THE FAWNIE RANGE PROJECT – GEOLOGY OF THE NATALKUZ LAKE MAP AREA (93F/6)

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(Contribution to the Interior Plateau Program
Canada – British Columbia Mineral Development Agreement 1991-1995)

KEYWORDS: Regional geology, Fawnie Range, Natalkuz Lake, stratigraphy, Capoose batholith, Capoose Au-Ag deposit.

INTRODUCTION

The Fawnie Range mapping project began in 1992 and is a component of the Interior Plateau program, a new multi-disciplinary study in the Interior Plateau physiographic region. The program is funded through the Canada-British Columbia Mineral Development Agreement (MDA) 1991-1995. The Interior Plateau program involves cooperative field investigations and research by geoscientists from the Geological Survey of Canada and the British Columbia Geological Survey (Diakow and van der Heyden; 1993, this volume).

The new Fawnie Range project is aimed at better understanding the stratigraphic and structural development of Mesozoic and Cenozoic volcanic sequences and assessing the geological controls of mineral deposits in the northern Interior Plateau.

Regional mapping at 1:50 000 scale, and at 1:20 000 scale in parts of the Fawnie Range, was completed in Natalkuz Lake map area in 1992 (Figure 1-5-1). Much of the area is dominated by low rounded hills covered by forest and mantled by extensive glacial deposits. Except for semi-continuous exposure in the Fawnie Range, outcrops tend to be widely separated and confined to the crests of hills and the shoreline of the Nechako Reservoir (Natalkuz Lake, Knewstubb Lake, Euchu Reach).

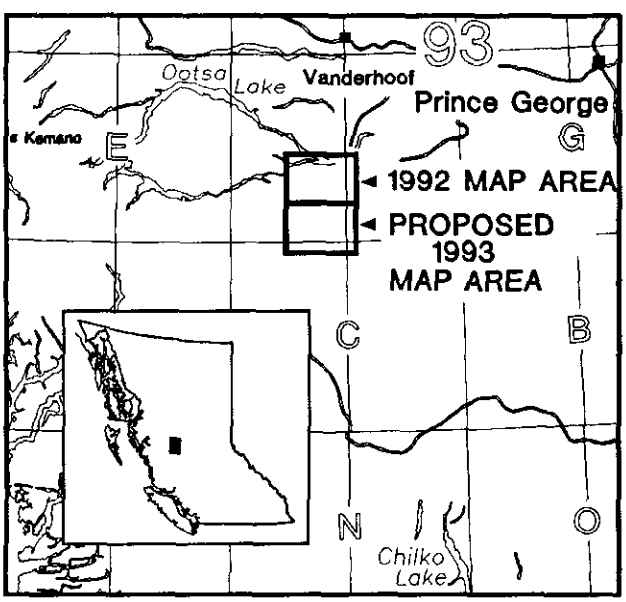

Figure 1-5-1. Location of Natalkuz Lake map area (93/F6) and proposed 1993 map area (93/F3).

ACCESS

A well-maintained network of logging roads connects the northeast corner of the map area with Vanderhoof, approximately 110 kilometres to the north-northeast. These roads, and the Nechako Reservoir which transects the northern part of the map area, provide good access to mainly Tertiary rock sequences. The oldest rock units crop out primarily southeast of the Nechako Reservoir in the Fawnie Range. This area is best reached by helicopter, although a barely passable four-wheel-drive road connects the southern segment of Fawnie Range and the Capoose prospect with an all-weather logging road. The drive to the Capoose prospect from Vanderhoof via the Kluskus-Ootsa Forest Service road is about 160 kilometres.

GENERAL GEOLOGY

Early geological investigations in the Natalkuz Lake map area formed part of a systematic regional mapping program conducted in the Nechako River area (93F) during the late 1940s to early 1950s and later synthesized in a Geological Survey of Canada memoir (Tipper, 1963). Refinement of stratigraphic rock units and their distribution in the Natalkuz Lake map area as determined in this study are shown in Figure 1-5-2.

The eastern and southeastern parts of the map area are underlain mainly by andesitic flows that are part of the lowest stratigraphic unit (Jv,s). Thin interflow sediments, we believe are well up-section in this unit, contain tentatively identified early Middle Jurassic fauna and suggest a possible correlation with the Early and Middle Jurassic Hazelton Group. Along the east-facing slope of the Fawnie Range these flows apparently constitute the base of a thin sequence of fine clastic sediments containing Callovian fauna which suggests a time-stratigraphic association with the Ashman Formation of the Bowser Lake Group. In turn the sedimentary unit passes up-section into a conformable package of andesitic fragmental rocks and minor interspersed flows. Although the age of these volcanic astic rocks is uncertain, they may represent a previously unrecognized, spacially restricted volcanic unit of presumable Middle to Late Jurassic age. Collectively, layered rocks south of Natalkuz Lake that form the backbone of the Fawnie Range

