Dease Lake Geoscience Project, Part II: Preliminary Report on the Mesozoic Magmatic History and Metallogeny of the Hotailuh Batholith and Surrounding Volcanic and Sedimentary Rocks

by B.I. van Straaten[1], J.M. Logan[1] and L.J. Diakow[1]

KEYWORDS: Geological mapping, Dease Lake, Stikine terrane, QUEST-Northwest, Hotailuh batholith, metallogeny, mineral occurrences

INTRODUCTION

This paper reports the preliminary results of a study on the magmatic history and metallogeny of the Hotailuh batholith, and is part of a larger British Columbia Geological Survey Dease Lake Geoscience Project (Logan *et al.*, 2012). The BCGS project is funded through Geoscience BCs QUEST-Northwest initiative, a program launched in early 2011 to stimulate mineral exploration in the northwestern part of the province along Highway 37. The Geoscience BC program includes two high resolution airborne magnetic surveys (Simpson, 2012), the collection of new regional stream sediment data and reanalysis of stream sediment samples (Jackaman, 2012), as well as new bedrock mapping described in this volume (Logan *et al.*; this paper; Moynihan and Logan; Iverson *et al.*). Collectively, these programs will provide detailed, high quality geoscience data that is intended to enhance metallic mineral exploration in an area of prospective geology adjacent to Highway 37, near Dease Lake, in northwestern British Columbia.

The study area is located within the Stikine terrane of the Canadian Cordillera, an aggregate of Late Paleozoic to Mesozoic magmatic arc successions accreted onto the North American margin during Middle Jurassic time (*e.g.* Gabrielse, 1991). The Stikine terrane comprises predominantly Triassic to Jurassic volcanic, sedimentary and plutonic rocks. This study focuses on the composite Hotailuh batholith (Figure 1), which has traditionally been subdivided into three plutonic suites of Late Triassic, Early Jurassic and Middle Jurassic age (Anderson, 1983; Gabrielse, 1998).

The main objectives of the Hotailuh project are to: 1) further refine the temporal magmatic and geochemical evolution of the batholith; 2) build a metallogenic framework that relates mineralization to magmatic events; and 3) identify prospective magmatic-hydrothermal systems in the area. Here, we present the field results, as well as results from assay analyses of mineralized samples. Results will be refined using techniques such as petrography (thin section study, feldspar staining), lithogeochemistry of least altered samples and geochronology. Furthermore, the results will be integrated with Geoscience BCs geophysical survey and updated regional stream sediment geochemistry databases as such information becomes available.

The composite Hotailuh batholith is exposed in a 2275 km^2 area southeast of Dease Lake. Nine weeks of 1:20 000-scale mapping by a two person team in summer 2011 included visits to 331 field stations and collection of 134 samples for laboratory study and analysis. The 2011 study focused on mapping within the Gnat Pass area and seven smaller areas to the east (Figure 1). The field areas were chosen for their mineral occurrences and suitability for understanding the internal geology and external contact relationships for various phases of the batholith. The study areas are covered by the 1:50 000 NTS map sheets 104I/04, 104I/03W, the southernmost part of 104I/05, and northernmost part of 104H/13. The Gnat Pass area is accessible by truck from Highway 37. Except for a section between Upper Gnat Lake and a point 7 km further south, the abandoned British Columbia railroad grade is driveable by truck up to the southern boundary of the study area. The remaining areas were mapped from fly camp locations accessed by helicopter chartered from Dease Lake.

The bedrock exposure is poor to moderate (5-10%) in the forested and brush-covered Gnat Pass area, except for exposures along road cuts, abandoned rail cuts and in old exploration trenches. The rock exposure improves dramatically above tree line, at approximately 1500 m. Exposure is best (10-30%) in the topographically higher areas of the Hotailuh batholith, with excellent exposure along alpine ridges, steep valley walls and cirques. However, glacial deposits and colluvium cover many alpine valleys, with only limited exposure in some creeks. Many of the exposures below, and especially above, treeline have an intense lichen cover. A notable exception is the lee side of alpine ridges where the thicker wind-accumulated winter snowpack appears to have inhibited lichen growth. These are prime locations for observing

[1] *British Columbia Geological Survey, Victoria, BC*

This publication is also available, free of charge, as colour digital files in Adobe Acrobat® PDF format from the BC Ministry of Energy and Mines website at http://www.empr.gov.bc.ca/Mining/Geoscience/PublicationsCatalogue/Fieldwork.

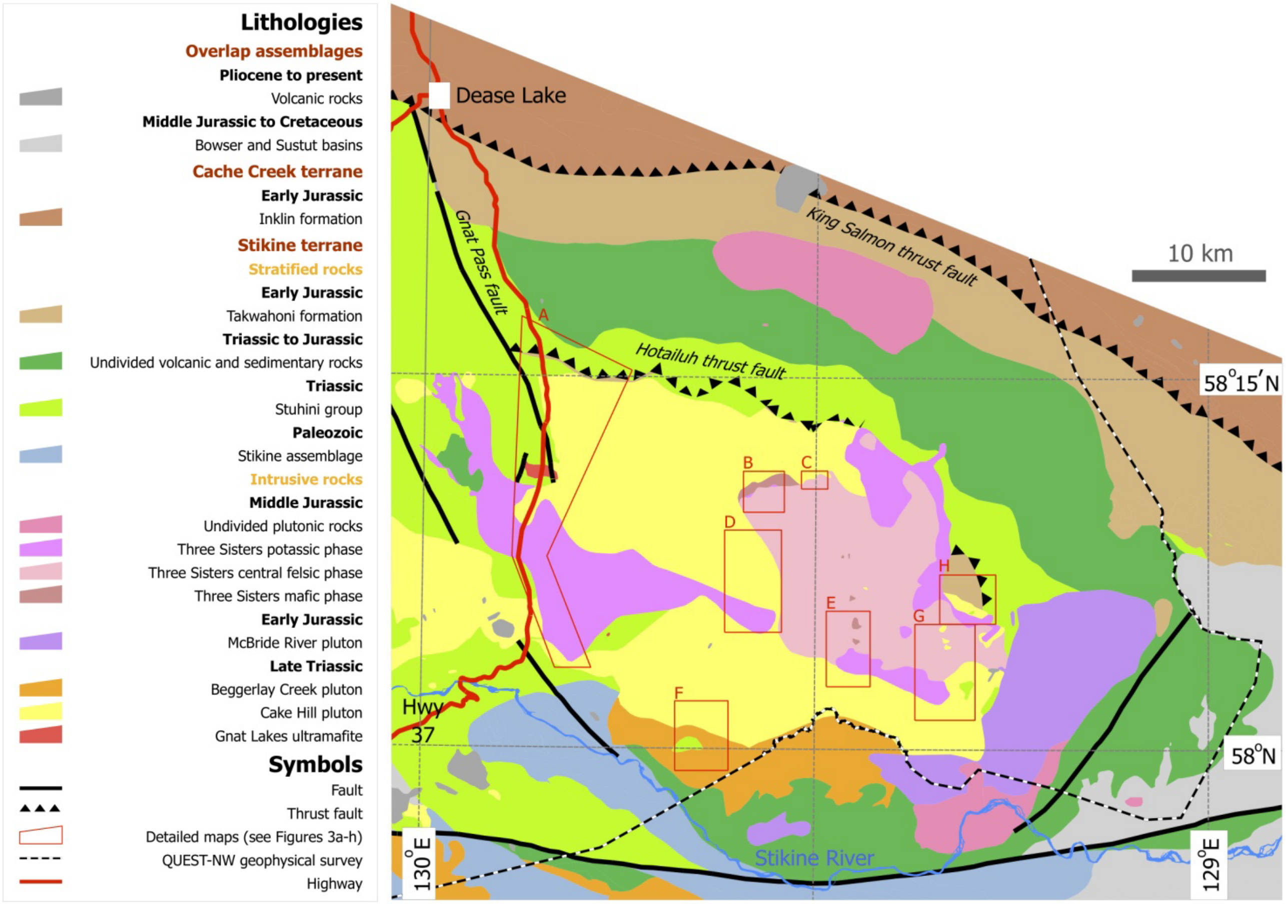

Figure 1. Regional geological setting of the Hotailuh batholith showing main lithologies and faults. Adapted from BC digital geological map compilation by Massey *et al.* (2005). The eight study areas are indicated, as well as the southern and eastern boundary of the QUEST-NW geophysical footprint.

complex crosscutting relationships among the intrusive phases of the batholith.

REGIONAL GEOLOGY

The study area is located near the north-northeastern margin of the Stikine terrane of the Canadian Cordillera (Figure 1), a volcanic island arc complex accreted onto the North American margin during Middle Jurassic time (Gabrielse, 1991; Nelson and Mihalynuk, 1993). The basement of the Stikine terrane is characterized by carbonate and volcanic rocks of the Devonian to Permian Stikine Assemblage, overlain by calcalkaline volcanic and associated sedimentary rocks of the Triassic Stuhini Group and Early to Middle Jurassic Hazelton Group (Marsden and Thorkelson, 1992; Currie and Parrish, 1997). The Stuhini Group volcanic rocks are predominantly mafic to intermediate in composition, whereas the Hazelton Group volcanic rocks are predominantly intermediate in composition with lesser felsic and mafic horizons (Marsden and Thorkelson, 1992).

Late Permian to Middle Triassic tholeiitic volcanism of the Kutcho assemblage formed a proto-arc on the inboard margin of the Stikine terrane, and was the subsequent locus for arc marginal clastic sedimentation in the Early Jurassic (English and Johnston, 2005; Schiarizza, 2011). Sedimentation within this forearc sedimentary basin (Whitehorse trough) comprises proximal conglomerates and more distal sandstones of the Takwahoni and Inklin formations, respectively. Closure of the Cache Creek ocean, subsequent collision with the Whitehorse trough and thrusting overtop the inboard margin of Stikinia occurred in the late Early to earliest Middle Jurassic (Ricketts *et al.*, 1992; Nelson and Mihalynuk, 1993). The rocks of the Cache Creek ocean and Whitehorse trough are currently exposed in a north-northwest striking belt north of Dease Lake (Figure 1), and are found in the hangingwall and footwall of the King Salmon thrust fault. The latter is generally interpreted as a major terrane bounding structure, separating autochthonous rocks of the Stikine terrane to the south from allochthonous rocks of the Cache Creek terrane to the north (*e.g.* Gabrielse, 1998). The Stikinia – Cache Creek accretionary event was complete by the Middle Jurassic (Bajocian), as indicated by sedimentation of Cache Creek derived chert clasts deposited in the molasse-type Bowser Basin to the south of the study area (Figure 1; Ricketts *et al.*, 1992).

Large granitoid plutons were emplaced during the Late Triassic to Middle Jurassic, and are exposed in an arcuate belt on the northern margin of the Bowser basin. This belt, commonly referred to as the Stikine arch, is centered on the Hotailuh batholith, and includes the Stikine pluton to the southeast and the Hickman batholith to the southwest (Anderson, 1983; Woodsworth *et al.*, 1991). Several smaller Late Jurassic to Cretaceous plutons are present within the Dease Lake area (Anderson and Bevier, 1992; Logan *et al.*, this volume).

Mineralization in the northern Stikine terrane comprises several Late Triassic to earliest Jurassic calcalkaline porphyry Cu-Mo±Au to alkaline porphyry Cu-Au deposits; notable examples include Galore Creek, Schaft Creek, KSM and GJ to the southwest, Red Chris to the south, and Kemess to the southeast (Ash *et al.*, 1997; Logan *et al.*, 2000; Duuring *et al.*, 2009; Norris *et al.*, 2011). These porphyry copper deposits are roughly located on the southwestern and southeastern apexes of the Stikine magmatic arch. Interestingly, despite the presence of similar rocks in the centre of the arch, no major porphyry copper deposits have been found in the immediate area of the Hotailuh batholith. Southwest of the study area, the Au-Ag-enriched Eskay Creek volcanogenic massive sulphide deposit is hosted in felsic volcanic rocks within the Early-Middle Jurassic Hazelton Group (Bartsch, 1993), and represents a relatively underexplored deposit type elsewhere in the Stikine terrane (Massey *et al.*, 1999).

GEOLOGICAL UNITS

Rock units encountered in the field are summarized in Table 1, and are described below from oldest to youngest. Magnetic susceptibility values for all rock units were measured in the field with a Terraplus KT-10 hand-held magnetic susceptibility meter. Magnetic susceptibility data is summarized in Figure 2, and shows clear distinctions between several major units.

All detailed geological maps presented here (Figures 3b-h) incorporate minor data from Anderson (1983) and Gabrielse (1998), as well as Read and Psutka (1990) and Evenchick and Thorkelson (2005) in the far south. The Gnat Pass compilation map in Figure 3a also incorporates data from Read (1984), Nixon *et al.* (1989; 1997) around the Gnat Lakes ultramafite, Dircks (1974) around the BCR property, Wetherill (1989; 1990) around the Dalvenie claims, Smith and Garagan (1990) around the Gnat Pass prospect, and preliminary detrital zircon results from near peak 2096 m (Iverson *et al.*, this volume). In addition, five preliminary U-Pb LA-ICP-MS zircon crystallization ages are reported as part of this study. Each age represents the mean of 16-50 analyses on individual zircon crystals, and is subject to further data processing and error propagation. Two standard deviation errors are ~2 Ma.

Rock classification schemes developed by the British Geological Survey (Gillespie and Styles, 1999;

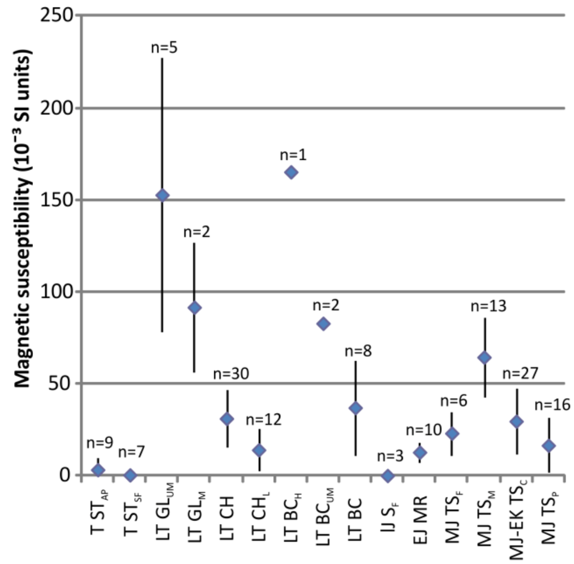

Figure 2. Graph showing the magnetic susceptibility values and one standard deviation for all major rock units. n = number of measurements, where each measurement represents the average of ten field measurements at one station point.

