996). Age ranges and facies from Bassett & Kleinspehn (1996).

Richards (1990)	Bassett & Kleinspehn (1996)	Facies	Age Range
Red Rose Fm.	Rocher Deboule Fm.	fluvial, deltaic	Albian-Cenoman-ian
Hanawald conglomerate			
Rocky Ridge volcanics	Rocky Ridge Fm.	volcanic arc	
Kitsuns Creek Fm	Bulkley Canyon Fm.	deltaic	Hauteriv-ian-Albian
	Kitsuns Creek Mbr.	fluvial, estuary	
Kitsumkalum shale	Couture Fm.	subtidal, turbiditic	Hauteriv-ian-Albian

Skeena Group sedimentary rocks in the Nakinilerak Lake map map sheet have previously been correlated with the Kitsuns Creek Formation, the Hanawald conglomerate and the Red Rose Formation or mapped as undivided Skeena Group. A small area of alkaline basalt and rhyolite in the southwest and southeast corners of the map area, have been mapped as Rocky Ridge Formation.

In the current study area, Skeena Group sedimentary rocks are generally poorly exposed because they are only preserved in down-dropped fault blocks or grabens which tend to be low-lying areas with extensive cover. Although exposure is limited the broad valley extending from the end of the northwest arm of Babine Lake northward along the Babine River appears to be filled with Skeena Group sedimentary rocks. The Skeena rocks are folded and have a moderate to steep dip.

Kitsuns Creek Formation

The Kitsuns Creek Formation, which includes feldspathic and volcanic sandstone, siltstone, shale and polymictic, volcanic clast conglomerate underlies a large, relatively flat area extending from Fort Babine to the northern limit of mapping. Although these rocks are poorly exposed, good outcrops do occur along the Morrison Main and Nilkitkwa haulage roads and near the height of land just east of the Fort Babine village. These feldspathic sedimentary rocks are apparently overlain by the Hanawald conglomerate; the Rocky Ridge Formation and Kitsumkalum shale members appear to be missing.

Rocky Ridge Formation

The Rocky Ridge Formation includes Early Albian to Early Cenomanian submarine alkali basalt flows, breccias and lapilli tuffs that were erupted along the southern margin of the Bowser Basin (Bassett and Kleinspehn, 1996). In the Old Fort Mountain map sheet (93M/1), a chain of rhyolite domes that intrude marine sedimentary rocks of the Skeena Group have U-Pb isotopic ages around 107 Ma (mid Albian) suggesting they are also correlative with the Rocky Ridge Formation. These rhyolite domes will be the subject of a B.Sc. thesis by Deanne Tackaberry at the University of Victoria. Rhyolite domes in the southwest corner of the study area are also mapped as part of the Rocky Ridge Formation.

Hanawald Conglomerate

In the Hazelton map area fluvial-deltaic chert pebble conglomerate beds of the Hanawald Conglomerate member are interbedded with, and overlie, feldspathic clastic sedimentary rocks of the Kitsuns Creek formation (Richards, 1990) and, where present, the Rocky Ridge Formation. The conglomerates are thick-bedded and are more resistant than finer-grained beds of the Kitsuns Creek Formation. The interval of conglomerate beds is probably not more than 200 metres thick at its maximum. The age of the conglomerates, based on stratigraphic position, is late Albian to early Cenomanian. They are, in part, interpreted to be correlative with Sustut Group chert-pebble conglomerates (Tango Creek Formation) which are found on the east side of the map area.

In the current study area, the Hanawald conglomerate member is exposed in road cuts along the Morrision main haulage road near the western edge of the 93M/8 map sheet, as a series of northwest trending hogback ridges located east of the northern end of Morrison Lake and in Tahlo Creek. Unlike Trout Creek conglomerates which have a high proportion of volcanic clasts relative to chert, the Hanawald conglomerate is composed mainly of well-rounded clasts of dark and light grey chert and white quartz. Locally there are also clasts of soft, altered felsic volcanic or intrusive rocks, chloritized granite and feldspar porphyry. Carbonaceous wood fragments are also common. The conglomerate can be either clast or matrix supported and is poorly sorted with clast sizes ranging from 1 to 6 centimetres in diameter. The matrix is predominantly greenish-grey sand and is less resistant to weathering than the clasts. The conglomerates are interbedded with brown weathering greenish grey wackes and granule conglomerates of a similar composition.

The Hanawald conglomerate was probably deposited in a near shore, deltaic to fluvial environment along the northwestern edge of a landmass. Facies changes to the northwest suggest deeper water, marine conditions in that direction (Bassett and Kleinspehn, 1996). The composition of the Hanawald conglomerate suggests a source area with abundant chert and quartz, possibly the Cache Creek terrane to the southeast.