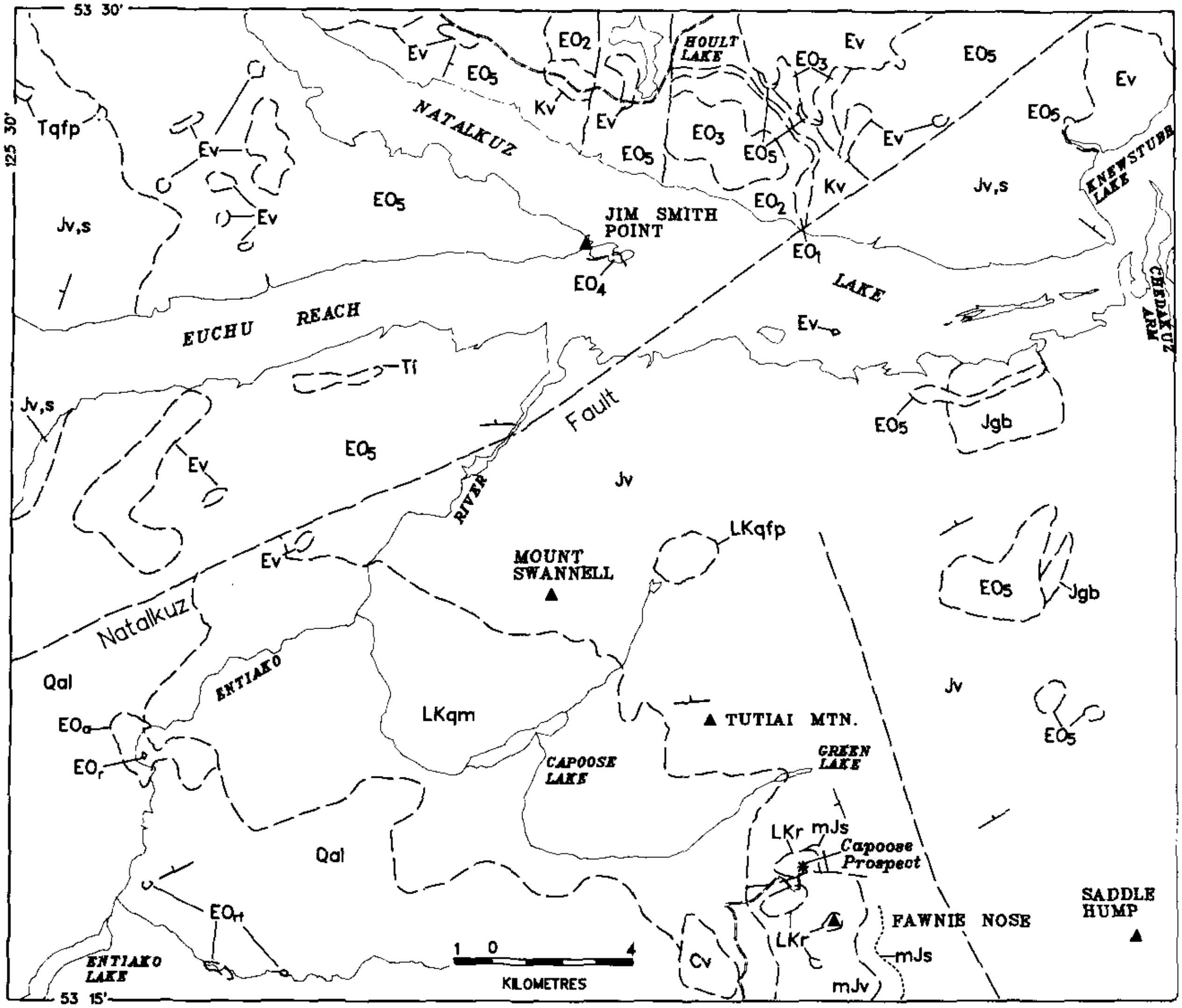

Figure 1-5-2. Distribution of rock units in the Natalkuz Lake map area as determined in this year's study.

are intruded and thermally altered by the latest Cretaceous Capoose batholith.

The Natalkuz fault, a regional northeast-trending extensional structure places pre-Tertiary successions and the Capoose batholith against predominantly volcanic rocks of the Eocene Ootsa Lake Group which underlies the west-northwest part of the map area. Basaltic flows of the Endako Group nonconformably overlie the Ootsa Lake Group. Basement for these Tertiary units is represented by generally small exposures of the Hazelton Group, hornblende-bearing pyroclastic deposits of the Upper Cretaceous Kasalka Group and one occurrence of Albian tuffaceous sediments.

The youngest rocks in the map area are fresh olivine tholeiite flows assigned to the Miocene and younger Chilcotin Group. A solitary erosional remnant of these flows rests nonconformably on the Capoose batholith along the southern margin of the map area.

STRATIGRAPHY

Jurassic Volcanic and Sedimentary Rocks (Unit Jv,s)

Unit Jv,s is particularly well exposed along the axis of the Fawnie Range south of Natalkuz Lake. The Late Cretaceous Capoose batholith intrudes and alters rocks of Unit Jv,s in a broad area of near continuous outcrop at Mount Swannell and Tutiai Mountain. Immediately east of the Fawnie Range numerous scattered outcrops are restricted to the crests of knolls. Adjacent to the narrow waterway connecting Natalkuz and Knewstubb lakes thick glacial cover limits exposure to a few, widely spaced low hills. Neither the top nor the bottom of the unit is recognized in the map area. Its total thickness is difficult to ascertain; however, part of a homoclinal section at Tutiai Mountain is at least 1 kilometre thick. The most representative section of relatively unaltered lava flows and associated volcaniclastic rocks, about 350 metres thick, is exposed immediately west of

LEGEND

CENOZOIC
QUATERNARY

Qal	*Area of thick glacial deposits.*

TERTIARY AND YOUNGER
Miocene to Pliestocene
CHILCOTIN GROUP

Cv	*Olivine basalt; dark grey; aphanitic or olivine-phyric; massive, columnar jointed or flow layered.*

TERTIARY
Late Eocene to Oligocene
ENDAKO GROUP

Ev	*Basalt; black to dark grey-brown; pyroxene -phyric; massive to columnar jointed; rare flow breccia; locally vesicular or amygdaloidal.*

Early to Middle Eocene
OOTSA LAKE GROUP

EOrt	*Lapilli - crystal tuff; medium buff-grey; phenocrysts of quartz up to 30% by volume; angular lithic fragments, 3 to 5 mm; moderately consolidated ash groundmass.*
EOr	*Rhyolite flows; light grey, quartz and feldspar-phyric; quartz phenocrysts up to 25% by volume.*
EOa	*Andesite flows; maroon; feldspar-phyric; trachytic; interlayered finely laminated flows and flow breccias.*
EO$_5$	*Rhyolite flows and tuffs; white, cream pink; massive to laminated; aphanitic to porphyritic; feldspar, quartz, and biotite-phyric; spherulitic; locally contains pitchstone layers.*
EO$_4$	*Dacite flows; light pink to grey; porphyritic; feldspar and biotite-phyric.*
EO$_3$	*Dacite flows; light blue-grey; sparsely porphyritic; feldspar and biotite-phyric; weathering along flow surfaces imparts platy jointing in outcrops.*
EO$_2$	*Coarse feldspar andesite flows; dark grey to green; feldspar-phyric; phenocrysts up to 1cm long.*
EO$_1$	*Amygdaloidal andesite; dark grey; amygdaloidal and massive; aphyric; amygdules filled with silica, calcite and epidote.*

MESOZOIC
CRETACEOUS
Late Cretaceous

LKr	*Rhyolite sills, dikes, flows and tuffs; white, cream and pink; massive to laminated flows and sills; thickly to thinly bedded ash, crystal and crystal - lapilli tuffs; finely-crystalline red and brown garnet occurs in sills and flows.*
Kv	*Andesite flows and tuffs; grey-green to purple; crystal, lapilli and block tuffs; clasts and groundmass are feldspar and hornblende-phyric.*

JURASSIC
Middle Jurassic (?)

mJv	*Andesite to dacite(?) crystal, lapilli and block tuffs; dark greyish-green, green and maroon; lapilli tuff locally with interbedded crystal and ash tuffs and minor sediments; clasts are feldspar-phyric andesite.*

Middle Jurassic
BOWSER LAKE GROUP
ASHMAN FORMATION

mJs	*Interbedded argillite and siltstone, minor greywacke; dark grey to black; thinly-bedded to massive; locally fossiliferous.*

Early to Middle Jurassic
HAZELTON GROUP

Jv,s	*Feldspar-augite-phyric andeste flows and lessor fragmental deposits; minor interlayered arkosic sediments; flows are dark grey to greenish-grey; massive or amygdaloidal; crowded feldspar texture; interbedded sediments include arkosic sandstone and siltstone; sediments are locally fossiliferous.*

INTRUSIVE ROCKS

CENOZOIC
TERTIARY

Ti	*Dacite subvolcanic intrusion; light grey, quartz and feldspar phyric, biotite and hornblende as accessories.*
Tqfp	*Quartz - feldspar porphyry; light grey to cream; quartz and feldspar-phyric;forms small stocks or dikes.*

MESOZOIC
CRETACEOUS
Late Cretaceous
CAPOOSE LAKE BATHOLITH

LKqm	*Quartz monzonite to granodiorite; pinkish grey, coarsely crystalline, feldspar megacrystic, biotite and hornblende as accessories.*
LKqfp	*Quartz - feldspar porphyry; grey to cream; quartz and feldspar-phyric; phenocrysts 1 to 3mm; euhedral; up to 20% by volume quartz.*

JURASSIC (?)

