PRELIMINARY BEDROCK GEOLOGY OF THE TOCHCHA LAKE MAP AREA (93K/13), BRITISH COLUMBIA

By D.G. MacIntyre, P. Schiarizza and L.C. Struik (GSC)

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

KEYWORDS: bedrock mapping, Nechako NATMAP, Tochcha Lake, Tertiary volcanic rocks, Takla Group, Topley Intrusions, Cache Creek Group, Sitlika assemblage, Ootsa Lake Group, Endako Group, Mac porphyry molybdenum deposit.

INTRODUCTION

The Tochcha Lake map area (93K/13), which is located east of the Babine porphyry belt project (MacIntyre, 1998, this volume) and south of the Sitlika project area (Schiarizza *et al.*, 1998, this volume), was mapped at 1:100,000 scale during the 1997 field season as part of the Nechako Natmap project (MacIntyre and Struik, 1998, this volume). Prior to the current mapping, the only published geologic maps for this area were by Armstrong, (1949) as part of his Fort St. James compilation. Don MacIntyre, Ryanne Metcalf, Stephan Munzar, and Deanne Tackaberry spent approximately 3 weeks mapping the Tochcha Lake maps area. They were assisted by Paul Schiarizza and Michele Lepitre of the B.C. Geological Survey Branch and Bert Struik of the GSC and his mapping crew for 5 days in late August. This report describes the results of this mapping. The information contained in this report is preliminary; samples submitted for radiometric dating and microfossil extraction have not yet been processed. This new information may significantly change the conclusions put forth in this paper.

PROJECT LOCATION

The Tochcha Lake map area (93K/13) is located in central British Columbia (Figure 3-1) between Babine and Takla Lakes. The closest towns are Burns Lake and Granisle. Tochcha Lake is located in the northwest corner of the map sheet in an area of rolling hills. This area has been extensively logged and is accessible via a network of private logging roads that connect to the barge crossing at Nose Bay on Babine Lake. The highest ground in this area is Deescius Mountain which is located east of the lake. The southeast, central and southwest parts of the map area are accessible by private logging roads which connect to Burns Lake via the southern barge crossing on Babine Lake. A northwest trending range, which includes Tsitsutl Mountain, crosses the northeast quadrant of the map area. This area was mapped by helicopter from a base camp located at Takla Narrows on Takla Lake.

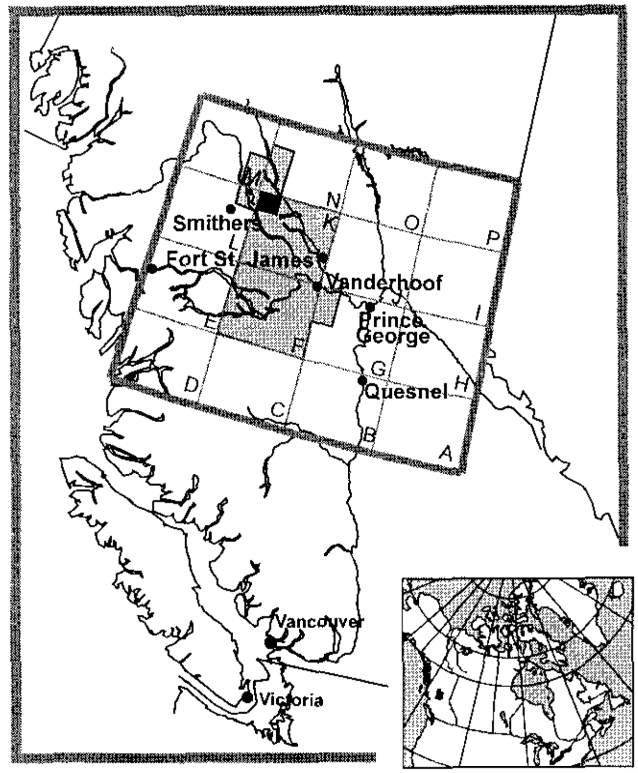

Figure 3-1. Location of the Nechako Natmap Project area (light grey shading), central British Columbia. Dark grey square is the Tochcha Lake map sheet (93K/13) which was mapped in 1997 and is the subject of this report.

ACCOMPLISHMENTS

Major geological accomplishments made during the 1997 field season in the Tochcha Lake area are as follows:

- completed bedrock mapping of the Tochcha Lake map sheet at 1:100,000 scale.
- mapped several new intrusions of monzonite to quartz monzonite with hornblende diorite border phases between Tochcha Lake and Deescius Mountain. These intrusions, which do not appear on previous maps, cut Takla volcanic rocks and are correlative with the Topley intrusions mapped in the 93L/16 map sheet. They were sampled for Ar-Ar isotopic dating.
- mapped a belt of Takla volcanic rocks in the western half of the map area. Several limestone beds were located and sampled for conodonts. Coarse augite

phyric flows were also sampled for Ar-Ar isotopic dating.
- mapped a belt of Cache Creek rocks underlying the eastern half of the map sheet. Several limestone beds were located and sampled for conodonts. Large plutons cutting the Cache Creek section were sampled for Ar-Ar dating.
- mapped a narrow belt of clastic rocks correlative with the Sitlika assemblage between the Cache Creek and Takla Groups. This indicates that Sitlika rocks extend further south than was originally thought. A limestone member was sampled for conodonts.
- mapped Tertiary volcanic rocks correlative with the Ootsa Lake and Endako Groups in the southwest corner and along the southern boundary of the map area. These rocks unconformably overlie Topley and Takla Group rocks

FUTURE PLANS

We plan to extend regional bedrock mapping eastward and southward into the 93K/14, 93K/12 and 93K/11 map sheets in 1998. The objective of this work will be to complete mapping of the northwest quadrant of the Fort Fraser map sheet (93K) to evaluate its mineral potential and to tie in with ongoing mapping by the GSC as part of the Nechako Natmap project.

REGIONAL GEOLOGIC SETTING

The northwest-trending boundary between the Stikine and Cache Creek terrane cuts diagonally across the map area. Rocks west of the boundary include basaltic volcanic rocks and interbedded sedimentary rocks of the Upper Triassic Takla Group. These rocks are cut by monzonite, quartz monzonite and hornblende diorite of the Late Triassic to Middle Jurassic Topley intrusions. Cache Creek rocks include metavolcanic, metasedimentary and ultramafic rocks that are cut by post deformation plutons of Jurassic or younger age. Separating the strongly deformed Cache Creek rocks and Takla Group volcanic rocks of Stikinia is a belt of metasedimentary rocks correlated with part of the Permian and younger Sitlika assemblage. Both Stikine and Cache Creek Terrane rocks are overlapped by relatively flat-lying Tertiary volcanic rocks of the Ootsa Lake and Endako Groups to the south. The Cache Creek rocks have a strong northwest trending, steeply dipping, bedding parallel foliation. These rocks are strongly deformed, often to the point that their protolith is unrecognizable. This deformation may be related to southwest directed structural transport. Rocks of the Stikine Terrane are folded and cut by high angle faults but otherwise are not penetratively deformed.

The current physiography of the study area is due to Tertiary block faulting. Strong northeast trending linears truncate the north to northwest trending ranges and appear to offset geologic units as well. Along the southern border of the map area, a high angle normal fault marks the boundary between uplifted Takla and Topley intrusive rocks, and low lying regions covered by Tertiary volcanic rocks of probable Eocene age. A downward vertical displacement of Eocene rocks is indicated south of the fault suggesting it is Eocene or younger.

LITHOLOGIC UNITS

The geology of the study area, based on mapping completed in 1997 is shown in Figure 3-2. Figure 3-3 illustrates our current understanding of the stratigraphic relationships between the different map units.

Stikine Terrane

Rocks exposed in the western part of the Tochcha Lake map sheet are part of the Stikine Terrane, the largest terrane of the Intermontane Belt. This terrane includes Lower Devonian to Middle Jurassic volcanic and sedimentary strata of the Asitka, Stuhini, Takla, Lewes River and Hazelton assemblages along with comagmatic plutonic rocks. Along the eastern margin of the Stikine Terrane the oldest rocks exposed are late Paleozoic carbonates and island-arc volcanic and volcaniclastic rocks of the Asitka Group. Overlying the Asitika Group are basaltic calc-alkaline to alkaline island arc volcanic and sedimentary rocks of the Late Triassic Takla Group and mafic to intermediate calc-alkaline volcanic and sedimentary rocks of the Lower to Middle Jurassic Hazelton Group. Overlap assemblages include Middle Jurassic to Early Cretaceous sedimentary rocks of the Bowser Lake and Skeena Groups and Late Cretaceous and Eocene volcanic rocks of the Kasalka, Ootsa Lake and Endako Groups.