Hallsworth and Knox, 1999) are used throughout this paper. Notably, the reported crystal size in igneous rocks is the volumetrically dominant size; the mineral qualifying suffixes –bearing and –rich indicate that <5% and >20% of the rock comprises the mineral in question, respectively. In the field, a gabbro has been defined as a rock plotting in the diorite QAPF field, but containing ≥50% mafic minerals. Elevations for unnamed peaks (“peak ... m”; Figures 3a-h) are spot heights from British Columbia’s TRIM database. All coordinates are in UTM NAD83 zone 9V.

Stratified rocks

TRIASSIC ROCKS

Rocks in the central and western part of the Gnat Pass valley predominantly comprise massive to foliated augite-phyric coherent rocks with lesser massive fine grained sedimentary rocks (Figure 3a; units T STAP and T STSF in Table 1 respectively), and have been assigned to the Triassic Stuhini Group (similar to assignments by Anderson, 1983 and Gabrielse, 1998). The coherent rocks represent extrusive rocks and/or sub-volcanic intrusions. The complex map pattern of the volcanic and sedimentary lithologies could be due to a number of factors such as faulting, folding, rapid lateral and vertical facies changes and/or irregular intrusion of augite porphyry into the sedimentary strata. The Stuhini augite-phyric rocks are cut by felsic dikes, likely genetically related to the Gnat Lakes ultramafite (unit LT GL$_F$, *ca.* 223 Ma), and appear to be intruded and partially assimilated by the Cake Hill pluton (unit LT CH, *ca.* 221-226 Ma). The Stuhini Group augite-phyric coherent rocks in the Gnat Pass valley north of Lower Gnat Lake are crosscut by the Gnat Pass intrusive (unit LT GP, *ca.* 217 Ma). These relationships, as well as their foliated nature (discussed below), suggest

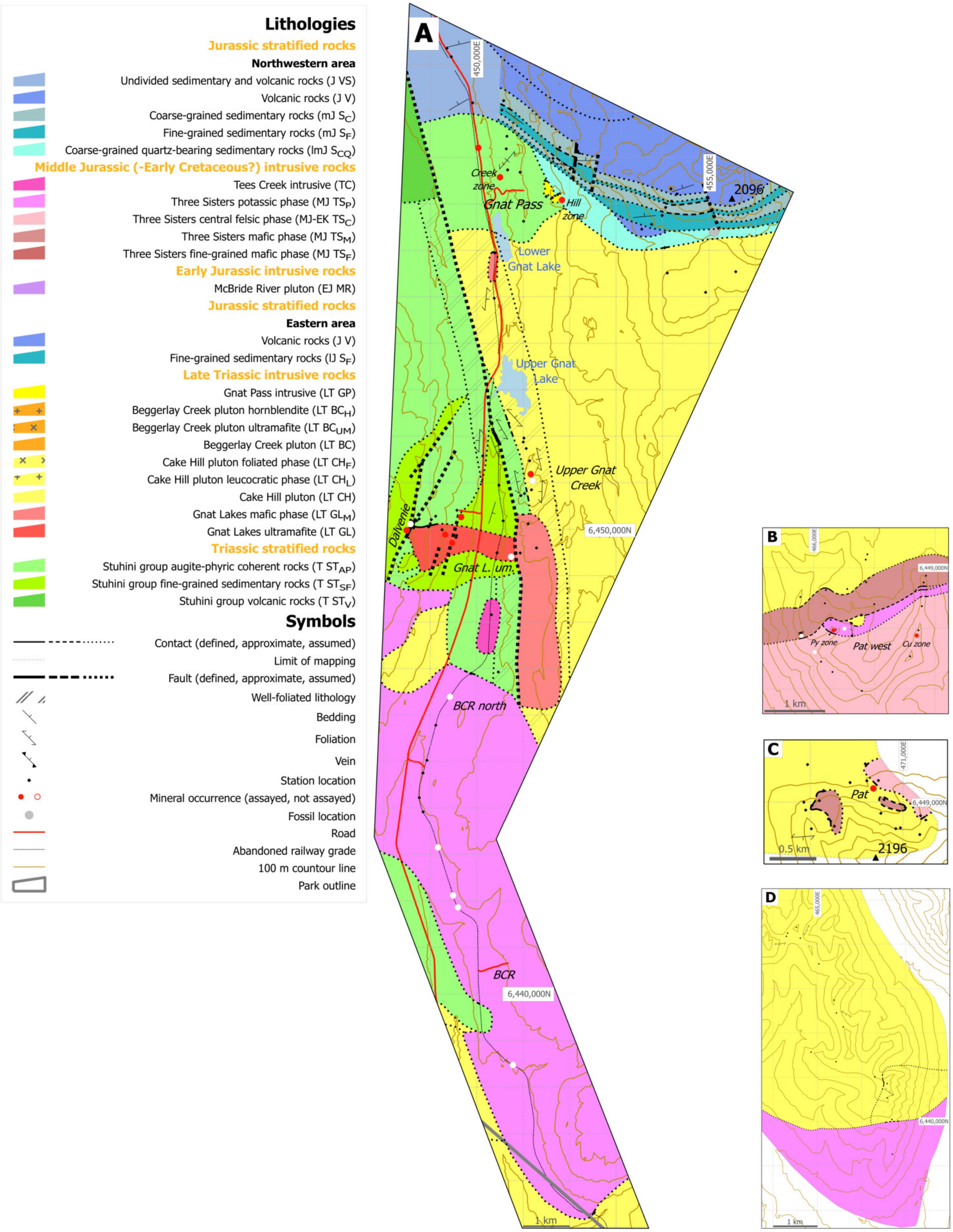

Figure 3. Detailed geological maps and legend of selected areas of the Hotailuh batholith. Location of each detailed map is indicated on Figure 1.

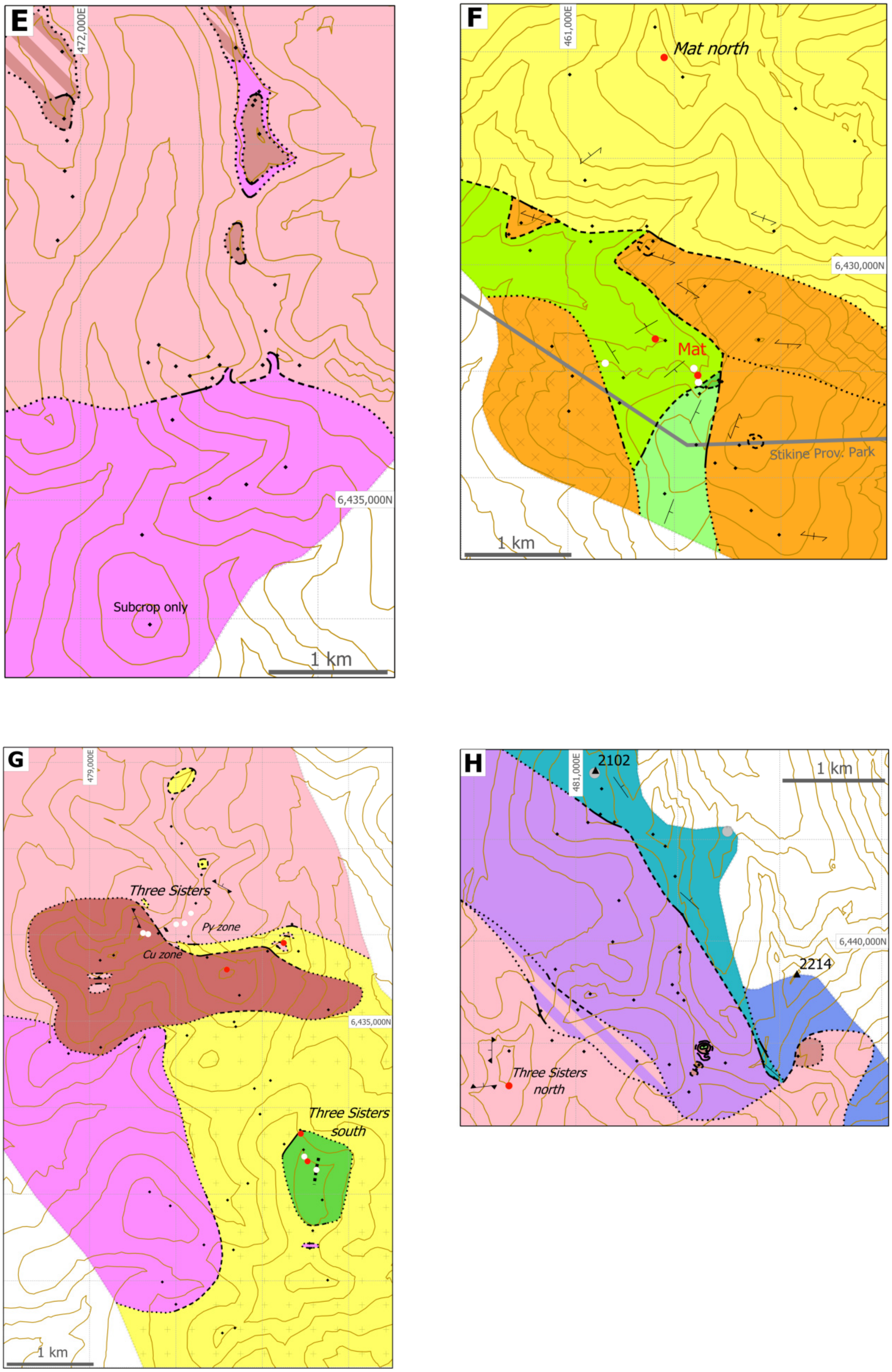

Figure 3. Continued.

Table 1: Summary of all geological units described in the field: a) Stratified rocks, b) Igneous rocks. Mineral abbreviations after Kretz (1983).

a) Stratified Rocks

Group	Area	Unit	Age	Code	Lithology
Jurassic sedimentary / volcanic (Hazelton?) group	Northwestern area	Undivided	J	VS	Includes J V, mJ S_C, mJ S_F and lmJ S_{CQ}; see below.
		Volcanic rocks	J	V	Granule, pebble and cobble-sized volcaniclastic conglomerate and pyroclastic breccia; contains Pl-Aug, Pl, Aug, Pl-Hbl-phyric, amygdaloidal clasts. Volcanic sediments commonly contain Aug crystals.
		Coarse-grained sedimentary rocks	mJ	S_C	Medium grey, medium bedded, medium and (very) coarse grained sandstone. Feldspathic ±lithic arenite. Minor interbedded siltstone; minor interbedded pebble conglomerate.
		Fine-grained sedimentary rocks	mJ	S_F	Dark grey to black, parallel laminated to (very) thinly bedded siltstone and fine-grained sandstone. Often recessive.
		Coarse-grained quartz-bearing sedimentary rocks	lmJ	S_{CQ}	Basal unit nonconformably(?) overlies Cake Hill pluton. Very coarse grained sandstone and pebble-sized conglomerate with granitoid clasts. Includes conglomerate, quartz-bearing feldspathic arenite, graphitic siltstone and micrite of Anderson (1983), Smith and Garagan (1990).
	Eastern area	Volcanic rocks	J	V	Pyroclastic breccia and volcaniclastic pebble-sized conglomerate; contains Hbl(?)-Pl-phyric clasts.
		Fine-grained sedimentary rocks	lJ	S_F	Alternating medium-dark grey (parallel) laminated siltstones, calcareous siltstones, fine to medium-grained sandstone and rare very thick bedded, likely Qtz-bearing, (very) coarse grained sandstone and granular conglomerate.
Triassic Stuhini Group	Entire area	Stuhini volcanic rocks	T	ST_V	Pyroclastic (?) breccia and volcaniclastic conglomerate; contains Pl-Aug-, Pl-phyric clasts. Laminated to (very) thinly bedded medium to very coarse grained volcaniclastic sandstone with some siltstone interbeds; Aug crystal bearing.
		Stuhini augite-phyric coherent rocks	T	ST_{AP}	Dark green, 1-5 mm euhedral, 20-40% Aug-phyric coherent rocks; rare Pl-Aug-phyric (ST_{PAP}). Can contain rare 1 m thick dark green fine grained sandstone intervals.
		Stuhini fine-grained sedimentary rocks	T	ST_{SF}	Medium to dark grey, laminated to very thinly bedded siltstone and fine to medium-grained sandstone. With minor concordant 0.5-1 m intervals of 2-5 mm 30-40% Aug-phyric coherent rocks.

