Newly Discovered Volcanic-Hosted Massive Sulphide Potential within Paleozoic Volcanic Rocks of the Stikine Assemblage, Terrace Area, Northwestern British Columbia (NTS 103I/08)

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INTRODUCTION

Mineralization and alteration consistent with a distal, Kuroko-type volcanic-hosted massive sulphide (VHMS) system were discovered within a package of highly altered, Paleozoic volcanic rocks 23 km southeast of Terrace, British Columbia (Fig 1).

The VHMS potential of the area was investigated during the 2007 field season in conjunction with a regional-scale mapping project (Fig 3; Nelson et al., 2008). The 2007 mapping project covers NTS map 103I/08, expanding on mapping carried out in the Terrace area over the last two years (Nelson et al., 2006 Nelson and Kennedy, 2007).

Key to this discovery was the recognition of a group of Palaeozoic, submarine volcanic rocks, named the Mount Attree volcanics, which had previously been mapped as part of the Lower Jurassic Telkwa Formation (Woodsworth et al., 1985). The Lower Telkwa volcanic rocks are not considered prospective for VHMS deposits because they formed in a subaerial, compressional environment, whereas the Paleozoic volcanic rocks formed in a submarine setting and an extensional tectonic environment favourable to VHMS formation. Furthermore, the Paleozoic volcanic rocks are correlative with the Stikine assemblage which is host to multiple, significant VHMS deposits within BC (Fig 2).

In order to fully assess the VHMS potential of the prospective area, known as the Gazelle property, 1:10 000 scale mapping delimiting alteration zones and mineralization was conducted, along with thin section examination, geochemical analysis and U-Pb dating. Results of samples sent for whole-rock analysis are pending. The results of this investigation indicate there is strong potential for Kuroko-type VHMS deposits in the area.

Mineral exploration in the Terrace area has historically focused on copper and gold vein, skarn and porphyry deposits. The discovery of Kuroko-type mineralization within the Paleozoic volcanic rocks is significant as it opens up a newly defined exposure of the Stikine assemblage to exploration, in an area that was previously not considered prospective for VHMS deposits.

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Volcanic-Hosted Massive Sulphide Deposits

Volcanic-hosted massive sulphide (VHMS) deposits are an important source of copper, zinc, lead and precious metals in Canada. A specific BC example is the currently-producing Myra Falls mine on Vancouver Island. These deposits are attractive exploration targets since they are high-grade, commonly contain significant amounts of precious metals, and are polymetallic, which offers protection against fluctuating metal prices.

Volcanic-hosted massive sulphide deposits form by focused discharge of metal-rich hydrothermal fluids on the seafloor. This results in the formation of sulphide lenses at, or near, the seafloor, hosted in submarine volcanic rocks and deep basinal sedimentary strata (Galley et al., 2007). The deposits vary considerably in their metal contents, alteration and mineralization styles. There are, however, several features that characterize these deposits: they generally have concordant lenses of massive (>40%), polymetallic sulphide minerals that stratigraphically overlie a crosscutting discordant zone of intense alteration and mineralization, often as stockwork veining.

Hoy (1991) provides a useful summary of Kuroko-type occurrences, which are the most common type of VHMS occurrences in British Columbia. The polymetallic lenses are rich in copper, lead, zinc, silver and gold, and are commonly comprised of massive pyrite, sphalerite, galena and chalcopyrite. They are associated with bimodal, calc-alkaline suites that typically form during a rifting event during constructive development of an island arc complex. The hostrocks are often felsic volcanic rocks with well-developed alteration zones beneath the sulphide lenses. The stockwork zone and immediate deposit are characterized by magnesium chlorite-sericite alteration and local silicification. VHMS deposits in BC are principally of Early Paleozoic, Devonian–Mississippian, Permian or Triassic ages (Massey, 1999).

VHMS Deposits within Stikinia

Stikinia, the largest terrane of the Intermontane Belt, (Fig 2) is comprised of island arc volcanic, sedimentary and plutonic rocks. Island arc building began in Stikinia during the middle to late Paleozoic (Price and Monger, 2003). This followed a shift from a passive ancestral North American margin to an extensional tectonic environment due to both

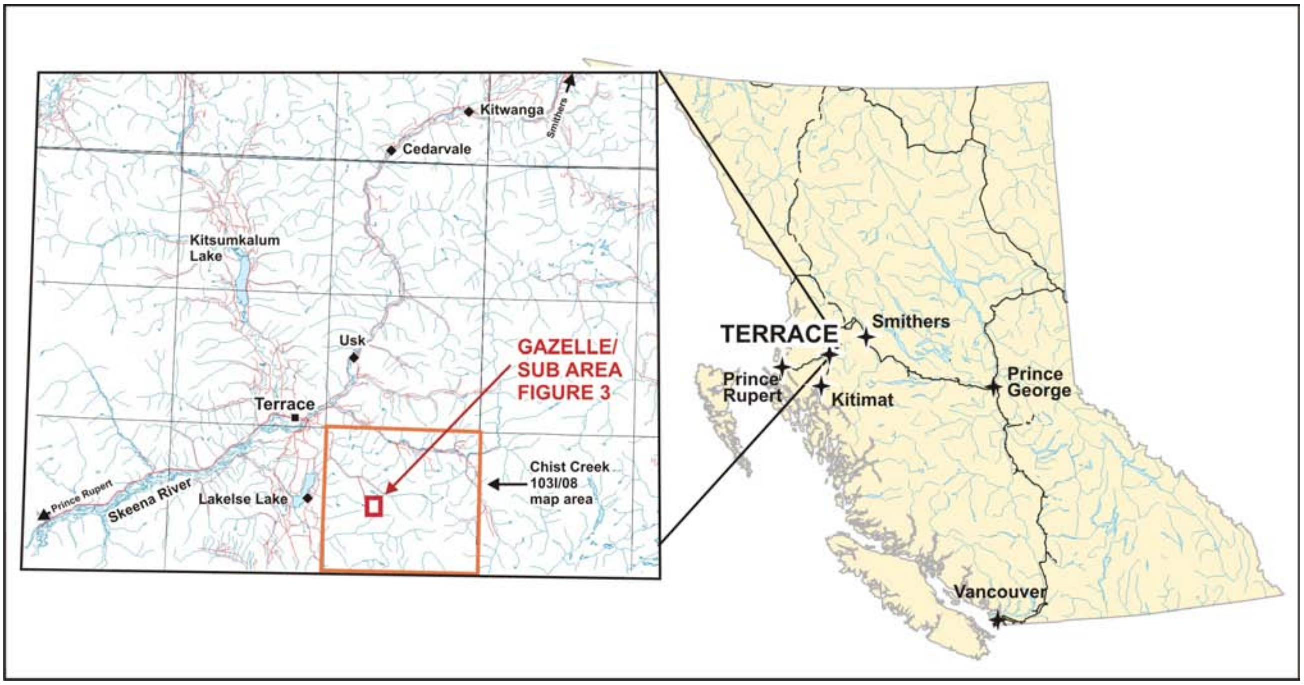

Figure 1. Location map of the project area southeast of Terrace, British Columbia.

the start of active subduction during the Late Devonian (between 390 Ma and 360 Ma) and retreat of the arc away from the western margin of the continent (Price and Monger, 2003). Paleozoic arc and associated rocks, mainly exposed in northern Stikinia, are referred to collectively as the Stikine assemblage. Younger overlapping arc assemblages include the Triassic Takla Group and Jurassic Hazelton Group. Stikinia is host to VHMS deposits of mid-Paleozoic, Triassic and mid-Jurassic age (Hoy, 1991). The most significant VHMS deposits include the Paleozoic Tulsequah Chief deposit and Foremore prospect as well as the Mesozoic Granduc, Eskay, and Anyox mines (Fig 2; Massey, 1999).

