# Geology and Mineralization of the Tchaikazan River Area Southwestern British Columbia (92O/4)

By Steve Israel and Lori Kennedy
The University of British Columbia

## INTRODUCTION

This paper presents preliminary results of bedrock mapping in the Taseko Lakes area. This work represents part of a Master's project funded by International Jaguar Equities (JAG), NWC Exploration Inc. and the University of British Columbia. Fieldwork was completed over two summers; two months of reconnaissance mapping in 1998 and two and a half months of more detailed 1:15 000-scale mapping in 1999. Emphasis was placed upon regional and local structure, their roles in localizing gold and copper mineralization, and their larger scale tectonic significance. More specifically the goals of the 1999 field season were to:

1) work out a coherent stratigraphy for the area and compare this to well-defined stratigraphic sections found to the east of the field area.
2) map the geometry of faults, determine their kinematics, and evaluate their role in the complex tectonic evolution of the region; and
3) identify the structural controls on the Northwest Copper (NWC) Cu-porphyry showing and the Pellaire gold veins and determine if they are temporally linked.

The project area encompasses about 180 square kilometers that is located southwest of upper Taseko Lake and approximately 200 kilometers due north of Vancouver (Figure 1).

It is within the Taseko Management Zone, along the east side of Ts'yl-os Provincial Park. The first geological compilation of the area is that of Tipper (1963), a 1:253 440-scale map covering the Taseko Lakes (92O) sheet. Subsequent work resulted in a more detailed 1:250 000-scale map of the same area (Tipper, 1978). The most detailed map of the project area prior to this study is a 1:100 000-scale map produced by McLaren (1990) as part of a mineral resource assessment of the Chilko Lake Planning Area.

Mineralization within the region includes epithermal and mesothermal veins, porphyry systems and fault-controlled mercury-antimony occurrences (McLaren, 1990). A number of occurrences in advanced stages of exploration are present in and around the project area. JAG has completed a bulk sampling project on the Pellaire gold and silver epithermal veins (MINFILE 092O 045) and is actively exploring the Chita (MINFILE 092O 049) and Northwest Copper (MINFLE 092O 043) occurrences. The Pellaire and Northwest Copper occurrences are found within the project area, whereas the Chita occurrence lies just outside of the project area on the southeast side of upper Taseko Lake. For a more extensive overview of regional mineralization the reader is directed to McLaren (1990).

## REGIONAL GEOLOGIC SETTING

The field area is located within the southeastern Coast Belt, which forms part of the boundary between the Intermontane and Insular superterranes (Figure 1; Monger *et al.*, 1982). This highly tectonized belt includes Paleozoic to mid-Mesozoic oceanic and volcanic arc rocks assigned to several different terranes, together with late Middle Jurassic through mid-Cretaceous sedimentary rocks of the Tyaughton-Methow basin, Upper Cretaceous continental arc volcanic rocks of the Powell Creek formation and mid-Cretaceous to Tertiary intrusive rocks of the Coast Plutonic Complex (Schiarizza *et al.*, 1997).

The study area is near the southeast end of a distinctive structural-stratigraphic domain (Eastern Waddington Domain) bounded by the Tchaikazan Fault on the northeast and by mid-Cretaceous to early Tertiary plutons to the southwest (Figure 2).

The oldest rocks within this domain are Upper Triassic volcanic and sedimentary rocks that have been correlated with Stikine Terrane (Mount Moore and Mosley formations of Rusmore and Woodsworth, 1991). These Triassic rocks are imbricated with Lower to Upper Cretaceous volcanic and sedimentary rocks across Late Cretaceous northeast-vergent thrust faults of the eastern Waddington thrust belt (Rusmore and Woodsworth, 1994).

The Tyaughton basin, east of the present study area, is characterized by upper Middle Jurassic to mid-Cretaceous clastic sedimentary rocks that are interpreted to have been deposited above oceanic rocks of the Bridge River Terrane (Schiarizza *et al.*, 1997). Middle Triassic to Middle Jurassic volcanic, plutonic and sedimentary rocks of the Cadwallader arc terrane, which occur mainly east and north of Bridge River Terrane, are likewise overlain by thick Jura-Cretaceous clastic sedimentary rocks comprising the Methow portion of the Tyaughton- Methow basin.

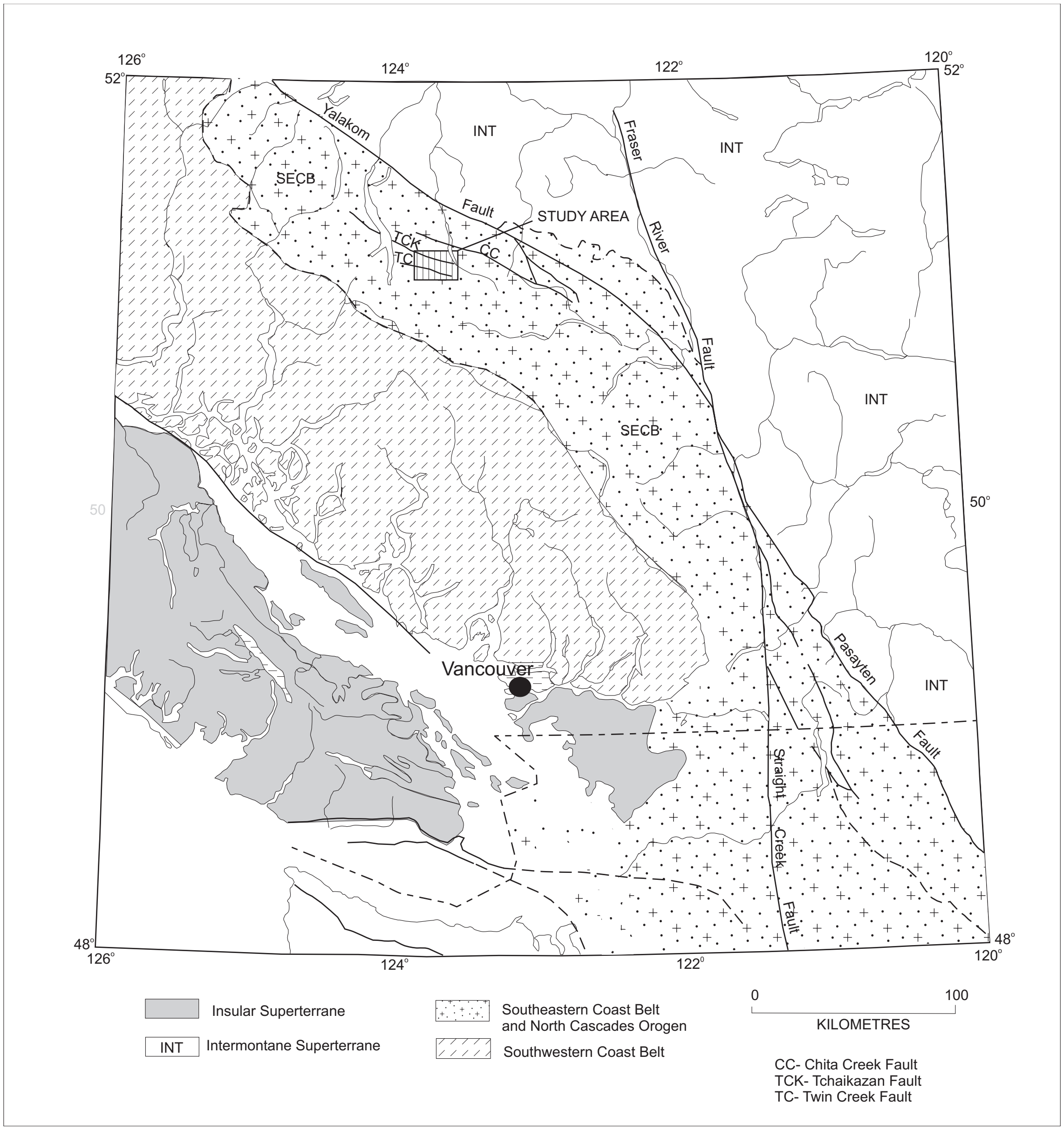


Figure 1. Location of field area, with regional tectonic framework (modified from Schiarizza *et al*., 1997).

Lower Cretaceous rocks on the southwest side of the Tchaikazan fault, including those within the present study area, are in part correlated with the upper Relay Mountain and Taylor Creek groups of the Tyaughton basin to the east. They differ, however, in their more restricted age range (no Jurassic rocks are recognized), and in the predominance of volcanic rocks. In these aspects, they more closely resemble Lower Cretaceous arc volcanic and related sedimentary rocks of the Gambier Group, which are widespread within the southwestern part of the Coast Belt (Monger and Journeay, 1994). Consequently, it has been suggested that this area represents part of the transition from the Early Cretaceous arc of the southswestern Coast Belt to a related back-arc basin, represented by the upper part of the Tyaughton basin (McLaren, 1990; Umhoefer *et al*., 1994). Another interpretation, presented by Monger *et al*. (1994), is that the Tyaughton basin is part of a long-lived accretionary fore-arc complex, and the southwestern Coast Belt arc was emplaced to the west of it by pre-mid-Cretaceous sinistral faulting.