Jgb	*Gabbro; grey to dark green, fine to medium-grained, salt-and-pepper texture; massive; contains phenocrysts of feldspar, pyroxene and olivine.*

SYMBOLS

Geological boundary (approximate, assumed)

Fault (approximate, assumed)

Bedding, tops known

Road

Saddle Hump. This section can be reached on foot from the Top Lake Forest Service campsite 3.5 kilometres to the south.

A secondary assemblage of epidote-quartz-chlorite is ubiquitous and a significant feature that distinguishes this unit from younger, comparatively unaltered rock sequences in the map area. This assemblage of alteration minerals generally lines fractures, and less commonly occurs as irregular clots in the lavas. Microscopically, calcite and sericite, with or without epidote, incipiently alter plagioclase phenocrysts. This is often accompanied by chlorite and granular opaques which selectively replace ferromagnesian phenocrysts and the matrix.

Unit Jv is made up predominantly of lava flows. Fragmental deposits are prominent locally, but regionally they are minor and occur as comparatively thin beds that interfinger with the lava flows. Rare interflow sedimentary rocks also occur sporadically throughout the unit.

Lava flows of Unit Jv are remarkably uniform in composition and texture. They are typical andesites with porphyritic and amygdaloidal textures, and contain plagioclase and relatively fresh pyroxene phenocrysts set in a dark green or maroon groundmass. Plagioclase phenocrysts typically vary from 1 to 3 millimetres in length and comprise between 15 and 35 volume per cent of the rock. The common occurrence of vitreous augite phenocrysts (1 to 5% by volume) is a diagnostic feature of these flows. Augite occurs in glomerocrysts with plagioclase and as microphenocrysts throughout the groundmass. Rare relict outlines of olivine grains may be present. The appearance of amygdules is variable in the porphyritic lavas from few volume per cent to 30 volume per cent of the rock. The amygdules are typically round and filled with chlorite, epidote and quartz. Hematite-rich breccia with calcite-filled interstices forms discontinous layers up to 1 metre thick on some flows. At one locality a lens of grey limestone about 50 centimetres thick is exposed at the top of an amygdaloidal flow.

Fragmental deposits comprised of monolithic lapilli and blocks interleave the lava flows. The best continuous exposure of these deposits is immediately southwest of Chedakuz Arm on Knewstubb Lake. The fragments have a similar texture and bulk composition to the porphyritic andesite flows.

Porphyritic andesites are interlayered with dark green to black basaltic andesite flows in the volcanic section immediately west of Saddle Hump. Distinguished by a dense, fine granular aphyric texture, these rocks form largely structureless flows as much as 75 metres thick that weather to a smooth, orange-hued surface. In several places they contain resistant laminae that protrude from the weathered surface (Plate 1-5-1). Olivine microphenocrysts comprise up to 3 volume per cent and minute augite grains occupy interstices between the plagioclase microlites.

Interflow pyroclastic units are difficult to recognize in the hydrothermally altered and hornfelsed section adjacent to the Capoose batholith at Mount Swannell. Elsewhere, the fragmental rocks tend to be areally restricted in rather massive featureless sections less than 50 metres thick. In the area of the reference section immediately west of Saddle Hump, an apparently minor fault juxtaposes a sequence of lavas and lapilli tuffs. The tuffs contain subangular maroon and mauve porphyritic and aphyric pyroclasts in an ash matrix charged with plagioclase crystal fragments. A superb bedded outcrop about 75 metres long on the north shore of Natalkuz Lake exposes variegated maroon to green fragmental rocks. Lapilli tuff forms several thick beds that alternate with thinner, well-laminated ash-tuff beds, some of which contain accretionary lapilli (Plate 1-5-2). The lapilli comprise a heterolithic mixture of crowded porphyritic andesite, flow-laminated rhyolite, porphyritic dacite and aphyric siliceous fragments. A similar section of variegated tuffs interleaved with sparsely fossiliferous waterlain ash tuff crops out in road cuts in the extreme northwest corner of the map area.

Sedimentary rocks (Unit Js) directly underlie porphyritic andesite lavas at several widely spaced exposures immediately north of Natalkuz Lake. The best outcrop is on the point that projects southward into the narrow waterway connecting Natalkuz and Knewstubb lakes. At this location a well-bedded sedimentary section about 75 metres thick is abruptly and conformably overlain by coarse augite-bearing porphyritic andesite flows and associated fragmental rocks. The sedimentary rocks consist mainly of drab, olive-green arkosic sandstone and siltstone, and black mudstone. The arkosic sandstone is composed of well-sorted subangular grains of plagioclase, augite and lithic clasts. The detritus is

Plate 1-5-1. Fine-grained basaltic andesites of Unit Jv sometimes display protruding laminae on weathered surfaces.

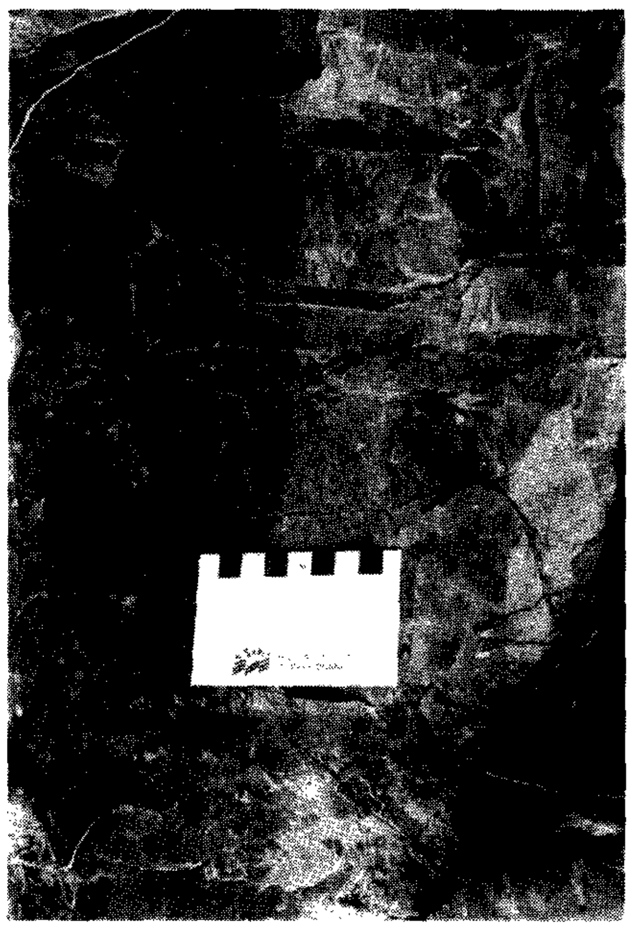

Plate 1-5-2. Accretionary lapilli in ash tuffs of Unit Jv.

undoubtedly derived from a local volcanic source, presumably from nearby augite-bearing porphyritic andesite flows. Concretions generally less than 10 centimetres in diameter on rare occasions reach 0.5 metre in diameter. The concretions are weakly calcareous and as a consequence weather recessively in the fine clastic beds. Conglomeratic sandstone with well-rounded siliceous (chert?) pebbles is exposed near the base of the section. A collection of pelecypod fossils, including *Trigonia* and scarce belemnites resembles some early Bajocian fauna (T.P. Poulton, personal communication, 1992). Moreover, the arkosic sedimentary beds replete with fossils resemble deposits of the Smithers Formation which crop out extensively 100 kilometres to the west, in the Whitesail Lake map area.