The Tulsequah Chief deposit, located in far northwestern BC (Fig 2), is currently moving towards production with indicated resources of 6 Mt grading 1.40% Cu, 1.24% Pb, 6.41% Zn, 2.67 g/t Au and 99 g/t Ag (Arsenault et al., 2007). The Tulsequah Chief and nearby Big Bull deposit are hosted by a sequence of Devonian to Mississippian felsic and mafic volcaniclastic rocks and flows of the Stikine assemblage. The deposits comprise several lenses in which the sulphides are massive and also banded to disseminated (Sebert et al., 1994). Quartz-sericite alteration is well-developed in footwall felsic rock types, and cordierite is locally abundant, probably as a result of metamorphic recrystallization of hydrothermal clays (Sebert et al., 1994). Rhyolite in the immediate footwall of the Tulsequah Chief deposit has been dated at ca. 327 Ma, Late Mississippian, by U-Pb methods on zircons (Childe, 1997). The mainly volcanic sequence that hosts it is overlain regionally by Pennsylvanian bioclastic limestone (Mihalynuk et al., 1994).

The Foremore deposit (MINFILE 104G 148, 181, 182; MINFILE, 2007) is also hosted by the Stikine assemblage (Logan, 2003). It consists of multiple lenses of massive sulphide minerals that occur in at least two separate stratigraphic levels, hosted in pyritic-quartz-sericite phyllite and schist within a larger alteration zone of chloritic, hematitic and carbonaceous phyllite. The mineral horizons occur near the contact between felsic and overlying mafic volcanic rocks along a strike length of several kilometres. Grades and thicknesses vary considerably, due in part to strong deformation. In 2004, the best drill intersection was 3.1 m with 14.6 g/t Au, 1114 g/t Ag, 0.2% Cu, 1.2% Pb and 6.6% Zn (MINFILE 104G 148). One of the footwall rhyolite units has yielded a preliminary Devonian–Mississippian U-Pb zircon date of ca. 359 Ma (J. Logan, pers comm, 2004).

The now-closed Granduc mine was developed on a series of massive sulphide lenses associated with a banded iron formation. Granduc is hosted by an unusual Late Triassic sequence, compared to the main Takla-Stuhini arc of Stikinia. It is associated with very primitive tholeiitic basalt that represents either a primitive arc or a back-arc setting (Childe, 1997). Ore reserves, before production began in 1971, were nearly 40 Mt grading 1.73 % Cu (MINFILE 104B 021).

The Eskay Creek mine is now nearing closure after production of nearly a hundred tonnes of gold between 1995 and 2008. It is hosted by a Lower to Middle Jurassic sequence of bimodal basalt and rhyolite flows and interbedded sedimentary strata that were deposited within a north-trending rift graben after main Hazelton arc volcanism had ceased (Alldrick et al., 2005). The deposits consist of stratabound massive sulphide layers with unusually high Ag-Au contents (Hoy, 1991). The Anyox mine was developed on a copper-rich massive sulphide deposit hosted by primitive basalt. It is thought to be the same age as Eskay Creek, and to lie along the trend of the Eskay rift to the south (Fig 2; Evenchick and McNicoll, 2002).

The above examples show that the most prospective hosts for VHMS mineralization within Stikinia are the Paleozoic Stikine assemblage, an unusual Triassic facies, and

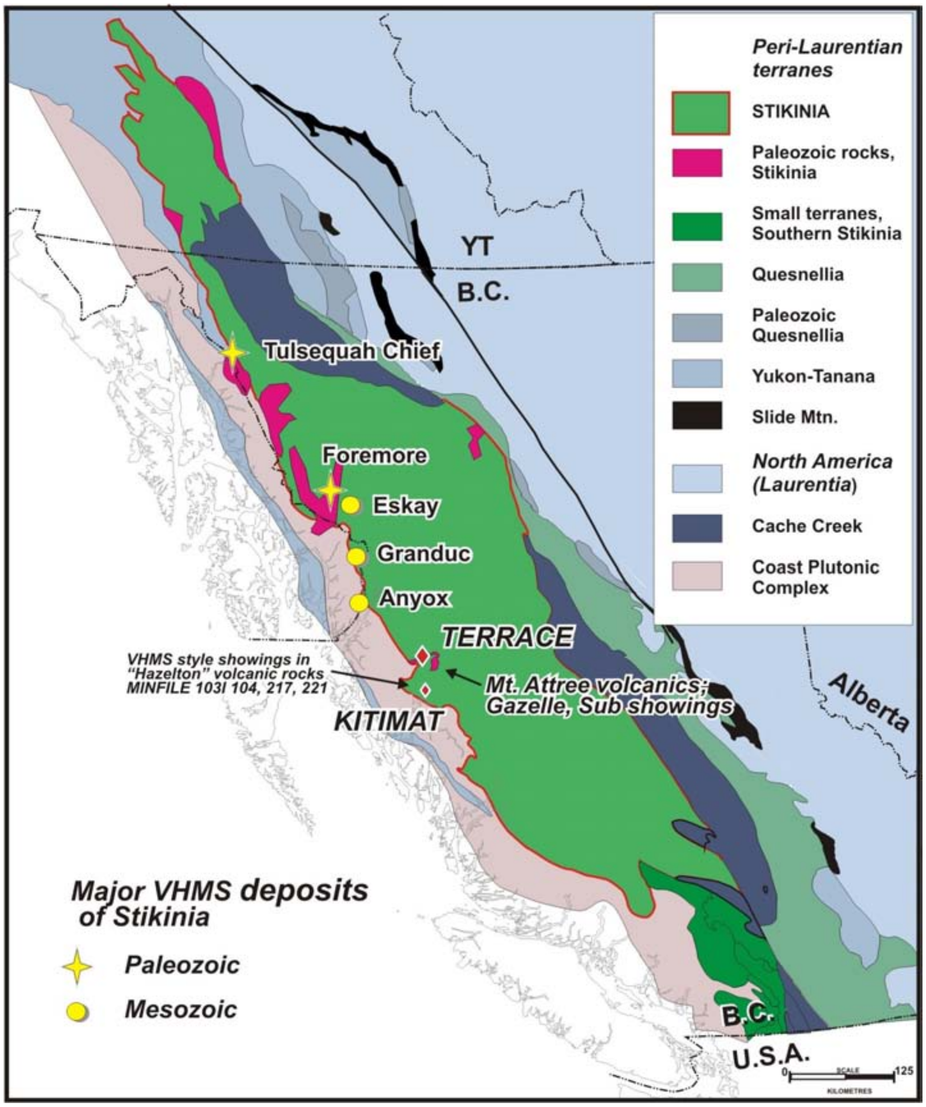

Figure 2. British Columbia terrane map, showing Stikinia and selected volcanic-hosted massive sulphide deposits within it.