The southeastern Coast Belt had a protracted and complex structural history, extending from at least mid-Cretaceous to Paleogene time, and involving an early phase of contractional deformation followed by dextral strike-slip and locally important extensional faulting (Journeay and Friedman, 1993; Umhoefer and Schiarizza, 1996; Schiarizza *et al*., 1997). The northeast-vergent structures of the eastern Waddington thrust belt, which were active by at least 87 Ma and became inactive before 68 Ma, formed relatively late in the contractional episode, and are interpreted as back thrusts

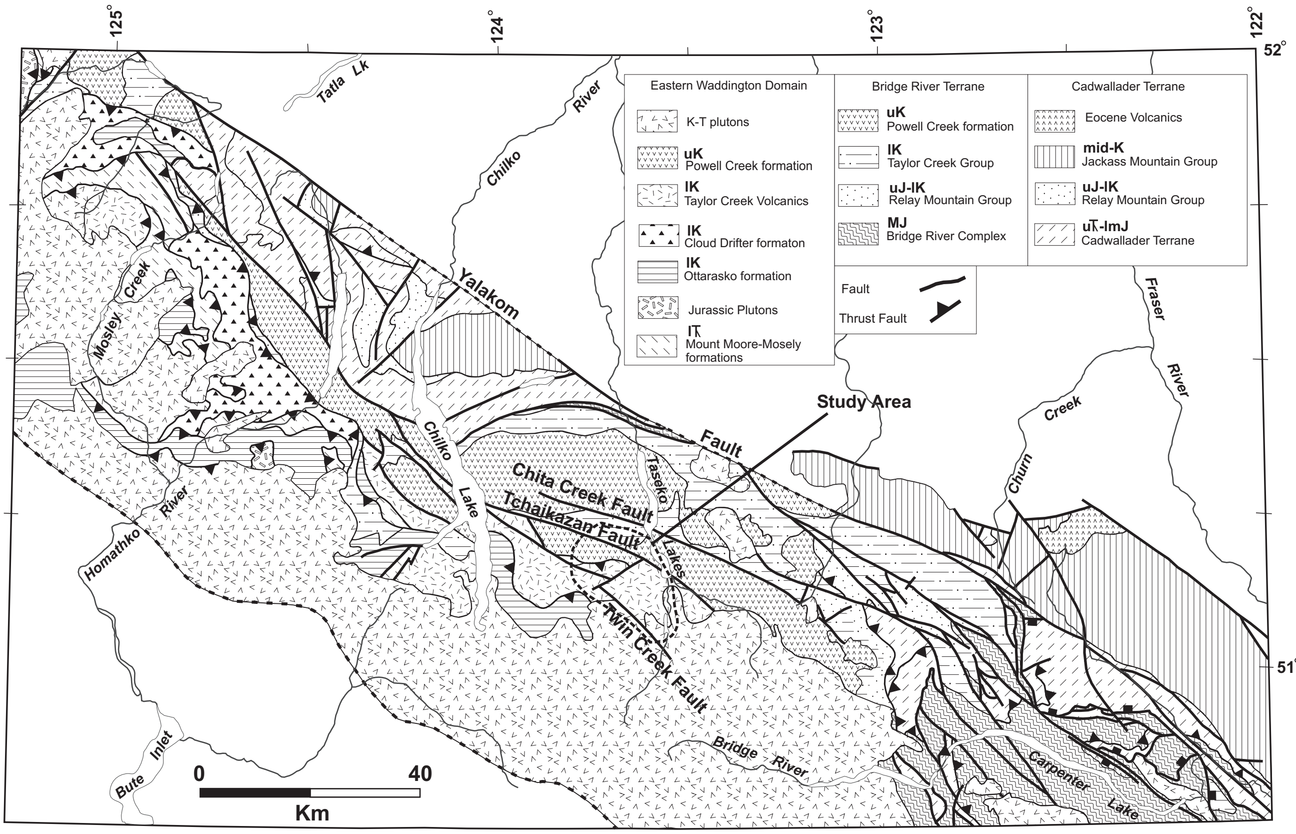


Figure 2. Geologic setting of the project area (based on an unpublished compilation by P. Schiarizza).

within the predominantly southwest-vergent orogen (Rusmore and Woodsworth, 1994).

The dominant regional structures are northwest-striking dextral strike-slip faults (Schiarizza *et al.*, 1997; Journeay *et al*., 1992; Figure 2). These include the Yalakom fault, northeast of the study area (Figure 2), which has a strike length of approximately 300 kilometers, and an estimated 115 kilometers of right-lateral displacement (Riddell *et al*., 1993). Umhoefer and Schiarizza (1996) suggest that the Yalakom fault system was active from approximately 70 Ma to 40 Ma, with most movement occurring in the early to middle Eocene. Faulting during this latter time period included the development of a series of en echelon left-stepping faults, including the Fortress Ridge and Chita Creek faults, with zones of contraction and uplift in the stepovers (Figure 2). Prominent structures within the present map area, including the Tchaikazan and Twin creek faults, may have formed at the same time and represent a western extension of this left-stepping system (Umhoefer and Kleinspehn, 1995; Figure 2).

## STRATIGRAPHY

Volcanic, volcaniclastic and clastic sedimentary rocks of Cretaceous age underlie most of the project area (Figure 3).

These are assigned to the Relay Mountain and Taylor Creek groups and the informal Powell Creek formation . Below we describe the lithologic characteristics of each unit. Emphasis is placed on the Taylor Creek Group as we propose new stratigraphic subdivisions for this thick package of volcanic and volcaniclastic rocks.

### Relay Mountain Group ($LK_{Rm}$)

Jeletzky and Tipper (1968) first identified Lower Cretaceous rocks belonging to the Relay Mountain Group in the area southwest of the Tchaikazan fault. These rocks are restricted to two localities mapped by Tipper (1978) and McLaren (1990) on the ridge system northwest of the Tchaikazan River. The eastern locality is in the present map area (north of the Tchaikazan River and the Charlie showing) and is interpreted as a fault-bound lens thrust over the Powell Creek formation and itself overthrust by rocks of the Taylor Creek Group. Here, the Relay Mountain Group consists of dark brown to black shales, interbedded with fine-grained grey to light brown sandstone. Abundant fragments of incoceramid bivalves and

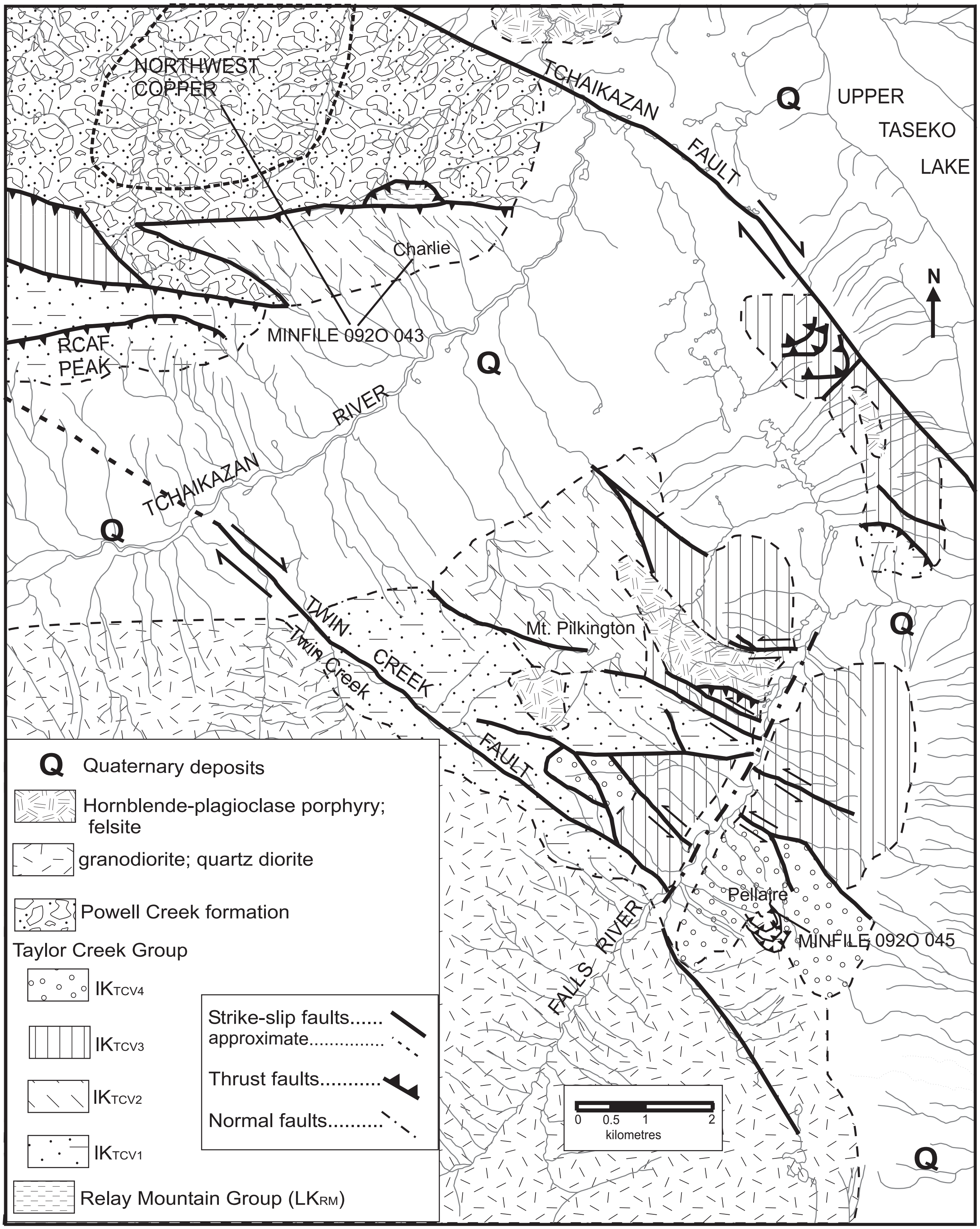


Figure 3. Generalized geology of the project area, showing only large-scale structures.

belemnites are present and a fossil collection from this area was assigned an early Hauterivian age by J.A. Jeletzky (McLaren, 1990).