Age abbreviations: l = lower, m = middle, u = upper, E = Early, M = Middle, L = Late, T = Triassic, J = Jurassic, K = Cretaceous.

b) Igneous Rocks

Suite	Pluton	Unit	Age	Code	Lithology
Middle Jurassic (-Early Cretaceous?) plutonic suite		Tees Creek intrusive	≤ MJ	TC	Altered Hbl-feldspar porphyry.
	Three Sisters pluton	Three Sisters potassic phase	MJ	TS_P	Bt (and Bt-bearing) granite, Qtz syenite and Qtz monzonite with Kfs>Pl. Equigranular 1 mm to 4 mm; often 5-20 mm Kfs porphyritic. Includes pink Bt porphyritic dikes.
		Three Sisters central felsic phase	MJ-EK?	TS_C	Bt and lesser Hbl-Bt (may include rare Bt-Hbl) Qtz monzonite and Qtz monzodiorite with Pl>Kfs. Equigranular, 2-3 mm; 4-5 mm Kfs porphyritic in places; dioritic xenoliths locally present.
		Three Sisters mafic phase	MJ	TS_M	Hbl-rich diorite (to Qtz diorite?). Acicular Hbl 0.5-4 mm to 2-7 mm; equant Hbl 1-2 mm to 4-10 mm.
		Three Sisters fine-grained mafic phase	MJ	TS_F	Hbl diorite (to Qtz diorite?). Equigranular, 1-1.5 mm, often 10 vol.% 1.5-3 mm Pl porphyritic.
Early Jurassic	McBride River	McBride River pluton	EJ	MR	Hbl monzogranite and granodiorite. Equigranular, 3 to 3-4 mm, with minor ubiquitous 4-7 mm Qtz blebs; tabular Hbl common.
Late Triassic plutonic suite		Gnat Pass intrusive	LT	GP	Hbl (and Hbl-bearing) diorite and granodiorite with lesser quartz diorite. Equigranular 2 mm euhedral-subhedral Pl, rarely 2-4 mm Qtz porphyritic.
	Beggerlay Creek pluton	Beggerlay Creek potassic dikes	LT	BC_P	Coarse pink Kfs (±Ep) dikes.
		Beggerlay Creek ultramafic body	LT	BC_{UM}	Highly altered (serpentinized?) plutonic ultramafic rock. Equigranular, 5 mm, massive.
		Beggerlay Creek pluton	LT	BC	Hbl-rich (and Bt-Hbl-rich) diorite to gabbro (BC) to rare Pl-bearing hornblendite (BC_H). Equigranular, 3-5 mm, massive to moderately foliated.
	Cake Hill pluton	Cake Hill foliated phase	LT	CH_F	Bt(?)-Hbl diorite and Qtz diorite. Foliated, equigranular, 1-3 mm.
		Cake Hill leucocratic phase	LT	CH_L	Light coloured and Ep altered Hbl Qtz diorite and tonalite(?). Equigranular, 1-2 to 2-3 mm, common tabular Hbl.
		Cake Hill pluton	LT	CH	Hbl to lesser Bt-Hbl Qtz monzodiorite and Qtz monzonite. Equigranular, 3-4 mm; tabular Hbl bearing, trace Ttn usually ubiquitous; trace Mag in places; massive to moderately foliated.
	Gnat Lakes ultramafite	Gnat Lakes felsic phase	LT	GL_F	Hbl granodiorite, monzodiorite and diorite. Equigranular 2 mm.
		Gnat Lakes mafic phase	LT	GL_M	Hbl-rich diorite and gabbro. Equigranular 1-5 mm Hbl.
		Gnat Lakes ultramafite	LT	GL_{UM}	Pl-bearing ultramafic rock (predominantly hornblendite) to rare pyroxene(?)-Hbl-rich gabbro. Equigranular 2-100 mm euhedral-subhedral Hbl, anhedral Pl.

a pre-*ca.* 226-217 Ma age for these rocks.

South of the Hotailuh batholith (Figure 3f), a succession of Stuhini Group rocks consists of predominantly sedimentary rocks grading into predominantly coherent rocks exposed at higher elevations (units T ST_{SF} and T ST_{AP} in Table 1, respectively). The approximate change from laminated and very thinly bedded siltstones and medium-grained sandstones with minor concordant intervals of massive augite-phyric coherent rocks to massive augite-phyric coherent rocks with rare fine grained sandstone intervals is well exposed in a steep gully. Here, laminated to very thinly bedded augite-bearing, medium grained volcaniclastic sandstones to granule-sized volcaniclastic conglomerates (unit T ST_V) occurs between these two rock units. Unfortunately, poor exposure and lichen-covered outcrops dominate the remainder of the area where it is often difficult to differentiate coarse grained, augite-bearing sediments from augite-phyric coherent rocks. This could explain the apparent lack of augite-bearing sediments at other locations near this contact. No way-up criteria were observed in the area, and although bedding in the southeastern half of the Stuhini succession has a uniform moderate southeasterly dip, structural disturbance appears to have occurred in the western half (Figure 3f). Based on the presence of augite-bearing volcaniclastic sediments, the augite-phyric coherent rocks most likely are extrusive in origin. The volcano-sedimentary rocks close to the Beggerlay Creek pluton contact are cut by coarse K-feldspar dikes that are presumed to be cogenetic with the latter pluton, implying a Late Triassic or older age for this Stuhini succession.

A limited number of Stuhini Group xenoliths occur within the Hotailuh batholith. A 0.5-1 km^2 raft or pendant of Stuhini is present within the Cake Hill leucocratic phase (Figure 3g) and comprises predominantly volcanic breccia and volcaniclastic conglomerate (unit T ST_V). To the east, a much smaller inclusion of augite-phyric coherent rocks (unit T ST_{AP}; Figure 3h) within the McBride River pluton is intruded and partly assimilated by the Three Sisters mafic phase. The augite-phyric rocks could be as young as Early Jurassic, but are included here based on their similarity to the Triassic Stuhini Group.

JURASSIC ROCKS

Sedimentary and volcanic rocks of Jurassic age were identified in the northwestern (Figure 3a) and eastern (Figure 3h) parts of the Hotailuh batholith.

Northwestern area

A succession of right-way-up Jurassic sedimentary rocks overlies the Cake Hill pluton (Figure 3a). It was mapped previously as a Lower Jurassic unit of the Takwahoni Formation overthrust by Lower to Upper Triassic Stuhini Group (Anderson, 1983; Gabrielse, 1998). However, preliminary U-Pb detrital zircon dates suggest the hangingwall rocks are also Jurassic in age (Iverson *et al.*, this volume).

The base of this succession comprises a coarse grained, quartz-rich sedimentary unit (lmJ S_{CQ} in Table 1), which was recognized in one outcrop. At this location it consists of a granitoid clast-bearing conglomerate and very coarse-grained sandstone (Figure 4). The lower contact lies within ten metres of intrusive rocks and may represent a nonconformable contact. Fossils from a sandy micrite associated with limey, quartz-bearing, feldspathic arenite located 4.5 km east of Lower Gnat Lake suggest an Early (to Middle?) Jurassic age (Henderson and Perry, 1981; Anderson, 1983, pages 209-214; Gabrielse, 1998, Appendix 2; Figure 3a). Conglomerate, quartz-bearing feldspathic arenite and graphitic siltstone intersected in drill core from a mineral prospect near Gnat Pass (Smith and Garagan, 1990; this study) appear similar to the rocks described above, and have been included in the basal unit.

The stratigraphically overlying package of rocks can be traced along most of the south-facing slopes of peak 2096 m, and consists of two coarsening-upward sequences of predominantly sedimentary rocks (Figure 3a; see also Figure 2, Iverson *et al.*, this volume). Preliminary results from three detrital zircon samples show distinct Middle Jurassic and Late Triassic populations (Iverson *et al.*, this volume). These results indicate that these rocks must be younger than the Triassic Stuhini Group. These sedimentary rock units (mJ S_F and mJ S_C in Table 1) dip moderately to the north, and are stratigraphically overlain by augite-phyric volcanic breccias (unit J V in Table 1). The coarse grained, quartz-bearing basal unit has traditionally been separated from these overlying, presumed Triassic Stuhini Group, rocks by the Hotailuh thrust (Anderson, 1983; Gabrielse, 1998). However, the new detrital zircon results eliminate the necessity for a thrust fault in this area

Figure 4. Very coarse grained sandstone to granule-sized conglomerate with several pebble-sized granitoid clasts (arrow). Altered Cake Hill pluton is exposed 10 m to the southeast and suggests a nonconformable contact. Hammer for scale.

(Figure 3a). A large outcrop of (hornblende)-plagioclase-phyric volcanic breccia is present southwest of peak 2096 m, between the basal quartz-bearing and the overlying fine grained sedimentary rock succession (Figure 3a). It does not appear to extend further east or west. The overlying fine-grained sediments contain two 10 m thick concordant columnar jointed augite-phyric coherent rock intervals, either representing fluidal flows or sills. The upper coarse-grained sediments in this unit comprise alternating medium-grained sandstones and concordant augite to plagioclase-augite phyric coherent rocks. The coherent intervals commonly contain a few percent disseminated pyrite, and either represent fluidal flows or sills. These exposures are correlated with similar plagioclase-augite phyric coherent rocks exposed in Gnat Creek. The fine to coarse grained stratified sedimentary rocks are overlain by volcanic breccias, and the entire sequence is cut by north trending subvertical faults.

The Jurassic rocks in this area are age equivalent with both the sedimentary Takwahoni Formation and the Hazelton Group. Marsden and Thorkelsen's (1992) definition for the Hazelton Group includes all Lower to Middle Jurassic volcanic and related sedimentary rocks on Stikinia, including the basinal sedimentary equivalents of the volcanic successions, and excludes distal strata whose origin is generally unrelated to Hazelton volcanism. Following this definition, the entire succession here is best assigned to the Hazelton Group.

Eastern area

A second succession of Jurassic sediments is present near peaks 2102 and 2214 m (Figure 3h). It was also mapped as Lower Jurassic Takwahoni Formation overthrust by Upper Triassic Stuhini Group (Anderson, 1983; Gabrielse, 1998).

The area around peak 2102 m at the eastern margin of the Hotailuh batholith comprises extensive exposures of reddish sedimentary rocks (Figures 3h, 5), previously assigned to the Takwahoni Formation (Gabrielse, 1998). The rocks comprise alternating medium to dark grey, parallel laminated siltstone, calcareous siltstone, fine to medium-grained sandstone and rare, very thickly bedded, likely quartz-bearing, coarse-grained sandstone to granule-sized conglomerate (unit lJ S_F in Table 1). The fine grained sedimentary rocks commonly contain a few percent disseminated and stratiform, very fine grained (0.05 mm) pyrite and are commonly iron oxide-stained. A sedimentary–intrusive rock contact is exposed in the south-facing headwall of peak 2102 m (Figures 3h, 5). Sedimentary rocks proximal to the margin of the *ca.* 190 Ma McBride River intrusion exhibit contact metamorphism. Fossils collected from this area suggest an Early to possibly Middle Jurassic (Toarcian and possibly Bajocian) age for these rocks (Gabrielse, 1998, Appendix 2). The Toarcian or younger (*i.e.* ≤183±1.5 Ma, International Commission on Stratigraphy, 2010) fossil constraint appears at odds with the pre-*ca.* 190 Ma

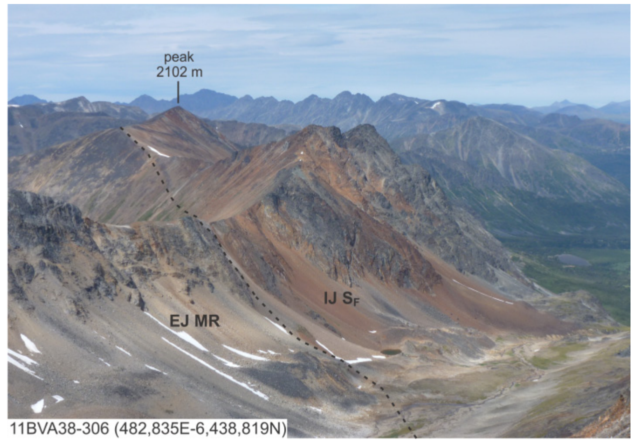

Figure 5. View northwest of peak 2102 m (on left) showing the contact between grey McBride River pluton on far left and rusty red, stratified sedimentary rocks (unit lJ S_F) on the right.

implied by the crosscutting relationship with the McBride pluton.

The exposures northeast of Lower Gnat Lake are part of a semicontinuous band of rocks previously assigned to the Triassic Stuhini Group on the north and northeastern margin of the Hotailuh batholith (Figure 1; Anderson, 1983; Gabrielse, 1998). The volcanic rocks in the eastern part of the batholith (Figure 3h) are presumed to be the easternmost extension of this belt. On the lower southwest ridge of peak 2214 m, black weathering, hornblende(?)-plagioclase phyric pyroclastic breccia and volcaniclastic pebble-sized conglomerate (unit J V in Table 1) stratigraphically overlie contact metamorphosed, well stratified fine grained sedimentary rocks similar to those exposed on peak 2102 m. No evidence for a thrust fault separating these two units could be found, and if the section is right-way-up, the volcanic rocks may be Early to Middle Jurassic in age, comparable to the succession northeast of Lower Gnat Lake.

Similar to interpretations for the Jurassic rocks in the northwestern area, the basal Lower Jurassic sedimentary rocks may represent deposition related to the Hazelton Group. Further work will need to address whether these rocks, and the entire band of volcanic and sedimentary rocks on the north and northeastern margin of the batholith, are part of the Hazelton Group.

Intrusive rocks

LATE TRIASSIC PLUTONIC SUITE

The Late Triassic plutons within the Cry Lake (104I) and Dease Lake (104J) 1:250 000 map sheets comprise the Stikine plutonic suite of Gabrielse (1998). Late Triassic plutonic rocks comprise about two-thirds of the Hotailuh batholith, and are exposed mainly in the west, northwest and southern part of the batholith (Figure 1). Here, we will only discuss the Late Triassic plutonic bodies within the main part of the Hotailuh batholith; namely the Cake Hill pluton, Beggerlay Creek pluton and Gnat Lakes ultramafite.

Gnat Lakes ultramafite

The Gnat Lakes ultramafite is a small 2.2 x 0.7 km body exposed both west and east of Highway 37, about three kilometres south of Upper Gnat Lake (Anderson, 1983; Nixon *et al.*, 1997; Figure 3a). The body comprises pyroxene(?)-hornblende gabbro and plagioclase-bearing ultramafite (likely predominantly hornblendite; unit LT GLUM). The body and its immediate surroundings has been mapped by Nixon *et al.* (1989, 1997), who describe it as an Alaskan-type ultramafic body based on the presence of hornblende clinopyroxenite, hornblendite and gabbro lithologies, minor zoning and distinctive whole rock and mineral chemistry data. The body has been dated by Zagorevski *et al.* (2011) as 223.2 ±2.0 Ma using the hornblende ^{40}Ar-^{39}Ar method. The ultramafic body is cut by irregular hornblende-bearing dikelets of granodiorite, monzonite and diorite composition, which form intrusive breccias (Figure 6). These leucocratic phases (unit LT GL_F in Table 1) have not been found outside of the Gnat Lake body, and are tentatively interpreted as cogenetic with the ultramafic body.

Anderson (1983) interpreted the Cake Hill pluton to predate the Gnat Lakes ultramafite, based on observations southwest of Lower Gnat Lake along the abandoned railroad grade. He reports (p. 85): "Irregular, dun weathering apophyses of hornblende pyroxenite engulf sphene-bearing, well foliated hornblende diorite and include rounded xenoliths of it." Upon revisiting these outcrops, we found intimately mixed ultramafic and mafic rock types, both cut by a felsic dike of Cake Hill composition (Figure 7). The mafic rocks exposed here are foliated, hornblende-rich diorites to gabbros, which both include and are included by plagioclase-bearing hornblendite. The mafic rocks are more hornblende-rich (40-60% hornblende) than typical Cake Hill. The felsic dike comprises foliated titanite-bearing hornblende diorite, and apart from the relatively low K-feldspar content (0-5% K-feldspar) appears similar to typical Cake Hill. Based on these observations we suggest that the Gnat Lakes body might predate the Cake Hill pluton. A similar mafic body is exposed immediately east of the main Gnat Lakes ultramafic body. The latter location also contains a decimetre-scale xenolith of ultramafic material similar to the Gnat Lakes ultramafic body. These relationships suggest a genetic link between the mafic phases and the Gnat Lakes ultramafite rather than to the Cake Hill pluton, which has made us reassign these rocks to a mafic subphase (LT GL_M, see Table 1, Figure 3a) of the Gnat Lakes body. These mafic exposures located immediately east of the Gnat Lakes ultramafite and other exposures located about 3 km south have been described as augite metagabbro by Read (1984) and Gabrielse (1998). To be consistent, these exposures have all been reassigned to the Gnat Lakes mafic subphase.