post-Hazelton rift facies. None of them are hosted by the Lower Jurassic Telkwa Formation or its correlatives. This is to be expected, because Telkwa volcanic sequences are generally developed in shallow marine or subaerial settings. In particular, the Howson facies between Terrace and Smithers (*see* Tipper and Richards, 1976) formed in a subaerial, compressional environment that is not prospective for VHMS deposits. Thus, the recognition of Paleozoic volcanogenic strata in an area previously included within the Telkwa Formation is significant as it opens up the potential for the presence of deposits similar to, for instance, Tulsequah Chief.

PREVIOUS WORK

Previous regional geological mapping of the Terrace area carried out by Duffell and Souther (1964) and later by Woodsworth et al. (1985) provides excellent groundwork for later mapping. However, because so little regional mapping has been conducted in the Terrace area, as for most of northern BC, many fascinating mysteries remain regarding the complex geological history of the area as well as its mineral potential.

Mineral exploration south of Williams Creek dates back to at least 1922, with the discovery of copper, iron and zinc showings. Several claims were staked in 1968; however, there are no assessment reports on government record until 1984, when the Gazelle showing was discovered (Hooper, 1984, 1985).The showing consists of multiple lenses of semi-massive to massive sulphides that were identified by D. Hooper. He noted that the style of mineralization and extensive quartz-sericite alteration of the hostrocks are consistent with a VHMS system. Despite the potential of the property, there has been no follow-up to this work in over 20 years.

Stratigraphy

The regional map area (NTS 103I/08) is underlain by a conformable sequence of pre-Permian to Permian submarine volcanic rocks and overlying limestone of the Zymoetz Group. This in turn is unconformably overlain by Lower Jurassic, subaerial volcanic and clastic strata of the Telkwa Formation. These units are intruded by the Early Jurassic Kleanza pluton, unnamed Paleocene (?) plutons, and the Eocene Williams Creek pluton. Structurally, the Paleozoic rocks occupy the core of a northeasterly-trending, north-plunging, regional anticline (Fig 3; Nelson et al., 2008).

The Zymoetz Group consists of Mt Attree volcanics overlain by limestone of the Ambition Formation (Nelson et al., 2008). The Mt Attree volcanics are a compositionally variable volcanogenic sequence that consists largely of dark green andesite flows, tuff and breccia with lesser rhyolite flows, tuff and breccia. The unit contains minor limestone and bedded calc-silicate. The Ambition Formation is a thick unit of grey limestone that is generally well-bedded, with some highly fossiliferous beds. In some areas it contains minor layers of green interbedded tuff and red silicified chert. The fossil assemblage includes horn and colonial corals, bryozoans, brachiopods, gastropods, fusulinids and sporifera. Brachiopods are of Pennsylvanian–Permian age, and fusulinids from one locality are specifically Early to mid-Permian (Duffell and Souther, 1964).

The lowest part of the Lower Jurassic Telkwa Formation is composed primarily of polymictic conglomerate and breccia. The basal Telkwa conglomerate, where present, is dominated by limestone and volcanic clasts. The conglomerate passes upsection into andesite and dacite breccia that are overlain by coherent and fragmental dacite and rhyolite of the lower felsic marker (Nelson et al., 2008). Vent-proximal units are often brick-red and feature spectacular pyroclastic textures.

Where the limestone is not present, having been removed by erosion, Telkwa Formation conglomerate, andesite tuff and breccia directly overlie the andesite tuff of the Mt Attree volcanics. Due to the compositional and textural similarities of the two units, past regional maps have included the Mt Attree volcanics within the Telkwa Formation (Woodsworth et al., 1985). An important goal of this project was to distinguish between the two groups in order to delimit their boundaries within the map area. Paleozoic age was established by referring to the following evidence:

- **Stratigraphic position**: The Paleozoic volcanic rocks lie depositionally below the Permian limestone. This is evident from:
  - the sharp, unsheared contacts between the highest Mt Attree flow or tuff and the overlying limestone and
  - the presence of fine, green tuff layers interbedded with the limestone unit in some areas, likely representing the last throes of explosive volcanism.
- **Distinctive volcanic sequences**: The Paleozoic volcanic sequence is distinguished from the Telkwa Formation based on volcanic textures, compositions, metamorphic grade and presence of foliation. Paleozoic andesite features large, blocky augite, and smaller anhedral plagioclase. Rhyolite typically contains large, embayed quartz phenocrysts. Lapilli tuff characteristically contains abundant unflattened scoria clasts. Rare marble-calcsilicate interbeds are important in that they indicate submarine deposition. Greenschist-facies assemblages and well-developed foliation also distinguish these rocks. Defining characteristics of the Telkwa andesite include abundant, large, generally irregularly-shaped amygdules which indicate subaerial eruption, and well-formed plagioclase phenocrysts that range from 1 millimetre to over a centimetre in length. Rhyolite is best distinguished by the presence of devitrification textures, including spherulites and a lavender-coloured matrix. They are plagioclase-phyric and lack quartz phenocrysts, except in rare cases. Foliation is never observed in Lower Telkwa rocks, and metamorphic grades are mostly sub-greenschist. Incipient actinolite development under static conditions is probably related to contact metamorphism. Table 1 expands on the differences between these two sequences.

GEOLOGY OF GAZELLE AREA

The Gazelle property is located on a 1200 to 1500 m high ridge between Williams Creek and Chist Creek, approximately 4.3 km east of Gunsight Peak (Fig 3). It is an area of very strong alteration, with prominent gossans, as shown in Figure 4 and on the detailed map (Fig 5).

All of the ground is covered by claims that are in good standing, those in the south held by Paget Resources and those in the north, by J. Wang (claims 549673, 555399, 564134, 550358, 564181).

Stratigraphy

The centre of the map area is dominated by an apparently homoclinal sequence of layered Paleozoic felsic to intermediate volcaniclastic rocks with large zones of intense alteration. Permian limestone of the Ambition Formation unconformably overlies the Mt Attree volcanics to the east. It is in turn unconformably overlain by Telkwa dacite breccia at the eastern-most edge of the map sheet. There are multiple stages of intrusions, including Triassic quartz-feldspar-rhyolite porphyry (Fig 5, 6, 7, Table 2) and extensive Eocene granodiorite of the Williams Creek pluton (Fig 5).