## Taylor Creek Group

In the main part of the Tyaughton basin, east of the field area, mid-Cretaceous rocks of the Taylor Creek Group either rest unconformably above the Bridge River Complex, or disconformably above Lower Cretaceous rocks of the Relay Mountain Group (Schiarizza *et al*., 1997). Garver (1989) conducted a detailed study of the group in the Big Creek - Bridge River area and subdivided it into four distinct sedimentary units, mostly of mid-Cretaceous (Albian) age. A youngest fission-track peak of 113-114 Ma reported by Garver and Brandon (1994) suggests that the Paradise formation, the lowest within the Taylor Creek Group in the area studied by Garver, is somewhat older (Aptian-Lower Albian). A detailed description of the group is given in Schiarizza *et al*. (1997) where they add the informal Beece Creek succession and a volcanic unit.

Within the field area, the Taylor Creek Group on the southwest side of the Tchaikazan fault comprises more than 2500 metres of dominantly volcanic and volcaniclastic rocks. (Figure 4).

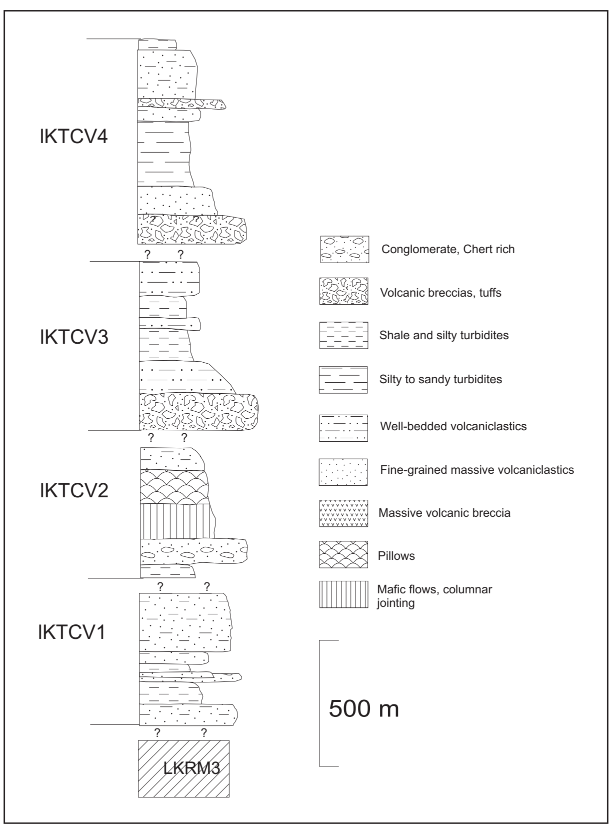


Figure 4. Generalized stratigraphic section from the study area.

We tentatively divide this succession into four separate units based on lithologic characteristics and stratigraphic relationships.

### *Unit $LK_{TCv1}$*

Unit $LK_{TCv1}$, the lowest part of the Taylor Creek succession exposed in the project area, is characterized by medium to fine-grained well bedded to massive, green to red volcaniclastics, silty grey to black turbidites and intermediate to felsic tuff horizons. The best section of this unit is found on the south slope of the ridge north of Twin Creek. The unit might continue to the east, towards the Falls River valley where similar felsic and lithic tuff horizons are found (Photo 1).

The lower part of the unit is not well exposed but seems to be characterized by light grey-green to black laminated silty turbidites and black shales. The turbidites occur in beds up to 5m thick with laminations from less than a centimetre to 5 cm. They typically form Tbd and Tcd sequences. The shale is found in beds from one to several metres thick interbedded with the turbidites.

The sediments quickly pass into dark grey volcaniclastic and pyroclastic rocks. The contact with the sediments is gradational. Sedimentary rocks are massive too slightly layered and occur as beds up to 2 metres thick. A distinctive felsic crystal-lithic tuff is present at this level in the unit. It is characterized by fragments composed of dark siltstone and intermediate to felsic volcanic rock within an intermediate to felsic ash matrix. Plagioclase crystals up to 1 millimeter in size occur throughout the bed. This interval has variable thickness, ranging from 1-2 metres in the Twin Creek area to over 20 m farther to the east, just west of the Falls River. A clast-supported conglomerate (1-2 metres thick) is located immediately above the tuff horizon. The clasts are composed of abundant intermediate to felsic volcanic rocks, chert and lesser amounts of siltstone. They are sub-angular to sub-rounded and range from less than 1 cm to 10 cm in size (Photo 2).

This stratigraphic position may be represented to the east where a similar lithic tuff is found. However in that locality the volcaniclastic conglomerate is absent and the lithic tuff horizon is up to 40 metres thick. This may suggest an easterly source for the volcanics, but structural complications in the area still need to be resolved.

Above the conglomerate are alternating, layered green to red volcaniclastics. These make up approximately half of the section totaling 250 metres of semi-exposed outcrop. They occur in well-bedded horizons up to 2 metres in thickness and exhibit normal grading of sub angular to rounded intermediate volcanic pebbles. In places they become more massive and much coarser, composed of angular to rounded intermediate to felsic volcanic fragments in an andesitic volcaniclastic matrix. Large chloritized hornblende crystals up to 1 cm in length occur within these horizons, confined mainly to the fine-grained pyroclastic matrix (Photo 3).

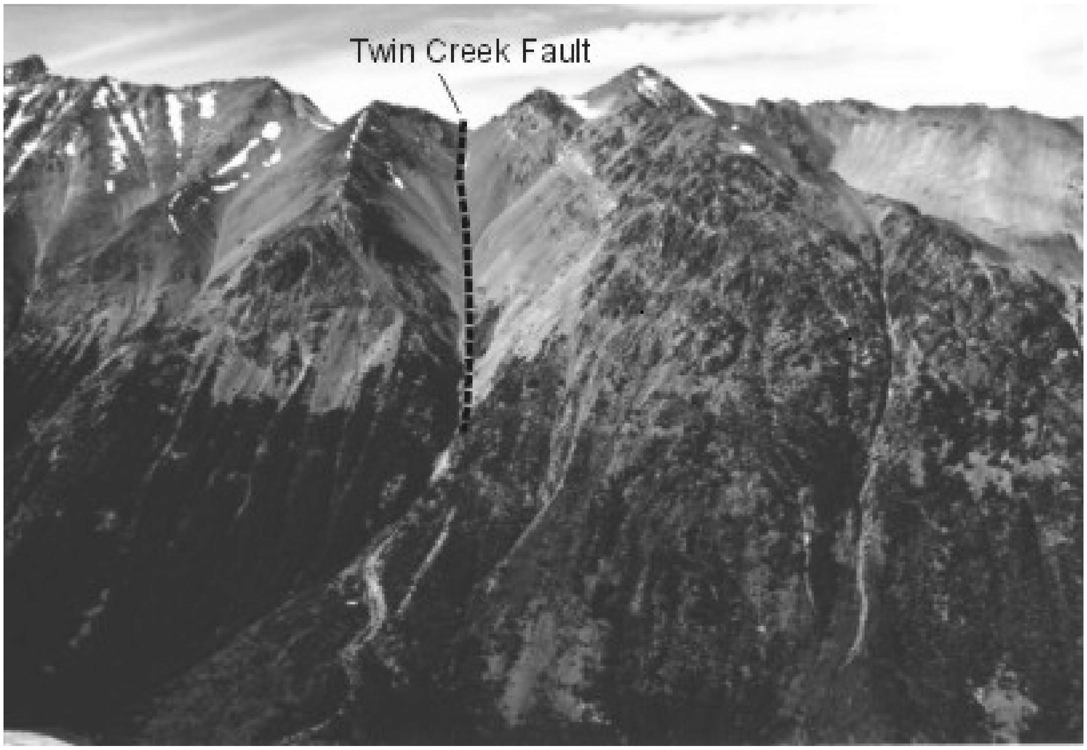

Photo 1. Well-stratified rocks of unit $lK_{TCV1}$, cut by Twin Creek fault.