Late Paleozoic Asitka Group

Although Upper Pennsylvanian to Lower Permian limestones are exposed in a small uplifted thrust plate in the Fulton Lake map sheet (MacIntyre *et al.*, 1996) which lies immediately west of the study area, no correlative rocks were observed in the Tochcha Lake map area.

Upper Triassic Takla Group

The Takla Group was first defined by Armstrong (1946, 1949) in the Fort St. James map-area. The type area is located west of Takla Lake in the 93N/4 and 93N/5 map sheets (Armstrong, 1949). As originally defined, the Takla Group included upper and lower divisions of arc related volcanic and sedimentary rocks ranging in age from late Triassic to late Jurassic, a subdivision also used by Lord (1948) in the McConnell Creek map area. Monger (1976) and Monger and Church (1977) redefined the Takla Group to include only sedimentary and basaltic volcanic rocks of Late Triassic age; the Jurassic part of the Takla Group was assigned to the Hazelton Group. Monger and Church further subdivided the Takla Group into the Dewar, Savage Mountain and Moosevale Formations. The Dewar Formation, which occurs at the base, is the most widespread, and includes thin to medium-bedded dark grey or greenish grey, brown weathering volcanic sandstone or bedded tuff, siltstone and interbedded argillite. It is a marine turbiditic succession up to 300 metres thick, and, near its base, consists mainly of graphitic and pyritic argillite with silty and sandy laminae and interbeds of argillaceous limestone and cherty argillite. Fossils collected from the Dewar Formation are upper Carnian in age (Monger and Church, 1977).

The Dewar Formation is overlain by and in part interbedded with the Savage Mountain Formation. This succession is up to 3000 metres thick and includes massive submarine volcanic breccias, aphanitic and augite-feldspar phyric pillowed and massive basalt flows and minor interbedded volcaniclastic sedimentary rocks and tuffs. The volcanic rocks are characterized by the presence of augite phenocrysts, which occasionally reach 1 centimetre in diameter. Coarse, bladed feldspar phyric basalt flows, with feldspar phenocrysts up to 3 centimetres, are also locally present.

The Savage Mountain Formation, which in places becomes subaerial near its upper contact, is overlain by the Moosevale Formation. The contact varies from gradational to sharp. Fossils from the Moosevale Formation, which is up to 1800 metres thick, are Late Triassic (Norian). Overall, the formation is more intermediate in composition than the underlying Savage Mountain Formation, and includes varying amounts of massive, red, green and maroon volcanic breccia, graded red and grey sandstone, argillite, fossiliferous mudstone, red volcanic conglomerate and lahar. Clasts in the fragmental volcanic rocks and conglomerates are typical of the underlying Savage Mountain Formation. The Moosevale Formation is mainly marine near its base, becoming non-marine up section.

Augite phyric dark green to grey basaltic flows, volcanic breccias, tuffs and minor interbedded volcaniclastic sedimentary rocks crop out along the western half of the Tochcha Lake map sheet and are correlated with the Savage Mountain Formation of the Takla Group. These rocks are at the southern end of a 65 kilometre long belt that can be traced northward into the 93N/4 and 93N/5 map sheets, terminating at Takla Landing on Takla Lake. East of Tochcha lake the basaltic flows are cut by hornblende diorite and pink weathering monzonite to quartz monzonite. Although there are not yet any isotopic dates available for these intrusions, similar intrusions to the west, which are part of the Topley Intrusions, give Late Triassic and Early Jurassic ages and are clearly intrusive into volcanic rocks that have a 208 Ma Ar-Ar isotopic age (MacIntyre *et al.*, 1996). Similar cross-cutting relationships are implied for the Tochcha Lake area.

The best exposures of Takla Group rocks in the Tochcha Lake area are on the west slope of Deescius Mountain where several hundred metres of massive flows are exposed. Thin sedimentary interbeds between flows indicate the succession dips moderately to the northeast. The volcanic rocks apparently overlie a lower sedimentary succession which is exposed along logging roads at the south end of Deescius Mountain. These sedimentary rocks may correlate with the Dewar Formation of the Takla Group. Near the western base of Deescius Mountain, at the top of a large clearcut, a thin foliated conglomerate that contains flattened clasts of limestone and chert is interbedded with massive augite phyric flows and volcanic breccias. The limestone and chert clasts may be derived from the Late Paleozoic Asitka Group. A sample of limestone clasts extracted from the conglomerate will be processed for conodonts.

Late Triassic to Middle Jurassic Topley Intrusive Suite

The Topley intrusions, as defined by Carter (1981), include quartz diorite to quartz monzonite of Late Triassic to Early Jurassic age. Earlier studies (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 most of these high-K 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.

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 using the old decay constants (MacIntyre *et al.*, 1996). Most of these dates are from large plutons in the Topley area and southwest of Babine Lake. In the current study, we consider the Topley intrusions to be an intrusive suite that is characterized by typically pink, potassium feldspar rich granite, quartz monzonite and monzonite of apparent Late Triassic to Middle Jurassic age. We consider the type area to be the southeast corner of the Fulton Lake map sheet where a large, composite 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 younger plutonic suites in Babine Lake area, that are mainly granodiorite to quartz diorite. Isotopic dating as part of the Babine project indicates that there is a significantly younger suite of intrusions with isotopic ages ranging from 179-169 Ma. (MacIntyre *et al.*, 1996) These intrusions are spatially associated with, and are lithologically similar to older phases of the Topley intrusive suite but are at least 20 million years younger. They are discussed below as the Tachek Creek phase.

Previous (Wanless, 1974; Carter, 1974)) and current isotopic dating (MacIntyre *et al.*, 1996) suggest that the Topley suite is divisible into 4 main phases. These are;

- an early hornblende diorite phase that occurs as a border phase of large, composite stocks in the Tochcha Lake (93K/13) and Takla Lake areas (93N/4, 5). May also occurs as smaller, isolated intrusions. Limited isotopic dating indicates a Late Triassic age (ca 219 Ma?).
- megacrystic granite as an early to intermediate phase of the Tachek stock (ca 215 Ma?)