Lithological Units

MOUNT ATTREE VOLCANICS

The volcanic rocks are well foliated, thoroughly altered and recrystallized in greenschist facies; the reconstructions of primary rock types, therefore, are based on textural and mineralogical relicts. Rhyolite protoliths are distinguished by the presence of relict quartz phenocrysts and lesser plagioclase and alkali feldspar, whereas andesite protoliths contain plagioclase phenocrysts and lack quartz eyes. The volcanic sequence is dominated by dark green, plagioclase-augite- phyric andesite tuff. Also abundant are white, quartz-phyric rhyolite tuffs, breccias and flows. The rhyolite crystal-lapilli tuffs contain heavily embayed quartz porphyroblasts and rare relict plagioclase.

An anomalous 12 m wide zone of limestone breccia occurs along East Creek, at the contact between the quartz-sericite schist and andesite tuff units (Fig 5). The limestone clasts are enclosed within a green, fine-grained, plagioclase-phyric matrix. The breccia may have formed as a slump deposit. This limestone unit was not seen at this contact anywhere else.

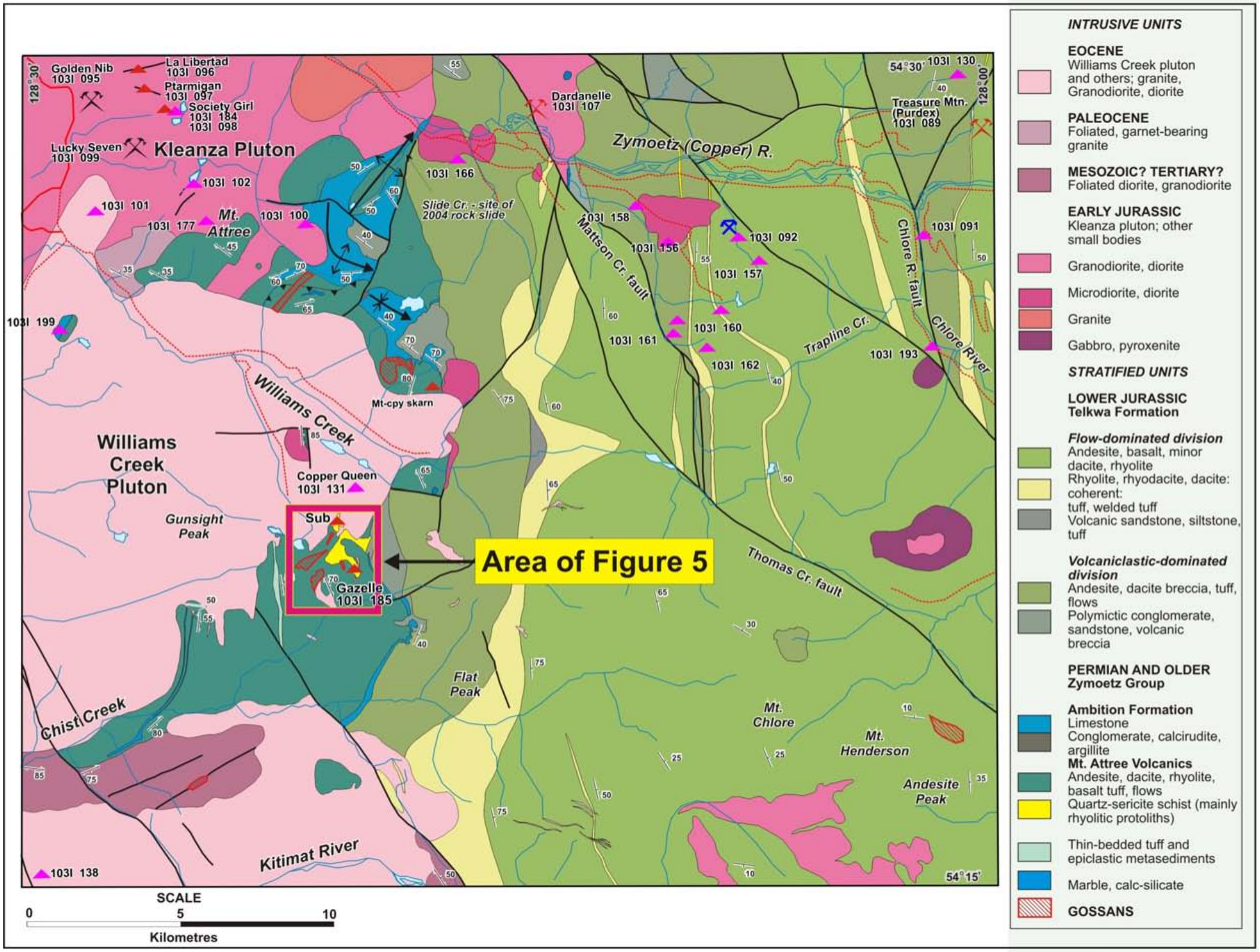

Figure 3. Regional geological map of the Chist Creek area (NTS 103I/08), based on 2007 mapping (Nelson et al., 2008). Inset shows the location of the detailed Gazelle geological map (Fig 5), focused on extensive alteration zones within the Paleozoic Mt Attree volcanics.

TABLE 1. COMPARISON OF DISTINGUISHING CHARACTERISTICS OF THE PALEOZOIC MT ATTREE VOLCANICS AND LOWER JURASSIC TELKWA FORMATION VOLCANIC ROCKS.

Distinguishing characteristics	Paleozoic volcanic rocks	Telkwa volcanic rocks (Lower Jurassic)
Phenocryst assemblage and textures:	Plagioclase: anhedral, broken, altered	Plagioclase: well-formed, may be large (up to several cm)
	Augite: large, blocky, abundant	Augite: rare, only in some basal volcaniclastics
Features of intermediate volcaniclastics:	Vesicular clasts	Lithic clasts
Texture of felsic volcaniclastics:	Quartz phenocrysts, sericitized ash lapilli	Devitrification, spherulites
Metamorphic grade:	Greenschist	Subgreenschist to albite-actinolite hornfels
Deformation:	Distinct foliation	Not foliated

AMBITION FORMATION

A white to grey limestone unit consisting of well-bedded, recrystallized marble with fossiliferous zones correlates with Ambition Formation limestone in the headwaters of Eight Mile Creek (Fig 3). In particular, it contains red chert layers and nodules, siliceous, networked veins and silicified crinoid and brachiopod fossils. Interbedded, fine, green tuffaceous laminae indicate continuity with the Mt Attree volcanics.

TRIASSIC INTRUSIONS

A small Late Triassic quartz-feldspar rhyolite porphyry stock is exposed in the central map area, cutting actinolite schist of the Mt Attree volcanics. It is weakly foliated and relatively unaltered (Fig 5, 6c, d). U-Pb isotopic dating conducted by R. Friedman of the Pacific Centre for Isotopic and Geochemical Research at the University of British Columbia, with assistance from H. Lin and Y. Feng, has provided an age of 211.16 ±0.41 Ma (Fig 7, Table 2). Thin section analysis revealed embayed, euhedral quartz phenocrysts and lesser plagioclase phenocrysts within a matrix dominated by fine-grained alkali feldspar, recrystallized quartz and minor biotite in fine, discontinuous trains (Fig 6c, d).