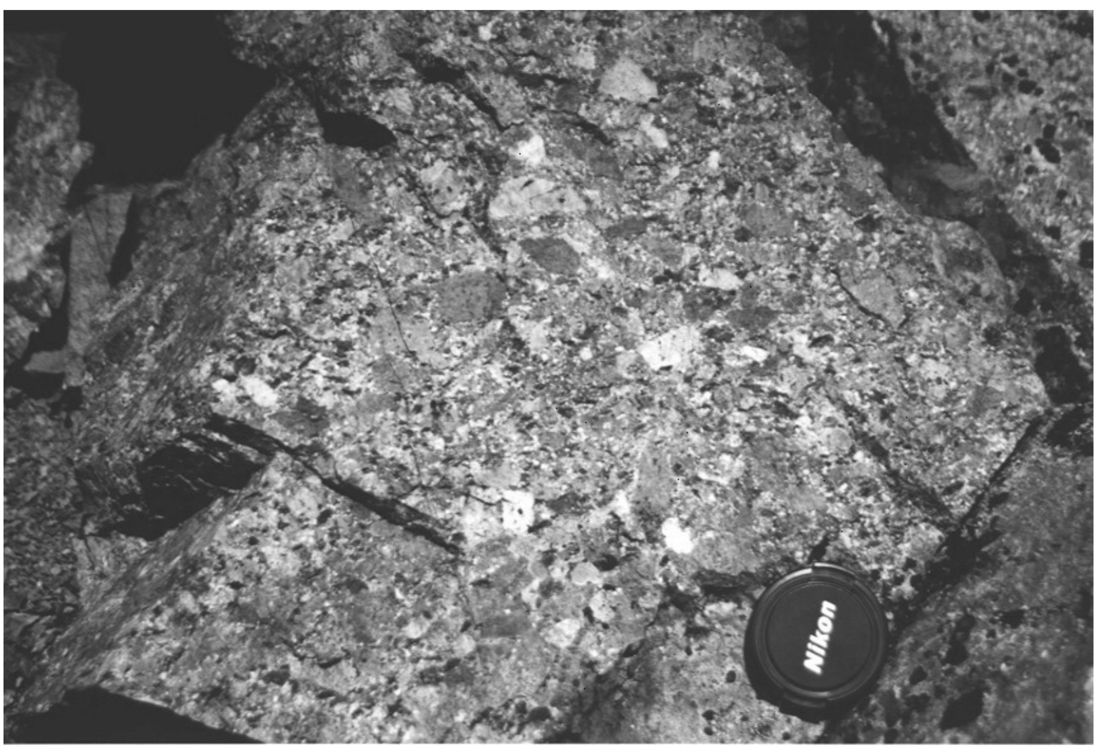

Photo 2. Chert pebble conglomerate found near the middle of unit $lK_{TCV1}$.

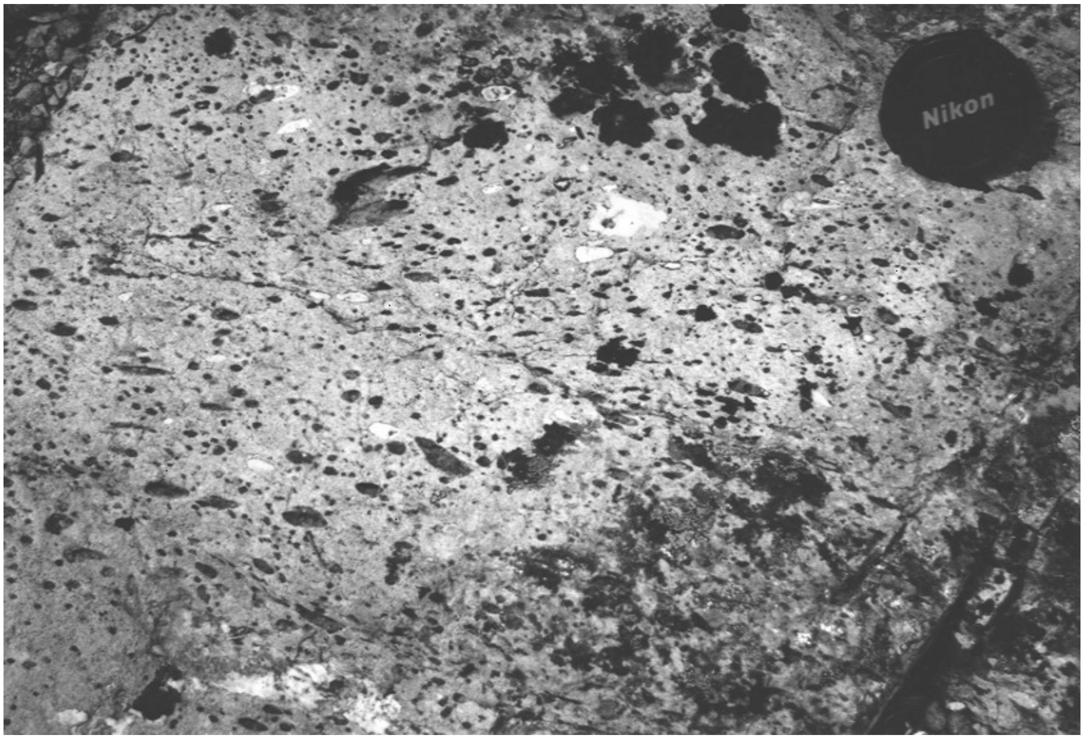


Photo 3. Chloritized hornblende crystals within green volcaniclastics near the top of unit $lK_{TCV1}$.

Fossils found in this unit consist of non-diagnostic gastropods, belemnites and bivalves in argillites interlayered with volcanic rocks (McLaren, 1990). Based on the presence of the belemnites, McLaren assigned a Hauterivian to Barremian age to the unit. This unit is thought to also occur to the west of RCAF Peak, where it apparently rests stratigraphically above rocks of the Relay Mountain Group (McLaren, 1990).

### *Unit $LK_{TCv2}$*

The second unit of the volcanic section outcrops on the ridge immediately south of the Tchaikazan River and east of unit $LK_{TCv1}$, as well as north of the Tchaikazan River east of RCAF Peak. It is characterized by a more mafic succession of volcanic and associated volcaniclastic rocks interbedded with marine sediments. It may also be present in a slightly different form in the northwest portion of the map area, where basaltic flows are interbedded with mafic tuff horizons.

The base of the unit consists of laminated dark grey-green to black turbidites and dark brown shales, which pass upward into a cobble conglomerate consisting entirely of sub-rounded to angular plagioclase-phyric intermediate volcanic clasts within a black shaly matrix. Within this horizon a metre-thick bed of dark brown, mafic pyroclastic rocks are host to a large number of bivalve fossils.

Apparently conformable above the conglomerates is a 50-metre-thick section of columnar jointed mafic to intermediate flows capped by 30 metres of pillowed volcanics (Photo 4).

The columns are roughly 50 cm across but locally reach widths of more than a metre. The pillows become less well defined higher in the section, until they pass into a fine to medium grained, dark green volcaniclastic. Chloritized hornblende crystals occur within the volcaniclastics, similar to those seen in unit $LK_{TCv1}$.

The stratigraphic position of this unit is somewhat problematic, as the base of it seems to coincide with a steeply dipping fault. However, the bedding dips and facing directions of unit $LK_{TCv2}$ are similar to those within unit $LK_{TCv1}$ and the close proximity to the lower unit could indicate a stratigraphic relationship between the two units. There is no mention of pillows within the Taylor Creek volcanic package by any other worker, suggesting it may just be a small discontinuous unit between $LK_{TCv1}$ and $LK_{TCv3}$.

### *Unit $LK_{TCv3}$*

The best exposure of $LK_{TCv3}$ is on the western side of the Falls River valley, directly west of the Pellaire gold deposit. The base of the unit is not well exposed. The top of the unit is involved in a large strike slip fault, but reconstruction along the fault may bring rocks of $LK_{TCv4}$ into place on top of unit $LK_{TCv3}$. Rocks within this unit are generally volcanic breccias, volcaniclastics and marine turbidites with few beds of tuffaceous sandstone.

Volcanic breccias of $LK_{TCv3}$ consist of large (up to 40 cm) clasts of intermediate to felsic volcanic rocks within

Photo 4. Columnar jointing found in volcanic rocks near the top of unit $lK_{TCV2}$.

a plagioclase-quartz crystal matrix of similar composition (Photo 5).

The breccias occur at the base of $LK_{TCv3}$ and continue for several tens of metres before grading into well-bedded volcaniclastics of the same material. Beds range from 1 cm to 15 cm in thickness and are commonly graded. Thin, 1 cm, fine-grained ash tuff layers occur throughout this section of the unit (Photo 6).

The volcaniclastics become increasingly sediment-rich higher up stratigraphically, ultimately grading into finely laminated turbidites and shales. The turbidites are dark grey-green to black and commonly show Tab and Tce sequences. Shales are interbedded with the turbidites and are generally massive and black. One, as of yet undated, fossil was found. At the top of the section approximately 30-40 metres of fine-grained grey-green volcaniclastic rock with small (1 mm) hornblende crystals is found interbedded with the sediments.