Red Rose Formation

The Red Rose Formation sits stratigraphically above the Rocky Ridge Formation and includes well-bedded, quartzo-feldspathic and muscovite bearing sandstone, siltstone, argillite, chert-pebble conglomerate, reddish sandstone and gritty mudstone (Richards, 1990). It is mainly fluvial and is in part correlative with the Tango Creek Formation of the Sustut Group. The formation is found mainly west of the map area and is probably the distal, finer-grained equivalent of the Hanawald conglomerate. The only strata mapped as Red Rose formation in the current study area are located in the northeast corner of the 93M/7 map sheet. Bassett and Kleinspehn (1996) have redefined the Red Rose Formation and Hanawald conglomerate as the Rocher Deboule Formation.

Mid Cretaceous Intrusions

Other than the rhyolite domes mentioned earlier under Rocky Ridge Formation, intrusions of Mid Cretaceous age are rare in west central British Columbia. However, in the current study area, Carter (1976) reported a K-Ar isotopic age of 105±4 Ma (revised decay constants) for an equigranular biotite granodiorite stock exposed at Trail Peak. The stock is cut by a mineralized, biotite-feldspar porphyry dike that gave a 49.8±4 Ma K-Ar isotopic age (Carter, 1976). The older age is very similar to the age determined for feldspar porphyry flows at the former Bell mine and rhyolite domes elsewhere in the Old Fort Mountain map sheet (MacIntyre *et al.,* 1997) and is coeval with Rocky Ridge volcanism in west central British Columbia. The close spatial association of intrusions with such disparate ages suggests reactivation of magmatic centers after a lull of some 50 million years.

Lower to Upper Cretaceous Sustut Group

The Sustut Group includes Cretaceous and Tertiary non-marine clastic rocks that overlap rocks of the Stikine Terrane and the Bowser Lake Group. The areal distribution of these rocks defines the northwest trending Sustut Basin which extends from the Stikine River in the northwest to Takla Lake in the southeast. The type area is along the Sustut River in the McConnell Creek map area (Lord, 1948). The Sustut Group is divisible into the Tango Creek and Brothers Peak formations (Eisbacher, 1974). Only the Tango Creek Formation is present in the Nakinilerak Lake map area.

Tango Creek Formation

The Tango Creek Formation includes poorly sorted non marine conglomerates, sandstones and mudstones that sit unconformably on Bowser Lake Group and older rocks. Spores and pollen collected from the formation indicate an age range from mid-Albian to Campanian (late Early to middle Late Cretaceous). Paleocurrent directions indicate an eastern to northeastern source area as does the presence of metamorphic chert clasts which are probably derived from the Cache Creek terrane. The formation thickens westward to a maximum of 1500 metres as a prograding deltaic sequence.

Chert pebble conglomerates of the Tango Creek Formation underlie the northeast corner of the current map area. The best exposures are on the shores of Takla Lake and in the area along the eastern edge of the Nakinilerak Lake map sheet. Here, the conglomerates dip moderately to the northeast and form a series of sparsely timbered hogback ridges between the two arms of Takla Lake, a distance of 15 kilometres. This 4 kilometre wide, north trending panel is bounded to the east by the Takla fault and to the west by an unnamed fault. Both of these faults have strong topographic linears and are presumably high angle. The Takla Fault juxtaposes Tango Creek conglomerates against an uplift of Late Triassic Takla volcanic rocks; the western fault separates the conglomerates from a narrow, fault bounded uplifted slice of Lower Jurassic volcanic and sedimentary rocks. This uplift or horst, is bounded on both sides by Tango Creek chert pebble conglomerates and can be traced northward across Takla Lake, and into the Lovell Cove area where Middle Jurassic Smithers Formation sedimentary rocks are exposed in the uplift. On the east shore of Takla Lake, the fault bounded panel is exposed at Red Bluff where it contains a highly fractured, sheared and brecciated, pink weathering monzonite intrusion that is probably Jurassic in age and related to the Topley intrusions. Along the shore, north of White Bluff, white weathering chert pebble conglomerates are overturned and dip steeply to the east. Distinctive beds of red weathering siltstone or tuff occur in the conglomerate section and were sampled for paleomagnetic studies by Randy Enkin of the Geological Survey of Canada. The steep dipping, overturned orientation of these conglomerate beds may be due to drag on a nearby high angle normal or reverse fault that bounds the north trending uplift.

Northeast-dipping beds of chert pebble conglomerate are also exposed in several other localities in the northeast corner of the study area where they are partly overlain by relatively flat-lying Tertiary volcanic rocks.

Assuming no structural repeats, the Tango Creek conglomerate section exposed along the eastern edge of the map area could be up to 5 kilometres thick. This sedimentary succession becomes finer-grained up section and consists predominantly of mudstone and siltstone where it is exposed on the shores of Takla Lake. Well-preserved plant fossils have been collected from these rocks and have previously been identified as

Cenomanian in age (Armstrong, 1949) suggesting the underlying chert pebble conglomerates are Cenomanian or older.