LOWER JURASSIC TELKWA FORMATION VOLCANIC ROCKS AND RELATED INTRUSIONS

The Lower Telkwa Formation can be distinguished from the Mt Attree volcanics by its lack of greenschist metamorphism and foliation, as well as the presence of red dacite clasts and crowded feldspar porphyry clasts. The Telkwa Formation is locally dominated by a polymict dacite breccia interbedded with minor flows. The breccia contains abundant millimetre-scale anhedral plagioclase clasts, local concentrations of limestone clasts and rare, subangular, red dacite clasts with fluidal boundaries, all within an aphanitic light grey to slightly maroon matrix. Towards the southern part of the map area there are localized zones containing crowded feldspar porphyry clasts up to 6 mm in diameter that contain blocky mafic phenocrysts and have a slight purple tinge, perhaps due to hornfelsing. These may have been derived from the Mt Attree volcanics. There are also localized, patchy zones of glassy, flow-foliated dacite that contain carbonate veinlets.

Figure 4. Mountain-scale gossan, quartz-sericite schist, Gazelle area. View from the ridge looking southeast towards Nifty creek (Fig 5).

EOCENE INTRUSION: WILLIAMS CREEK PLUTON

The large intrusive body dominates the northern part of the map area. It engulfs the northern end of the Paleozoic exposure and forms abundant dykes and plugs throughout the property. The intrusion is a postkinematic, unfoliated, white-weathering biotite-hornblende granodiorite.

Structure and Metamorphism

The presence of chlorite, actinolite and minor biotite in the metavolcanic rocks indicates metamorphism in greenschist facies. Metamorphic grade increases downsection, towards the south, where an abundance of biotite and well-formed darker green amphibole, as well as calcic plagioclase show the rocks are in upper greenschist to amphibolite facies.

The Mt Attree volcanics on the Gazelle property are generally well-foliated. There are two dominant foliations, striking northerly and to the northeast. The felsic, altered rocks have a strong F1 schistosity parallel to compositional layering. The foliation is fairly consistent throughout the property and the rocks show signs of multiple isoclinal folding, perhaps due to progressive deformation. There is small-scale faulting with, however, very few documentable offsets. The shears are oriented northeast and north-northwesterly. There is a major shear oriented north-northeast along East Creek and another small-scale fault, oriented north-northwest, exposed along Nifty creek. A steeply-plunging fold occurs along the ridge parallel to Ice Bridge Lake with a north-northeast fold axis plunging 45°.

The geological units of different ages display varying degrees of deformation. The Paleozoic volcanic rocks have undergone intense and likely multiple stages of deformation early in their history, while the Triassic stock is only

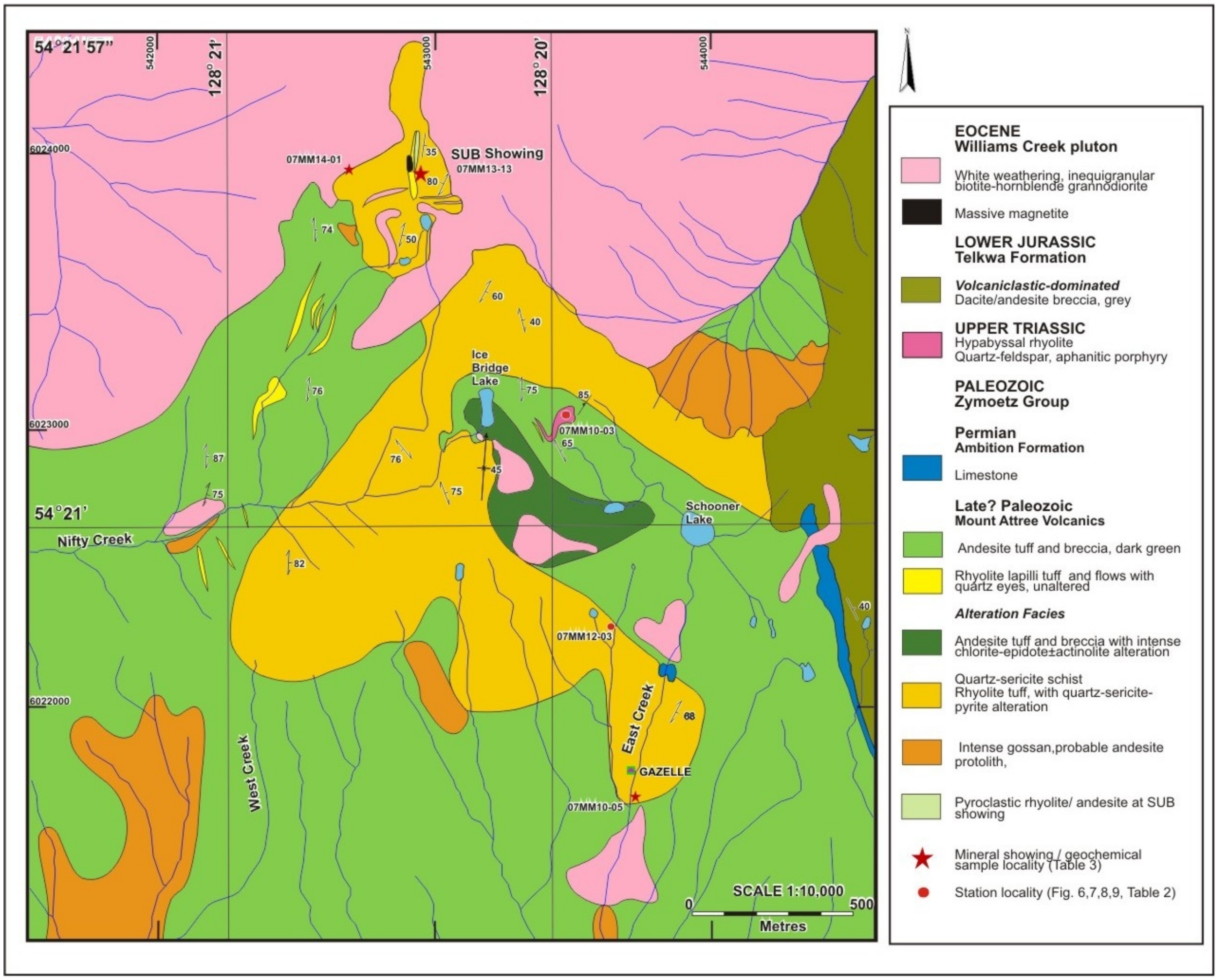

Figure 5. Detailed map of Gazelle area. Field work done in 2007by M. McKeown and J. Nelson. Data also from Hooper (1984, 1985).

slightly deformed (Fig 6c, d) and the Telkwa dacite does not appear deformed. Although this likely indicates multiple stages of deformation, the variable intensity of deformation of the rock units may be in part a function of their position within the regional-scale fold, with the highly deformed Paleozoic volcanic rocks in the nose of the fold and the undeformed Telkwa breccia nearer the limb, and certainly a function of clastic versus coherent texture and intensity of alteration.