### *Unit $LK_{TCv4}$*

The most complete section of $LK_{TCv4}$ is located at the Pellaire occurrence. Here it is roughly 500 metres thick and is composed of volcanic breccias, volcaniclastics and turbidites. It differs from unit $LK_{TCv3}$ in that it does not have shale, has a larger component of turbidites and contains very distinct red jasper within the breccias (Photo 7)

The volcanic breccias of unit $LK_{TCv4}$ are similar to those of unit $LK_{TCv3}$ except that the clasts are more rounded and not as large. The red jasper suggests a difference in the provenance of the breccias. The breccias grade into a fine-grained purple to green massive volcaniclastic, with plagioclase crystals up to 2mm long. West of the Falls River, the same jasper-rich breccias are found to grade into a purple to maroon andesitic flow 30 metres thick, which is overlain by the purple-green volcaniclastics.

Conformably overlying the volcaniclastics is a large package of Tab and Tbc grey-green to black silty turbidites. The package is a monotonous continuation of the same lithology for more than 200 m, eventually grading into more volcaniclastics with slightly larger intermediate to felsic volcanic clasts than seen lower down in the section.

The stratigraphic position of unit $LK_{TCv4}$ is somewhat suspect, but on the west side of the Falls River it apparently overlies unit $LK_{TCv3}$. However, the actual contact is not exposed making certain interpretation difficult. The lack of shale and higher sandstone content might suggest a change to shallower waters and less volcanic activity.

## Beece Creek Succession

The Taylor Creek Group to the east of Taseko Lakes (Figure 2) is dominated by exposures of shale, micaceous sandstone and chert-rich polymictic conglomerate that have been assigned to the informal Beece Creek succession by Schiarizza *et al*. (1997) and Schiarizza and Riddell (1997). The Beece Creek succession forms the upper part of the Taylor Creek Group in this area, and is inferred to represent, at least in part, a distal facies of Garver's (1992) Silverquick conglomerate. Within the present study area, rocks that are confidently assigned to the Beece Creek succession occur as a series of small outcrops near the bridge over the Tchaikazan River, just north of the extent of map in figure 3. These rocks are separated from the volcanic-dominated rocks of the Taylor Creek Group described above by the Tchaikazan fault. However, a mica-rich sandstone found on top of a ridge south of the Tchaikazan fault, near the southwest side of Upper Taseko Lake, may also belong to the Beece Creek succession, although the exposure is limited due to the presence of a felsite intrusion. This observation is significant however, for if this unit is the Beece Creek succession, then it apparently overlies rocks belonging to unit $LK_{TCv3}$.

The exposures correlated with the Beece Creek succession near the Tchaikazan bridge include chert-pebble

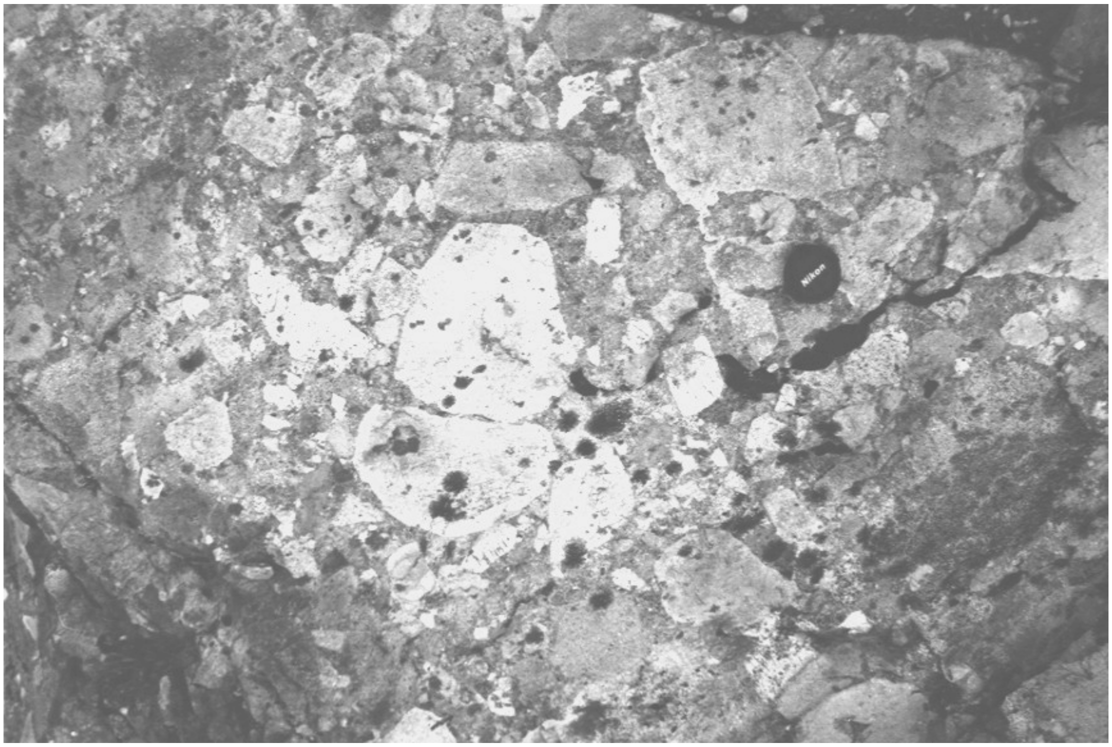


Photo 5. Large clasts of intermediate to felsic volcanic rocks within basal breccia of unit $lK_{TCV3.}$

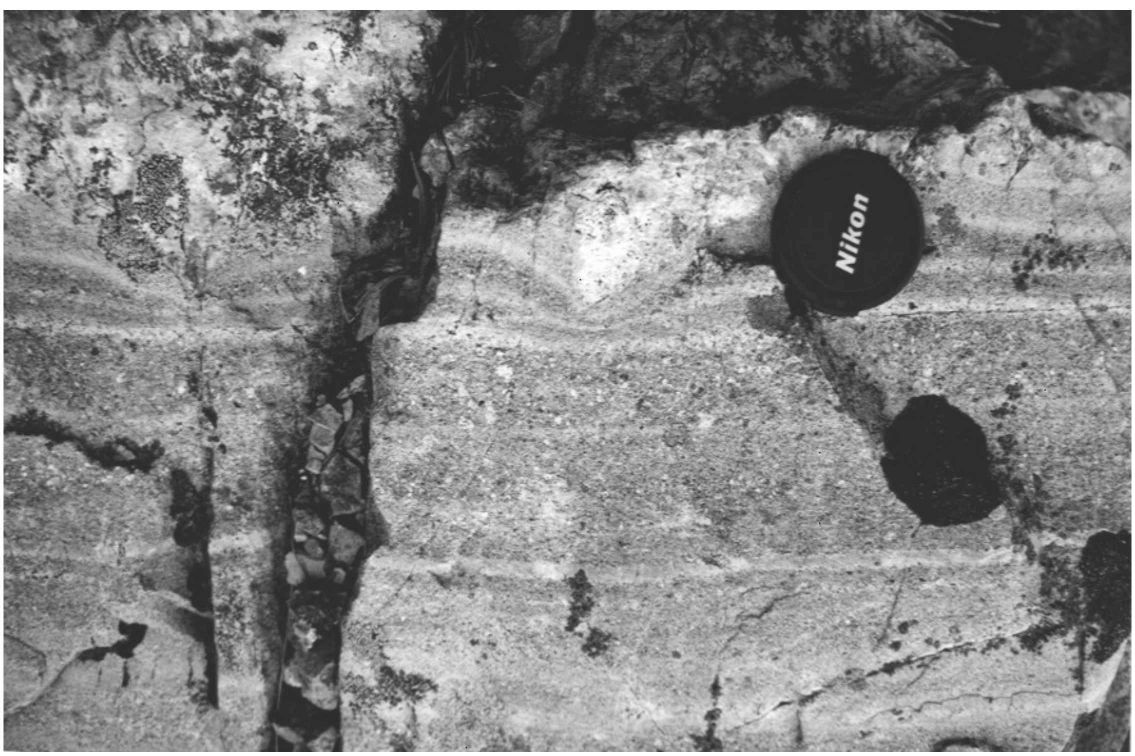


Photo 6. Well-bedded volcaniclastics with thin (1cm)-ash horizons in unit $lK_{TCV3.}$