MIDDLE TO LATE(?) JURASSIC ROCKS

In the Fawnie Range, between Fawnie Nose and Green Lake a west-southwest-dipping monoclinal succession of sedimentary strata passes stratigraphically up-section into predominantly fragmental volcanic rocks that have been cut by a variety of felsic hypabyssal intrusions and also thermally metamorphosed by the nearby Capoose batholith. Topographically lower, and presumably comprising the stratigraphic base of this succession, are volcanic rocks tentatively assigned to Unit Jv. Near the midpoint of the ridge, an east-trending normal fault offsets the layered succession and in the uplifted northern block exposes a basal section about a kilometre thick. The stratigraphically lowest rock is a maroon and green block-lapilli tuff. The fragments are subangular to subrounded, monolithic and contain up to 40 volume per cent of feldspar phenocrysts. Up-section feldspar-phyric maroon and green crystal-lapilli tuff interlayered with amygdaloidal flows predominates. At the Capoose prospect a succession of sedimentary rocks overlies the flows and tuffs with slight angular unconformity.

SEDIMENTARY ROCKS (UNIT mJs)

Sedimentary rocks crop out discontinuously from the Capoose prospect in the north to Fawnie Dome in the south. At the Capoose prospect sediments weather recessively in a section 120 metres thick and composed of interbedded argillite and tuffaceous siltstone (Tipper, 1963). To the south, lithologically similar rocks are exposed 0.6 and 1.4 kilometres east and southeast of Fawnie Nose. At these locations the section is over 300 metres thick and consists of alternating argillite and siltstone layers 1 to 2 centimetres thick with conspicuous massive interbeds of greywacke. A layer of black chert-pebble conglomerate less than 10 metres thick occurs locally near the top of the sedimentary sequence. The conglomerate contains subrounded quartz, chert, argillite and tuffaceous clasts up to 1.5 centimetres in diameter, supported by a fine-grained, dark grey matrix.

Fossil collections from sedimentary sections in the south as well as in the northern section include ammonites, bivalves and belemnites. The age of the sedimentary rocks near Fawnie Nose, as inferred from preliminary examination of the fossils, is tentatively Middle Jurassic, probably Bathonian or Callovian (T.P. Poulton, personal communication, 1992). This corresponds with the Callovian age for fossils identified in the sediments from the northern locality (Tipper, 1963). This sedimentary unit is probably correlative with the Ashman Formation of the Bowser Lake Group as the ages and lithologic characteristics are broadly similar.

VOLCANIC ROCKS (UNIT mJv)

In the Fawnie Nose area the sediments of Unit mJs are overlain with slight angular unconformity by approximately 600 metres of crowded feldspar crystal tuff, crystal-lapilli tuff and local accumulations of maroon and green block-lapilli tuff. The stratigraphically highest member of the unit is crystal-lapilli tuff with distinctive chloritic fiammé (Plate 1-5-3), that crops out for 1.5 kilometres along the ridge crest between Fawnie Nose and the Capoose prospect.

Hornfels alteration, caused by emplacement of the Capoose batholith, is extensive in the volcanic section exposed between Fawnie Nose and the Capoose prospect. The effects of the intrusion are indicated by the increased hardness of the rocks and accompanying destruction of primary volcanic textures to form massive and crudely bedded units in which the fragmental texture is totally obliterated or only faintly revealed on the weathered surface. Veinlets and clots of epidote and chlorite are ubiquitous throughout the section. The age of Unit mJv is loosely bracketed by underlying Callovian sedimentary strata of Unit mJs and a Maastrichtian date obtained from the Capoose batholith (Andrew, 1988).

CRETACEOUS VOLCANIC ROCKS (UNIT Kv)

Volcanic rocks of tentative Late Cretaceous age crop out mainly in the vicinity of Hoult Lake and extend as scattered outcrops in a belt trending southeastward towards Natalkuz Lake. Several representative exposures of Unit Kv, one of which was sampled for U-Pb and K-Ar geochronometry, crop out adjacent to the road along the south shore of Hoult Lake.

The volcanic rocks comprise a structureless mass of block-lapilli tuff. The pyroclasts are characteristically monolithic, grey-green or purple hornblende-phyric andesite that are up to 15 centimetres in diameter. Plagioclase crystals between 1 and 3 millimetres long comprise up to 35 volume per cent and hornblende as long as 4 millimetres accounts for up to 5 volume per cent of the rock. Despite the presence of quartz-epidote veinlets cutting the tuffs and incipient replacement of plagioclase by epidote, the hornblende in many sections is remarkably fresh.

RHYOLITE (UNIT LKr)

Rocks of Units Jv,s, mJs and mJv, which underlie the ridge between Green Lake and Fawnie Nose are intruded by numerous rhyolitic dikes and sills (*see* Intrusive Rocks) and overlain by rhyolitic flows and tuffs. A Late Cretaceous age has been determined for the rhyolitic intrusions exposed at the Capoose prospect (Andrew, 1988).

Rhyolite flows and tuffs: South of the Capoose property rhyolite flows and tuffs overlie volcanic rocks of Unit mJv with apparent angular unconformity. The flows are white to light grey, finely laminated or brecciated and vary in texture from aphanitic to sparsely porphyritic. Quartz and feldspar