Cake Hill pluton

The Cake Hill pluton is the most areally extensive pluton of the Hotailuh batholith (Figure 1). The pluton is relatively homogeneous, xenolith free, comprises equigranular hornblende quartz monzodiorite to quartz monzonite, and contains trace amounts of titanite (LT CH in Table 1). Generally, the Cake Hill can be distinguished from the Three Sisters central felsic phase by the presence of abundant tabular hornblende rather than biotite, presence of trace titanite, rare presence of a moderately developed fabric, and possibly also a lack of fine grained dioritic xenoliths. A preliminary U-Pb zircon crystallisation age of *ca.* 226 Ma from the southern part of the Cake Hill pluton determined by this study

Figure 6. Hornblende-bearing granodiorite (Gnat Lake felsic phase, GL_F) intruding and brecciating the Gnat Lake ultramafite (GL_{UM}). Hammer for scale.

Figure 7. Titanite-bearing hornblende diorite dike (CH) intruding hornblende-rich diorite to gabbro to plagioclase-bearing hornblendite (GL_M, GL_{UM}). Pencil for scale.

corroborates the 221±3 Ma age reported by Anderson and Bevier (1992). A light coloured, epidote altered, hornblende quartz diorite to tonalite (?) phase is present in the southeast corner of the batholith (Figure 3g). These rocks were mapped as the leucocratic phase of the Three Sisters by Anderson (1983, page 287), and were reinterpreted as Cake Hill by Gabrielse (1998). The rocks contain tabular, epidote-altered hornblende, appear K-feldspar-poor in the field (to be tested by staining and petrography), and resemble the main Cake Hill pluton. In addition, the unit contains several irregular metre-scale domains of hornblende quartz monzonite to quartz monzodiorite containing tabular hornblende and trace titanite, characteristic of the Cake Hill pluton. We adopt Gabrielse's interpretation, and have assigned the leucocratic unit to the Cake Hill pluton (unit LT CH_L in Table 1). The presence of a ~4 km wide west-northwest to east-southeast corridor of Cake Hill rocks connecting the southeasternmost exposures with the main pluton has not been confirmed during this study (*cf.* Figures 1, 3e), and remains to be tested. Several <1 km enclaves of hornblende quartz monzodiorite to quartz monzonite, presumed to represent Cake Hill, are hosted by the Three Sisters central felsic phase in the southeast (Figure 3g). However, gradational contacts complicate distinguishing these domains from surrounding biotite-hornblende to hornblende-biotite quartz monzodiorite and quartz monzonite of the Three Sisters central felsic phase. Similar relationships are found in the north-central part of the batholith, where differentiating Cake Hill from the Three Sisters central felsic phase is problematic (Figure 3c). In this area, rocks previously mapped as Three Sisters central felsic phase (Anderson, 1982; Gabrielse, 1998) are reinterpreted as Cake Hill based on the presence of tabular hornblende and trace titanite. Some of the ambiguity in distinguishing the Cake Hill from the Three Sisters central felsic phase is likely due to the (partial to complete) assimilation of Cake Hill by the Three Sisters central felsic phase pluton. A foliated, finer grained biotite(?)-hornblende diorite to quartz diorite is present in the southeast of Figure 3d, and has been assigned to the Late Triassic Cake Hill pluton due to the presence of hornblende and its foliated nature (LT CH_F in Table 1). The presence of Cake Hill rocks in the far southeast and eastern parts of the Hotailuh batholith suggests that this pluton occupied much of eastern half of the batholith before intrusion of the Three Sisters pluton.

Beggerlay Creek pluton

The Beggerlay Creek pluton is confined to the southern part of the Hotailuh batholith, and straddles the boundary between the NTS 104I and 104H map sheets north of the Stikine River. The pluton has been studied previously by Anderson (1983), Read and Psutka (1990), Gabrielse (1998) and Evenchick and Thorkelson (2005). We visited the pluton where it forms the southernmost part of the Hotailuh batholith (Figure 3f). All but the southwestern exposures in this area are comprised of hornblende-rich diorite to gabbro (unit LT BC) with minor plagioclase-bearing hornblendite domains (unit LT BC_H). Exposures in the southwest comprise highly altered (serpentinized?) plutonic ultramafic rocks (unit LT BC_{UM} in Table 1). The nature of the Beggerlay Creek – Cake Hill contact was reinterpreted, and now includes all hornblende-rich diorite and gabbro up to an abrupt change (over a 10 m covered interval) to titanite-bearing, hornblende quartz monzonite of the Cake Hill pluton (Figure 3f; *cf.* Anderson, 1983, pages 84-85, pages 139-140, Appendix 2.3c). Hornblende-rich diorite and gabbro closest to the contact, now assigned to the Beggerlay Creek pluton, are intensely foliated roughly parallel to the trace of the contact.

Minor coarse K-feldspar±epidote dikes (unit LT BC_P) crosscut the northwestern Beggerlay Creek pluton, and may be related to a 5 by 1 km biotite metasyenite phase of the Beggerlay Creek pluton mapped about 7 km to the east (Read and Psutka, 1990). Coarse K-feldspar dikes, similar to those within the Beggerlay Creek pluton, also crosscut the augite-phyric coherent rocks of the Stuhini Group near the contact with the mafic phases of the Beggerlay Creek intrusion. Intrusive relationships between the Beggerlay Creek and Cake Hill plutons were not observed, however Anderson (1983, pages 84-85, Appendix 2.3c) reports that in two locations a gabbro dike of suspected Beggerlay Creek affinity intrudes quartz monzodiorite of the Cake Hill.

EARLY JURASSIC MCBRIDE RIVER PLUTON

The McBride River pluton underlies an 8 x 20 km area at the easternmost margin of the Hotailuh batholith, dissected by the McBride River (Anderson, 1983; Gabrielse, 1998; Figure 1). The main body of the McBride River pluton was not visited during this study; however, we reassigned an intrusive body originally assigned to the Late Triassic Cake Hill pluton (Anderson, 1983; Gabrielse, 1998) to the McBride River pluton. It is composed of massive, equigranular (3-4 mm) hornblende monzogranite and granodiorite plutonic rocks that are significantly more quartz rich than typical Cake Hill, and, notably, contain minor but ubiquitous 4-7 mm quartz blebs, a feature common in the McBride River pluton (Anderson, 1983, p. 377). In addition, adjacent Toarcian to possibly Bajocian sedimentary strata (Gabrielse, 1998) are clearly contact metamorphosed by the pluton, providing a minimum Early Jurassic age that is untenable with the pluton being Late Triassic. We report a new preliminary U-Pb zircon crystallization age of *ca.* 190 Ma for this intrusive body, which is within error of the 184±8 Ma U-Pb zircon age for the main McBride River pluton established by Anderson and Bevier (1992).

MIDDLE JURASSIC (–EARLY CRETACEOUS?) THREE SISTERS PLUTON

The Three Sisters pluton comprises about one-third of the Hotailuh batholith. It is predominantly exposed in the eastern half of the batholith and also forms a significant exposure around and west of Highway 37

(Figure 1). The Three Sisters pluton is internally heterogeneous, and has been subdivided into four separate phases by Gabrielse (1998). The four phases studied include the fine grained mafic phase, mafic phase, central felsic phase and potassic phase (Table 1).

Fine grained mafic phase

The Three Sisters fine grained mafic phase is restricted to a 8 x 2 km body in the southeast of the Hotailuh batholith (Figure 3g); it also occurs as centimetre- to decimetre-sized xenoliths within parts of the Three Sisters central felsic phase. The fine grained mafic phase comprises massive, equigranular to sparsely plagioclase porphyritic, hornblende quartz (?) diorite with a 1-1.5 mm crystal size. Hornblende tonalite dikes intrude the fine grained mafic phase.

Mafic phase

The mafic phase is a volumetrically small unit of the Three Sisters pluton. Overall, it is fairly uniform compositionally, and comprises massive, equigranular, hornblende-rich diorite. Texturally, the rocks are varied, and comprise either acicular hornblende or equant blebby hornblende, with both textural types exhibiting wide variations in crystal size (1-20 mm). The mafic phase occurs as small to medium-sized (<1-2 km^2) bodies within the Three Sisters central felsic phase (Figure 3e). The central felsic phase intrudes into, as well as assimilates and includes fluidal fragments of the mafic phase. Furthermore, the fluidal domains of mafic phase within central felsic phase rocks often show a decrease in grain size towards the clast edge (Figure 8), interpreted as chilled margins. All evidence suggests that the two phases formed roughly at the same time. Similar mafic plutonic rocks crop out as several small (<0.5 km^2) bodies within the Cake Hill and McBride River plutons close to the contact with the main Three Sisters pluton (Figures 3c, h respectively). Where the mafic phase is present within these older plutonic rocks, the latter are observed intruding, and often including, the mafic phase rocks. Anderson (1983, p.86) reports similar observations at these locations, but also reports irregular mafic phase dikelets intruding Cake Hill, features interpreted to reflect remelting and remobilization of felsic rocks by intrusion of hot mafic melts. The remelting of felsic rocks by intrusion of mafic melts is a common feature in batholiths worldwide (*e.g.* Blundy and Sparks, 1992). In the southeast (Figure 3e), the mafic phase intrusions form subhorizontal tabular bodies confined to the highest ridge tops. In the north (Figure 3b), a body several square kilometres in size forms the margin of the Three Sisters pluton.

Central felsic phase

The areally most extensive phase occupies the central portion of the Three Sisters pluton. It consists of massive, equigranular (2-3 mm) biotite and lesser hornblende-biotite quartz monzonite and quartz monzodiorite, locally

Figure 8. Irregular xenolith of acicular hornblende diorite (TS_M) within hornblende-biotite quartz monzodiorite (TS_C). Note decrease in grain size within mafic xenolith from core to rim. Pencil for scale.

with K-feldspar phenocrysts. In addition to the internal variation in composition and texture, the central felsic phase encloses several other intrusive phases. For example, an estimated 15 to 50% of the north-south traverses along ridges in Figures 3e, g, h comprise either older (partly assimilated?) Cake Hill pluton, roughly coeval Three Sisters mafic phase, or crosscutting Three Sisters potassic phase. Notably, certain ridges that have been mapped by Anderson (1983) and Gabrielse (1998) as solely central felsic phase (north-south trending ridge in northwestern part of Figure 3e), comprise substantial proportions of other rock types.

The age of the central felsic phase is only constrained by K-Ar dates reported in the '70s and early '80s (see compilation in Anderson and Bevier, 1992). A preliminary U-Pb zircon crystallisation age from a biotite quartz monzonite exposed along the eastern margin of the Three Sisters pluton yielded a *ca.* 117 Ma age (this study). Ongoing research will address whether part or all of the Three Sisters central felsic phase may in fact be Early Cretaceous, rather than Middle Jurassic in age. This raises the possibility that some or all of the crosscutting potassic dikes, the roughly coeval mafic phase, as well as the fine grained mafic phase are significantly younger than previously recognized.

Potassic phase

The Three Sisters potassic phase comprises massive, equigranular (1-4 mm crystal size) to locally K-feldspar porphyritic (5-20 mm crystal size), biotite to rarely biotite-bearing, granite, quartz syenite and quartz monzonite. This phase occurs as a large body straddling Highway 37 that appears to be connected to the main part of the Three Sisters pluton through a relatively narrow (~1.5 km wide) corridor occupied by associated potassic phase rocks (Figure 1; Anderson, 1983; Gabrielse, 1998).

Elsewhere, several medium sized bodies of the potassic phase form the margin of the Three Sisters pluton in the eastern half of the batholith. Several smaller potassic phase bodies crosscut the central felsic phase pluton, and immediately adjacent plutons (Figure 3e, g, h).

A preliminary U-Pb zircon crystallisation age of *ca.* 165 Ma (this study) is only slightly younger than a 171±1 Ma date by Anderson and Bevier (1992) for these coarse grained intrusive rocks. Abundant fine grained, pink, biotite-phyric dikes, presumed to be related to the potassic phase, cut almost all adjacent plutonic and sedimentary rocks. The potassic and central felsic phases are distinguished by more quartz, less biotite and more K-feldspar than plagioclase in the potassic phase. In places, the potassic phase can be difficult to distinguish from the central felsic phase. Some areas mapped previously as the potassic phase corridor (Figure 1; Anderson, 1983; Gabrielse, 1998) consist of massive, relatively fine grained (1-2 mm crystal size), biotite quartz diorite (Figures 3d, e). Further investigations are needed to fully characterize distinctions between these phases.

OTHER INTRUSIVE ROCKS

In addition to the plutonic rocks described above, several small intrusive bodies and numerous dikes are present throughout the study area. A mineralized intrusive body is the "Gnat Pass intrusive" (unit LT GP in Table 1). Where unaltered, it comprises massive, equigranular (2 mm crystal size) to quartz porphyritic (2-4 mm crystal size), hornblende to hornblende-bearing diorite to quartz diorite and granodiorite. The intrusive occupies an area of ~0.1 km^2 in the "hill zone" (main zone) of the Gnat Pass mineral prospect (Smith and Garagan, 1990). A preliminary U-Pb zircon crystallisation age from the Gnat Pass intrusive at the hill zone yielded a *ca.* 217 Ma age (this study), only slightly younger than the Late Triassic plutons in the area. Similar intrusive bodies and dikes 1-10 m in width, generally also associated with minor sulphides, are found along Gnat Creek downstream of Lower Gnat Lake ("creek zone" of the Gnat Pass prospect) as well as along Highway 37 north of Lower Gnat Lake. In all areas, the intrusive cuts Triassic Stuhini Group augite-phyric coherent rocks. Interestingly, Asbury (1967) reports a 0.5 by 1 km-size granodiorite intrusion approximately 3.5 km northwest of Lower Gnat Lake. The body is described as "... a medium-grained, granular rock containing grey to pink plagioclase, an estimated 15% free quartz and 1% to 2% mafic minerals." This body is not shown on the regional geological map of Gabrielse (1998), and warrants additional study to determine its spatial extent and possible association with mineralization. In addition, possible cogenetic Fe-carbonate altered rhyodacite dikes that postdate all other units and are typically associated with sulphide mineralization are reported at the Dalvenie showing (Wetherill, 1990, page 13).