In the current study area, the Tango Creek Formation is predominantly poorly to moderately sorted, moderate to thick bedded, brown to grey weathering conglomerates that were probably deposited in a fluvial environment. The conglomerates contain well-rounded pebble to cobble sized clasts of chert and quartz of a probable metamorphic provenance with lesser mafic and felsic volcanic and granitic clasts in a gritty, sandstone matrix of similar composition. Conglomerate beds are often cross-bedded especially where they fill channels in underlying strata and typically fine upward into intervals of granule conglomerate and quartz sandstone. Thin beds of red weathering siltstone or tuff are locally present and were the target of paleomagnetic sampling by Randy Enkin of the Geological Survey of Canada.

Upper Cretaceous Kasalka Group

The Kasalka Group, as defined by MacIntyre (1985), is comprised of calc-alkaline continental volcanic rocks that sit with angular discordance on Skeena Group and older strata. The type area for the Kasalka Group is at Tahtsa Lake where a volcanic section up to 1500 metres thick overlies a basal conglomerate member. These volcanic rocks are part of a north-trending continental volcanic arc that transected west-central British Columbia in Late Cretaceous time. The predominant rock types are hornblende-feldspar-phyric latite-andesite and andesite, volcanic breccia, lapilli tuff and lahar. Sutherland Brown (1960) mapped similar rocks as the Brian Boru Formation in the Rocher Déboulé Range north of Smithers, and MacIntyre and Desjardins (1988) documented Kasalka Group rocks in the Babine Range west of the study area.

In the northwest corner of the Nakinilerak Lake map sheet, coarse porphyritic andesite flows are exposed along a northwest-trending fault scarp and in clear-cuts east of the scarp. These rocks, which apparently unconformably overlie Lower Cretaceous chert pebble conglomerates, are lithologically identical to flows near the Lennac Lake porphyry prospect described in a previous report (MacIntyre *et al.*, 1996). The flows, which display sheeted jointing and are generally unaltered and unmineralized, contain 25 to 30 percent hornblende laths, biotite "books" and equant plagioclase in a finer-grained, greenish grey groundmass. Although previously mapped as a Babine intrusion, the coarse porphyritic texture and presence of books of biotite are features atypical of the Eocene Babine intrusions. Rather, these features are more characteristic of Kasalka Group volcanic rocks and related Bulkley Intrusions. A 2 to 3 metre wide, northeast-trending dike of similar composition to the flows was observed cutting the underlying chert pebble conglomerates and may have been a feeder to the flows.

Late Cretaceous Bulkley Intrusions

The term Bulkley Intrusions was first used by Kindle (1954) for granitic rocks in the Hazelton area. This suite of intrusions 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 southward to the Eutsuk Lake area. They are believed to be the exhumed roots of an Andean type magmatic arc that formed during a period of oblique plate subduction in Late Cretaceous time. Volcanic centers were probably localized in areas of crustal extension along dextral strike slip faults.

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 at 78.3 ± 0.8 Ma (MacIntyre *et al.*, 1996), identical to a previous 78.3 ± 2.5 Ma K-Ar age determined by Carter (1973). There are no known occurrences of Bulkley Intrusions in the Nakinilerak Lake map area.

Cretaceous to Tertiary Intrusions

Several small stocks, sills and dikes of medium to coarse-grained greenish grey diorite and gabbro crop out in the map area. Best exposures are on Frypan peak and in the southern Bait Range where diorite sills up to 10 metres thick intrude Lower and Middle Jurassic sedimentary rocks and volcanic rocks. For the most part the intrusions have been emplaced passively with little disruption of regional bedding attitudes. Zones of biotite hornfels are locally present, especially around larger bodies. In places the diorite contains 1 to 2 millimetre phenocrysts of feldspar and less commonly pyroxene and hornblende. 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 apparently true diorites or quartz diorites.

The age of diorite intrusions in the map area is uncertain. They are found cutting rocks ranging from Early Jurassic through to Early Cretaceous in age. Therefore, assuming there is only one episode of dioritic magmatism, these intrusions must be Early Cretaceous or younger. 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 is divisible into two main units - the Babine Intrusions and the Newman volcanics (Carter, 1976; 1981; Ogryzlo, 1994). Both are early Eocene in age as indicated by isotopic age dating

(Villeneuve and MacIntyre, 1997). New isotopic dating as part of the Nechako Natmap project suggests the Babine Igneous Suite is slightly older (2-3 million years?) than the Ootsa Lake Group volcanic rocks (Mike Villeneuve, personal communication).

Babine Intrusions

The Babine Intrusions include small plugs and dikes of crowded biotite±hornblende feldspar porphyry, quartz±biotite feldspar porphyry and equigranular hornblende-biotite granodiorite to quartz diorite that occur as multi-phase intrusive centres in a north-trending belt that extends from Fulton Lake to Trail Peak (Figure 2-1). Potassium-argon isotopic ages biotite and hornblende phyric phases range from 50.2 to 55.8 indicating the intrusions are early Eocene in age (Villeneuve and MacIntyre, 1997). 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 volcanic rocks found further to the west. This suggests similar, transtensional, volcanic environments prevailed during the Late Cretaceous and, into the early Eocene, and that locus of volcanism moved progressively eastward with time.