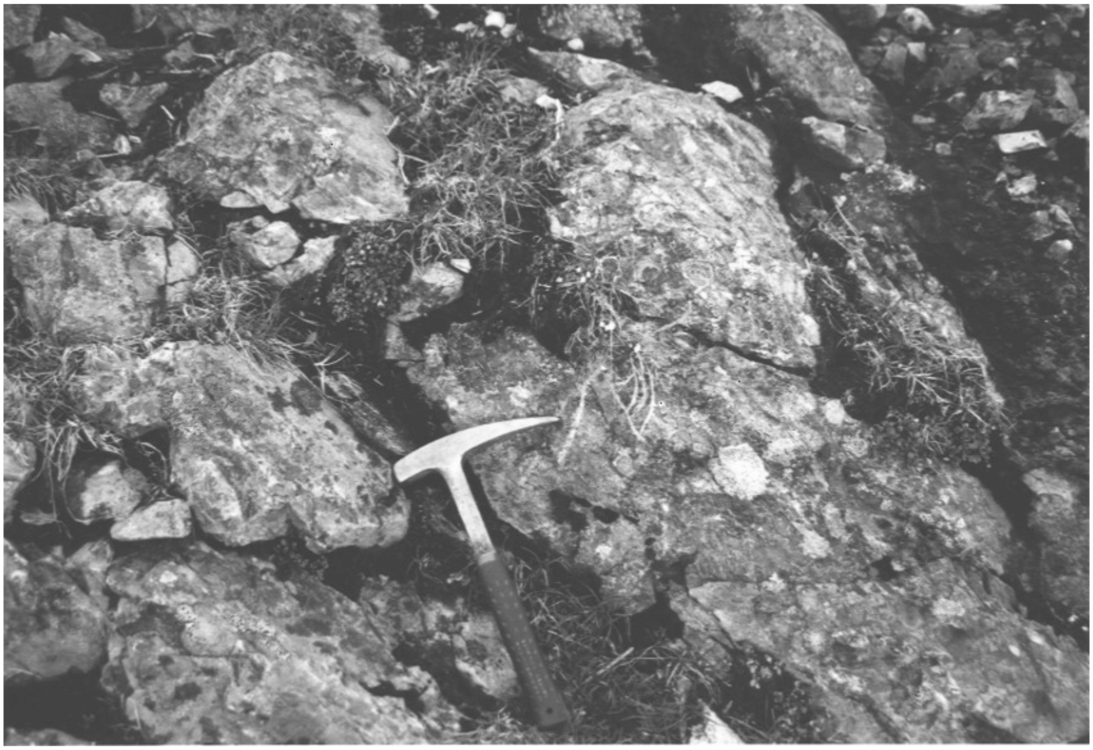

Photo 7. Red jasper within volcanic breccia at base of unit $lK_{TCV4.}$

conglomerate, mica-rich sandstone and shale. The conglomerates are matrix supported and dominated by mottled white-blue-green chert clasts. The chert clasts range from 1 cm up to 7 cm in diameter. Small well-rounded clasts of intermediate to felsic volcanics are rare. The conglomerate package is at least several metres thick, but true thickness is unknown as the top is not exposed.

Sandstones within the Beece Creek succession are characterized by light-grey-weathered, mica-rich, medium-grained beds up to several meters thick, commonly with scour marks. They are interbedded with a dark brown to black sandy shale. A few of the shale horizons host black tabular concretions up to a metre in length.

## Taylor Creek Group Correlations

Provenance studies to the east of the project area by Garver (1992) indicate that the lower formations, Paradise and Elbow Pass, of the Taylor Creek Group were derived from a volcanic source to the west. The formations described by Garver have components that are very similar to the units described in this paper. Up to 70% of the clasts found within the coarser sections of the Paradise formation are characterized by green-aphanitic, feldspar-porphyritic and siliceous volcanic rocks (Garver, 1992). Furthermore, a change from a more mafic and intermediate to a clearly andesitic source for the Paradise and Elbow Pass formations, respectively, may reflect a similar change in the project area as one travels up stratigraphic section.

Two U-Pb isotopic dates from intrusive rocks reported here suggest that the age of deposition for the Taylor Creek volcanic rocks in this study area is older than $104 \pm 4$ Ma, and a Taylor Creek volcanic rock within the eastern Waddington thrust belt to the northwest has yielded a U-Pb zircon date of 107 Ma (Albian; Mustard and van der Heyden, 1997). Fossils described by McLaren (1990) suggest that unit $LK_{TCV1}$ is as old as Hauterivian or Barremian. These dates are compatible with the Barremian to Albian range obtained by fission track dating of detrital zircons from the Paradise formation (Garver and Brandon, 1994).

Figure 5 is a schematic representation of the correlation between rocks found within the study area and rocks found at two localities within the main part of the Tyaughton basin to the east. The rocks found in the study area likely form the western margin of a volcanic sub-marine fan, in which the Paradise and Elbow Pass formations formed the more sediment dominated distal portions of the fan (Garver, 1992). As the basin filled from the west, uplift of the Bridge River complex within the basin to the east reached a sufficient height to initiate deposition of an easterly-derived chert-rich petrofacies, including the Dash formation, Silverquick conglomerate and Beece Creek succession (Garver, 1992; Schiarizza *et al*, 1997) (Figure 5). These chert-rich units are intercalated with arkosic rocks, found mainly in the Lizard formation, which were derived from a continental sediment source still farther east (Garver, 1992). The onset of extensive upper Cretaceous volcanism within the Tyaughton basin,

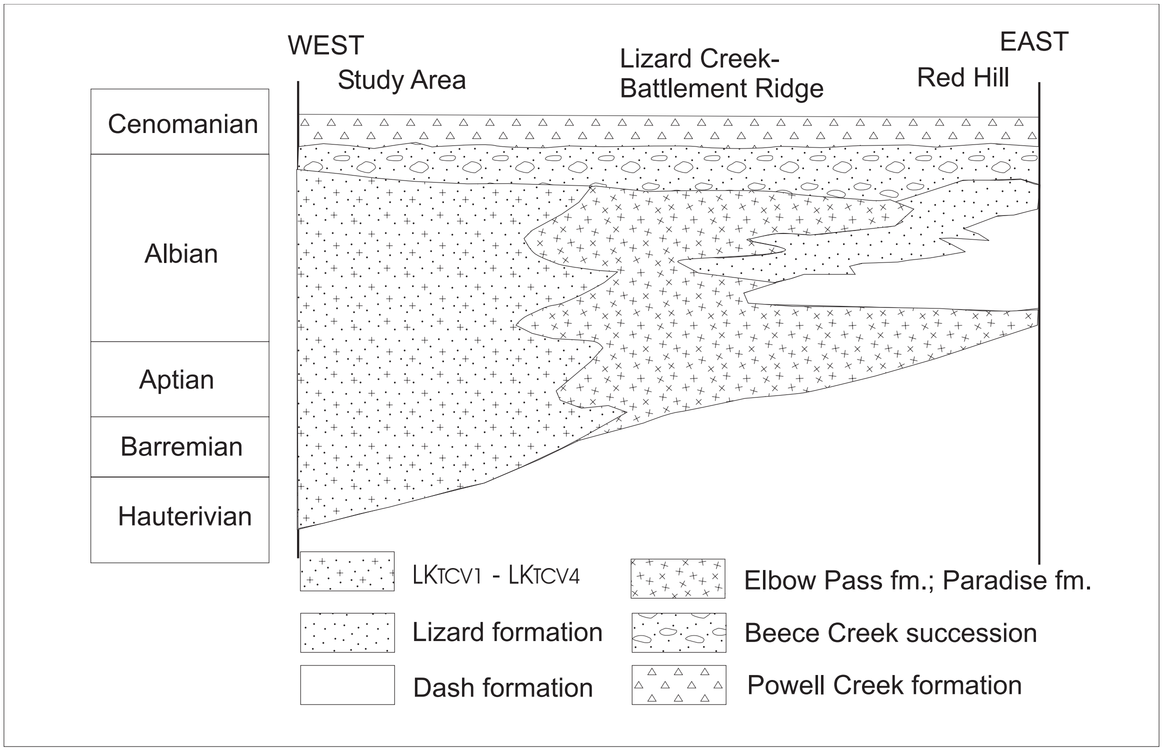


Figure 5. Schematic stratigraphic correlation between the study area, Lizard Creek/Battlement Ridge and Red Hill (after Garver, 1992 and Schiarizza *et al.* 1997).

represented by the Powell Creek formation, reflects an eastward migration of the Cretaceous Coast Belt arc with time (Schiarizza *et al*., 1997).

Garver's interpretation of a western volcanic domain as the source material for the lower formations of the Taylor Creek Group is essentially confirmed by this study. Rocks found within the project area have the right composition and apparently span the appropriate time range to be that domain. The ongoing isotopic and paleontologic work from the study area will help further constrain these ideas.

## Powell Creek Formation

An extensive belt of pyroclastic and volcaniclastic rocks crops out in the northwest corner of the map area, directly southwest of the Tchaikazan fault. These rocks were assigned to an unnamed Lower Cretaceous unit by Tipper (1978) and McLaren (1990), but are here correlated with the Upper Cretaceous Powell Creek formation (informal, Schiarizza *et al*., 1997), which overlies the Taylor Creek Group on the northeast side of the Tchaikazan fault, and also occurs as fault bounded lenses along the southwest side of the fault to the northwest of the present study area (Figure 2). This correlation is based on the markedly similar appearance of these rocks to known outcrops of the Powell Creek formation, and similar structural relationships to those shown by Rusmore and Woodsworth (1993) to the northwest, where the Taylor Creek Group is thrust over the Powell Creek formation along the south side of the Tchaikazan fault.

The Powell Creek formation within the study area occurs south of the Tchaikazan fault, just north of RCAF Peak, where it forms the footwall to several large-scale thrust faults which have Taylor Creek and Relay Mountain groups in their hanging walls. It is composed of massive to well-bedded pyroclastic and volcaniclastic rocks of a deep maroon to red colour. Bedded intervals can be as thick as 2 metres, whereas the massive portions are several tens of metres thick. A 20-metre-thick lahar is found on top of an unnamed ridge northeast of RCAF peak and assumed to be part of the Powell Creek formation. It locally has clasts of intermediate volcanic rock several metres in diameter.