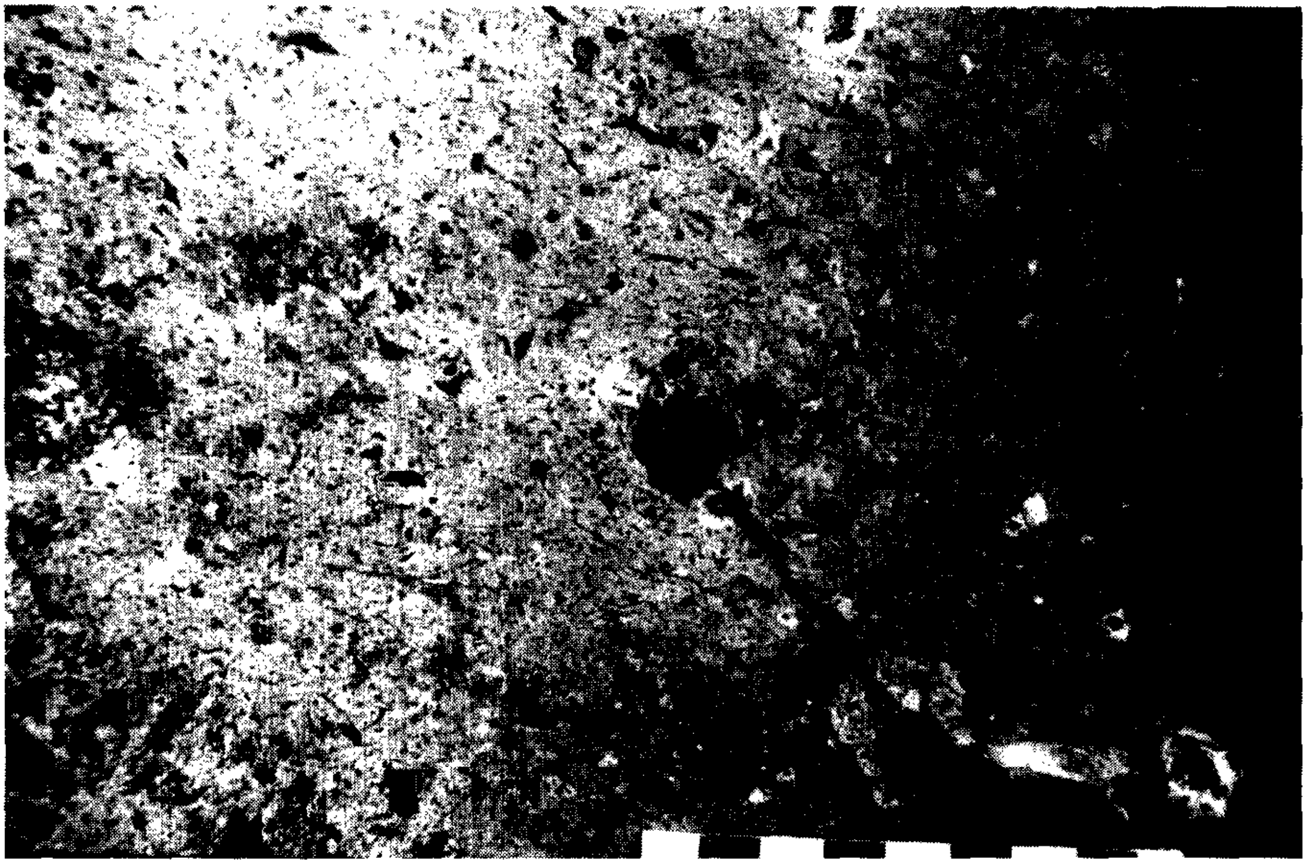

Plate 1-5-3. Chloritic fiammé are a distinctive feature in crystal-lapilli tuffs of Unit mJv.

phenocrysts, less than 1 millimetre in diameter, and finely crystalline brown garnet occur in the flows in concentrations of less than 5 per cent by volume.

Light grey to pink rhyolite ash, crystal and crystal-lapilli tuffs are interlayered with the flows. The tuffs are thickly to thinly bedded. The ash tuffs are very fine grained and appear cherty in outcrop. Crystal and crystal-lapilli tuffs contain euhedral to fragmented quartz (up to 30% by volume) and feldspar (<5% by volume) phenocrysts from 1 to 3 millimetres in diameter. Lithic fragments, 0.4 to 1.5 centimetres across, are predominantly angular, aphanitic, siliceous volcanic rocks.

Eocene Ootsa Lake Group

The Ootsa Lake Group is the name applied to a succession of continental calcalkaline basaltic to rhyolitic volcanic rocks of Eocene age (50.0 Ma) exposed in the Whitesail Range and Whitesail Reach areas (Duffell, 1959; Diakow and Mihalynuk, 1987a, b). Ootsa Lake Group volcanic rocks in the Natalkuz Lake area are confined, for the most part, to the northwest side of the Natalkuz fault. A 750-metre section of volcanic rocks consisting of amygdaloidal andesite, coarse feldspar-phyric flows and platy dacite unconformably overlies Upper Cretaceous volcanic rocks along the north side of Natalkuz Lake. Rhyolite flows and lesser tuffaceous rocks underlie most of the northwestern corner of the map area. Field relationships suggest that the rhyolite overlies older lithologies on a surface with significant paleotopography. Biotite-phyric dacite flows exposed on an island 1 kilometre east of Jim Smith Point either underlie or are interlayered with the rhyolite flows.

AMYGDALOIDAL ANDESITE FLOWS (UNIT EO_1)

North of Natalkuz Lake, dark grey, massive and amygdaloidal andesite flows less than 75 metres thick unconformably overlie hornblende-bearing crystal-lapilli and block-lapilli tuffs of Unit Kv. The flows are aphanitic and locally brecciated with matrix infillings of chalcedonic quartz. Amygdules contain silica, calcite and epidote. Similar amygdaloidal flows are interlayered with bladed feldspar phyric flows of Unit EO_2.

BLADED FELDSPAR ANDESITE PORPHYRY FLOWS (UNIT EO_2)

Dark green-grey coarse feldspar-phyric andesite flows approximately 250 metres thick conformably overlie the amygdaloidal andesite flows. Alignment of tabular, 5-millimetre to 1.5-centimetre, feldspar phenocrysts impart a well-developed flow fabric to outcrops. Hand samples contain a phenocryst assemblage of plagioclase (20-40% by volume) and pyroxene (5-10% by volume). Phenocrysts are extensively replaced by calcite and chlorite. Epidote, hematite and silica occur on fracture surfaces. These flows are lithologically similar to andesites of the Ootsa Lake Group mapped to the west in the Whitesail area (Unit 6, Diakow and Mihalynuk, 1987b)

SPARSELY PORPHYRITIC DACITE FLOWS (UNIT EO_3)

Sparsely feldspar-phyric dacite flows overlie the coarse feldspar-phyric andesites with apparent conformity. The dacite flows have an estimated thickness of 150 metres. However, this is a minimum thickness as the upper contact is not exposed. The dacite weathers readily along flow surfaces producing flaggy, porcellaneous fragments. The rock is medium to light blue-green or grey and contains tabular feldspar phenocrysts 2 to 3 millimetres long (5-10% by volume) and acicular hornblende phenocrysts 1 to 3 millimetres long. Alignment of the phenocrysts imparts a trachytic texture to the flows. Calcite and epidote have selectively replaced the feldspar phenocrysts. Hornblende phenocrysts are commonly replaced by chlorite and fine-grained opaque minerals.

DACITE FLOWS (UNIT EO_4)

Biotite-phyric dacite flows underlying or interlayered with rhyolite flows are exposed on a island approximately 1 kilometre east of Jim Smith Point. At this location dacite flows about 140 metres thick are exposed on the side of a hill directly above lake level. This represents a minimum thickness because the base of the dacite is not exposed. The dacite has a light grey to pinkish grey fine-grained groundmass and contains a phenocryst assemblage of plagioclase (20% by volume), anorthoclase (20% by volume) and biotite (5-10% by volume). Plagioclase phenocrysts (An_{12}) are white, euhedral, subvitreous to chalky and commonly up to 0.5 centimetre long. Anorthoclase phenocrysts range from 0.3 to 0.5 centimetre long and are colourless, euhedral and vitreous. In thin section anorthoclase is observed rimming plagioclase phenocrysts. Biotite occurs as vitreous, euhedral, 1 to 2-millimetre phenocrysts. Clots of intergrown fine-grained feldspar and biotite up to 1 centimetre across occur throughout the groundmass. A bulk sample has been collected for the purpose of determining a K-Ar age on biotite for the dacite flows.