Biotite-hornblende quartz diorite to granodiorite

Stocks of medium-grained, equigranular to sub-porphyritic biotite-hornblende quartz diorite to granodiorite are exposed at the Nak and Trail Peak properties and in the southeast corner of the 93M/7 map sheet (Figure 2-2). Zones of biotite hornfels and disseminated and fracture controlled pyrite, up to several hundred metres in width enclose the equigranular stocks. Although the equigranular phase of the Babine intrusions can host low-grade copper mineralization, better grades are typically associated with younger porphyritic phases.

Biotite-feldspar porphyry

The most characteristic rock type of the Babine intrusive suite is a crowded, dark grey biotite-feldspar porphyry which typically occurs as small plugs and dikes. This rock type contains 40 to 60 percent of 2 to 3-millimetre phenocrysts of biotite, plagioclase and rarely hornblende and quartz, in a 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.

Northeast to north trending dikes of biotite-feldspar porphyry cut earlier equigranular granodiorite and quartz diorite stocks and surrounding wall rocks at the Nak and Trail Peak porphyry copper prospects. These dikes have associated copper mineralization and are locally strongly altered.

Quartz-biotite-feldspar porphyry and quartz feldspar porphyry

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, which contain partially resorbed quartz phenocrysts, are weakly mineralized relative to the biotite-feldspar porphyry phase. This intrusive phase is most common around the Bell pit but also occurs as small stocks and dikes in the Old Fort Mountain map sheet (Figure 2-2). No quartz phyric Babine intrusions were mapped in the Nakinilerak Lake map sheet.

Newman Volcanics

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 (1976) because they are well-exposed on both sides of the Newman Peninsula in the Fulton Lake map sheet (93L/16). The Newman volcanics are Early Eocene, with Ar-Ar isotopic ages ranging from 49.9±0.6 to 52.7±0.6 Ma. (Villeneuve and MacIntyre, 1997). These ages overlap those determined for lithologically identical porphyries of the Babine Intrusions and the volcanic rocks are, therefore, considered to be the extrusive equivalent of these rocks (Villeneuve and MacIntyre, 1997). Typical hornblende-biotite-feldspar phyric andesites of the Newman Volcanics crop out sporadically along the western shore of Babine Lake and on Bear Island in the 93L/16 and 93M/1 map sheets. The only known occurrence of Newman volcanics in the Nakinilerak Lake map sheet is at Trail Peak where hornblende-biotite-feldspar porphyry flows cap the ridge southeast of the main showings.

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 basalts, 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 volcanic rocks erupted 50 million years ago for a period as short as 1 million years (Diakow and Mihalynuk, 1987).

In the relatively flat, northeast corner of the current study area, brown, maroon and red weathering aphanitic to feldspar phyric vesicular and amygdaloidal basalt flows, flow top breccias, maroon lapilli tuffs and volcanic conglomerates are exposed in road cuts and along the north banks of Sinta Creek. Although exposures are poor, these mafic volcanics appear to be relatively flat lying and sit unconformably on chert pebble conglomerates of the Upper Cretaceous Tango Creek Formation and fossiliferous siltstones of the Middle to Upper Jurassic Smithers and Ashman formations (Figure 2-3). The basaltic flows have a strong aeromagnetic response relative to underlying sedimentary rocks and this has been used to define their areal extent in areas lacking outcrop. A distinctive lithology within this succession is a basalt flow with 5 to 10 millimetre, aligned plagioclase laths. The flows are very vesicular in places and locally have calcite and chlorite filled amygdules that are flattened and elongated parallel to flow directions. These basaltic rocks are tentatively correlated with the Ootsa Lake Group based on stratigraphic position and lithology.

Rhyolite to rhyodacite flows, breccias and intrusive domes occur sporadically in the northeast corner of the Nakinilerak Lake map sheet and in an area north of Friday Lake. These rocks are also tentatively correlated with the Ootsa Lake Group. The rhyolites are cream to white weathering, flow banded and have 10 to 15 percent of 2 to 3 millimetre phenocrysts of biotite, hornblende and plagioclase in a pink to grey, siliceous aphanitic groundmass. The rhyolitic rocks occur both as flows interbedded with vesicular basalt and as subcircular, columnar-jointed domes that form isolated topographic highs.

In the northeast corner of the map area, near Takla Lake, a biotite-hornblende-feldspar phyric rhyodacitic ash flow is well exposed on a northwest trending scarp and appears to be in fault contact with chert pebble conglomerates of the Tango Creek Formation. A sample was collected from the ash flow for Ar-Ar isotopic age dating.