Crosscutting relationships and the unfoliated, fresh textures of the Eocene (?) Williams Creek pluton show that it was intruded after all ductile deformation had ceased. There is also evidence that the Paleozoic volcanic rocks have undergone earlier deformation, some likely shortly after deposition. On Mt Attree (Fig 3), clasts of foliated Paleozoic volcanic rocks occur as clasts within diorite assigned to the Jurassic Kleanza pluton (Nelson et al., 2008). On the Gazelle property, the Paleozoic rocks have undergone intense prekinematic alteration whereas the Triassic intrusion is largely unaltered, which suggests two different deformation events.

Alteration

The property features extensive, intense gossans (Fig 4, 5) that occur in the quartz-sericite schist as well as in the silicified, chlorite-pyrite andesite tuff. In plan view, they are prominent, linear alteration zones oriented perpendicular to each other in northeast and northwest directions (Fig 5).

The two alteration types in the area are phyllic, consisting of quartz-sericite-pyrite (quartz-sericite schist), and propylitic, consisting of chlorite-epidote-actinolite±pyrite. Feldspar phenocrysts in porphyritic rocks have been completely altered to sericite, leaving only quartz phenocrysts. Propylitic alteration occurs in the form of chlorite-altered matrixes and quartz-epidote veins.

The andesite and rhyolite volcanic rocks were likely deposited at the same time (or the rhyolite only slightly after) and have undergone the same alteration and deformation. The difference in alteration type is greatly influenced by the composition of the protolith. The feldspars in rhyolite are preferentially altered to sericite, which in turn enables deformation. In andesite, primary phases such as the clinopyroxene and hornblende are metamorphosed to as-

TABLE 2. U-PB THERMAL IONIZATION MASS SPECTROMETRY ANALYTICAL DATA FOR ZIRCON.

Fraction[1]	Wt	U[2]	Pb*[3]	^{206}Pb[4]	Pb[5]	Th/U[6]	Isotopic ratios ±1σ,% [7]			ρ[8]	% [9]	Apparent ages ±2σ,Ma [7]		
	(μg)	(ppm)	(ppm)	^{204}Pb	(pg)		$^{206}Pb/^{238}U$	$^{207}Pb/^{235}U$	$^{207}Pb/^{206}Pb$		discordant	$^{206}Pb/^{238}U$	$^{207}Pb/^{235}U$	$^{207}Pb/^{206}Pb$
07MM-10-03, deformed quartz-feldspar porphyry, UTM 543533E, 6023013N; 211.2 ± 0.4 Ma														
A	2.0	787.4	27.1	2351	1.4	0.47	0.03332 ± 0.15	0.2307 ± 0.35	0.05020 ± 0.30	0.49727	-3.4	211.3 ± 0.6	210.8 ± 1.3	204.5 ± 13.9/14.0
B	3.1	1129.7	37.4	3030	1.5	0.38	0.03285 ± 0.21	0.2285 ± 0.37	0.05046 ± 0.28	0.64689	3.7	208.3 ± 0.9	209.0 ± 1.4	216.2 ± 13.0/13.1
C	3.8	472.5	15.7	2460	1.5	0.39	0.03293 ± 0.31	0.2282 ± 0.42	0.05026 ± 0.26	0.78363	-0.8	208.8 ± 1.3	208.7 ± 1.6	207.2 ± 12.0/12.1
D	2.8	322.1	10.8	1376	1.4	0.39	0.03329 ± 0.10	0.2314 ± 0.53	0.05042 ± 0.50	0.38923	1.5	211.1 ± 0.4	211.4 ± 2.0	214.2 ± 23.0/23.3
E	4.8	472.9	16.1	1151	4.1	0.45	0.03309 ± 0.17	0.2297 ± 0.34	0.05035 ± 0.28	0.56056	0.6	209.8 ± 0.7	209.9 ± 1.3	211.0 ± 13.1/13.2

[1] All analyzed zircon grains air abraded; all single grain analyses

[2] U blank correction of 0.2 pg ± 20%; U fractionation corrections were measured for each run with a double $^{233-235}U$ spike

[3] Radiogenic Pb

[4] Measured ratio corrected for spike and Pb fractionation of 0.23/amu ± 20% (Daly collector) a value determined by repeated analysis of NBS Pb 982 reference material throughout the course of this study

[5] Total common Pb in analysis based on blank isotopic composition: $^{206}Pb/^{204}Pb$ = 18.5 ± 3%, $^{207}Pb/^{204}Pb$ = 15.5 ± 3%, $^{208}Pb/^{204}Pb$ = 36.4 ± 3%

[6] Model Th/U derived from radiogenic ^{208}Pb and the $^{207}Pb/^{206}Pb$ age of fraction

[7] Blank correction of 1.0 pg Pb with blank isotopic composition listed above; 0.2 pg U; remaining common Pb is based on Stacey-Kramers model Pb isotopic composition at 211 Ma (Stacey and Kramers, 1975)

[8] Correlation coefficient

[9] Discordance in % to origin

Figure 6. Photomicrographs from Gazelle property: a) hypabyssal quartz-feldspar porphyry in cross-polarized and b) plane-polarized light (Sample 07MM12-03) with large recrystallized and embayed quartz porphyroblast (right), a heavily embayed ash fragment (left), and a matrix dominated by recrystallized quartz and sericite; c) Palaeozoic andesite lapilli-tuff in contact with Triassic quartz-feldspar rhyolite porphyry in cross-polarized and d) plane-polarized light (Sample 07MM10-03) with visible chlorite and sericite in the foliation.

semblages of actinolite±epidote±chlorite. These rocks are less prone to deformation, since micas are not abundant. Clastic rocks of either composition are more readily altered than their coherent counterparts, due to increased permeability.

Textural evidence shows that primary alteration occured prior to deformation. Sericite and pyrite are found mostly along foliation that, in turn, has been cut by quartz-epidote veins showing signs of folding and shearing. Sericite forms rootless, isoclinal folds and pyrite is smeared into the lineation in the most deformed rocks.

Mineralization

There are two unrelated types of mineralization within the Gazelle property: syngenetic, VHMS-related, and that related to later intrusions.

Volcanic-hosted massive sulphide – style mineralization includes small lenses of semi-massive to massive (>50%) chalcopyrite and sphalerite that were identified by previous assessment work in the East Creek Fault Zone (Fig 5; Hooper, 1984, 1985). During the 2007 field season, minor disseminated chalcopyrite±galena was found within the sheared quartz-sericite schist, near the Gazelle showing along East Creek (Fig 5). More importantly, the Sub showing, a new zone of silicification with base-metal sulphide deposits as well as barite, was discovered during 2007 mapping (*see* below).