RHYOLITE FLOWS AND TUFFS (UNIT EO_5)

Rhyolite flows and tuffaceous rocks comprise the most laterally extensive unit of the Ootsa Lake Group in the map area. Rhyolite flows outcrop along the north shore of Natalkuz Lake; interlayered flows and tuffs predominate along the south side of Euchu Reach. Rhyolite flows are exposed on ridges at two locations southeast of the Natalkuz fault unconformably overlying lava flows of Unit Jv. The thickest accumulation of rhyolite is exposed in the canyon walls along the Entiako River near its confluence with the Nechako Reservoir. At this location a fractured, pyritic subvolcanic plug domes the overlying sequence of flows, tuffs and sediments about 850 metres thick into a broad antiformal structure. This is a minimum thickness as the upper contact is not exposed.

Rhyolite Flows: Chalky white, pink and cream-coloured rhyolite flows are the most abundant rocks in the map area. Textures in the rocks vary considerably over short distances. They include massive flows and flow breccias, planar and contorted laminated flows, spherulitic flows (1 mm to 1 cm spherulites) and interlayered pitchstones. The phenocryst assemblage in the flows is variable across the map sheet. Flows typically contain a phenocryst assemblage of plagioclase (up to 20% by volume), quartz (5-10% by volume), potassium feldspar (up to 20% by volume) and traces of biotite. Plagioclase is vitreous and occurs as euhedral, 2 to 3-millimetre phenocrysts. Quartz is almost always present as 1 to 2-millimetre euhedral phenocrysts. Salmon pink, 2 to 3-millimetre euhedral potassium feldspar phenocrysts are generally uncommon but locally comprise up to 20 per cent of hand samples. Biotite is usually present as euhedral, vitreous phenocrysts between 1 and 2 millimetres in diameter.

Rhyolitic Air-fall Tuffs: White and light green, massive to well-bedded ash, crystal, crystal-lapilli and lapilli-block tuffs are interlayered with rhyolite flows along the Entiako River and on low ridges south of Euchu Reach. Rhyolitic lapilli and ash-tuff beds are sharply overlain by Endako flows in Chedakuz Arm on Knewstubb Lake. A section of graded crystal-lapilli tuffs 300 metres thick crops out along the north side of Natalkuz Lake almost directly north of Jim Smith Point. The tuffs contain a phenocryst assemblage of feldspar, quartz and biotite. Lithic fragments are fine-grained, subangular to angular and predominantly felsic volcanic rocks. Carbonized wood fragments and rare upright tree trunks occur in the tuffs at a number of locations in the map area indicating that the tuffs were, in part, subaerially deposited.

Tuffaceous sediments are preserved beneath basalt flows of the Endako Group at three locations north of Natalkuz Lake. Locally they contain carbonaceous plant fragments and delicate bivalves. The thickest accumulation of sediments is exposed in a stream canyon 0.5 kilometre southwest of the western end of the road which runs along the northern edge of the map sheet. Here they are estimated to be 50 metres thick and grade upwards from laminated, quartz-rich tuffaceous siltstone to carbonaceous, coarse-grained lithic wacke.

EOCENE VOLCANIC ROCKS NEAR ENTIAKO LAKE

Andesite flows conformably overlain by rhyolite flows crop out in the southwestern corner of the map area along the Entiako River near Entiako Lake. We believe they are part of the Ootsa Lake Group, however, their depositional relationship with other stratigraphic units is uncertain. They are discussed separately because their mineralogy and texture differs from other volcanic units described as Ootsa Lake Group.

ANDESITE FLOWS (UNIT EO_a)

Maroon, feldspar-phyric flows crop out in a bend of the Entiako River approximately 5 kilometres downstream from Entiako Lake. The flows unconformably overlie quartz monzonite of the Capoose batholith. Flows are finely laminated with individual flow laminations averaging 0.5 centimetre thick. Flow breccias consisting of dark red to black vitrophyric fragments are interlayered with the laminated flows through the andesite section. The andesite contains a phenocryst assemblage of plagioclase (15% by volume), biotite (1% by volume) and clinopyroxene (1% by volume). The phenocrysts are trachytically aligned in a very fine grained groundmass of feldspar microlites and devitrified volcanic glass.

RHYOLITE FLOWS (UNIT EO_r)

Quartz-phyric rhyolite flows directly overlie the laminated andesite flows along the top of a ridge at the bend in the Entiako River. The rhyolite flows are massive to thickly layered. The phenocryst assemblage comprises quartz (25% by volume), feldspar (5-10% by volume) and biotite (1% by volume). Quartz and feldspar phenocrysts are vitreous, euhedral and 2 to 4 millimetres in diameter. Biotite phenocrysts are 1 millimetre across and subhedral to euhedral. The groundmass is light grey, very fine grained and contains vugs lined with yellow clay.

RHYOLITE TUFFS (UNIT EO_{rt})

An isolated outcrop of rhyolitic lapilli-crystal tuff occurs approximately 1 kilometre downstream from Entiako Lake on the east side of the Entiako River valley. The tuff is well bedded with individual beds from 3 to 10 centimetres thick and has a buff-grey, moderately consolidated ash matrix. Crystals in the tuff include euhedral and fractured quartz phenocrysts (30% by volume), feldspar (5% by volume) and trace amounts of microscopic biotite, augite and sphene. Lithic fragments are 3 to 5 millimetres across and consist of devitrified siliceous glass shards, fine-grained rhyolite and fine-grained granitic rock.

ENDAKO GROUP (UNIT Ev)

The Endako Group, as originally defined by Armstrong (1949), included Oligocene or younger, flat-lying lava flows of variable composition up to 600 metres thick that underlie the Endako River drainage basin in the Babine Lake-Francois Lake areas. More recently, Diakow and Koyanagi (1988) have identified basalt flows dated at 41 Ma (whole-rock K-Ar) that unconformably overlie Ootsa Lake Group rocks in the Whitesail map area as Endako Group. Basalt flows mapped as Endako Group in the Natlakuz Lake map area nonconformably overlie rocks of the Ootsa Lake Group and infill pre-existing valleys within Ootsa Lake Group strata. These basalts occur less frequently as flat-lying erosional remnants capping hills and ridges in the northern part of the map area.

Exposures of the basaltic flows are generally massive but locally display columnar jointing. The flows are characteristically dense, black, aphyric to sparsely porphyritic but commonly include vesicular or amygdaloidal varieties. Black, glassy, feldspar-phyric flows that occur at a few localities are also included in the Endako Group. The phenocryst assemblage in the basalt flows includes plagioclase (An_{60}), augite, hypersthene and trace olivine. Clay minerals and chlorite occur as alteration products of both phenocrysts and groundmass phases. Amygdules are commonly filled with creamy opalescent silica, and calcite.