## INTRUSIVE ROCKS

A large pluton of equigranular granodiorite to quartz diorite crops out extensively in the southern portion of the map area where it intrudes volcanic rocks of the Taylor Creek Group. A preliminary U-Pb zircon analysis from the intrusion at the Pellaire occurrence yielded an age of 104 Ma. Several titanite fractions are currently being selected for analysis to confirm the preliminary zircon data.

Diorite and quartz diorite occur as intrusions scattered throughout the central portion of the map area (McLaren, 1990). These consist of plagioclase and hornblende phenocrysts within a fine-grained matrix of the same material. Quartz is not common but was observed at some localities. Analysis of one of these plutons near Mount Pilkington yielded a conservative U-Pb zircon age of 104±4 Ma. Age similarities between the Pellaire and Mount Pilkington samples suggest a genetic link between the two igneous bodies.

McLaren (1990) mapped a distinctive group of white-weathering, biotite-feldspar porphyries that intrude sedimentary and volcanic rocks of the Taylor Creek Group and the Powell Creek formation. Most of these intrusions are found north of the Tchaikazan fault, with the exception of one that occurs at the southwest corner of Upper Taseko Lake. No geochronological work had been done on these rocks, but Tipper (1978) assigned them an Eocene age.

Dikes of several different compositions are found throughout the area. These include biotite-hornblende to hornblende-biotite-plagioclase porphyries, diabases, aplites and biotite-rich lamprophyres. Diabase, aplite and lamprophyre dikes are most common in the area east of the Tchaikazan River, whereas biotite-hornblende and hornblende-biotite-plagioclase porphyries are found mainly to the west of the river.

## STRUCTURE

The map area is extremely dissected by several generations of faults. One of the primary goals of the 1999 field season was to identify fault geometries and kinematics with the aim of unraveling the structural evolution of the study area. Interpretation of kinematically linked faults is on going and, in part, contingent upon isotopic dating (in progress).

The map area is characterized by undeformed panels of rock separated by either thrust/reverse faults or high-angle strike-slip faults. Open folding occurs within the panels but is not common. Metamorphic grade is low to non-existent and cleavage development is localized around high strain zones, near strike slip faults or folds.

Below we describe the fault geometries and kinematics mapped in the field area.

### Contractional Faults

Large north-northeast-verging reverse and thrust faults are located in the northwest portion of the map area. They have classic older-over-younger geometry, placing rocks of the Taylor Creek Group over Powell Creek formation. These faults are likely part of the eastern Waddington thrust belt and are interpreted as the oldest structures in the field area. This deformation event was also likely responsible for eastward tilting of most units and large northeast-verging folds within the Taylor Creek Group south of the Tchaikazan River.

Reverse faults at Pellaire deposit host a series of epithermal gold-silver-bearing quartz veins. These faults verge to the southeast and are tentatively interpreted as transfer structures between the Tchaikazan and Twin Creek faults during left-stepping dextral movement (Figure 3). This interpretation is contingent upon further structural analysis and isotopic dating. The reverse faults must be younger than the 104 Ma (U-Pb) granodiorite wall rock.

Several other contractional fault systems of limited extent are found within the field area and are likewise inferred to be linked to movement on the larger strike-slip faults. This is based on the geometry of the thrusts with respect to the strike-slip faults. They have varying vergence, from north to south.

### Strike-Slip Faults

The predominant northwest-trending lineaments in the field area are strike-slip faults. Large-scale dextral systems are the most obvious, however, less obvious and possibly older sinistral faults are common.

#### *Sinistral*

Sinistral faults with well-developed shear fabrics (Photo 8) are exposed in the southeast portion of the field area (Figure 3).

They are oriented at low-angles to the northwest-striking dextral faults. The strike lengths of the sinistral faults are typically less than one kilometer, and no easy correlation can be made for the faults across the large glacial valleys, suggesting that younger faults offset them.

The sinistral faults are relatively large structures, with the shear zones reaching up to 200 m in width. The shear zones consist of well-developed shear fabrics and associated smaller scale folds and fault arrays. Both brittle and ductile features are present within the fault zones. The absolute timing of these faults is not yet determined, although field relationships indicate that the sinistral faults offset relatively small, north-verging thrust faults. However, the age of these north-verging thrust faults is not yet known; they might be related the eastern Waddington thrust belt, but might be local structures that formed during dextral or sinistral strike-slip faulting. Recrystallized illite from the sinistral fault rock will be dated to constrain timing of deformation.

#### *Dextral*

Most of the obvious, continuous lineaments in the field area are interpreted as dextral strike-slip faults. The major strike-slip faults in the field area are the Tchaikazan fault and the Twin Creek fault (Figure 3). Dextral faulting post-dates contractional structures, as exemplified by offsetting relationships (Photo 9).

The Tchaikazan fault, with a strike length of close to 200 km (Figure 2), is the largest of the steeply-dipping faults. It cuts through the northeast corner of the field area with a northwest-southeast strike, although it is very poorly exposed. Mustard and van der Heyden (1994) suggest that the Tchaikazan fault to the west of the project area was the locus of 7 to 8 kilometers of dextral offset. This portion of the fault is inferred to be Eocene in age and


Photo 8. Sinistral shear fabrics from high strain zone, west of Falls River.

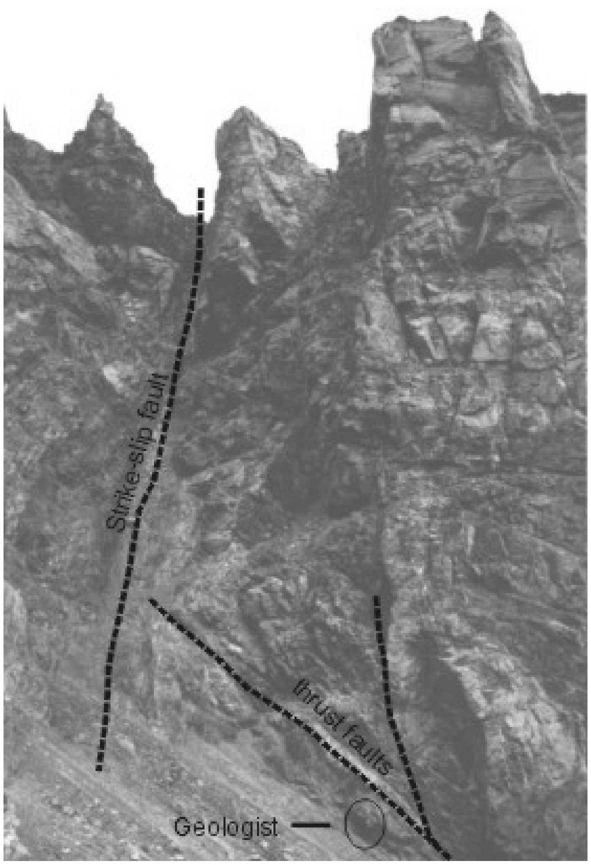


Photo 9. Southwest verging reverse faults crosscut by high angle, strike slip fault.

broadly coeval with the Yalakom fault system to the north (Umhoefer and Kleinsphen, 1995). Schiarizza *et al*. (1997) show the Tchaikazan fault to the southeast being truncated by the 92 Ma Dickson-McLure batholith, however, and suggest that the fault system had a long history of movement that may have included a Late Cretaceous sinistral component.

Within the project area the Tchaikazan fault is exposed near the shore of the Tchaikazan River as a semi-ductile zone within shale at least 300 m wide. Gently-plunging ($5^o$-$15^o$) fault groove lineations suggest strike-slip movement, and shear-sense indicators, such as sheared calcareous concretions, indicate dextral movement. The amount and timing of displacement, however, is poorly constrained in the field area.

The Twin Creek fault is located in the southern portion of the field area and extends the length of the mapped region, parallel to the Tchaikazan fault. Dextral movement on this fault is not proven, but is suspected, based partly on its association with mercury showings which elsewhere in the region are along dextral strike-slip faults of the Yalakom system (Schiarizza *et al*, 1997).

Numerous smaller scale structures are interpreted as transfer structures between the Tchaikazan and Twin Creek faults. The reverse and strike slip faults exposed at the Pellaire deposit are interpreted as components to a Reidel geometry. Interpretation assumes left-stepping movement from the Tchaikazan to the Twin Creek fault, setting up a zone of compression where the reverse faults were formed. Ar-Ar dating of syn-tectonic illite associated with the Pellaire thrust faults will place constraints on the timing of deformation of this system. If the structures at the Pellaire occurrence are Eocene and are related to the Tchaikazan, at least a part of the dextral movement along the Tchaikazan must also be Eocene in age.

### Extension Faults

Small extensional faults of varying strike occur within the field area, and larger northeast-striking normal faults were mapped by McLaren (1990) to the west of the field area. The smaller normal faults have limited strike length and have little offset associated with them. These are interpreted as accommodation structures related to strike-slip faulting.

Sinistral faults found on either side of the Falls River show apparent dextral offset across a fault that may run through the valley (Figure 3). The actual displacement vector along this fault is unknown, but down-to-the-south displacement with a slight dextral component could account for both the apparent dextral offset and the down-dropping of the jasper rich unit of $lK_{TCv4}$.

## MINERALIZATION

Several mineral occurrences occur within the map area (Figure 3), including copper porphyries and epithermal to mesothermal Au-Ag-bearing quartz veins. The occurrences most actively explored by JAG include Pellaire vein system, Chita Cu-porphyry and Northwest Copper Cu-porphyry. Discussion here is restricted to Pellaire and Northwest Copper.