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 in response to the collision of Stikinia with the Cache Creek Terrane. This was followed in mid Cretaceous time by a contractional event that produced northwest-trending folds and northeast directed thrust faults. In the Bowser Basin and in the current study area, rocks as young as Cenomanian were involved in this folding event. In the southern part of the Bowser Basin, just north of the study area, folds are cut by plutons as old as 82 Ma thus constraining deformation to the early part of the Late Cretaceous. This is consistent with observations in the Tahtsa Lake area, where relatively flat-lying Late Cretaceous volcanic rocks of the Kasalka Group sit with angular discordance on Albian Skeena Group rocks (MacIntyre, 1985). The unconformity is marked by an erosional conglomerate. Crustal extension and development of north trending grabens and horsts took place in Late Cretaceous to Eocene time during a period of oblique subduction and transpression along the Skeena Arch. The latest episodes of block faulting are Eocene or younger because Late Cretaceous and Eocene plutons and their extrusive equivalents, the Kasalka and Newman volcanics, have been truncated and displaced by high angle faults that bound the grabens. Within the grabens, the younger rocks can have moderate tilts and form broad open folds. This contrasts with Cenomanian and older rocks which are more tightly folded, and in part, imbricated by thrust faults. The latest event, which may be as young as Miocene, involved northwest-southeast crustal extension and tilting of fault blocks between north to northwest trending strike slip faults. In general, because of the Eocene and younger subsidence of fault blocks, younger rocks typically occur at lower elevations within north trending valleys while older rocks compose the ridges that bound 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 Nak and Trail Peak properties are the main porphyry copper occurrences in the 1997 study area (Table 2-2). In addition, the Bear Hill epithermal prospect occurs near the eastern boundary of the map area.

Nak (Minfile 93M 010)

The Nak porphyry copper prospect is located approximately 3 kilometres east of Nakinilerak lake (Figure 2-2) and is accessible by helicopter or via an overgrown foot trail connecting to the end of the Nak haulage road. Noranda exploration first explored the property between 1960 and 1970, during the main phase of porphyry exploration in the district. Over this time period they did geochemical, geophysical and geological surveys and drilled 28 holes totaling 1837 metres. Tri Alpha Investments acquired the property and cut a new grid in 1992 and 1993, but subsequently cancelled their program. Hera Resources Inc. subsequently restaked the ground and completed induced polarization and magnetic surveys in late 1994 and early 1995. Their work defined a large, chargeability low rimmed by an area of higher chargeability that coincided with the known distribution of disseminated pyrite. Hera then drilled 43 BQ size holes totaling 8007 metres in 1995 and an additional 28 holes totaling 5304 metres in 1996. The property was not active in 1997.