Later mineralization related to the Williams Creek pluton includes small skarn and porphyry occurrences. There is a small skarn zone where Telkwa dacite and Permian limestone have been intruded by granodiorite (Fig 5). It is marked by 0.5 metre-wide zones of epidote alteration, minor disseminated to blebby magnetite and malachite staining. Quartz veins containing abundant disseminated pyrite, chalcopyrite and minor molybdenite occur in the northern map area (Fig 5). Three sets of the veins, up to 50 cm in width, occur within bright orange quartz-sericite schist in contact with granodiorite.

U-Pb Geochronology

All sample preparation and analytical work for the U-Pb radiometric age presented here were conducted using the thermal ionization mass spectroscopy (TIMS) technique at the Pacific Centre for Isotopic and Geochemical Research, located in the Department of Earth and Ocean Sciences of the University of British Columbia. Details of analytical techniques are presented in Logan et al. (2007). U-Pb results are plotted on a standard concordia diagram (Fig 7) and listed in Table 2.

Uranium-lead single-grain analyses were performed on air-abraded zircons (Table 2). All of the analyzed grains gave statistically concordant results but three yielded slightly younger ages, likely due to minor Pb loss (Fig 7). An age estimate of 211.2 ±0.4 Ma is based on a two-point

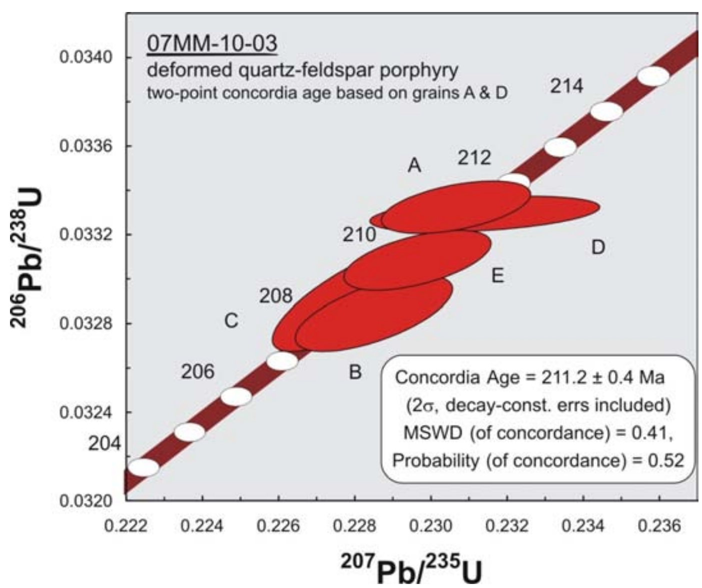

Figure 7. U-Pb concordia diagram for sample 07MM-10-03 with data plotted at the 2σ confidence level. Concordia curve is shown as a band that includes decay-constant errors. Details of the concordia age interpretation are listed on the diagram and discussed in the text.

concordia interpretation (Ludwig, 2003) for older, concordant, and overlapping grains A and D. Although these grains were air abraded, we cannot rule out that they did not also undergo very minor Pb loss; however, this is considered unlikely to significantly affect the crystallization age estimate.

SUB SHOWING

Mineralization indicative of a VHMS deposit has been discovered in an intensely-altered body within the Mt Attree volcanics. The body is approximately 250 by 50 m, trending north-south (Fig 5, 8) and is partially enclosed by the Williams Creek pluton.

Stratigraphy

The mineralized unit is part of a stratigraphic sequence dominated by rhyolite tuffs, breccias and flows. Intensely altered quartz-sericite schist (Fig 8a) is overlain by rhyolite flows (Fig 8b, c), which in turn are overlain by a heterolithic, plagioclase-phyric, (andesite?) breccia that contains clasts of the underlying rhyolite (Fig 8c). The breccia grades into thinly- layered, fine- grained tuff and welded tuff (Fig 8b). The sequence youngs to the east, consistent with facing directions from the surrounding area (Nelson et al., 2008).

Mineralization and Alteration

There are two types of mineralization in the Sub showing, both hosted in sericitized rhyolite tuff with intense silica flooding and pyritic alteration:

- A small, localized zone, 1 metre thick and 4 metres long, of massive barite occurs in an intensely-altered quartz-sericite schist. Thin sections reveal a protomylonitic texture, with barite porphyroblasts within a foliated matrix of finer-grained barite neoblasts (Fig 8, 9a, b). The predeformational, coarse grain sizes indicate barite veins, rather than exhalite (Samples from stations 07MM13-13 01A and 07MM13-13 01B; *see* Table 3).
- Massive to semi-massive galena is hosted within intensely-silicified, pyritic rhyolite in a zone 2 metres thick and 10 metres long (Fig 5; Sample 07MM13-13 01C; *see* Table 3). The mineralization occurs in a zone situated stratigraphically below the barite. Disseminated galena also occurs over a larger zone within the quartz-sericite schist in the northern area of the showing.

Interpretation

The styles of mineralization and alteration at the Sub showing, as throughout the Gazelle area, most likely represent a VHMS feeder zone below the seafloor. The intense sericitization and silicification, in zones both parallel to bedding and crosscutting bedding at a high angle, suggest that low pH fluids were channelled both along structures and along permeable, fragmental layers in the volcanic pile. The originally coarse-grained barite is more likely to have crystallized in a vein, rather than as part of a bedded sequence. In addition to pyrite, local showings of galena, sphalerite and chalcopyrite indicate that the fluids transported base metals. High silver values accompany high lead values in the barite sample at the Sub showing (Table 3). The low copper values, as well as the moderate zinc and high lead values, indicate the showing is part of a distal VHMS system. Higher copper values would likely occur more proximal to the system. The slightly high gold values represent the enrichment of precious metals which is common for a VHMS deposit.

EXPLORATION POTENTIAL

Alteration and mineralization discovered in the Gazelle map area likely represent that of a distal VHMS system. The Mt Attree volcanics correlate with the pre-Permian volcanic hostrocks of the Stikine Assemblage, which host the Tulsequah Chief deposit and Foremore prospect.

The extent of the alteration identified thus far is approximately 18 kilometres along strike and up to 10 kilometres in width. However, it is likely that more could be identified with further mapping and exploration (*see* Nelson et al., 2008, Fig 3). An immediate target for exploration are the intense gossans and malachite staining in the southwest corner of the map sheet, spotted from a helicopter in the cliffs south of Chist Creek (Fig 3). Their northeasterly strikes are parallel to the transposed layering of the Mt Attree volcanics in that area.