### Pellaire Gold and Silver Bearing Quartz veins (MINFILE 092O 045)

Exploration in the 1930's led to the discovery of gold and silver-bearing veins at Pellaire and subsequent underground exploration. Exploration was initiated again in the late 1980's, leading to further underground work (McLaren, 1990). International Jaguar Equities acquired the property in 1996 and began extensive underground and surface exploration, followed by extraction of a 2000 tonne bulk sample of high-grade ore (34.2 grams per tonne gold and 102.9 grams per tonne silver) from the No. 4 and No. 5 veins (MINFILE 092O 045 report). In 1998 JAG initiated further underground exploration which led to a 10 000 tonne bulk sampling project in 1999.

The Pellaire occurrence is situated near the southeastern corner of the field area at the northern margin of the large granodiorite pluton that occupies the southern part of the map area. It consists of several epithermal to mesothermal, gold-silver bearing quartz veins. The quartz veins are found along steeply dipping, southeast verging reverse faults, that juxtaposes rocks of the Taylor Creek Group against the granodiorite. Extreme sericitic alteration of both the Taylor Creek Group and adjacent granodiorite occurs around the veins and is likely related to vein formation rather than to the intrusion. The faults are found within both units but quartz veins occur only within the granodiorite. Veins attain widths range from 0.3 to 7.5 meters, have sheared margins, and are interpreted as having formed during thrusting. Mafic dikes are found throughout the property and are found to both crosscut and be cut by the veins. Where the dikes crosscut the veins, grade generally increases and rare sulphide mineralization in the form of chalcopyrite occurs. Areas such as the joining of two veins or where the veins change dip are also sites of increased grade.

The veins are post-104 Ma, as indicated by the U-Pb date of the granodiorite. The brittle nature of the structures and the veins suggest they were formed well after the crystallization age of the pluton. The orientation of the thrust faults that host the veins is significantly different than the majority of structures in the project area. As previously described these thrust faults are interpreted as step-over structures related to large strike-slip faults. However, southeast of the field area, mesothermal veins of the Bralorne system are hosted in similar structures that formed late within the major southeastern Coast Belt contractional event (Schiarizza *et al*., 1997). The possibility that the Pellaire veins are also related to this event cannot be ruled out at this time. Isotopic ages from the Pellaire veins are forthcoming and will place timing constraints on mineralization.

### Northwest Copper (MINFILE 092O 043)

The presence of the Charlie Cu-Mo-Au prospect (MINFILE 092O 043) found in the Tchaikazan valley south of RCAF Peak led to exploration programs concentrating on the surrounding area. JAG undertook exploration of the area in 1998 based on several copper showings identified by McLaren (1990). The exploration program of 1998 identified a mineralized area of at least 8 square kilometers, which was identified as the Northwest Charlie occurrence and later as Northwest Copper (NWC).

**TABLE 1**
**SELECTED ASSAY RESULTS FROM MAJOR SHOWINGS AT NORTHWEST COPPER**
**(COURTESY OF JAGUAR EQUITIES)**

| Showing Name | Au ppb | Ag ppm | Cu ppm |
|---|---|---|---|
| D&O | 20 | 71.2 | 13200 |
| D&O | 10 | 41 | 4920 |
| Chikapow | <5 | 13.4 | 21100 |
| Chikapow | <5 | 3.8 | 8080 |
| Crater | <5 | 7.2 | 15800 |
| Crater | <5 | 1 | 3960 |
| Far Side | 35 | 110 | 9310 |
| Far Side | 80 | 234 | 18000 |
| Far Side | <5 | 17.8 | 88100 |
| Leach Cap | 10 | 1.2 | 13600 |
| Leach Cap | <5 | <0.2 | 320 |
| Leach Cap | 90 | 211 | 44400 |
| S.Acid Leach | 145 | 90.4 | 20800 |
| S.Acid Leach | 95 | 125 | 19100 |

Subsequent geophysical exploration conducted in the spring of 1999 confirmed a large geophysical anomaly in the area. Several showings within the NWC property were discovered during the field program of 1999. The largest of these include Leach Cap, D and O, Far Side, South Acid Leach, Crater and Chikapow (Table 1).

These showings are all characterized by malachite and azurite with minor native copper (locally found in seams up to 2 cm thick) and chalcopyrite found along fracture planes, associated with quartz-epidote veins. The showings cover and area of roughly 8 square kilometers, with the individual showings only marginally defined.

The Leach Cap is characterized by advanced argillic alteration found in fine-grained tuffs. Drilling in the summer of 1999 has shown that hornblende porphyry intrusive rocks exhibit propylitic (epidote, chlorite, and sericite) alteration in the vicinity of the leach zone. General sequence of alteration seems to be hydrothermal alteration (fracture-controlled quartz-carbonate, chlorite) to argillic to advanced/extreme argillic (kaolinite) alteration as one approaches the leach zone (Andrew Smith, personal communication, 1999). There is abundant iron within the system in the form of hematite, which is found ubiquitously within the volcanic rocks of the Powell Creek formation and may indicate a low sulphur system. This characteristic is confirmed by the lack of pyrite and may also be responsible for the absence of gold mineralization. There is associated silicification in the area around the leach cap, but is likely part of quartz-sericite alteration found within the vertical structures (example the D and O and the south acid leach showings) (Andrew Smith, personal communication, 1999).

Mineralization is thought to be structurally controlled. Mineralized hornblende-porphyry dikes are located in the middle of steeply-dipping shear zones thought to reach a source pluton beneath the Powell Creek formation. The Tchaikazan fault sharply bounds NWC to the northeast, and likely offsets it. Structures splaying off the Tchaikazan may have provided weak areas for intrusion of the dikes.

## SUMMARY

The oldest rocks in the map area, Hauterivian shale and sandstone assigned to the Relay Mountain Group, are restricted to a small lens bounded by south-dipping thrust faults. Most of the area is underlain by volcanic, volcaniclastic and associated sedimentary rocks assigned to the Taylor Creek Group. These have been subdivided into four distinct lithologic units. Present constraints suggest they range from Hauterivian-Barremian to Albian age (McLaren, 1990), but paleontologic and isotopic dating in progress may provide tighter constraints on some of the units. Small exposures of conglomerate, sandstone and shale on the northeast side of the Tchaikazan fault are also assigned to the Taylor Creek Group, and correlated with the Albian-Cenomanian Beece Creek succession of Schiarizza *et al.* (1997). An extensive panel of non-marine volcanic and volcaniclastic rocks directly southeast of the Tchaikazan fault, previously assigned to the Lower Cretaceous, is here correlated with the Upper Cretaceous Powell Creek formation, based on lithologic similarity and structural position.

The first deformation event in the area is interpreted as the northeast-directed contraction associated with the eastern Waddington thrust belt. Discontinuous, but well-developed sinistral shear zones crosscut north-verging thrust faults that may be related to eastern Waddington structures. Absolute timing of sinistral movement is not yet known, but likely occurred before dextral movement in the Eocene. Isotopic dating will place constraints on the timing of sinistral movement. The importance of sinistral faulting is not yet known, however, their well-developed shear fabrics and shear zone thickness suggest that these faults accommodated significant displacement. Dextral strike-slip faulting, responsible for the prominent lineaments in the area, is thought to represent the last deformation event. Numerous small-scale thrust faults, normal faults and strike-slip faults are interpreted to have formed during transfer of displacement between the regional dextral strike-slip faults.

Porphyry-style copper mineralization is hosted in rocks of both the Taylor Creek Group and Powell Creek formation associated with hornblende-porphyry intrusions of an unknown age. Epithermal-style gold-silver veins are found along reverse faults within granodiorite of the Coast Plutonic Complex. The faults (and associated mineralization) are suspected to be Eocene in age, an interpretation that will be tested by isotopic dating.

## FUTURE WORK

Future efforts will focus on the elucidation of the kinematics and timing of deformation. This requires a more thorough structural analysis and more detailed analyses of fault geometries and kinematics. Both Ar-Ar and U-Pb geochronology will be used to date fabrics within shear zones and to date plutons. Illite from the Pellaire veins and zircon or hornblende from syn-mineralization dikes from NWC will constrain ages of mineralization at each property.

A more robust stratigraphic column will be constructed based on future isotopic dates and fossil identification.

## ACKNOWLDGEMENTS

Steve Israel would like to thank: Danny Lilly, Chris Roach and Adrian Garner for excellent assistance in the field; Andrew Smith and Bernie Gaboury for support both in and out of the field. We are grateful to International Jaguar Equities and NWC Exploration Inc. for funding the project. In particular we would like to thank Paul Schiarizza for his endless patience with questions and discussions on the regional geology and taking time to visit the field area. We also thank Paul Umhoefer of Northern Arizona University for sharing his knowledge and ideas of the regional geology. Finally Graeme McLaren for his helpful discussion on the local geology. Project funded by International Jaguar Equities, NWC Exploration Inc. and Collaborative Research and Development Grant (CRD) to Lori Kennedy. We thank Dave Lefebure for helpful editorial comments on an earlier version of the manuscript and Janet Holland for formatting the final version.

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