CHILCOTIN GROUP (UNIT Cv)

Early Miocene to early Pleistocene basalt flows cover an area of approximately 25 000 square kilometres extending from the Okanagan Highland northward to the Nechako Plateau (Mathews, 1989). Basalt flows mapped as Chilcotin Group are exposed in a valley, near the base of the western slope of Fawnie Nose. The basalt flows crop out as small, flat-lying, isolated knobs and boulder piles. Larger exposures occasionally display columnar jointing or flow layering. The flows are dark grey, fine grained and contain up to 15 per cent by volume yellow-green olivine phenocrysts (1 mm). Iddingsite, identified in thin section, is commonly pseudomorphous after olivine phenocrysts. Vesicles and amygdules, up to a centimetre in diameter, are often present: most are partially filled with fine-grained drusy quartz crystals. The zeolite natrolite, identified in thin section, is present in small (1 mm) amygdules.

INTRUSIVE ROCKS

The largest intrusion in the map area is the Capoose batholith (Unit LKqm) which underlies an area of approximately 100 square kilometres in the southern half of the area. The batholith has subdued relief and typically crops out along low ridges and in creeks. Exposed surfaces weather readily to produce rounded knobs and boulder piles. The batholith intrudes and pervasively alters Jurassic volcanic strata (Unit Jv) along the southwestern side of the Fawnie Range between Mount Swannell and Fawnie Nose. Alteration associated with the intrusion varies from intense silicification immediately adjacent to the contact to a zone of hornfels alteration up to 2 kilometres wide, characterized by destruction of primary volcanic textures and the local development of secondary biotite. The batholith has a bulk composition consistent with quartz monzonite but locally varies between quartz monzonite and granodiorite. Outcrops are typically light grey to salmon pink with a coarse-grained or feldspar-megacrystic texture. The phenocryst assemblage includes plagioclase, potassium feldspar, quartz, biotite and trace hornblende. Plagioclase and potassium feldspar typically occur as euhedral phenocrysts up to 1.5 centimetres in diameter. Chlorite has been identified in thin section partially replacing biotite and hornblende phenocrysts. The batholith is truncated along its western margin by the Natalkuz fault. A K-Ar date of 67.1 ± 2.3 Ma (on biotite) has been determined for the batholith (Andrew, 1988).

An oval-shaped, 1 by 2 kilometre quartz feldspar porphyry plug (Unit LKqfp) intrudes volcanic rocks of Unit Jv in the valley between Mount Swannell and Tutiai Mountain. We believe it is a satellite intrusion related to the Capoose batholith.

At the Capoose property rhyolitic dikes and sills (Unit LKr) intrude sedimentary rocks of Unit mJs and underlying volcanic rocks of Unit Jv. The intrusions are generally massive but locally are finely laminated. The texture in the intrusions varies from sparsely porphyritic to aphanitic. Euhedral, 1 to 2-millimetre quartz (7% by volume) and finely crystalline, anhedral, red and brown garnet (3% by volume) comprise the phenocryst assemblage. Potassiumargon dates on three whole-rock specimens from the rhyolitic intrusions vary from about 64 to 70±2.3 Ma (Andrew, 1988). These dates are concordant with the K-Ar age determined for the Capoose batholith.

Volcanic rocks of Unit Jv are intruded by a gabbro stock (Unit Jgb) which underlies an area of approximately 9 square kilometres along the south side of Natalkuz Lake near the eastern edge of the map area. A dike with a similar appearance and mineralogy underlies a prominent ridge 3 kilometres south of the stock. The gabbro is fine to medium grained displaying a salt-and-pepper texture and contains a phenocryst assemblage of plagioclase (50% by volume), chlorite pseudomorphs after olivine (15-20% by volume) and augite (20-25% by volume).

A number of quartz feldspar porphyry dikes (Unit Tqfp) are exposed in the northwestern corner of the map area intruding Jurassic volcanic and sedimentary rocks. The dikes contain phenocrysts of quartz, feldspar and biotite in a fine-grained siliceous groundmass.

A subvolcanic dacite plug (Unit Ti), compositionaly similar to the dacite flows of Unit EO_4 crops out along the south shore of Euchu Reach. The plug is massive and has a porphyritic texture. The groundmass is light grey, fine grained and contains anorthoclase and plagioclase phenocrysts up to 1 centimetre long. Biotite is vitreous, euhedral and 3 to 5 millimetres across. Quartz (1-5% by volume) occurs as small 1 to 3-millimetre subhedral phenocrysts. Plagioclase phenocrysts commonly have anorthoclase rims.

STRUCTURE

Rocks in the Natalkuz Lake map area are characterized by crudely layered sequences in which numerous small high-angle faults locally disrupt bedding. However, in general there is a problem recognizing throughgoing faults in the field because of sparse outcrop or broad areas underlain by homogeneous rock units that have only minor lithologic variations. For example, flow measurements and bedding attitudes from interflow sediments in Unit Jv south of Natalkuz Lake indicate a consistent, gentle northward dip. This general trend in attitude deviates abruptly westward in a segment of the Fawnie Range south of Green Lake. A northerly trending fault immediately east of the Fawnie Range may account for this change in bedding attitude. The anomalous thickness of Unit Jv east of the Fawnie Range may be caused by subparallel northeast-striking normal faults with south-side-down movement. One such east-striking fault in the Fawnie Range displaces a distinctive fossiliferous sedimentary unit (mJs). South-side-down motion on this structure resulted in about 150 metres of displacement on the upper sediment-volcanic contact.

A major structure called the Natalkuz fault is assumed to trend diagonally across the map area through heavily forested, low-lying terrain. Indirect evidence for this structure is the abrupt change from older Jurassic units and the Late Cretaceous Capoose batholith to the southeast, to mainly Tertiary volcanic units to the northwest. The age of this structure is uncertain; it may be synchronous with or post-date Ootsa Lake magmatism. Some obvious north-trending high-angle faults juxtapose Ootsa Lake rocks against Jurassic and Cretaceous basement north of Natalkuz Lake. The Endako Group appears to be unaffected by faults.

With the exception of disharmonic folds resulting from rheomorphism in viscous rhyolitic flows, the rocks in the map area lack evidence of compressional structures.