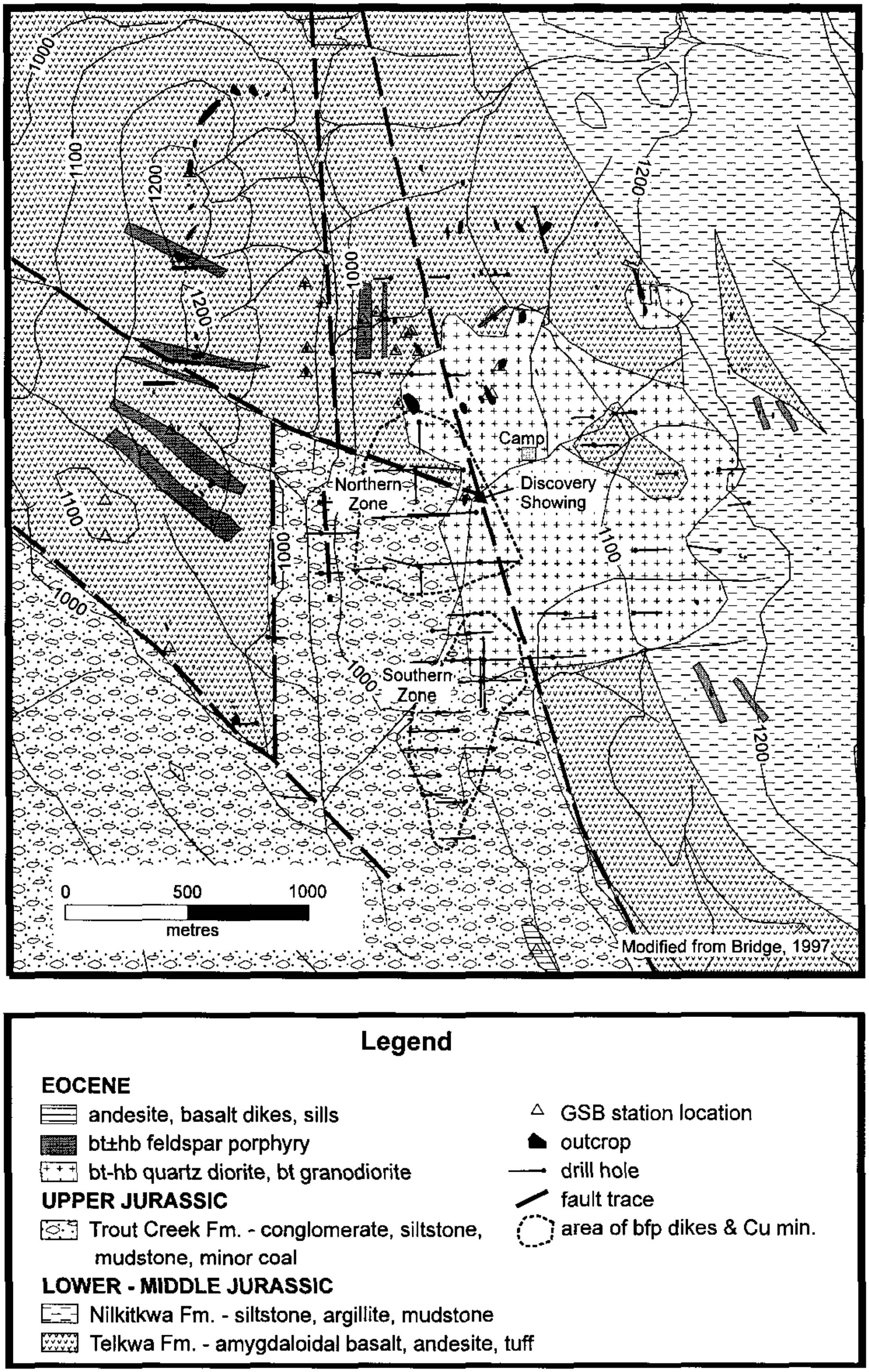

Figure 2-5. Generalized geology of the Nak property. See Figure 2-3 for property location.

Volcanic rocks also crop out sporadically in the area north and northeast of the stock. The volcanic rocks at Nak are tentatively correlated with the Lower Jurassic Telkwa Formation based on lithologic similarity. This correlation implies a high angle fault contact with younger Upper Jurassic Trout Creek sedimentary rocks that were intersected in drilling between the two ridges and also crop out to the west along the shores of Nakinilerak Lake. Both the volcanic rocks and sedimentary rocks are cut and have been hornfelsed by several northwest trending, moderately northeast dipping dikes or sills of biotite-feldspar porphyry that are typical of the Eocene Babine Intrusions.

The geology of the Nak property, based on company reports (Bridge, 1997) and mapping done in 1995 and 1997, is shown in Figure 2-5. The property covers the area between two north trending ridges that are located east of Nakinilerak Lake. Here, porphyry copper mineralization is associated with north to northwest trending biotite-feldspar porphyry dikes and a subcircular stock of biotite quartz diorite to granodiorite that intrude volcanic and sedimentary rocks of the Lower Jurassic Telkwa and Nilkitkwa formations and sedimentary rocks of the Upper Jurassic Trout Creek Formation. The volcanic rocks crop out on the western ridge, which is an uplifted block bounded by north-trending high angle faults and in the area north of the quartz diorite stock. Good exposures of amygdaloidal, feldspar phyric andesite or basalt, with varying amounts of chlorite and epidote alteration and disseminated pyrite occur along the crest of the ridge. The south end of the ridge is truncated by a regional, northwest trending fault that is the contact between volcanic rocks exposed on the ridge and conglomerates and sandstones that crop out down slope towards Nakinilerak Lake. The sedimentary rocks are tentatively mapped as Late Jurassic Trout Creek Formation. Drill hole (N96-61), which was collared in volcanic rocks on the southeast nose of the ridge and drilled to the west at a -56 degree inclination, intersected the sedimentary rocks at depth suggesting the fault contact dips moderately to the north and places older rocks over younger.

The eastern ridge has less outcrop but appears to be a northeast dipping section of hornfelsed fragmental volcanic rocks that, near the crest of the ridge, are overlain by mudstone, siliceous shale, and siltstone of the Nilkitkwa or Ashman Formation. These rocks have up to 5 percent disseminated pyrite and chlorite-epidote veinlets.

The main area of copper mineralization is located in the drainage basin between the two north trending ridges. Sporadic outcrop and drill intersections indicate that a semi-circular, hornblende quartz diorite stock, 1.0 kilometres in diameter, intrudes and has hornfelsed volcanic rocks and sedimentary rocks of probable Late Jurassic age. The contact of the quartz diorite stock apparently dips steeply outward as indicated by drilling (Bridge, 1997). A small stock of hornblende diorite crops out in the northeast corner of the property and may be an early phase of the Babine Intrusions or an older Cretaceous intrusion.

The western side of the quartz diorite stock is cut by a north trending, high angle fault that is coincident with a prominent topographic lineament. Drill holes intersected this fault, and other parallel faults in the ravine along the western side of the deposit (Bridge, 1997). These faults are mineralized indicating they predate or are the same age as the main period of sulphide mineralization. Retrograde, late stage clay alteration, observed in drill core, may be associated with circulation of low temperature fluids along these fault conduits as the porphyry system cooled.

Drill holes located southwest of the quartz diorite stock intersected mainly siltstones, sandstones and mudstones that are interbedded with heterolithic pebble to cobble conglomerate. These rocks have pervasive argillic and phyllic alteration, and are cut by north trending faults and dikes of biotite feldspar porphyry. These sedimentary rocks, which are in a fault bounded graben, are mapped as Trout Creek Formation because of the presence of poorly sorted, clast to matrix supported heterolithic conglomerate beds and the absence of marine fossils.