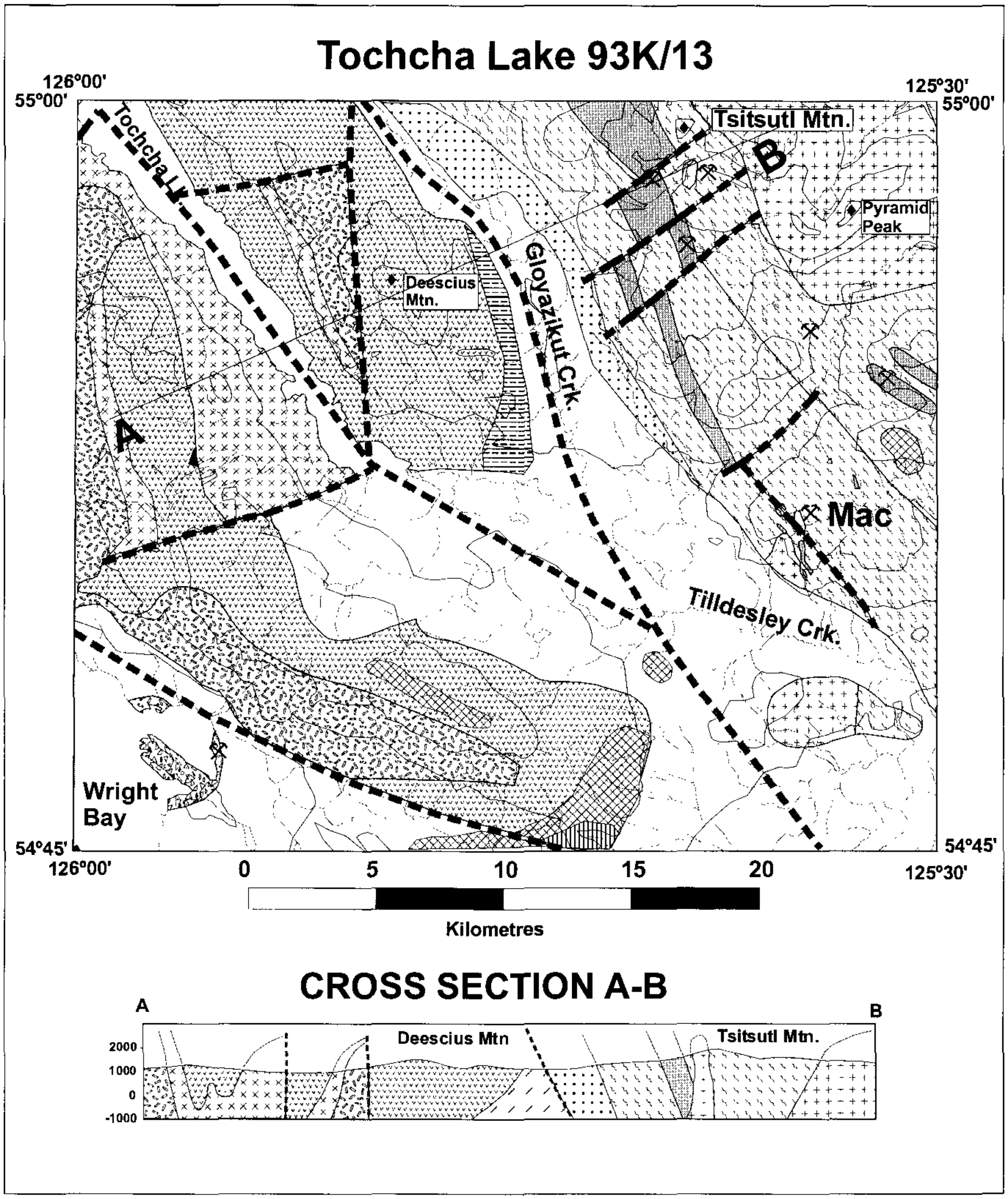

Figure 3-2. Generalized geology of the Tochcha Lake map area (93K/13).

Legend for Figure 3-2

TERTIARY
Endako Group: basalt, andesite
Ootsa Lake Group: rhyodacite, andesite
Wright Bay volcanics: lapilli tuff, breccia, basalt
JURASSIC-CRETACEOUS
granodiorite, porphyritic quartz monzonite
LATE TRIASSIC-MIDDLE JURASSIC
Topley Intrusive Suite
porphyritic quartz monzonite (Middle Jurassic)
granite, monzonite, quartz monzonite, aplite
hornblende diorite
LATE TRIASSIC
Takla Group
augite basalt, breccia, tuff
siltstone, argillite, limestone, conglomerate
PENNSYLVANIAN-JURASSIC
Sitlika Assemblage
sandstone, siltstone, slate, limestone
Cache Creek Group
metavolcanics, metasediments
ultramafic rocks

mineral occurrence

- porphyritic monzonite to quartz monzonite, as a late phase in large stocks and as isolated dikes cutting Takla Group rocks. These intrusions give isotopic ages between 194-191 Ma.
- pink aplitic to rhyolitic dikes and small porphyritic quartz monzonite to granite stocks cutting the Tachek stock and Takla Group volcanic rocks. These intrusions, named here the Tachek Creek phase, are the youngest intrusions of the Topley suite and have isotopic ages ranging from 179-169 (Middle Jurassic). Porphyry copper mineralization is associated with dikes of this age at Tachek Creek (Carter, 1981; MacIntyre *et al.*, 1995)

Locally the Topley Intrusive suite contains numerous xenoliths. The xenoliths vary from a few centimetres to several metres in diameter and are composed either of mafic volcanic rocks of probable Triassic age or an earlier hornblende diorite phase. In one locality, a xenolith of dark grey mafic volcanic flow, with 1 to 2-millimetre feldspar laths, grades into a fine-grained flow-top breccia with recessive calcite-filled cavities. Such lithologies are typical of the Upper Triassic Takla Group.

Most of the Topley intrusive rocks have some degree of alteration, the most common being chlorite after biotite and hornblende. This has made it difficult to find material suitable for Ar-Ar isotopic dating. In addition, fractures sometimes have potassium feldspar alteration envelopes around them, typically a few millimetres wide. This alteration is probably related to discharge of volatile-rich fluids during the final stages of crystallization. Epidote veins and clots are locally observed and generally have no consistent orientation. Rarely a criss-crossing network of chloritic veinlets penetrates the rock.

The high potassium content of the Topley intrusions is reflected in the presence of potassium feldspar either as 2 to 3-centimetre equant megacrysts or as a major component of the groundmass. Previous workers (Carter, 1981) felt these intrusions were comagmatic with the Lower Jurassic Telkwa Formation but isotopic dating indicates that the Topley suite, for the most part, is older and is probably coeval if not comagmatic with the Takla Group. Younger phases of the Topley suite may be comagmatic with the Telkwa Formation and Saddle Hill volcanics of the Hazelton Group but this seems unlikely since both of these volcanic successions are predominantly low-K basalt and andesite. However, since the Topley intrusive suite is only found intruding Takla volcanic rocks and direct links with younger strata which may, at one time, have overlain the Takla rocks, are no longer observable, the nature of extrusive equivalents to the Topley intrusive suite is unknown.

Hornblende Diorite Phase

Hornblende diorite, locally with a weak mineral lineation, is well exposed in clearcuts east and west of Tochcha Lake. The diorite occurs both as isolated intrusions and as a relatively narrow border phase to large monzonite to quartz monzonite stocks. The contact between the two phases is a zone of intense diking with fingers of pink monzonite to quartz monzonite injected into the diorite. There is some evidence of cooling and thermal metamorphism associated with the dikes, indicating the diorite was largely crystallized and cooled prior to intrusion of the monzonite phase. The diorite has intruded and thermally metamorphosed Takla Group volcanic and sedimentary rocks. Similar intrusive relationships were observed further to the north in the area between the two arms of Takla Lake (Schiarizza *et al.*, 1997, this volume).

Medium-grained equigranular, hornblende-biotite diorite underlies the hills along the west side of Tochcha lake. Here, the diorite has a pronounced mineral lineation that is defined by the alignment of hornblende and biotite. Xenoliths of biotite microdiorite, up to 10 centimetres in diameter, have indistinct (resorbed?) margins and are abundant in the intrusive. Fine-grained, pink aplitic dikes cut the diorite. An Ar-Ar isotopic age of 219 ± 2 Ma was determined on hornblende collected from this locality in 1995 (MacIntyre *et al.*, 1996). If this age is representative of the hornblende diorite found elsewhere in the Tochcha Lake area it indicates that the diorite is approximately the same age as the Takla volcanic rocks that it intrudes and may be comagmatic with the volcanic rocks. Additional dating is required to verify this correlation. The 219 Ma Ar-Ar isotopic age is similar to dates determined for