A small intrusion located further south of Gnat Pass is tentatively named the "Tees Creek intrusive". This altered hornblende-feldspar porphyry is exposed along the abandoned railroad about 1.5-3.5 km south of the Gnat Lakes ultramafite; it also occurs as irregular dikes intruding the coarse grained potassic phase of the Three Sisters pluton. The intrusive is associated with minor pyrite at the "BCR north" mineral occurrence.

STRUCTURAL GEOLOGY AND METAMORPHISM

Whereas the Hotailuh batholith appears to be mostly unaffected by post-intrusion contractional deformation, most surrounding sedimentary and volcanic rocks have been deformed. The area north of the Hotailuh batholith comprises predominantly moderately north-dipping strata, ascribed to result from south-directed thrusting along the King Salmon and Hotailuh faults (Gabrielse, 1998). The Gnat Pass area appears to be a major structural zone with evidence for a north to north-northwest striking ductile to brittle fault zone localized along part of the western margin of the Cake Hill pluton. Faulting and folding is common in Triassic sedimentary and volcanic rocks east of this fault zone (Read, 1984; Gabrielse, 1998). The structural style in the area south and east of the batholith is poorly understood. Two regional-scale faults inferred along the Stikine River include the Beggerlay Rapids and Pitman faults (Evenchick and Thorkelson, 2005).

Anderson (1983, pages 67-76) and Gabrielse (1998, page 64) described the Cake Hill pluton as pervasively or well foliated. However, we found the fabric within the Cake Hill pluton to be moderately developed to absent, except in a north-northwest striking zone in the Gnat Pass area where it is well developed. The fabric is defined by alignment of tabular hornblende crystals. Although moderately aligned hornblende is regularly observed in outcrop, it is commonly inconsistent over the metre scale. Where present, the orientation of the foliation measured herein is generally similar to the northwest-southeast striking, subvertical orientations reported by Anderson (1983). Except within the Gnat Pass zone (see below), the foliation is likely magmatic in origin.

Gnat Pass fault

The Gnat Pass fault strikes north-northwest, and is found on the western margin of the Hotailuh batholith. This subvertical brittle fault is exposed in a 2 m wide recessive zone in an exposure along the abandoned railroad. Augite-phyric coherent rocks on the east wall of the fault, as well as within at least 500 m on both sides of the fault, are intensely foliated, with foliation orientations parallel to the trend of the brittle fault. The foliation comprises newly formed green platy minerals (chlorite?) wrapped around relict augite phenocrysts, likely indicating greenschist facies metamorphic conditions. Sedimentary rocks on the west wall of the fault and further southwest lack a foliation, appear unmetamorphosed, and show bedding attitudes roughly parallel to the fault. In addition, granitoid rocks of the

Cake Hill pluton are well foliated up to a distance at least 750 m from the brittle fault. Foliation is defined by alignment of tabular hornblende, and the foliation is parallel to the brittle fault. Based on these observations, we infer the presence of a north-northwest striking, subvertical, ductile shear zone, roughly situated on the western margin of the Cake Hill pluton. Syn-intrusion shear would explain the relatively narrow band of foliated and metamorphosed country rocks, as well as the presence of a well-developed fabric formed by igneous hornblende in the pluton. The ductile shear zone became the locus of brittle deformation during subsequent cooling and/or exhumation.

The north-northwest striking belt of foliated rocks continues at least 3 km to the north and 5 km to the south where it appears to be cut by undeformed plutonic rocks of the Three Sisters potassic phase. Further north, the location of the Gnat Pass shear/fault zone is unconstrained, and it is inferred to truncate the Hotailuh thrust northwest of Lower Gnat Lake (Anderson, 1983; Gabrielse, 1998; Evenchick *et al.*, 2005). The northern terminus of this fault is inferred to intersect the King Salmon thrust fault, separating the Hotailuh allochthon from rocks further west (Figure 1; Gabrielse, 1998).

Hotailuh thrust fault

An exposure of the Hotailuh thrust could not be found during current mapping between Highway 37 and peak 2096 m (Figure 3a). Reported evidence for the fault is the presence of presumed Triassic Stuhini rocks overlying Early Jurassic fossil-bearing siliciclastic sedimentary rocks of the Takwahoni Formation (Anderson, 1983; Gabrielse, 1998). However, preliminary detrital zircon results (Iverson *et al.*, this volume) suggest a Middle Jurassic or younger age for the overlying package, leaving no requirement for the presence of a thrust fault in this particular location. On the eastern margin of the batholith (Figure 3h), the Hotailuh thrust has been inferred within steep and largely inaccessible topography surrounding peak 2214 m (Anderson, 1983; Gabrielse, 1998). Study of the lower southwest ridge of peak 2214 m found no evidence for a thrust fault, and if the section is right-way-up, the volcanic rocks previously assigned to the Triassic Stuhini Group may be Early to Middle Jurassic in age, comparable to the succession further west that yielded Jurassic detrital zircon populations.

Other structures and metamorphism

The succession of Middle Jurassic sedimentary and volcanic rocks around peak 2096 m is cut by several north-northeast to north-northwest trending, subvertical faults with stratigraphic offset suggesting a dextral strike slip and/or east-side-down dip slip motion. Another important structure is the Dalvenie fault, which hosts the Dalvenie copper-gold-silver prospect (Figure 3a). Several roughly parallel lineaments and/or possible faults are present in the immediate area (Figure 3a; Nixon *et al.*, 1989).

At the eastern margin of the Hotailuh batholith, sedimentary rocks with Early (to Middle?) Jurassic fossils are contact metamorphosed by the *ca.* 190 Ma hornblende monzogranite to granodiorite of the McBride River pluton (Figure 3h), providing an Early Jurassic or older age constraint for this sedimentary unit. Several skarn bodies comprising brown garnet, dark green pyroxene (?), light bright green vesuvianite (?) and/or white fibrous wollastonite (?) occur within about 50 m of the contact with the intrusive, and represent contact metamorphosed calcareous, fine grained sedimentary rocks. In addition, three apophyses of altered felsic intrusive rocks extend into the sedimentary rocks. Anderson (1983, p. 305) interpreted these intrusives as Late Triassic Cake Hill, and attributed the contact metamorphism to intrusion of the nearby Three Sisters pluton. Current mapping shows that the Three Sisters pluton is at least 1-1.5 km away from most of the calcic exoskarns, and given the very local skarn development near the monzogranite/granodiorite contact, it appears implausible that this contact metamorphism is caused by the intrusion of Three Sisters.

Mafic intrusive rocks of the Beggerlay Creek pluton are intensely foliated in a 500-750 m wide zone adjacent to the Cake Hill contact (Figure 3f). The steeply dipping, east to east-northeast striking foliation is defined by elongated (recrystallized?) hornblende and plagioclase, imparting an almost gneissic compositional banding in places.

MINERALIZATION

Five mineralized prospects and showings in the MINFILE database (see http://minfile.gov.bc.ca) have been visited within the Hotailuh study area. Most of these occur in the easily accessible Gnat Pass area where rock exposure is poor to moderate. An additional eight new mineral occurrences were identified, both within the Gnat Pass area, and on well-exposed ridges of the Hotailuh batholith.

A total of 20 mineralized (grab) samples were collected from 4 MINFILE locations, as well as 7 from the newly identified mineral occurrences. The samples were jaw crushed and pulverized in a Cr-steel mill at the Geological Survey sample preparation facilities in Victoria and analysed at Acme Labs in Vancouver. The samples were dissolved using a four-acid digestion followed by multi-element ICP-MS analysis. Gold was also analysed by lead-collection fire assay fusion followed by ICP-ES analysis. Values reported in Table 2 include analysis of one repeat on a jaw crushed reject sample, an external standard, and Acme's internal quality control duplicate samples and standard.

Table 2. Assay results and coordinates of mineralized rock samples collected during 2011 field work in the Hotailuh area.

Mineral occur.	Element				Au*	Ag	Cu	Mo	W	Sn	Bi	As	Sb	Ba	Pb	Zn	Rb	Sr	Cd	Ni	Co
	Units				ppb	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
	Detection limit				2	0.1	0.1	0.1	0.1	0.1	0.1	1	0.1	1	0.1	1	0.1	1	0.1	0.1	0.2
	Station no.	UTM E	UTM N	Unit																	
Gnat P.	BVA-5-30	450,034	6,458,207	LT GP	12	0.1	161	<0.1	1.0	0.3	0.9	30	4.2	463	4	5	79	211	<0.1	3	109
	BVA-9-48	450,502	6,457,572	LT GP	4	<0.1	34	0.4	0.5	0.6	0.1	7	2.4	598	2	23	66	182	<0.1	2	6
	JLO32-319	451,832	6,457,090	LT GP	41	0.6	7221	16.7	0.6	0.6	0.1	5	1.0	510	7	32	134	315	0.2	4	8
Dalv.	BVA-11-62a	448,489	6,449,977	T ST$_{SF}$	14	<0.1	87	<0.1	29.5	0.9	4.8	535	54.9	53	2	3	64	38	<0.1	230	31
	BVA-11-62b	448,489	6,449,977	T ST$_{SF}$	570	2	463	0.5	9.8	1.2	61.0	>10000	205	36	32	21	38	121	<0.1	53	93
Gnat Cr.	BVA-2-12	451,163	6,451,183	LT CH	1703	81.7	>10000	5.5	<0.1	0.1	483	<1	1.4	50	79	125	62	599	0.5	5	18
Gnat L. um.	BVA-11-57	449,665	6,450,261	T ST$_{SF}$	<2	<0.1	72	1.9	0.3	3.9	0.3	<1	0.3	341	11	33	64	21	<0.1	21	11
	BVA-11-58b	449,472	6,449,706	LT GL$_F$	<2	0.1	87	8.2	0.8	0.9	0.1	5	1.8	1005	8	78	19	689	<0.1	39	22
	BVA-11-59	449,321	6,449,882	LT GL$_{UM}$	5	0.2	402	3.7	0.2	1.3	0.1	2	1.9	245	4	93	5	424	0.2	30	96
	Acme Dup	,,	,,	,,	*4*																
Mat	BVA-26-184	462,220	6,428,961	T ST$_{SF}$	2	0.2	139	7.0	0.4	0.7	<0.1	4	<0.1	27	5	129	2	80	0.4	146	20
	BVA-26-187	461,821	6,429,303	T ST$_{SF}$	<2	0.1	133	0.9	0.2	0.6	<0.1	22	0.4	36	73	57	2	272	0.2	63	39
Mat N	BVA-25-172	461,904	6,431,947	LT CH	39	9.1	>10000	0.7	0.2	0.2	5.4	<1	0.4	3102	13	86	32	1120	0.1	25	22
Pat	BVA-13-74	470,681	6,449,148	LT CH?	32	1.1	2962	2.2	0.4	1.8	1.0	12	0.7	392	4	24	25	568	<0.1	10	20
Pat W	BVA-14-82	467,697	6,447,881	MJ-EK TSc	21	0.7	7079	0.1	2.4	1.1	0.6	19	1.3	1083	2	49	117	159	0.2	2	15
	BVA-15-90	466,323	6,447,968	MJ TSp	<2	<0.1	131	2.0	0.1	0.5	<0.1	4	<0.1	1179	4	7	84	461	<0.1	2	8
3 Sis. N	BVA-30-216	480,344	6,438,583	MJ-EK TSc	9	0.2	3645	6.4	>200	3.4	<0.1	3	0.4	130	3	92	19	195	0.2	5	51
3 Sis.	BVA-32-241	480,590	6,435,596	MJ TSf	80	<0.1	3520	0.8	6.1	0.7	0.2	<1	0.2	41	2	59	2	270	<0.1	3	15
	BVA-32-246	481,249	6,435,903	LT CH	<2	<0.1	144	3.8	3.2	2.7	<0.1	<1	<0.1	188	3	9	4	550	<0.1	2	15
3 Sis. S	BVA-33-253	481,447	6,433,699	T ST$_V$	<2	<0.1	55	6.8	1.1	0.8	0.1	5	0.2	40	1	3	2	1028	<0.1	10	124
	BVA-33-257	481,525	6,433,380	T ST$_V$	14	0.4	3367	314	33.3	3.1	2.4	11	2.7	51	2	58	9	521	<0.1	11	123
	Acme Dup	,,	,,	,,		*0.3*	*3452*	*332*	*39*	*3.2*	*2.3*	*9*	*2.6*	*51*	*2*	*59*	*9*	*537*	*<0.1*	*11*	*122*
	BVA-33-257Dup	,,	,,	,,	*14*	*0.3*	*2925*	*240*	*32*	*4.6*	*2.4*	*8*	*3.1*	*50*	*2*	*54*	*7*	*560*	*<0.1*	*12*	*105*
Standards	*RU-1*	-	-	*Standard*	*238*	*3.9*	*7546*	*10.9*	*8.5*	*9.9*	*18.9*	*67*	*0.9*	*31*	*380*	*>10000*	*9*	*88*	*60*	*32*	*104*
	*Expected***	-	-	,,	*300*	*7*	***8540***									***22370***			*70*	*70*	
	OREAS45C	-	-	*Standard*		*0.2*	*595*	*2.2*	*1.0*	*2.8*	*0.2*	*11*	*0.8*	*279*	*24*	*81*	*24*	*35*	*0.2*	*317*	*100*
	OREAS45C	-	-	,,		*0.1*	*591*	*2.6*	*1.2*	*3.0*	*0.2*	*10*	*0.8*	*272*	*25*	*79*	*24*	*39*	*0.1*	*302*	*98*
	*Expected***	-	-	,,		*0.28*	*620*	*2.26*	*1.06*	*2.9*	*0.21*	*10.1*	*0.79*	*270*	*24*	*83*	*24*	*36.4*	*0.15*	*333*	*104*

Significant values in yellow, anomalous values in orange, slightly elevated values in blue. Abbreviations used for mineral occurrences: Gnat P. = Gnat Pass, Gnat Cr. = Upper Gnat Creek, Dalv. = Dalvenie, Gnat L. um. = Gnat Lakes ultramafite, 3 Sis. = Three Sisters, W = west, N = north, S = south. For unit abbreviations, see Table 1.