The discovery outcrop on the Nak property is located just north of a small creek that drains the mineralized area. This outcrop is a biotite feldspar porphyritic quartz diorite or granodiorite with moderate to strong clay alteration and pyrite, chalcopyrite and minor bornite disseminations, fracture coatings and quartz veinlets.

Drilling has defined two main zones of copper mineralization - the Northern and Southern zones, both of which are situated west of the quartz diorite stock (Figure 2-5). The southern zone is at the southwest corner of the quartz diorite stock and is defined by the presence of potassic alteration superimposed on hornfelsed sedimentary rocks with disseminations and veinlets of chalcopyrite, bornite, molybdenite and magnetite. Mineralization is spatially associated with a swarm of biotite-feldspar porphyry dikes of uncertain orientation. A resource estimate for this zone is 54 million tonnes grading 0.17 percent Cu and 0.254 grams per tonne Au (Bridge, 1997). The northern zone is immediately west of the quartz diorite stock and is defined by disseminated, fracture and vein controlled chalcopyrite, bornite and molybdenite in zones of potassic, phyllic and argillic alteration. Mineralization and alteration are spatially associated with biotite-feldspar porphyry dikes that cut volcanic and sedimentary rocks and the quartz diorite stock. Like the southern zone, a late, fault-controlled argillic alteration has been superimposed on the earlier alteration and mineralization. A resource estimate for the northern zone, which is gold poor relative to the southern zone, is 217 million tonnes grading 0.187 percent Cu and 0.0398 grams per tonne Au (Bridge, 1997).

A north trending vein or tabular zone of high grade copper was intersected southwest of the quartz diorite stock. The discovery hole (N96-58) intersected the vein obliquely and returned 2.614 percent Cu and 0.143 grams per tonne Au over a 12.5 metre intersection. A second hole (N96-65) collared 200 metres further north

Table 2-2. MINFILE Mineral Occurrences

NO.	PROPERTY NAME	STATUS	METALS	TYPE
010	NAK	Showing	Cu,Mo,Au Zn,Pb	Porphyry
011	Trail Peak	Showing	Ag,Zn,Cu, Pb	Porphyry
137	Bear Hill	Showing	Cu,Ag,Ba, Zn, Pb	Shear vein
163	Friday Green	Showing	Cu	?
164	Friday Red	Showing	Cu	?

and drilled in the opposite direction intersected a conglomerate partially replaced with tourmaline and chalcopyrite that graded 1.318 percent Cu over 18.28 metres (Bridge, 1997). This intersection is on strike with the vein intersected in hole N96-58. Other than these high grade intersections, the best and longest intersection obtained in 1996 was drill hole N96-55 which is located southwest of the quartz diorite stock. This hole had a 24.69 metre intersection grading 0.439 percent Cu and 0.704 grams per tonne gold.

Alteration at Nak is comprised of an early prograde potassic alteration overprinted by a late stage, retrograde phyllic to argillic alteration. The potassic alteration is characterized by the presence of veinlets of biotite and K-feldspar, accompanied by magnetite, quartz, chalcopyrite, pyrite, bornite and rare molybdenite in hornfelsed sedimentary rocks along the southern contact of the quartz diorite stock.

Advanced argillic alteration is peripheral to and superimposed on the potassic zone. It extends north and south of the zone along northerly trending faults. This alteration assemblage includes pervasive, feldspar destructive clay-quartz-tourmaline alteration and veinlets of quartz and tourmaline with or without chalcopyrite, pyrite, magnetite and sericite. Argillic alteration is also common in the fault zone and consists of clay-carbonate alteration with rare arsenopyrite-pyrite-calcite with or without quartz veins. Trace amounts of dumorterite are reported to occur in sedimentary rocks west of the quartz diorite stock (Bridge, 1997).

Phyllic alteration is also common and is characterized by light grey zones of sericite and quartz associated with carbonate-pyrite-chalcopyrite-bornite veins that cut dark grey, biotite hornfelsed volcanic and sedimentary rocks.

Propylitic alteration, which is comprised of chlorite, epidote, calcite and pyrite veinlets and disseminations, occurs mainly in volcanic rocks on the west, north and east sides of the property.

Trail Peak (Minfile 93M 011)

The Trail Peak porphyry copper prospect (CAVZ), which is located approximately 13 kilometres north of Nakinilerak Lake, is an isolated, conical, topographic high on a broad northwest trending uplift. Texas Gulf Sulphur Company conducted geological mapping, geophysical and soil surveys, bulldozer trenching and 1080 metres of diamond drilling in 12 holes between 1968 and 1975.