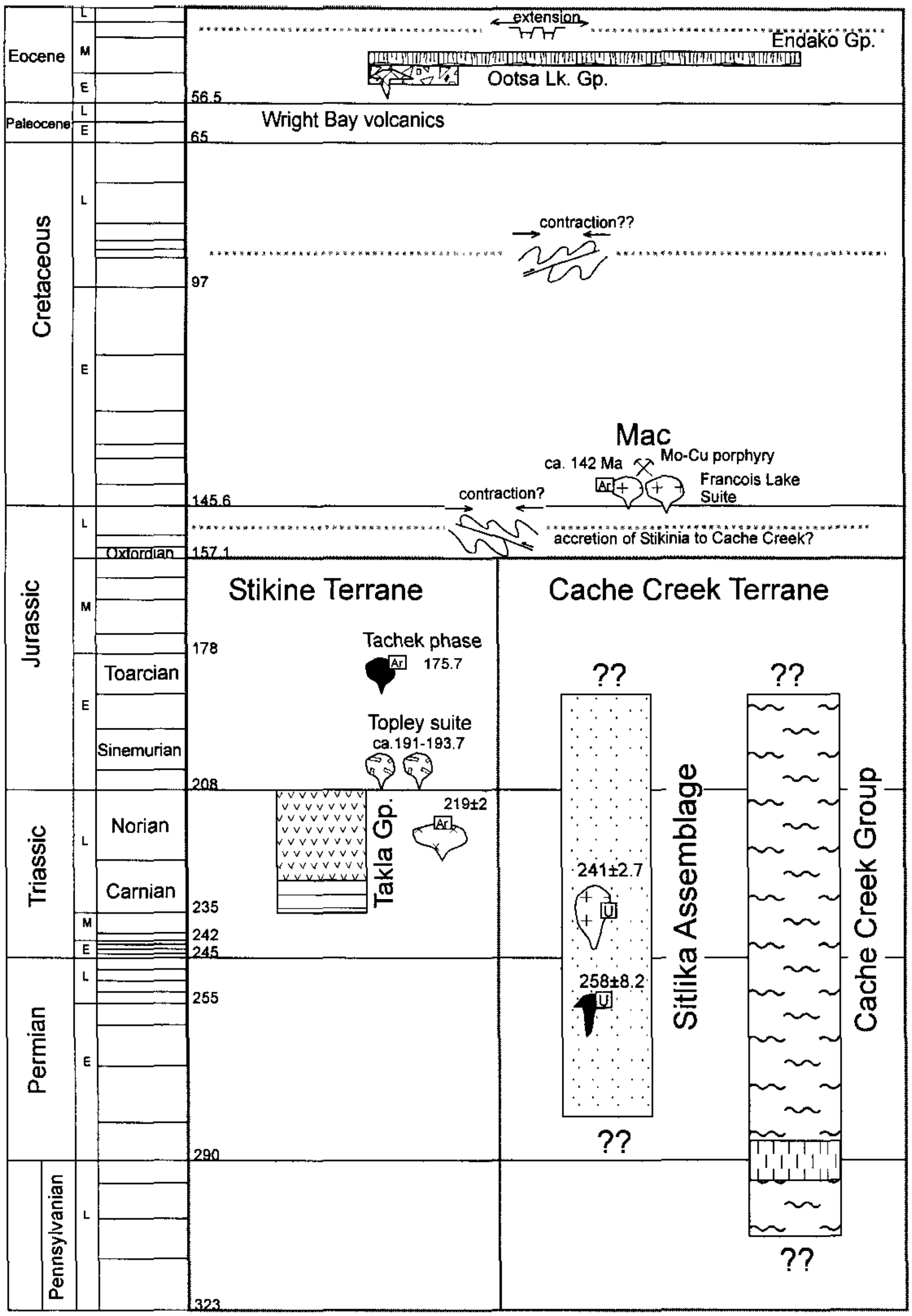

Figure 3-3. Generalized stratigraphy for the Tochcha Lake Map area (93K/13)

diorites of the Boer Lake intrusive suite in the Endako area (Mike Villeneuve, personal communication, 1997).

Granite Phase

The granite phase comprises the largest proportion of the Tachek stock and is well exposed east and west of Babine Lake (MacIntyre *et al.*, 1996). The granite is more monotonous in composition and visual appearance than the quartz monzonite phase. It typically has a medium to coarse-grained equigranular texture and weathers pale pink. Locally the granite is sparsely porphyritic with scattered orthoclase megacrysts up to 2 centimetres long. Quartz phenocrysts up to 1 centimetre long occur as irregular, elongate crystals that are intergrown with a groundmass of orthoclase, plagioclase and lesser quartz. This phase also carries up to 2 percent biotite and/or hornblende phenocrysts. A very weak foliation, defined by the alignment of quartz and mafic minerals, locally occurs in the granite. The granite phase is not well represented in the Tochcha Lake area and only crops out sporadically in the southwest corner of the map sheet.

The granite phase of the Tachek stock is not well dated. In 1995, a sample for U-Pb isotopic dating was collected from an excellent exposure in a quarry near the Port Arthur landing on the west shore of Babine Lake, south of Topley Landing. This sample gave a poorly defined Late Triassic U-Pb isotopic age of 215 to 230 Ma (MacIntyre *et al.*, 1996). The Tachek stock intrudes Takla Group volcanic rocks, which are presumed to have a similar Late Triassic age.

Monzonite to Quartz Monzonite Phase

The early granite and hornblende diorite phases of the Topley suite are intruded by a younger, leucocratic, medium to coarse-grained, equigranular to plagioclase-phyric phase that is monzonite to quartz monzonite in composition. This phase is locally porphyritic and contains 10 to 15 percent, 2 to 8 millimetre plagioclase phenocrysts, and up to 3 percent biotite and rare hornblende in a groundmass of intergrown potassium feldspar and quartz. Miarolitic cavities, which range from several millimetres to 2 centimetres in diameter, are also common. The cavities are typically filled with terminated quartz crystals which may have a black coating, and less frequently with epidote crystals.

The monzonite to quartz monzonite phase occupies the eastern part of the Tachek stock on the Fulton Lake map sheet (93L/16). It typically weathers orange and forms some of the conspicuous, large orange outcrops seen in clear-cuts on the east side of Babine Lake. The Tachek stock extends eastward into the Tochcha Lake area. This phase is also exposed in clearcuts east of Tochcha Lake where it intrudes an earlier hornblende diorite border phase. This composite intrusion was not shown on previous geologic maps of the area.

Currently there are only two isotopic age dates for this phase of the Topley intrusions. An Ar-Ar age of 191.1 ± 1.9 Ma was determined on biotite from the quartz monzonite phase of the Tachek stock, east of Babine Lake (MacIntyre *et al.*, 1997). This age is close to another Ar-Ar age of 193 ± 1.9 Ma determined on hornblende from a biotite-hornblende porphyritic monzonite dike that intrudes Takla volcanic rocks north of Granisle. In the current study area, an Ar-Ar sample was collected from the quartz monzonite stock east of Tochcha Lake but results are not yet available.

Pink Aplite to Rhyolite Phase

There are several later dike phases that intrude both the quartz monzonite and granite phases of the Tachek stock and surrounding rocks. The dikes appear to have a potassium-rich composition like the main granitoid phases and are therefore included as part of the intrusive suite. They typically have vertical contacts and predominantly northeast and northwest trends. All of the dikes have an aphanitic to sugary-textured groundmass that can be pink, orange, orange-brown, orange-tan or light grey in colour. The dikes are locally sparsely porphyritic with two distinct phenocryst assemblages. One has orthoclase phenocrysts up to 4 millimetres long, the other has both orthoclase and glassy quartz eyes up to 3 millimetres. The latter may be part of the younger Tachek Creek phase.

The composition of these fine-grained, dense rocks is difficult to determine. Rock names such as aplite, rhyolite, syenite and monzonite all seem appropriate, depending on the colour of the rock, its mineralogy and grain size. This apparent variation in dike chemistry may mimic the range of compositions in the main phases of the Topley suite. In several localities, the borders of dikes are flow banded and/or spherulitic, suggesting these are high-level, volatile-rich intrusions.

Tachek Creek Phase

The Tachek Creek phase, as defined here, includes rocks that are lithologically similar to older phases of the Topley suite but are Middle Jurassic in age and therefore some 20 million years younger. This phase, like older phases, is only observed cutting Takla Group volcanic rocks even though it is young enough to cut Hazelton Group strata as well. It also has the same areal extent as older phases, extending from Topley Landing on Babine Lake to north of Takla Landing in the Takla Lake area.