* Analysed by lead-collection fire assay fusion followed by ICP-ES, all other elements analysed by four-acid digestion followed by ICP-MS.

** Recommended values for CANMET standard RU-1 in bold (Faye *et al.*, 1977). Expected values for Acme Labs internal standard.

Table 2. continued.

Element	Cr	V	Nb	Y	Zr	Sc	La	Hf	Ta	Ce	Th	U	Li	Be	Mn	Ti	Al	Fe	Mg	Ca	Na	K	P	S
Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	%	%	%	%	%	%	%	%
Detection limit	1	1	0.1	0.1	0.1	1	0.1	0.1	0.1	1	0.1	0.1	0.1	1	1	0.001	0.01	0.01	0.01	0.01	0.001	0.01	0.001	0.1
Station no.																								
BVA-5-30	63	24	2.0	2	22	1	2	0.9	<0.1	5	0.7	0.8	4	<1	23	0.08	7.7	2.5	0.1	0.1	4.09	1.82	0.01	1.6
BVA-9-48	30	39	3.3	3	40	3	5	1.3	0.2	12	1.6	1.0	7	2	103	0.15	7.9	1.5	0.1	0.2	4.53	2.39	0.05	0.2
JLO32-319	32	53	3.7	8	24	4	8	1.0	0.2	16	1.8	1.2	5	<1	221	0.20	7.1	1.3	0.2	0.5	2.10	5.76	0.08	0.5
BVA-11-62a	769	168	0.3	9	13	23	21	0.5	<0.1	41	0.2	0.4	16	<1	4597	0.22	3.9	3.9	0.7	5.0	0.03	1.75	0.10	0.1
BVA-11-62b	299	91	0.4	2	17	10	43	0.5	<0.1	60	0.5	1.3	22	<1	336	0.08	2.9	10.2	0.1	0.0	0.03	1.02	0.04	4.0
BVA-2-12	17	77	0.2	2	2	<1	6	<0.1	<0.1	6	0.2	7.1	10	<1	815	0.02	4.0	24.8	0.7	1.5	0.03	2.31	0.01	9.7
BVA-11-57	64	22	1.1	4	13	9	7	0.3	<0.1	22	1.0	0.3	17	<1	1088	0.11	3.9	1.3	1.0	0.1	0.10	1.76	0.02	0.4
BVA-11-58b	60	326	1.9	17	20	31	8	1.0	<0.1	19	0.7	0.4	4	<1	1249	0.65	7.6	6.5	3.6	5.8	3.57	0.84	0.30	0.1
BVA-11-59	88	511	1.9	17	31	64	4	1.3	<0.1	13	0.4	0.2	3	<1	1544	1.06	5.8	13.3	6.3	7.9	1.15	0.60	0.06	1.9
Acme Dup																								
BVA-26-184	105	333	6.0	21	24	22	14	0.8	0.4	27	2.9	1.4	2	<1	833	0.47	8.0	4.7	1.1	1.2	7.67	0.12	0.07	1.3
BVA-26-187	499	212	1.0	10	17	51	5	0.7	<0.1	12	1.1	0.5	11	<1	1741	0.31	4.8	5.9	6.4	10.4	1.88	0.09	0.18	1.0
BVA-25-172	27	107	4.2	6	4	<1	19	0.2	0.3	35	2.0	2.4	27	2	827	0.58	8.6	3.3	2.5	2.0	3.75	1.34	0.13	0.2
BVA-13-74	61	69	3.6	12	8	4	16	0.5	0.2	35	3.5	1.7	8	1	592	0.21	7.2	4.6	0.9	3.5	2.99	0.65	0.06	0.2
BVA-13-82	52	85	3.7	18	8	9	11	0.5	0.2	26	7.6	6.9	8	<1	811	0.22	6.8	3.3	0.8	0.5	2.23	3.05	0.09	<0.1
BVA-15-90	66	18	4.0	12	17	2	20	0.6	0.3	39	7.5	2.5	6	1	162	0.13	7.1	1.6	0.4	1.0	3.63	2.82	0.05	0.5
BVA-30-216	40	244	1.7	24	11	31	11	0.5	0.1	24	4.7	27.5	6	3	1683	0.18	5.1	22.0	2.0	3.2	1.11	0.70	0.07	<0.1
BVA-32-241	53	99	2.8	15	41	9	14	1.4	0.2	29	4.2	6.2	5	<1	627	0.26	6.6	5.4	1.9	1.6	3.53	0.09	0.07	<0.1
BVA-32-246	32	54	6.2	19	31	10	70	1.2	0.3	105	3.7	2.9	1	2	310	0.28	7.8	1.8	0.8	3.3	4.38	0.21	0.06	0.6
BVA-33-253	36	136	5.4	21	55	17	17	1.5	0.3	34	3.8	1.1	2	1	258	0.55	9.6	7.1	2.4	4.9	3.55	0.17	0.16	2.4
BVA-33-257	58	180	4.1	22	57	18	15	1.6	0.2	31	2.4	2.2	5	1	1906	0.43	5.7	16.3	3.5	3.3	0.68	0.20	0.10	1.8
Acme Dup	*59*	*182*	*4.2*	*22*	*61*	*17*	*15*	*1.5*	*0.2*	*32*	*2.5*	*2.3*	*5*	*1*	*1978*	*0.44*	*6.0*	*15.7*	*3.6*	*3.3*	*0.70*	*0.20*	*0.11*	*1.8*
BVA-33-257Dup	*67*	*182*	*3.8*	*23*	*56*	*19*	*17*	*1.6*	*0.2*	*34*	*2.5*	*2.5*	*5*	*1*	*1805*	*0.41*	*5.8*	*15.6*	*3.2*	*3.7*	*0.69*	*0.19*	*0.10*	*1.6*
Standard RU-1	*53*	*59*	*1.4*	*9*	*34*	*11*	*8*	*1.0*	*<0.1*	*17*	*1.2*	*0.8*	*5*	*<1*	*778*	*0.12*	*3.5*	*22.9*	*3.1*	*2.6*	*0.40*	*0.26*	*0.02*	*>10.0*
*Expected***															*1000*	*0.2*	*4.3*	***24.40***	*3.3*	*2.8*	*0.8*	*0.6*		***21.6***
OREAS45C	*934*	*252*	*23.1*	*13*	*160*	*59*	*26*	*4.1*	*1.4*	*49*	*10.1*	*2.2*	*15*	*<1*	*1111*	*1.05*	*6.9*	*17.5*	*0.2*	*0.5*	*0.10*	*0.34*	*0.05*	*<0.1*
OREAS45C	*925*	*239*	*22.9*	*12*	*173*	*58*	*25*	*4.2*	*1.5*	*52*	*10.7*	*2.3*	*15*	*<1*	*1113*	*1.11*	*7.2*	*18.5*	*0.3*	*0.5*	*0.10*	*0.34*	*0.05*	*<0.1*
*Expected***	*962*	*270*	*23.1*	*12.9*	*170*	*59.0*	*26.2*	*4.27*	*1.43*	*54*	*10.2*	*2.4*	*15.7*		*1160*	*1.131*	*7.59*	*18.33*	*0.25*	*0.48*	*0.097*	*0.36*	*0.051*	*0.02*

MINFILE prospects and showings

GNAT PASS (MINFILE 104I 001)

The Gnat Pass copper developed prospect is located immediately north to northeast of Lower Gnat Lake (Figure 3a), and comprises two different zones. The "hill zone" is about 1.1 km east of the lake outlet and was drilled in 1965 and 1989 (Smith and Garagan, 1990). Indicated reserves (non-NI 43-101 compliant) are 30.4 million tonnes grading 0.389 % copper, including 20 % dilution with wall rock grading 0.15 % copper (Lytton Minerals Ltd., 1972, reported in MINFILE 104I 001). The "creek zone" is exposed along the creek draining Lower Gnat Lake, about 750 m north of the lake outlet, and has not been drill tested.

Apart from minor outcrop at the hill zone and along Gnat Creek, very few exposures are present in the immediate area. Mapping conducted during this study indicates that the area is underlain by predominantly augite-phyric coherent rocks of the Triassic Stuhini Group. The augite-phyric rocks are cut at several locations by altered intrusive rocks. Where less altered, these intrusive rocks are plagioclase and sparsely quartz phyric, hornblende to hornblende-bearing diorites, quartz diorites and granodiorites, termed here the "Gnat Pass intrusive". These intrusive rocks are found both in the hill and creek zones, as well as one small outcrop along Highway 37. A preliminary U-Pb zircon crystallization age yields a date of *ca.* 217 Ma (this study). This age implies that these intrusive are part of the Late Triassic plutonic suite, and indicate a pre-217 Ma age for the augite-phyric coherent rocks. The Stuhini augite-phyric coherent rocks and associated intrusive rocks are overlain by a northeast dipping sequence of conglomerate, quartz-bearing feldspathic arenite and graphitic siltstone, as evident in the 1989 drill core (Smith and Garagan, 1990; this study). We have tentatively assigned these rocks to an Early (-Middle) Jurassic coarse grained quartz-rich sedimentary rock unit (lmJ S_{CQ}, Figure 3a). The contact between the Stuhini and siliciclastic rocks is generally brecciated (Smith and Garagan, 1990), however it is unclear whether this is caused by faulting, or a possible unconformable relationship exists. Assay results of 1989 drill core (Smith and Garagan, 1990) indicate that mineralization is mostly associated with the Stuhini Group and intrusive rocks; minor copper occurs in the brecciated contact zone, and only trace copper is present within the siliciclastic succession.

Silicification, tourmaline veining and Fe-carbonate cemented breccias are common in the hill zone. Here, chalcopyrite and pyrite range up to several percent, occur in disseminations or fracture fillings, and are also found within tourmaline veins and Fe-carbonate cement in brecciated zones. A grab sample from subcrop of quartz and plagioclase porphyritic granodiorite on the G-89-8 drill pad returned 0.7% Cu and slightly elevated Au and Mo (sample 11JLO32-319, Table 2). Several percent of pyrite associated with possible K-feldspar alteration is found just north of the creek zone, and pyrite associated with Fe-carbonate alteration is found in the small intrusion along Highway 37. Assay samples of altered intrusive rocks from both locations (11BVA09-48, 11BVA05-30) returned no significant mineralization.

DALVENIE (MINFILE 104I 003)

The Dalvenie gold-copper-silver prospect is located immediately west of the Gnat Lakes ultramafite (Figure 3a). The prospect was mapped, trenched and drilled in the 1960's. Results from the program indicated a 1146 m long mineralized shear zone (Dalvenie shear) with short intercepts of up to 1.5 m containing 4.8 g/tonne gold and 3.73% copper (Wetherill, 1990). The report describes a 10-15 m wide, steeply west dipping shear zone that separates the Gnat Lakes ultramafic body on the east from sedimentary and volcanic rocks on the west side of the fault zone. The shear zone contains abundant, weathered grey quartz; 5 cm wide zones of massive pyrite, chalcopyrite and arsenopyrite; disseminated pyrite and chalcopyrite; and is locally silicified (Wetherill, 1990). Bornite, hematite, siderite, barite, magnetite, pyrrhotite and sphalerite have also been reported (MINFILE 104I 003). A polymictic breccia zone was identified along the trace of the Dalvenie shear, and associated mineralization was sampled (Table 2). Two assay samples were taken about 2 m apart and show the highly variable metal content of the prospect. A sulphide rich sample (11BVA11-62b) returned values of 0.57 g/t Au, > 1% As, anomalous Sb and Bi and slightly elevated Cu and Ag. A intensely silicified and sericitized sample (11BVA11-62a) contained 535 ppm As as well as slightly elevated Sb, Bi and W.

BCR (MINFILE 104I 068)

The BCR copper-zinc-lead-molybdenum showing is located along the abandoned British Columbia railway grade, about 12.5 km south of Upper Gnat Lake (Figure 3a). It is hosted within biotite granites and quartz syenites belonging to the potassic phase of the Middle Jurassic Three Sisters pluton. The rocks contain chalcopyrite with minor sphalerite, galena and molybdenite in north trending sets of fractures, locally with argillic and quartz-sericite alteration envelopes (MINFILE 104I 068). Fifteen percussion holes with a total length of 437 m were drilled along the British Columbia railway grade and drill roads marked 'BCR' on Figure 3a. Samples from drill core returned low copper (<112 ppm) and zinc (<81 ppm; Dircks, 1974). The few outcrops along the British Columbia railroad grade within 1 to 2.5 km north and 1 km south of the drilled area are intensely iron oxide stained and contain several percent disseminated and fracture-hosted pyrite (this study; marked on Figure 3a). Salmon pink K-feldspar alteration developed along epidote-filled fractures is common within the plutonic rocks of the Gnat Pass area, and locally increases in intensity south of the BCR showing. Despite discouraging drill results, the large alteration footprint of this showing warrants additional investigation.

PAT (MINFILE 104I 043)

The Pat copper-molybdenum showing is centred around a drift covered valley north of peak 2196 m (Figure 3c). In addition to copper ± molybdenum soil anomalies, several small mineralized outcrops have been described to the south and southeast of the valley (Sadlier-Brown and Chisholm, 1971; Sadlier-Brown and Nevin, 1977). The mineralization reported by these authors comprises disseminations and siliceous veins carrying chalcopyrite and/or molybdenite. In one outcrop, mineralization is characterized by 1-10 mm pyrite±copper sulphide veins with silicified haloes. An assay sample from this location returned 0.3% Cu and slightly elevated Au and Ag (11BVA13-74 in Table 2). The veins are hosted by biotite-hornblende quartz monzonite and quartz monzodiorite, most likely related to the Cake Hill pluton. Biotite quartz monzonite and quartz monzodiorite, interpreted as the central felsic phase of the Three Sisters pluton, is exposed 100 m to the northeast of this mineral occurrence (Figure 3c).