Most of the Trail Peak property is at or above tree line. Good exposures of bedrock occur on Trail Peak and on a lower, parallel ridge to the east. Gossanous outcrops on Trail Peak are hornfelsed siliceous siltstones with disseminated pyrite. Crystal lithic tuffs are interbedded with the siltstones west of Trail Peak. The sedimentary rocks are mapped as part of the Middle to Late Jurassic Ashman Formation (Richards, 1990). Siltstone and mudstones that crop out in the southeast corner of the property and these may be an inlier of Skeena Group rocks (Carter, 1990).

A small stock of biotite granodiorite crops out on the south end of Trail Peak and is exposed in a series of east west trending trenches downslope to the south. Both the hornfelsed sedimentary rocks and granodiorite stock are cut by north to northwest trending, altered biotite-feldspar porphyry dikes. Carter (1976) reports a 105±4 Ma K-Ar isotopic age for the granodiorite stock and a 49.8±4 Ma K-Ar isotopic age for one of the biotite-feldspar porphyry dikes.

Hornblende-feldspar phyric andesite, with crude columnar jointing caps the ridge southeast of Trail Peak. These rocks may be the extrusive equivalent of the porphyry intrusions and therefore, correlative with the Newman volcanics. If this correlation is correct, it implies that the northeast trending faults that cut the property bound successively downdropped fault blocks going to the southeast.

Although disseminated pyrite is widespread in hornfelsed sedimentary rocks at Trail Peak, chalcopyrite and minor bornite are only found as fracture controlled disseminations and in quartz-tourmaline veinlets near and within biotite-feldspar porphyry dikes and along northeast trending fault zones (Carter, 1990). Potassic alteration is coincident with copper mineralization and is comprised of secondary biotite, some K-feldspar and sericite. Pervasive retrograde clay alteration, similar to that observed at Nak, appears to be spatially associated with late, northeast-trending faults.

Bear Hill (Minfile 93M 137)

The Bear Hill property is located in the northeast corner of the map area, approximately 5 kilometres north of the end of Takla Lake (Northwest Arm). The main area of interest is around Bear Hill, a small, northerly elongate knoll of Lower Jurassic Telkwa Formation volcanic rocks protruding from a broad, flat, north trending valley (Findlay and Hoffman, 1981). Bear Hill is one of a chain of knolls that occur along a long, narrow, north-trending, uplifted fault block of Jurassic and older volcanic and sedimentary rocks. This fault block, which at its maximum is 4 kilometres wide, can be traced from the end of the Northwest Arm of Takla Lake to around Lovell Cove, a distance of 30 kilometres. It is bounded to the east and west by downdropped blocks of Late Cretaceous Sustut chert pebble conglomerate and Eocene Ootsa Lake Group and Endako Group volcanic rocks (Figure 2-2).

The Bear Hill property was first staked by BP Minerals Limited in late 1980 after they located malachite and pyrolusite staining in fractured andesitic volcanic rocks on Bear Hill. They subsequently did geological mapping and sampling in 1981. Placer Development Limited optioned the property in late 1981 and in 1982 did an induced polarization survey and additional geochemical sampling in the vicinity of Bear Hill. Placer then drilled two west dipping holes approximately 100 metres apart near the base of Bear Hill on its eastern side. This drilling intersected a steep, east dipping zone of barite and quartz veining with minor chalcopyrite, galena, sphalerite and rare bornite, tetrahedrite and cuprite. The mineralization occurs as tiny grains, blebs and stringers in intensely fractured and locally silicified andesitic to dacitic flows and volcaniclastic rocks (Gareau and Kimura, 1982). One of the higher grade chip samples from the property assayed 0.73 percent Cu, 117 grams per tonne Ag, and 5.4 percent Ba across 5 metres (Kimura *et al.*, 1982). The main commodity of interest on the property is silver.

The mineralogy and style of alteration and veining at Bear Hill suggests the mineralization is epithermal. Hydrothermal activity was apparently localized along, steep, north trending fault zones that bound a long, narrow, uplifted block of Jurassic volcanic and sedimentary rocks. These faults, which are Eocene or younger in age, might be favourable targets for additional epithermal mineralization elsewhere in the area.

Friday Green (Minfile 93M 163)

The Friday Green occurrence is approximately 5 kilometres northeast of the Nak porphyry copper occurrence. The property is underlain by gently dipping mudstones and siltstones of the Early Jurassic Nilkitkwa Formation that are intruded by small dikes of biotite-feldspar porphyry presumably related to the Eocene Babine Intrusions. The porphyry, which contains minor disseminated chalcopyrite, has locally hornfelsed the sedimentary rocks. Pyrite occurs on fractures in the hornfels.

Friday Red (Minfile 93M 164)

The Friday Red occurrence is located approximately 7 kilometres northeast of the Nak porphyry copper occurrence. The property is underlain by green volcanic flows, tuffs, tuff-breccia and minor intercalated mudstones of the Lower Jurassic Telkwa Formation. These rocks are intruded by a strongly magnetic feldspar porphyry dike that has been mapped as an Eocene Babine Intrusion. Trace amounts of disseminated chalcopyrite are reported to occur in the amygdaloidal flows.

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