Carter (1981) first recognized intrusions of Middle Jurassic age at the Tachek Creek porphyry copper prospect where biotite from a biotite-quartz-feldspar porphyry dike gave a 176 ± 7 Ma (178 Ma revised) K-Ar isotopic age. This age is similar to two other isotopic dates determined as part of the Babine project. Hornblende from a small hornblende feldspar porphyritic monzonite stock exposed in a clearcut west of Tochcha Lake gave an Ar-Ar isotopic age of 175.7 ± 1.7 Ma. (MacIntyre *et al.*, 1996) Zircon extracted from a biotite granite phase within the Tachek stock east of Babine Lake gave a U-Pb isotopic age of 178.7 ± 0.5 Ma. Further north, in the Takla Lake area, Schiarizza and Payie (1997) describe a red to pink-weathering granite cut by feldspar porphyry dikes just east of the Takla Fault. Zircons extracted from this intrusion gave a U-Pb isotopic age of 169.1 + 1.0 / -4.8 Ma (Schiarizza *et al.*, 1998, this volume), slightly younger than ages determined for similar intrusions in the Babine and Tochcha lake areas. This age is also similar to the Stag Lake-Twentysix Mile Lake plutonic suite in the Hallet Lake area (Anderson *et al.*, 1997) although this suite is predominantly hornblende diorite and therefore, lithologically different from the Tachek Creek phase of the Topley Intrusive suite.

The Topley Intrusive suite is part of a long lived, magmatic arc that was active periodically over a time span of up to 60 million years. Its close spatial association with Takla and possibly Hazelton Group volcanic rocks suggests it is genetically associated with formation of these volcanic terranes. Although orientation of subduction zones is difficult to establish because of post Jurassic strike slip fault displacements, it is permissable that the Topley Intrusive suite is part of a Late Triassic to earliest Cretaceous magmatic arc that formed above an east dipping subduction zone. In terms of age, composition and geologic setting the Topley Intrusive suite is similar to composite stocks of the Hogem batholith that occur east of the Pinchi Fault and are part of the Quesnel terrane. It is possible that the Topley suite and associated Takla rocks are actually a northwardly displaced fragment of Quesnel terrane that has been positioned west of the Cache Creek Terrane by dextral strike slip fault motion.

Cache Creek Terrane

Sitlika Assemblage

The term Sitlika assemblage was assigned by Paterson (1974) to greenschist facies metavolcanic and metasedimentary rocks on the east side of Takla Lake that had previously been included in the Cache Creek and Takla Groups by Armstrong (1949). Schiarizza and Payie (1997) re-examined that area and described these rocks in more detail, and Schiarizza *et al.* (1998) traced the assemblage southward to about 10 km north of the Tochcha Lake map area. This Sitlika belt, which is bounded by the Cache Creek Group to the east, and Stikine Terrane to the west, is apparently truncated by a major northeast-striking fault that follows the valleys of Gloyazikut and Bivouac creeks near the south end of the 93N/4 map sheet. Rocks tentatively identified as the offset southern extension of the belt within the Tochcha Lake map area underlie a narrow north to northwesterly trending zone along the east side of Gloyazikut Creek (Figure 3-2).

Rocks assigned to the Sitlika assemblage in the Tochcha Lake map area include sandstone, siltstone, slate and limestone. These rocks are correlated with the Triassic and/or Jurassic eastern clastic unit of Schiarizza and Payie (1997) and Schiarizza *et al.* (1998) which, in the type area, stratigraphically overlies Permo-Triassic bimodal tholeiitic volcanic rocks of the assemblage. The succession along Gloyazikut Creek is inferred to be a fault-bounded panel juxtaposed against the Cache Creek Group to the east and the Takla Group and Topley Intrusive suite to the west. It faces to the east, as determined from grading and cleavage/bedding intersections in the sandstone and slate units, and can be divided into three units, based on the dominant rock type. These are, stratigraphically upward from west to east: sandstone, slate and limestone.

Westernmost exposures of the Sitlika eastern clastic unit are dominated by brown and grey-weathering, grey sandstone. It occurs as massive beds, 3 to 15 centimetre thick, that consist primarily of quartz and chert grains (0.25-1.0 millimetre). The sandstone beds are separated by interbeds of slate and siltstone; locally these are more prevalent than the sandstone.

To the east of the sandstone are exposures of slate and siltstone with minor amounts of limestone. The slate is banded in various shades of grey on a centimetre scale and breaks in thin sheets parallel to cleavage. Siltstone forms thin interbeds in portions of the slate sequence, and limestone forms widely spaced 20 to 70 centimetre beds, with sharp contacts with the slate. The limestone is light grey weathering, dark grey to grey, finely crystalline and permeated with calcite veinlets.

The upper part of the exposed Sitlika succession is dominated by light grey weathering dark grey to grey limestone and minor light grey weathering white sugary textured dolostone. The carbonates are bioclastic, locally with 2-15 millimetre, well preserved crinoid stem fragments. Depositional features have mostly been destroyed or are obscured by a shear fabric that strikes 350 degrees and dips steeply to the east. Subcrop of dark grey slate overlies the limestone to the east.

Cache Creek Group

The Cache Creek Terrane is represented mainly by the Late Paleozoic to mid-Mesozoic Cache Creek Group, which includes structurally imbricated carbonate, chert, argillite, basalt, gabbro and alpine ultramafic rocks. This assemblage of deformed oceanic rocks is generally interpreted to represent remnants of subduction complexes and dismembered ophiolite successions. The terrane is a prominent component of the Intermontane Belt over most of the Canadian Cordillera, where it occurs between the coeval arc terranes of Stikinia to the west and Quesnellia to the east. These terranes were amalgamated and juxtaposed against the western margin of North America in early to mid-Mesozoic time.

The Cache Creek Group in central British Columbia (Stuart Lake belt of Armstrong, 1949) includes polydeformed chert, siliceous argillite, limestone, phyllite, slate, siltstone, sandstone, and mafic metavolcanic and meta-intrusive rocks. Thick limestone units contain fusulinids, corals, brachiopods, bryozoans, gastropods and conodonts that are Pennsylvanian and Permian in age (Armstrong, 1949; Thompson, 1965; Orchard and Struik, 1996); radiolarian chert and cherty mudstone range from Early Permian to earliest Jurassic in age (Cordey and Struik, 1996a,b). Ultramafic rocks within the Stuart Lake belt were referred to as the Trembleur intrusions by Armstrong, who interpreted them to be intrusive bodies cutting the Cache Creek sedimentary and volcanic rocks. These rocks are now included within the Cache Creek Group, and interpreted to be the tectonically emplaced upper mantle and lower crustal portions of dismembered ophiolite sequences (Paterson, 1977; Ross, 1977; Whittaker, 1983; Ash and Macdonald, 1993; Struik *et al.*, 1996).

The Cache Creek Group rocks in the northeast corner of the Tochcha map area include ultramafic rocks, greenstone, amphibolite, limestone, phyllite and quartzite. The latter two lithologies were largely derived from metamorphosed ribbon chert. These rocks are interlayered throughout the area and appear to be fault bounded slivers in a highly imbricated or translated sequence. This contrasts with the Cache Creek Group farther to the north, where ultramafic rocks are restricted to a single belt that separates the metasedimentary part of the Cache Creek Group on the east from the Sitlika assemblage to the west.

Most of the ultramafic rocks are moderately to highly serpentinized. The serpentinite has a well developed foliation in places, but elsewhere is massive. Protolith compositions are generally not apparent, but massive, blocky, reddish-brown weathered harzburgite, with local dunite pods, outcrops on the east flank of Tsitsutl Mountain. Elsewhere, the protolith apparently includes partially serpentinized pyroxenite or harzburgite. Serpentinite foliations are defined by distended, broken and flattened pyroxenes and chromite, and aligned serpentine. In places, strongly foliated serpentinite, locally grading to magnesite-serpentine-talc schist, contains knockers, from a few metres to tens of metres in size, of greenstone, amphibolite, limestone, and cherty metasedimentary rocks. On the map scale, the ultramafite is largely distributed as distinct, north-northwest trending linear zones that are separated from each other by amphibolite and greenstone similar to the rocks form the knockers. Lenses of listwanite border some of the serpentinite bodies. Where contacts are seen or can be inferred, the serpentinite has a shear fabric, and each of the contacts is inferred to be a fault.

The greenstone is everywhere well foliated. It is dark grey and variably olive to dun weathering. It can be massive and finely crystalline or appear fragmental with augen (2-15 millimetre) of more darkly coloured greenstone. The finely crystalline variety generally has a phyllitic texture. The greenstone is locally interlayered with amphibolite and gabbro. The gabbro is orange to dark grey weathering and has 2 to 8 millimetre amphibole crystals. The amphibolite weathers dark green-grey and is dark grey on fresh surfaces. It consists mainly of 0.2 to 4 millimetre acicular and blocky hornblende or ortho-amphibole, and has very little plagioclase.