MAT (MINFILE 104I 034)

The Mat copper-lead-zinc showings are located in a deeply incised forested valley system on the southern margin of the Cake Hill pluton, several kilometres north of the Stikine River (Figures 1, 3f). The area south and southwest of the showing is part of the Stikine River Provincial Park. Poorly exposed fine grained, stratified sedimentary rocks are found in the valleys and are overlain by more competent augite-phyric coherent rocks exposed at topographically higher levels (Figure 3f). Both the sedimentary and volcanic rocks, as well as surrounding foliated hornblende diorites and gabbros, ultramafic rocks and hornblende quartz monzonites, have been reported to host copper, lead and/or zinc sulphide occurrences (McAusland, 1971). In addition, a soil survey (McAusland, 1971) indicated moderately elevated values of nickel (>300 ppm) over part of the survey area, likely related to occurrences of ultramafic rocks. We identified several sulphide occurrences in the fine grained sedimentary rocks, and one within the Cake Hill pluton (see "Mat north" new mineral occurrence). The mineralization within the sedimentary rocks occurs in laminated to very thinly bedded siltstones to medium-grained sandstones, and forms stratiform and more irregular-shaped bodies up to 20 m wide. The sulphides occur as fine to very fine grained disseminations, stratiform horizons and/or within veinlets. Silicification and/or quartz-pyrite veins occur locally. No copper oxides, copper sulphides, galena or sphalerite were observed, possibly due to their very fine grain size. Two assay samples returned no significant metal values (11BVA26-184, 187 in Table 2).

New mineral occurrences

Eight new mineralized and/or alteration zones were discovered within the Hotailuh batholith. Mineralized samples were collected and submitted for base and precious metal assay analysis. Pending further petrographic work, the locations have been described as 'mineral occurrences' rather than 'showings'.

TRIASSIC OCCURRENCES

Four of the new zones are hosted in probable Late Triassic rocks, and include the "Upper Gnat Creek", "Mat north", "Gnat Lakes ultramafite" and "Three Sisters south" mineral occurrences.

The "Upper Gnat Creek" occurrence is located 1.5 km south of Upper Gnat Lake, on a brush and forest-covered ridge about 750 m east of the British Columbia railroad grade. The occurrence comprises a 1-10 cm wide vein of massive sulphides (locally widening to a 20 by 20 cm pod) with associated copper oxide staining, within well-foliated Cake Hill plutonic rocks. The wider mineralized zone is associated with brecciated wallrocks (Figure 9). An assay sample of the massive sulphide breccia returned significant results of 1.7 g/t Au, 82 g/t Ag, >1 % Cu and 483 ppm Bi (11BVA02-12a in Table 2). An outcrop containing copper sulphide-bearing veinlets was found in the same hostrock about 140 m further southeast along the ridge.

The "Mat north" mineral occurrence is found on the east face of an alpine ridge, a couple of kilometres north of the Mat showing. It is hosted by the Late Triassic Cake Hill pluton, and comprises decimetre-size pods containing about 5% disseminated sulphides (pyrite, possible bornite; chrysocolla and malachite staining common). One assay sample returned >1% Cu and slightly elevated Ag, Au and Bi (11BVA25-172 in Table 2). Abundant coarse grained euhedral biotite immediately surrounds the mineralized pods, but is absent further away in the plutonic rocks. The occurrence might be similar to one described by McAusland (1971) where bornite is found in epidote stringers within the Cake Hill pluton.

The "Gnat Lakes ultramafite" occurrences occur within, or immediately surrounding, the Gnat Lakes ultramafite. They are spatially associated with significant topographic lineaments, interpreted as faults, and might be genetically linked to the Dalvenie prospect. Subcrop of intensely silicified and sericite (?) altered, fine grained Stuhini sedimentary rocks contains several percent disseminated pyrite and occurs along strike of a topographic lineament (sample 11BVA11-57 in Table 2). Several ultramafic outcrops contain disseminated pyrite, either directly within ultramafic rocks or associated with later crosscutting felsic dikes (samples 11BVA11-59 and 58b, respectively). Only one of three samples assayed (11BVA11-59 in Table 2) returned slightly elevated copper values. In addition, the easternmost exposures of the ultramafic body contain several percent sulphides and are associated with another north trending topographic

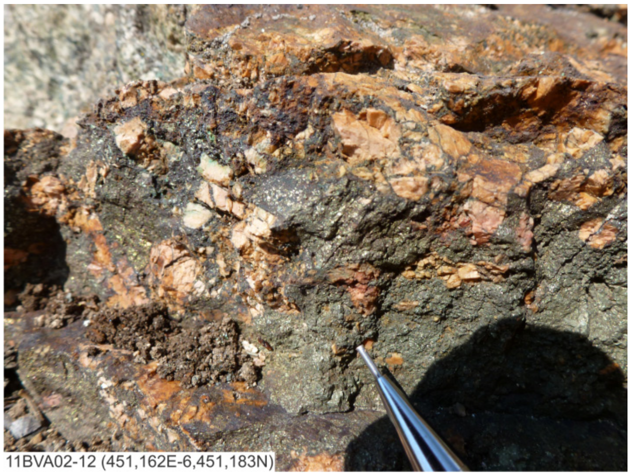

Figure 9. Mineralization at "Upper Gnat Creek". Intensely pink-orange altered and brecciated plutonic rock clasts within massive sulphide matrix. Pencil for scale.

lineament, believed to be the southern extension of the Gnat Pass fault.

The "Three Sisters south" mineral occurrence is hosted in a kilometre size Stuhini inclusion within the leucocratic Cake Hill pluton (LT CHL in Table 1, Figure 3g). Mineralization consists of several zones with 1-5% pyrite disseminated and in veinlets, locally associated with green actinolite. The linear and recessive nature of the gullies suggests that the ≤20 m-wide pyritic zones represent north-northwest to northeast striking subvertical faults cutting the Stuhini succession. One of two assay samples (11BVA33-257 in Table 2) returned 0.3% Cu, 0.03% Mo and slightly elevated W.

THREE SISTERS OCCURRENCES

The remaining four new zones, the "Pat west", "Three Sisters", "Three Sisters north", and "BCR north" mineral occurrences, are hosted in Middle Jurassic (and/or Early Cretaceous?) intrusive rocks of the Three Sisters pluton.

The "Pat west" occurrences are subvertical, roughly east to northeast-trending zones hosted in the Three Sisters pluton, and are spread over the entire local map area (Figure 3b). A one metre wide zone exposed on the easternmost ridge contains quartz+pyrite±copper sulphide veins hosted in biotite quartz monzonite and quartz monzodiorite of the central felsic phase, and returned assay values of 0.7% Cu (11BVA14-82). The mineralized central and western gossanous exposures are larger in aerial extent (30-50 m wide, ≥200-300 m long), contain disseminated pyrite and/or quartz + pyrite veins, and lack copper sulphides. An assay from the latter location (11BVA15-90) did not return any anomalous values.

The "Three Sisters" occurrences are named after the group of peaks on which the fine grained mafic phase of the Three Sisters pluton is exposed (Figure 3g). They are found within the northern margin of the fine grained mafic phase, and within the adjacent central felsic phase and leucocratic Cake Hill pluton. A brown-orange weathering zone, up to 200 m wide and 2 km long, is exposed within the Three Sisters central felsic phase close to contact with the fine grained mafic phase (Figure 10). The zone contains abundant west-northwest striking and steeply north dipping goethite-coated fractures after pyrite, and pyrite is also disseminated throughout the hostrock. Three small exposures with quartz+pyrite±chalcopyrite±epidote veins, locally associated with in situ brecciation, are found several hundred metres to the south and southwest of this zone and are hosted in the fine grained mafic phase. One assay sample from the latter location (11BVA32-241) returned 0.35% Cu and slightly elevated Au. An assay sample from the gossanous pyrite zone (11BVA32-246) returned no anomalous values.

The "Three Sisters north" occurrence is hosted within the Three Sisters central felsic phase. The rocks are intensely veined (roughly 5% veins by volume in a several metre wide interval), with one 10 cm wide east-southeast oriented, steeply north dipping, epidote+actinolite+sulphide vein. The assay results for this vein indicate 0.36% Cu, >200 ppm W and slightly elevated U (11BVA30-216 in Table 2).

The "BCR north" occurrence is situated on the British Columbia railroad grade 7 km south of Upper Gnat Lake. It is associated with irregular bodies of (potassic?) altered hornblende-feldspar porphyry (Tees Creek intrusive, see Table 1) intruding the Three Sisters potassic phase. Minor pyrite is evident in this location, disseminated in both the fringes of the Tees Creek and adjacent potassic phase intrusive.

DISCUSSION AND CONCLUSIONS

Geological units

The Hotailuh batholith comprises a number of different plutons and plutonic phases. It can be subdivided into three plutonic suites, the Late Triassic (*ca.* 222-226 Ma), Early Jurassic (*ca.* 184-190 Ma) and a Middle Jurassic–Early Cretaceous suite (*ca.* 165-171 Ma and *ca.* 117 Ma, respectively).

The Late Triassic plutonic suite comprises, in decreasing age, the Gnat Lake ultramafic to mafic bodies, Cake Hill felsic pluton and Beggerlay Creek ultramafic to mafic pluton. Similar mineralogy, texture, compositional variation and magnetic susceptibility may indicate a genetic link between the Gnat Lake and Beggerlay Creek plutons. Limited evidence of crosscutting relationships suggest that the Gnat Lake ultramafite is older than the Cake Hill pluton, and earlier studies by Anderson (1983) suggest that the Beggerlay Creek pluton is younger than the Cake Hill pluton. However, demonstrable crosscutting relationships are rare, and perhaps all Late Triassic mafic–ultramafic plutonic rocks are roughly age equivalent. The Late Triassic plutonic suite is spatially associated with, and in places intrudes, poorly exposed and poorly dated, intermediate-mafic volcanic and

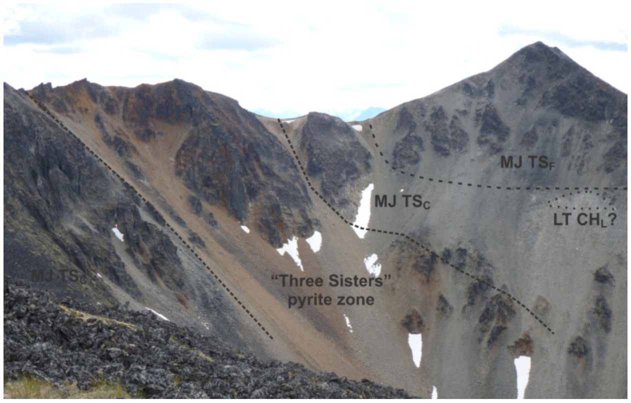

Figure 10. View south towards westernmost peak hosting the Three Sisters fine grained mafic phase, showing orange-brown altered zone of the "Three Sisters" mineral occurrence. Zone is intensely goethite-stained, contains abundant disseminated pyrite and pyrite in steeply dipping, west-northwest striking fractures. The Three Sisters central felsic phase (TS$_C$) is exposed along the ridge in the foreground; the Three Sisters fine grained mafic phase (TS$_F$) is exposed on the right-hand peak. Light-coloured scree below this peak may be an inclusion of the Cake Hill leucocratic phase (CH$_L$).

sedimentary rocks of the Triassic Stuhini Group.

The Early Jurassic plutonic suite comprises the McBride River felsic pluton exposed on the easternmost edge of the batholith. An area within the eastern part of the batholith has been reinterpreted as a large apophysis of the McBride River pluton. The pluton has contact metamorphosed Lower Jurassic, fine grained, stratified sedimentary rocks.

The Three Sisters pluton comprises at least four phases, namely the early fine grained mafic phase, a subsequent mafic phase, central felsic phase, and a crosscutting potassic phase. Preliminary U-Pb zircon crystallization ages confirm the Middle Jurassic age for the coarse grained Three Sisters potassic phase. However, an Early Cretaceous age for the Three Sisters central felsic phase raises the possibility that part or all of this pluton is much younger than previously recognized.

Northwest of Lower Gnat Lake, a granitoid clast-bearing conglomerate nonconformably overlies the Cake Hill pluton, and is correlated with Lower(-Middle) Jurassic, quartz-bearing, coarse grained sedimentary rocks reported within the immediate area. The latter are overlain by rocks previously assigned to the Triassic Stuhini Group (Anderson, 1983; Gabrielse, 1998) that in light of new U-Pb detrital zircon data are reinterpreted here as Middle Jurassic sedimentary and volcanic rocks (Iverson *et al.*, this volume). Evidence for the presence of the Hotailuh thrust in the present study areas appears to be lacking. The Lower to Middle Jurassic sedimentary and volcanic successions studied herein (Figures 3a, h) are part of a belt of rocks exposed on the north and northeastern margin of the batholith. The Lower Jurassic rocks have previously been assigned to the Takwahoni Formation, a formation predominantly composed of greywacke, siltstone, shale, conglomerate and minor limestone exposed in the footwall of the King Salmon thrust fault (Gabrielse, 1998). However, another important Lower to Middle Jurassic unit in Stikinia is the Hazelton Group, a succession of volcanic and sedimentary rocks. Following definitions by Marsden and Thorkelson (1992), and in light of the new U-Pb detrital zircon dates (Iverson *et al.*, this volume), the entire succession of volcanic and sedimentary rocks around peak 2096 m (Figure 3a) is reassigned to the Hazelton Group. In addition, the entire belt of rocks along the north and northeastern margin of the batholith may be part of the Hazelton Group.

Mineralization

The Gnat Pass area appears especially well endowed with mineral occurrences. In addition to the mineral occurrences described here, many other showings are present just outside of the map area shown in Figure 3a (*e.g.* Louise (MINFILE 104I 054), Bell (MINFILE 104I 033), Moss (MINFILE 104I 029), Kay 19, 49 (MINFILE 104I 037, 026), and Crown (MINFILE 104I 046). The latter three comprise the Pliny project that is currently under exploration by West Cirque Resources (2011). The area is cut by the north-northwest trending Gnat Pass ductile shear zone/brittle fault. The shear zone likely formed during emplacement of the Cake Hill pluton in the Late Triassic, was the locus of subsequent brittle faulting (this study), and may have been reactivated during south-verging thrusting in the Middle Jurassic (*e.g.* Gabrielse, 1998). These structures likely played an important role in the introduction of magmas, fluids and associated mineralization in the Gnat Pass corridor.