ALTERATION AND MINERALIZATION

Hydrothermally altered rocks occupy a belt about 7 kilometres long adjacent to the eastern contact of the Capoose batholith, from Tutiai Mountain in the north to Fawnie Nose in the south. The most diagnostic altered rocks are white and stained with iron oxides on weathered surfaces. The contact between the Capoose batholith and country rocks appears to be a relatively planar surface inclined gently toward the east beneath the Fawnie Range. Generally, altered rocks nearest the contact are characterized by pervasive replacement of the primary minerals by silica, and destruction of primary textures. These rocks commonly grade imperceptibly, over just a few metres, into an assemblage of silica and pyrite with or without clay minerals. Disseminated pyrite is particularly abundant (up to 15% by volume) in rocks around Green Lake where it is oxidized and forms an extensive gossan. Minor sericite accompanies the quartz-pyrite assemblage in this area. On the southwest side of Tutiai Mountain the silicified zone is at least 100 metres thick and probably thicker as exposure continues down slope where it is obscured by cover. The silicified zone passes abruptly outward into a broad zone of hornfelsed propylite. The volcanic rocks are typically dark grey-green and recrystallized so that fresh surfaces have a fine granular or rare spotted appearance which obscures the primary textures. A secondary mineral assemblage of chlorite, epidote and calcite, with or without pyrite, is ubiquitous but rapidly diminishes in intensity outward from the silicified zone. Unit Jv, the most common country rock in contact with the batholith at Mount Swannell and Tutiai Mountain, contains a regional metamorphic epidote-quartz-chlorite assemblage which can be difficult to distinguish from intrusion-related alteration.

Metallic mineral occurrences in the map area all occur close to either the Capoose batholith or subvolcanic intrusions (Table 1-5-1). The main styles of mineralized showings include:

- Disseminated and fracture-controlled copper-molybdenum in the Capoose batholith and adjacent country rocks.
- Disseminated gold and silver in base metal bearing rhyolite sills (Capoose prospect).
- Minor lenses of pyrrhotite in hornfelsed propylite.
- Disseminated pyrite associated with an Eocene subvolcanic dome.

The Capoose base and precious metal deposit is the most extensively explored prospect in the map area. Rio Tinto Canadian Exploration Limited discovered the prospect in 1970 during a regional exploration program focused on the Capoose batholith and porphyry-style mineralization. Granges Exploration Ltd. explored the property from 1976 to 1985. An inventory of 28.3 million tonnes grading 0.91 gram per tonne gold and 36 grams per tonne silver was

TABLE 1-5-1
DOCUMENTED MINERAL OCCURRENCES IN THE NATALKUZ LAKE MAP AREA

TYPE	NAMES	MINFILE NO.	ECONOMIC MINERALS	DESCRIPTION
VEIN	CAP	093F 021	chalcopyrite, molybdenite, covellite, pyrite	Sulphide mineralization occurs along fractures in quartz monzonite of the Capoose Lake Batholith. East - west trending dikes of probable Tertiary age occur proximal to mineralized fractures and may be associated with mineralization.
VEIN	CAPOOSE, CAP	093F 022	chalcopyrite, molybdenite, covellite, pyrite malachite	Northwest - southeast trending fractures within the Capoose Lake Batholith contain Cu-Mo sulphide mineralization. Best assays reported are 0.56% Cu and 0.007% $MoS2$ from a grab sample taken from one of 14 blast pits on the property.
DISSEMINATED	NED	093F 039	chalcopyrite, molybdenite, pyrite	The only outcrop on the property contians trace amounts of disseminated pyrite, chalcopyrite and molybdenite. The best intersection reported from a percussion drill hole assayed 0.044% $MoS2$ and 0.15 % Cu.
PORPHYRY	CAPOOSE, CAPOOSE LAKE (or CAPOOSE PROSPECT)	093F 040	pyrite, sphalerite, galena, chalcopyrite, arsenopyrite.	Mineralization at the Capoose prospect is hosted in and adjacent to Late Cretaceous garnet-bearing rhyolite sills which intrude Hazelton Group volcanic and sedimentary rocks. Sulphides occur mainly as disseminations but also as veinletts and fracture fillings within the rhyolite. Granges Exploration Ltd. has reported unclassified reserves of 28.3 million tonnes grading 0.51 g/t Au, and 36 g/t Ag.

reported (U.S. Securities and Exchange Commission, Form 10-K 1987).

Although the Capoose prospect was not studied in detail in 1992, its setting will be examined more closely during the field program in 1993. The reader is referred to thesis research by Andrew (1988) for a comprehensive review of the geology and genesis of this deposit. Briefly, precious metals occur in base metal sulphides disseminated in a series of rhyolitic sills. Isotopic evidence cited by Andrew favours a genetic association of the sills and the nearby Capoose batholith and a hydrothermal event involving both magmatic and meteoric fluids. She concludes that Capoose resembles "a low grade, epigenetic, intrusion-related, porphyry-style deposit".

Disseminated pyrite occurs locally within rhyolitic volcanic and subvolcanic rocks of the Ootsa Lake Group. The canyon near the confluence of the Entiako River and Euchu Reach exposes limonite-stained rhyolite with finely disseminated grains of pyrite. This rhyolite is homogeneous and well jointed; it is interpreted as an endogenous dome that may be cogenetic with an upwarped section of flanking rhyolitic flows and tuffs. The primary interest in this mineralization, albeit sparse, is as an indication of hydrothermal activity associated with Eocene magmatism in the map area.

ACKNOWLEDGMENTS

Fieldwork in the Natalkuz Lake map area was funded by the Canada-British Columbia Mineral Development Agreement (MDA) 1991-1995.

Jack Whittles and Audrey Perry provided cheerful and able assistance in the field. We are especially grateful to Joyce of Northern Mountain Helicopters Inc., Vanderhoof, for tuning us in every morning and permitting the use of storage facilities at the base. Northern Mountain is also credited for the superb flying and courteous service maintained by pilots Joe Meier and Randy Diston. We also thank Dr. T.P. Poulton of the Geological Survey of Canada for promptly identifying fossil collections on short notice.

REFERENCES

Andrew, K.P.E. (1988): Geology and Genesis of the Wolf Precious Metal Epithermal Prospect and the Capoose Base and Precious Metal Porphyry-style Prospect, Capoose Lake Area, Central British Columbia; unpublished M.Sc. thesis, *The University of British Columbia*, 334 pages.

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

Diakow, L.J. and Koyanagi, V. (1988): Stratigraphy and Mineral Occurrences of Chikamin Mountain and Whitesail Reach Map Areas (93E/6, 10), *in* Geological Fieldwork 1987, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1988-1, pages 155-168.

Diakow, L.J. and Mihalynuk, M. (1987a): Geology of the Whitesail Reach and Troitsa Lake Map Areas; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Open File 1987-4.

Diakow, L.J. and Mihalynuk, M. (1987b): Geology of the Whitesail Reach and Troitsa Lake Map Areas; *in* Geological Fieldwork 1986, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1987-1, pages 171-179.

Diakow, L.J. and van der Heyden, P. (1993): An Overview of the Interior Plateau Program; *in* Geological Fieldwork 1992, Grant, B. and Newell, J.M., Editors, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1993- , this volume.

Duffell, S. (1959): Whitesail Lake Map-area, British Columbia; *Geological Survey of Canada*, Memoir 299, 119 pages.

Mathews, W.H. (1989): Neogene Chilcotin Basalts in South-central British Columbia: Geology, Ages and Geomorphic History; *Canadian Journal of Earth Sciences*, Volume 26, pages 969-982.

Tipper, H.W. (1963): Nechako River Map-area, British Columbia; *Geological Survey of Canada*, Memoir 324, 59 pages.

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