Metasedimentary rocks occur mainly within eastern exposures of the Cache Creek Group, where they are commonly intercalated with greenstone, that is in part derived from pillowed metabasalt. Metasedimentary intervals are dominated by light to dark grey platy quartz phyllites and quartzites, comprising plates and lenses of fine-grained recrystallized granular quartz, typically a centimetre or less thick, separated by phyllitic, mica-rich partings. Locally these platy rocks grade into less siliceous and more homogeneous medium to dark grey phyllites, or into light to medium grey thin-bedded chert. Less common, are light to dark grey recrystallized limestone intervals ranging in thickness from a few metres to a few tens of metres that occur within the siliceous metasedimentary successions.

Late Jurassic to Early Cretaceous (?) Intrusions

The northeast corner of the Tochcha Lake map sheet is underlain by a large pluton of biotite granodiorite. This pluton, which extends northward to Takla lake in the 93N/4 map sheet is unnamed. We propose the name Pyramid Peak pluton because it is well exposed at this locality. This pluton intrudes intensely deformed rocks of the Cache Creek Group. Emplacement appears to have been passive with little thermal metamorphism of the surrounding rocks. Although not observed in the current map area, further to the north, near Takla Lake, rafts of Cache Creek rocks are found in a coarse-grained, leucocratic, biotite granite border phase of the pluton.

Most of the Pyramid Peak pluton is monotonous, massive, blocky, grey to pink weathering, coarse-grained equigranular biotite ± hornblende granodiorite. In places the biotite is arranged in clusters which give the rock a spotted appearance. This phase tends to break down to pinkish coloured sand comprised mainly of feldspar and quartz. The early, coarse grained granodiorite phase is cut by a younger, subporphyritic to crowded porphyritic biotite-hornblende granodiorite or quartz monzonite phase. The younger phase is more quartz rich and white to light grey weathering. Locally, both phases of the pluton are cut by porphyritic andesite dikes comprised of 10-15 percent, 2-3 millimetre feldspar and less than 1 millimetre hornblende needles in a dense, dark grey groundmass. These dikes have well-developed chill margins and were clearly emplaced after crystallization and cooling of the main granodiorite body. The youngest dikes are fine-grained pink aplite and grey feldspar phyric rhyolite to rhyodacite.

The age of the Pyramid Peak pluton is not known at this time but it resembles other plutons in the area which have been mapped as the latest Jurassic (c.a. 145-147 Ma) Francois Lake Suite. Samples were collected from the pluton for U-Pb and Ar-Ar radiometric dating.

Small stocks of quartz-biotite-hornblende feldspar porphyritic granodiorite to quartz-feldspar porphyritic rhyodacite crop out on the peak southeast of Tsitsutl Mountain and at the Mac porphyry molybdenum property near Tilldesley Creek (Figure 3-2). The Tsitsutl mountain stock intrudes ductilely deformed, greenschist facies, Cache Creek metavolcanic and metasedimentary rocks. There is a zone of disseminated pyrite enclosing the stock and in places the Cache Creek rocks appear to be hornfelsed. The porphyry is a white to pink weathering, light to medium grey, siliceous rock with 10-15 percent, 1-2 millimetre quartz eyes and in places, up to 20 percent, 10 millimetre feldspar phenocrysts.

At the Mac property, small stocks and dikes of quartz-±biotite±hornblende-feldspar porphyry intrude Cache Creek metasedimentary and metavolcanic rocks and have associated molybdenum mineralization. Biotite from the stock in the Camp zone gave a 142.5 ± 1.4 Ma (earliest Cretaceous) Ar-Ar isotopic age (MacIntyre *et al.*, 1997). This age is slightly younger than those of the Francois Lake suite (145-147 Ma) and suggest the porphyries and associated molybdenum mineralization at Mac may be the latest phase of the Francois Lake intrusive suite. Some of the late dikes in the Pyramid Peak pluton may also have similar ages to the porphyries at Mac and Tsitsutl Mountain.

Tertiary Overlap Assemblages

Tertiary volcanic rocks crop out along the southern margin of the Tochcha Lake map sheet where they overlie Late Triassic to Early Jurassic Topley intrusions and Late Triassic volcanic rocks of the Takla Group. The Tertiary succession is divided into three map units. These are;

- fragmental volcanic rocks and flows containing clasts of Topley Intrusions exposed at Wright Bay on Babine Lake
- hornblende and biotite phyric rhyodacitic ash flows and tuffs that are correlated with the Eocene Ootsa Lake Group
- vesicular and amygdaloidal basalt flows, flow breccias, tuffs and epiclastic rocks that are correlated with the Eocene Endako Group

Wright Bay volcanic rocks

The Wright Bay volcanic rocks, which were previously mapped as Jurassic Hazelton Group, appear to sit directly on pink weathering monzonite of the Late Triassic to Early Jurassic Topley intrusions. The volcanic rocks, which are flat-lying to gently dipping, are comprised of lapilli tuff, volcanic breccia, lahar and basaltic flows. In places the lapilli tuffs are welded and may be ash flows. The lapilli tuffs and breccias contain 1 to 5 centimetre, subrounded to angular clasts of the underlying Topley intrusions plus white weathering rhyolite clasts in a greenish grey crystal-ash matrix. In places these rocks resemble the Nose Bay Intrusive breccia which is located east of Wright Bay. This breccia, which was described in a previous report (MacIntyre *et al.*, 1996), may have been a feeder vent for the Wright Bay volcanic rocks. Similar breccias containing Topley clasts crop out south of Tachek Creek on the west side of Babine Lake, and these too may be related to the Wright Bay volcanic rocks. The latter were mapped as the Tachek Group by Armstrong and were thought to be Jurassic. Because of the relationships observed at Wright Bay, we feel these breccias are more likely Tertiary in age and may in part be correlative with the Ootsa Lake or Endako Groups.

Ootsa Lake Group

Grey to pinkish grey weathering, hornblende-biotite-feldspar phyric to aphyric rhyodacitic ash flows, with lesser, thin, andesite and brown weathering basalt flows crop out as a series of knolls along the southern edge of the Tochcha Lake map sheet. The ash flows locally contain 5-10 percent hornblende and biotite phenocrysts that are up to one centimetre in diameter. Granitic inclusions are also common in some cooling units. The lower contact of the ash flow succession, which appears to be flat lying, was not seen but it is likely they sit unconformably on either Topley intrusions or Takla volcanic rocks. The ash flows are overlain by vesicular basalts which are tentatively correlated with the Endako Group. A sample of ash flow with fresh hornblende and biotite was collected for Ar-Ar isotopic dating.

Endako Group

Brown weathering, flat-lying, vesicular to amygdaloidal basaltic flows cap a northwest trending ridge along the southern margin of the Tochcha Lake map sheet. Locally, the flows contain small crystals of pyroxene. The vesicules range from 1 to 10 millimetres in diameter and comprise 20 to 35 percent of the rock. Vesicules and amygdules are often flattened parallel to the flow direction. Similar rocks are exposed in road cuts in the broad valley south of the ridge. On the ridge crest the flows are well exposed as a series of near vertical cliffs which may be fault scarps. Here, individual flows, separated by thin interbeds of volcaniclastic material, are 5 to 15 metres thick and sit unconformably on Takla volcanic rocks or Topley intrusive rocks. These rocks are correlated with the Eocene Endako Group based on lithologic similarity.

STRUCTURE

The structure of the Tochcha lake area reflects the effects of at least four major tectonic events. The oldest event included Jurassic (?) ductile deformation and metamorphism during southwest directed thrust imbrication of Cache Creek Group with Sitlika Assemblage and then emplacement above Stikine Terrane (Monger *et al.*, 1978) This was followed in mid Cretaceous time by a contractional event that produced northwest-trending folds and northeast directed thrust faults in Stikinia. 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 volcanic rocks 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. In the southern part of the Tochcha Lake map area Tertiary volcanic rocks cap a northwest trending ridge. The same volcanic rocks are exposed in road cuts in the broad valley south of the ridge. This suggests that the Tertiary volcanic rocks, which are probably Eocene Endako Group, were displaced and possibly rotated several hundred metres downward to the south across a west to northwest trending fault. Similar displacements of Eocene volcanic rocks were noted in the Babine Lake area (MacIntyre *et al.*, 1996).