Mineralization hosted in Late Triassic rocks varies widely in hostrock, metal tenor and mineralization style and comprises:

- Cu only at the Gnat Pass porphyry-style prospect;
- Au+As±Sb (Cu, Ag reported) hosted in a shear/fault zone at the Dalvenie prospect;
- Au+Cu+Ag massive sulphide vein in felsic plutonic rocks at the newly discovered "Upper Gnat Creek" mineral occurrence;
- Cu±Mo pyritic fault zones in Stuhini volcanics at "Three Sisters south";
- Cu with trace Ag as small bodies within the Cake Hill pluton at "Mat north";
- Cu+Pb+Zn (reported) within stratiform to irregular bodies at the Mat showing; and
- Cu (and Mo reported) at the vein-hosted Pat showing, found within the Late Triassic Cake Hill pluton, but closely associated with the Three Sisters pluton.

Mineralization hosted in the Three Sisters pluton appears less variable, and comprises:

- Cu only at the "Pat west" and "Three Sisters" mineral occurrences;

- Cu±W at the "Three Sisters north" mineral occurrence; and
- Cu+Zn+Pb+Mo reported at the BCR showing.

Possible metal zonation is present in both the "Pat west" and "Three Sisters" occurrences, with relatively large, gossanous, pyrite-dominated zones trending towards smaller quartz vein-hosted, pyrite+copper sulphide occurrences. Assay samples indicate 0.3-0.7% Cu in the copper sulphide-bearing zones, and Cu±W in the possibly related "Three Sisters north" occurrence.

The presence of mineralization in both the Late Triassic rocks and the Three Sisters Middle Jurassic (-Early Cretaceous?) pluton is suggestive of at least two mineralizing events within the Hotailuh batholith. Known intrusion-related mineral deposits in the northern Stikine tectonic terrane are predominantly of Late Triassic to Early Jurassic age (*e.g.* Red Chris, Galore, Shaft, GJ, KSM), and little to no Middle Jurassic to Early Cretaceous deposits have been recognized. Importantly, the presence of mineral showings and occurrences hosted in the Three Sisters pluton suggests that these younger intrusions might deserve more attention than previously received.

FUTURE WORK

The subsequent stage of the QUEST-Northwest Hotailuh project will focus on the petrology and geochemistry of intrusive phases within the batholith using feldspar staining techniques, thin section study and lithogeochemistry data of least altered samples. Additional study of mineralized and/or altered samples will include transmission and reflective light studies of thin sections. Five rock samples have been submitted for ^{40}Ar-^{39}Ar hornblende and biotite geochronology; results are pending. The digital geological dataset will be integrated with the QUEST-Northwest airborne geophysical survey and regional geochemical stream sediment survey. The combined results will allow for the development of a metallogenic framework relating mineralization and magmatism, and be used to indicate anomalous areas of potential interest for mineral exploration.

ACKNOWLEDGMENTS

We would like to acknowledge financial support from Geoscience BC that covered field, analytical and salary costs associated with the Hotailuh project. Travis McCarron, Catie Young, Meagan Hogg and Olivia Iverson are thanked for their capable assistance during the field season. A warm thanks to Patricia McIntosh for opening her home for our use during the summer mapping project, to Jan Anderson and Dempsey Callison for the cooking, logistical support and help in setting up camp, and to Pacific Western Helicopters for safe flying and efficient communication. Thanks also to Bob Anderson for sharing his knowledge of the Hotailuh batholith during discussions and Graham Nixon for a thorough review of this paper.

REFERENCES

Anderson, R.G. (1983): Geology of the Hotailuh batholith and surrounding volcanic and sedimentary rocks, north-central British Columbia; *Carleton University*, Ottawa, Canada, unpublished Ph.D. dissertation, 669 pages.

Anderson, R.G. and Bevier, M.L. (1992): New Late Triassic and Early Jurassic U-Pb zircon ages from the Hotailuh batholith, Cry Lake map area, north-central British Columbia; in Radiogenic Age and Isotope Studies (Report 6); *Geological Survey of Canada*, Paper 92-2, pages 145-152.

Asbury, D.W. (1967): Report of geological, magnetometer and geochemical soil surveys on Moss claims 53 to 71, Gnat Lake, B.C.; *BC Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 1106, 10 pages.

Ash, C.H., Macdonald, R.W.J. and Friedman, R.M. (1997): Stratigraphy of the Tatogga Lake area, northwestern British Columbia (104H/12&13, 104G/9&16); *BC Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1996, Paper 1997-1, pages 283-290.

Bartsch, R.D. (1993): Volcanic stratigraphy and lithochemistry of the Lower Jurassic Hazelton Group, host to the Eskay Creek precious and base metal volcanogenic deposit; *The University of British Columbia*, Vancouver, Canada, unpublished M.Sc. thesis, 124 pages.

Blundy, J.D. and Sparks, R.S.J. (1992): Petrogenesis of mafic inclusions in granitoids of the Adamello Massif, Italy; *Journal of Petrology*, Volume 33 (5), pages 1039-1104.

Currie, L.D. and Parrish, R.R. (1997): Paleozoic and Mesozoic rocks of Stikinia exposed in northwestern British Columbia: Implications for correlations in the northern Cordillera; *Geological Society of America Bulletin*, Volume 107 (11), pages 1402-1420.

Dircks, N.J. (1974): Percussion drilling report for Railway property 104I/4W; *BC Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 5298, 24 pages.

Duuring, P., Rowins, S.M., McKinley, B.S.M., Dickinson, J.M., Diakow, L.J., Kim, Y.-S. and Creaser, R.A. (2009): Magmatic and structural controls on porphyry-style Cu-Au-Mo mineralization at Kemess South, Toodoggone District of British Columbia, Canada; *Mineralium Deposita*, Volume 44, pages 435-462.

English, J.M. and Johnston, S.T. (2005): Collisional orogenesis in the northern Canadian Cordillera: Implications for Cordilleran crustal structure, ophiolite emplacement, continental growth, and the terrane hypothesis; *Earth and Planetary Science Letters*, Volume 232, pages 333-344.

Evenchick, C.A. and Thorkelson, D.J. (2005): Geology of the Spatsizi River map area, north-central British Columbia; *Geological Survey of Canada*, Bulletin 577, 189 pages.

Evenchick, C.A., Gabrielse, H. and Snyder, D. (2005): Crustal structure and lithology of the northern Canadian Cordillera: alternative interpretations of SNORCLE seismic reflection lines 21 and 2b; *Canadian Journal of Earth Sciences*, Volume 42, pages 1149-1161.

Faye, G.H., Bowman, W.S. and Sutarno, R. (1977): Zinc-copper ore RU-1: Its characterization and preparation for use as a certified reference material; *Ministry of Energy, Mines and Resources Canada*, Canada Centre for Mineral and Energy Technology Report 77-7, 18 pages.

Gabrielse, H. (1991): Late Paleozoic and Mesozoic terrane interactions in north-central British Columbia; Canadian *Journal of Earth Sciences*, Volume 28, pages 947-957.

Gabrielse, H. (1998): Geology of Cry Lake and Dease Lake map areas, north-central British Columbia; *Geological Survey of Canada*, Bulletin 504, 118 pages.

Gillespie, M.R. and Styles, M.T. (1999): Classification of igneous rocks; *British Geological Survey*, BGS Rock Classification Scheme, Volume 1, Research Report RR 99-06, 52 pages.

Hallsworth, C.R. and Knox, R.W.O'B. (1999): Classification of sediments and sedimentary rocks; *British Geological Survey*, BGS Rock Classification Scheme, Volume 3, Research Report RR 99-03, 44 pages.

Henderson, C.M. and Perry, D.G. (1981): A Lower Jurassic heteroporid bryozoan and associated biota, Turnagain Lake, British Columbia; *Canadian Journal of Earth Sciences*, Volume 18, pages 457-468.

International Commission on Stratigraphy (2010): International stratigraphic chart; Available online at http://www.stratigraphy.org/ics%20chart/09_2010/StratChart2010.pdf

Iverson, O., Mahoney, J.B. and Logan, J.M. (this volume): Dease Lake Geoscience Project, Part IV: Tsaybahe Group: lithological and geochemical characterization of Middle Triassic volcanism in the Stikine Arch, North-central British Columbia; *BC Ministry of Energy and Mines*, Geological Fieldwork 2011, Paper 2012-1.

Jackaman, W. (2012): QUEST-Northwest Project: new regional geochemical survey and sample reanalysis data (NTS 104F,G,H,I,J), northern British Columbia; *Geoscience BC*, Summary of Activities 2011, Report 2012-1.

Kretz, R. (1983): Symbols for rock-forming minerals; *American Mineralogist*, Volume 68, pages 277-279.

Logan, J.M., Drobe, J.R. and McClelland, W.C. (2000): Geology of the Forrest Kerr-Mess Creek area, northwestern British Columbia (NTS 104B/10, 15 & 104G/2 & 7W); *BC Ministry of Energy and Mines*, Bulletin 104, 132 pages.

Logan, J.M., Diakow, L.J., van Straaten, B.I., Moynihan, D.P. and Iverson, O. (2012): QUEST-Northwest Mapping, BC Geological Survey Dease Lake Geoscience Project, northern British Columbia; *Geoscience BC*, Summary of Activities 2011, Report 2012-1.

Logan, J.M., Moynihan, D.P. and Diakow, L.J. (this volume): Dease Lake Geoscience Project, Part I: Geology and mineralization of the Dease Lake (104J/8) and east-half of the Little Tuya River (104J/7E) map sheets, northern British Columbia; *BC Ministry of Energy and Mines*, Geological Fieldwork 2011, Report 2012-1.

Marsden, H. and Thorkelson, D.J. (1992): Geology of the Hazelton volcanic belt in British Columbia: Implications for the Early to Middle Jurassic evolution of Stikinia; *Tectonics*, Volume 11 (6), pages 1266-1287.

Massey, N.W.D., Alldrick, D.J. and Lefebure, D.V. (1999): Potential for subaqueous hot-spring (Eskay Creek) deposits in British Columbia; *BC Ministry of Energy and Mines*, Open File Report 1999-14, 54 pages.

Massey, N.W.D., Macintyre, D.G., Desjardins, P.J. and Cooney, R.T. (2005): Digital geology map of British Columbia: Whole Province; *BC Ministry of Energy, Mines and Petroleum Resources*, Geofile 2005-1.

McAusland, J.H. (1971): Combined geochemical, geophysical, and geological report on mineral claims Mat 1 to Mat 26 inclusive; *BC Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 3028, 9 pages.

Moynihan, D.P. and Logan, J.M. (this volume): Dease Lake Geoscience Project, Part III: Age, emplacement and mineralization of the Cretaceous Snow peak pluton; *BC Ministry of Energy and Mines*, Geological Fieldwork 2011, Report 2012-1.

Nelson, J. and Mihalynuk, M. (1993): Cache Creek ocean: Closure or enclosure?; *Geology*, Volume 21, pages 173-176.

Nixon, G.T., Ash, C.H., Connelly, J.N. and Case, G. (1989): Alaskan-type mafic-ultramafic rocks in British Columbia: The Gnat Lakes, Hickman, and Menard Creek complexes; *BC Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, Paper 1989-1, pages 429-442.

Nixon, G.T., Hammack, J.L, Ash, C.H., Cabri, L.J., Case, G., Connelly, J.N., Heaman, L.M., Laflamme, J.H.G., Nuttall, C., Paterson, W.P.E. and Wong, R.H. (1997): Geology and platinum-group-element mineralization of Alaskan-type ultramafic-mafic complexes in British Columbia; *BC Ministry of Energy and Mines*, Bulletin 93, 132 pages.

Norris, J.R., Hart, C.J.R., Tosdal, R.M. and Rees, C. (2011): Magmatic evolution, mineralization and alteration of the Red Chris copper-gold porphyry deposit, northwestern British Columbia (NTS 104H/12W); *Geoscience BC*, Summary of Activities 2010, Report 2011-1, pages 33-44.

Read, P.B. (1983): Geology, Classy Creek (104J/2E) and Stikine Canyon (104J/1W), British Columbia; *Geological Survey of Canada*, Open File Map 940.

Read, P.B. (1984): Geology, Klastine River (104G/16E), Ealue Lake (104H/13W), Cake Hill (104I/4W) and Stikine Canyon (104J/1E), British Columbia; *Geological Survey of Canada*, Open File Map 1080.

Read, P.B. and Psutka, J.F. (1990): Geology, Ealue Lake east-half (104H/13E) and Cullivan Creek (104H/14) map areas, British Columbia; *Geological Survey of Canada*, Open File Map 2241.

Ricketts, B.D., Evenchick, C.A., Anderson, R.G. and Murphy, D.C. (1992): Bowser basin, northern British Columbia: Constraints on the timing of initial subsidence and Stikina-North America terrane interactions; *Geology*, Volume 20, pages 1119-1122.

Sadlier-Brown, T.L. and Chisholm, E.O. (1971): A geochemical report on the Pat claims (1 to 24); *BC Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 3963, 6 pages.

Sadlier-Brown, T.L. and Nevin, A.E. (1977): A report on geochemical and geophysical surveys of the Mac group; *BC Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 6323, 33 pages.

Schiarizza, P. (2011): Geology of the Kutcho assemblage between Kutcho Creek and the Tucho River, northern British Columbia (NTS 104I/01); *BC Ministry of Energy and Mines*, Geological Fieldwork 2010, Paper 2011-1, pages 99-118.

Simpson, K.A. (2012): QUEST-Northwest: Geoscience BC's new minerals project in northwest British Columbia (104G, 104J, parts of NTS 104A,B,F,H,I,K, 103O,P); *Geoscience BC*, Summary of Activities 2011, Report 2012-1.

Smith, G. and Garagan, T. (1990): Summary report on the 1989 exploration program on the Gnat Pass property; *BC Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 20408, 156 pages.

West Cirque Resources Ltd. (2011); West Cirque discovers new copper-gold zone; stakes Pliny property; *West Cirque Resources*, Press Release, Aug. 11, 2011.

Wetherill, J.F. (1989): Geological report on the Pass 40 claim; *BC Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 19177, 23 pages.

Wetherill, J.F. (1990): Geological, geochemical and geophysical report on the Gnat Pass property; Equity Silver Mines Limited, *BC Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 19885, 176 pages

Woodsworth, G.J., Anderson, R.G. and Armstrong, R.L. (1991): Plutonic regimes; in Geology of the Cordilleran Orogen in Canada, Gabrielse, H. and Yorath, C.J. (eds.); *Geological Survey of Canada*, Geology of Canada, no. 4, pages 491-531.

Zagorevski, A., Joyce, N., Mihalynuk, M. and Logan, J. (2011): Regional U/Pb zircon and Ar/Ar geochronology of Carboniferous to Early Jurassic Stikinia; *AME BC Mineral Exploration Roundup*, January 2011, poster presentation.