MINERAL OCCURRENCES

The most important mineral occurrence in the Tochcha Lake area is the Mac porphyry molybdenum deposit which is actively being explored by Spokane Resources. Other occurrences consist of chromium, tin and copper showings in Cache Creek rocks (Table 3-1). Only the Mac property is discussed here.

Mac (Minfile 93K 097)

The Mac porphyry molybdenum prospect, which has recently been described by Cope and Spence (1996), is

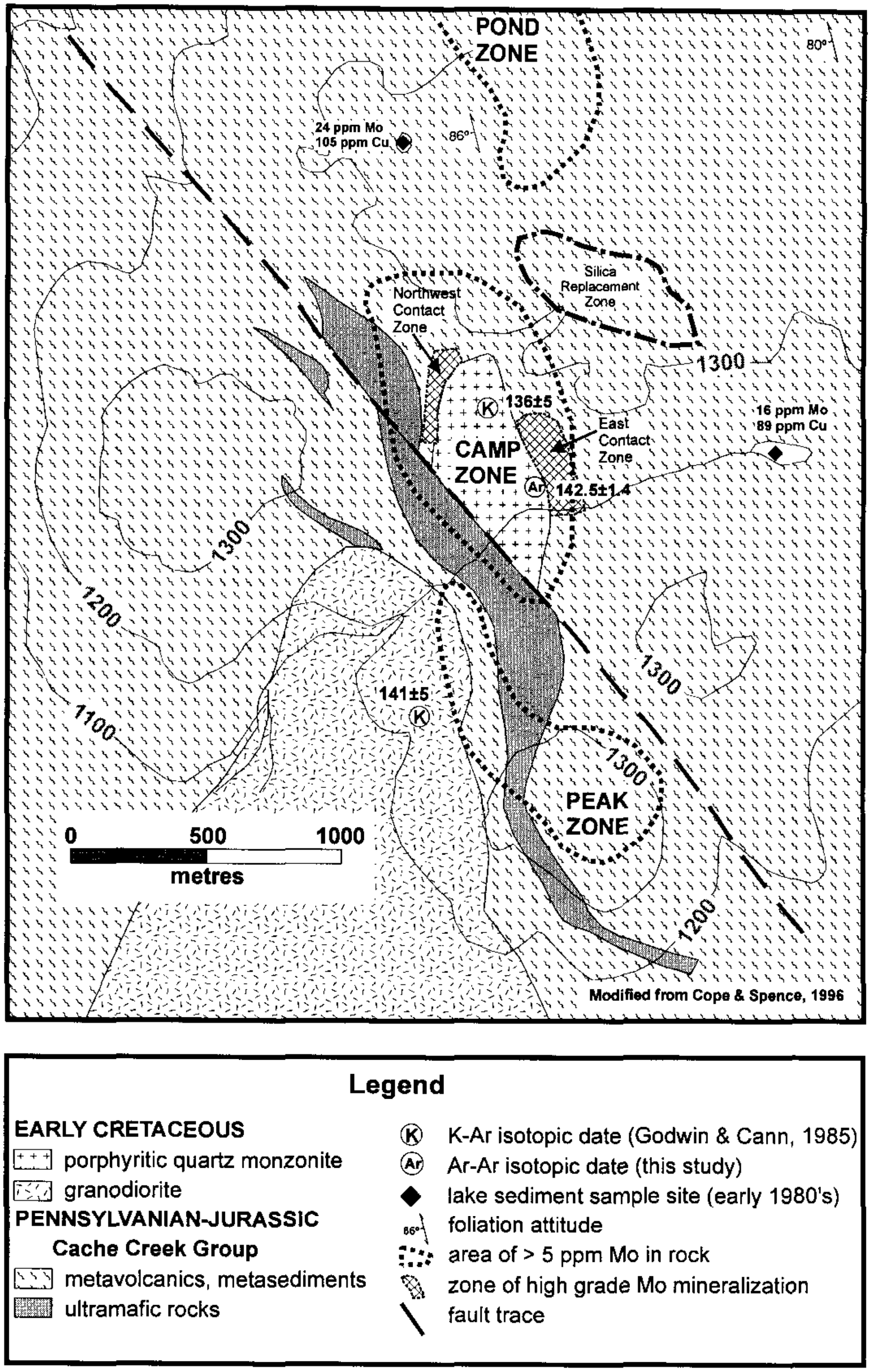

Figure 3-4. Geology of the Mac porphyry molybdenum property. Modified from Cope and Spence, 1996.

Table 3-1. Mineral Occurrences, 93K/13

No..	Property Name	Metals	Hosts
37	Tsitsutl Mountain Chromium	Cr	Cache Creek
38	Tilldesley Creek	Cr	Cache Creek
42	Tsitsutl Mountain Tin	Sn, Mn, Va, Co, Zn, Ro, Gs	Cache Creek
63	Tsitsutl Mountain	Cu	Cache Creek
67	Diane	Cu	Cache Creek
75	Mary Ann	Cu	Ootsa Lake
97	Mac	Mo, Cu	Cache Creek

located on the crest of the ridge north of Tilldesley Creek (Figure 3-2). The area was first explored in the early 1980's by Rio Algom Exploration Inc. (then Riocanex Inc,). They staked the property in 1982 after boulders of granitic rock with molybdenite mineralization were located in an area that also had anomalous Mo, Cu and Ag metal values in lake and soil samples. Additional soil sampling, geophysical surveys and trenching were done in 1983 and 1984. No further work was done until 1989, when 12 diamond drill holes totaling 1489 metres were completed. Although results were encouraging, Riocanex did no additional work and in early 1995 the property was acquired by Spokane Resources. In late 1995 and early 1996, they contracted Fox Geological Services to do more geological mapping, prospecting and induced polarization surveys. This was followed by 3600 metres of drilling in 19 holes. Based on drilling to date, indicated reserves are 52.4 million tonnes with an average equivalent grade of 0.12 percent MoS_2 using a 0.040 Mo cutoff. There is an additional inferred resource of 47.5 million tonnes of similar grade (Spokane Resources Ltd. News Release, April 23, 1997).

The Mac property is underlain by metavolcanic, metasedimentary and serpentinized ultramafic rocks of the Pennsylvanian to Jurassic Cache Creek Group. The Cache Creek rocks have a strong, regional foliation that trends 130 to 160 degrees and dips steeply to the southwest. These rocks are intruded by stocks of biotite granodiorite to porphyritic quartz monzonite that are part of the latest Jurassic to earliest Cretaceous Francois Lake intrusive suite. These intrusions also host the Endako porphyry molybdenum deposit in the Fraser Lake area, approximately 90 kilometres south-southeast of the Mac. As at Endako, molybdenum mineralization at Mac is associated with these intrusions and occurs in three areas - the Peak, Camp and Pond zones (Figure 3-4). Drilling to date has mainly focused on the Camp zone. Here, a 300 by 500 metre, northerly elongate stock of porphyritic quartz monzonite intrudes metavolcanic and metasedimentary rocks of the Cache Creek Group. The southern end of the stock is truncated and possibly offset southeastward by a northwest trending, high angle, sinistral strike-slip fault. The intrusion is medium-grained, leucocratic, and porphyritic to equigranular with 15 percent, 1-3 millimetre feldspar, 25 percent, 1-2 millimetre quartz and 35-45 percent, 1-4 millimetre K-feldspar and up to 5 percent biotite, muscovite and hornblende (Cope and Spence, 1996).

As part of the current study, a 142.5 ± 1.4 Ma (earliest Cretaceous) Ar-Ar isotopic age (MacIntyre *et al.*, 1997) was determined on biotite from the Camp zone stock. This is older than the previous 136 ± 5 Ma K-Ar age obtained by Godwin and Cann (1985) from the same stock but close to the 141 ± 5 Ma K-Ar age they determined for an unmineralized stock of biotite granodiorite that crops out on the south facing slope below the Camp and Peak zones (Figure 3-4). As mentioned above, the 142.5 Ma age is slightly younger than the new Ar-Ar isotopic ages determined for the Francois Lake suite (145-147 Ma) (Mike Villeneuve, personal communication, 1997). This suggests that the Camp zone stock may be a late, porphyritic phase of the Francois Lake intrusions.

Molybdenum mineralization at Mac occurs as molybdenite on fractures, as disseminations and in quartz veinlet stockworks peripheral to and within the porphyritic quartz monzonite or granite stock. Where the quartz monzonite stock is exposed on surface it is leached and has only minor ferrimolybdite staining on fractures. Disseminated chalcopyrite also occurs in the mineralized zones at Mac. Drill results indicate that the best molybdenum grades occur in 50 metre wide zone of biotite bearing, hornfelsed rocks along the east, north and west contacts of the stock,. One of the best drill intersections from this zone was 90 metres grading 0.308 percent MoS_2 and 0.256 percent Cu. A pyritic halo also encloses the stock and is roughly coincident with the biotite hornfels zone. Limited drilling in the Peak and Pond zones has intersected similar styles of mineralization. These zones are still relatively untested.

ACKNOWLEDGMENTS

The authors acknowledge the excellent assistance provided by geological field assistants Ryanne Metcalf, Stephen Munzar, Deanne Tackaberry, Michele Lepitre, Mike Hrudey, Crystal Huscroft, and Andrew Blair. Their enthusiasm and positive attitude even under less than ideal working conditions were exceptional. In addition, the authors acknowledge the excellent service provided by Pacific Western Helicopters, in particular pilot Bob Wellington from their base at Lovell Cove.

REFERENCES

Anderson, R., L'Heureux, R., Wetherup, S. and Letwin, J.M. (1997): Geology of the Hallet Lake map area, central British Columbia: Triassic, Jurassic, Cretaceous, and Eocene? plutonic rocks; *in* Current Research 1997-A; *Geological Survey of Canada*, pages 107-116.

Armstrong, J.E. (1946): Takla, Cassiar District, British Columbia; *Geological Survey of Canada*, Map 844A.

Armstrong, J.E. (1949): Fort St. James map-area, Cassiar and Coast Districts, British Columbia; *Geological Survey of Canada*, Memoir 252, 210 pages.

Ash, C.H. and Macdonald, R.W.J. (1993): Geology, Mineralization and Lithogeochemistry of the Stuart Lake Area, Central British Columbia (Parts of 93K/7, 8, 10 and 11); *in* Geological Fieldwork 1992, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1993-1, pages 69-86.

Carr, J.M. (1965): The Geology of the Endako Area; *in* Lode Metals in British Columbia 1965, *B.C. Ministry of Energy, Mines and Petroleum Resources*, pages 114-135.

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

Church, B.N. (1974): Geology of the Sustut area; Geology, Exploration and Mining in British Columbia in 1973, *B.C. Dept. of Mines and Petroleum Resources*, pages 411-455.

Cope, G.R. and Spence, C.D., (1996): Mac porphyry molybdenum prospect, north-central British Columbia; *in* Porphyry Deposits of the Northwestern Cordillera of North America, Schroeter, T.G., Editor, *Canadian Institute of Mining, Metallurgy and Petroleum,* Special Volume 46, pages 757-763.

Cordey, F. And Struik, L.C., (1996a): Scope and Preliminary Results of Radiolarian Biostratigraphic Studies, Fort Fraser and Prince George Map Areas, Central British Columbia; *in* Current Research 1996-A; *Geological Survey of Canada*, pages 83-90.

Cordey, F. and Struik, L.C., (1996b): Radiolarian Biostratigraphy and Implications, Cache Creek Group of Fort Fraser and Prince George map area, central British Columbia; *in* Current Research 1996-E; *Geological Survey of Canada*, pages 7-18.

Godwin, C.I. and Cann, R.M., (1985): The MAC porphyry molybdenite property, central British Columbia, *in* Geological Fieldwork 1984, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1985-1, pages 443-449.

Kimura, E.T., Bysouth, G.D. and Drummond, A.D. (1976): Endako; *in* Porphyry Deposits of the Canadian Cordillera, Sutherland Brown, A., Editor, *Canadian Institute of Mining and Metallurgy,* Special Volume 15, pages 444-454.

Lord, C.S. (1948): McConnell Creek Map-area, Cassiar District, British Columbia; *Geological Survey of Canada*, Memoir 251, 72 pages.

McMillan, W.J., Thompson, J.F.H., Hart, C.J.R. and Johnston, S.T., (1995): Regional geological and tectonic setting of porphyry deposits in British Columbia and Yukon Territory. *In* Porphyry Deposits of the Northwestern Cordillera of North America. Edited by T.G. Schroeter. *Canadian Institute of Mining, Metallurgy and Petroleum*, Special Volume 46, p. 46-57.

Monger, J.W.H. (1976): Lower Mesozoic rocks in McConnell Creek map-area (94D), British Columbia, *Geological Survey of Canada*, Paper 76-1a, pages 51-55.

Monger, J.W.H. and Church, B.N. (1977): Revised stratigraphy of the Takla Group, north-central British Columbia; *Canadian Journal of Earth Sciences*, Volume 14, pages 318-326.

Monger, J.W.H., Richards, T.A. and Paterson, I.A. (1978): The Hinterland Belt of the Canadian Cordillera: New Data from Northern and Central British Columbia; *Canadian Journal of Earth Sciences*, Volume 15, pages 823-830.

Monger, J.W.H., Wheeler, J.O., Tipper, H.W., Gabrielse, H., Harms, T., Struik, L.C., Campbell, R.B., Dodds, R.B., Gehrels, G.E. and O'Brien, H., (1991): Part B. Cordilleran terranes, Upper Devonian to Middle Jurassic assemblages, Chapter 8 of Geology of the Cordilleran Orogen in Canada; *in* Geology of Canada, No. 4, Edited by H. Gabrielse and C.J. Yorath, p. 281-327.

Orchard, M.J., and Struik, L.C. (1996): Conodont biostratigraphy, lithostratigraphy and correlation of the Cache Creek Group near Fort St.James, central British Columbia; *in* Current Research 1996-A; *Geological Survey of Canada.*

Paterson, I.A. (1974): Geology of Cache Creek Group and Mesozoic Rocks at the northern end of the Stuart Lake Belt, Central British Columbia; *in* Report of Activities, Part B, *Geological Survey of Canada*, Paper 74-1, Part B, pages 31-42.

Paterson, I.A. (1977): The Geology and Evolution of the Pinchi Fault Zone at Pinchi Lake, Central British Columbia; *Canadian Journal of Earth Sciences*, Volume 14, pages 1324-1342.

Ross, J.V. (1977): The Internal Fabric of an Alpine Peridotite near Pinchi Lake, Central British Columbia; *Canadian Journal of Earth Sciences*, Volume 14, pages 32-44.

Schiarizza, P. and Payie, G. (1997): Geology of the Sitlika Assemblage in the Kenny Creek - Mount Olsen Area (93N/12, 13); *in* Geological Fieldwork 1996, *B.C. Ministry of Employment and Investment*, Paper 1997-1.

Schiarizza, P., Massey, N.W.D and MacIntyre, D.G. (1998): Geology of the Sitlika assemblage in the Takla Lake area (93N/3,4,5,6,12); *in* Geological Fieldwork 1997, *B.C. Ministry of Employment and Investment*, Paper 1998-1 (this volume).

Struik, L.C., Floriet, C., and Cordey, F. 1996: Geology near Fort St. James, central British Columbia; *in* Current Research 1996-A; *Geological Survey of Canada*, pages 71-76.

Thompson, M.L. (1965): Pennsylvanian and Early Permian Fusulinids from Fort St. James Area, British Columbia, Canada; *Journal of Paleontology*, Volume 39, pages 224-234.

Wanless, R.K. (1974): Age Determinations and Geological Studies, K-Ar Isotopic Ages; *Geological Survey of Canada*, Report 11, Paper 73-2, pages 22-23.

Whittaker, P.J. (1983): Geology and Petrogenesis of Chromite and Chrome Spinel in Alpine-type Peridotites of the Cache Creek Group, British Columbia; unpublished Ph.D. Thesis, *Carleton University*, 339 pages.