At some distance from there, it is possible that the northeasterly striking Mt Attree volcanics in lower Chist Creek could project southwest across the Kitimat valley, into an area of foliated metavolcanic rocks that are currently included in the Telkwa Formation (Woodsworth et al., 1985). Within the foliated basaltic to rhyolitic flows and tuff are three showings of probable or possible volcanogenic character. Two of the showings occur within a coarse pyroclastic belt approximately 8 kilometres long and at least 1.5 kilometres wide (Belik, 1987). The Bowbyes showing (MINFILE 103I 104) comprises two massive sulphide/magnetite lenses, each about 1 metre thick and 3 to 4 metres long, in chloritic schist. Mineralization consists of massive, crudely-banded chalcopyrite, pyrite and magnetite. Quartz-eye rhyolite overlies and underlies the mineralized horizon. A selected sample assayed 11.4 % Cu and 124.8 g/t Ag (Belik, 1987). At the Barite showing (MINFILE 103I 217), white to grey, dense to thinly-laminated semi-massive barite occurs in foliated, silicified and pyritized breccia and tuff, which are concordantly underlain by a coarse quartz-eye rhyolite. (Belik, 1987). Close to the showing, several lenses of massive barite up to 1.1 metres thick and 15 metres long occur in altered and recrystallized, intermediate to felsic pyroclastic volcanic rocks, that may be favourable for VHMS deposits (Gunning, 1988). Chip samples from this showing were anomalous in silver, gold, copper and zinc. Quartz-sericite schists occur 1.5 km to the northeast of this showing. The sericite has a distinct northeast foliation, similar to the Gazelle property schist. The J showing (MINFILE 103I 221) is considered to be of either Kuroko or Besshi type. Mineralization is exposed along a CNR railway cut on the south side of the Wedeene River. Stratiform pyrite and pyrite-chalcopyrite mineralization occurs within bedded tuff, with a maximum exposed width of about 0.5 m. A grab sample assayed 0.265 g/t Au, 13.3 g/t Ag, 1.978 % Cu and 11.069 % Fe (Raynor, 1987).

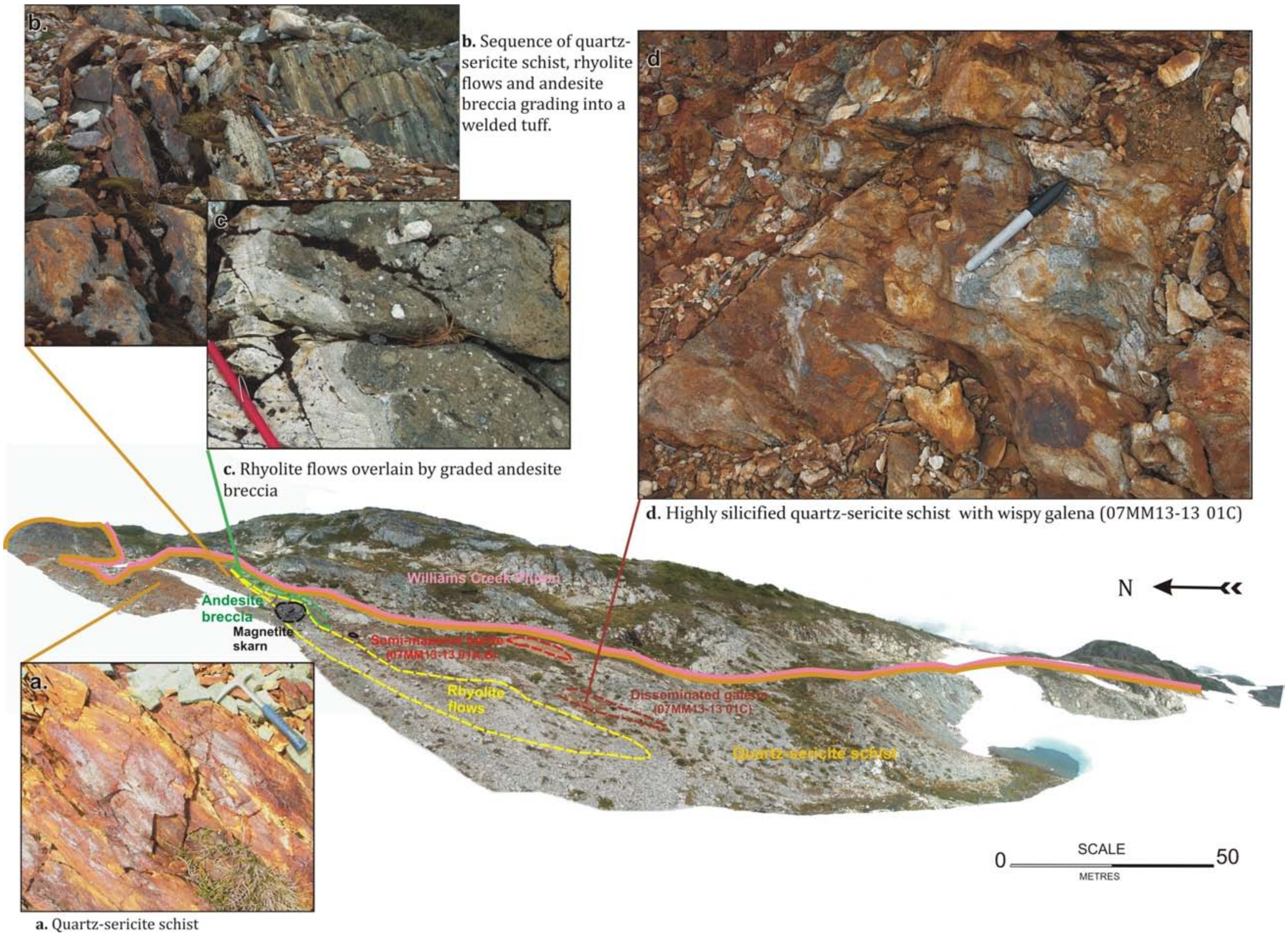

Figure 8. Photomosaic of the Sub showing units: a) quartz-sericite schist; b) sequence of quartz-sericite schist, rhyolite flows and andesite breccia grading into a welded tuff; c) rhyolite flows overlain by graded andesite breccia; d) highly silicified quartz-sericite schist with wispy galena and also a magnetite-clinopyroxene-amphibole skarn.

TABLE 3. GEOCHEMICAL DATA FROM SAMPLES COLLECTED DURING THE 2007 FIELD SEASON IN THE GAZELLE AREA.

Station number	UTM Easting	UTM Northing	Description	Cu	Zn	Pb	Ag	Au	Ba	Mo
			Element:	Cu	Zn	Pb	Ag	Au	Ba	Mo
			Units:	(ppm)	(ppm)	(ppm)	(ppb)	(ppb)	(ppm)	(ppm)
			Method:	ARMS	ARMS	ARMS	ARMS	ARMS	LMB	ARMS
			Lab:	ACM	ACM	ACM	ACM	ACM	ACM	ACM
			Detection limit:	0.01	0.1	0.01	2	0.1	5	0.01
07MM13-13 01A	543083	6023645	Grab sample: barite in highly silicified quartz-sericite schist	11.26	267.9	643	72787	362.4	>50000	22.77
07MM13-13 01B	543083	6023645	Representative sample: barite in highly silicified quartz-sericite schist	37.78	7956	>10000.00	>100000	208.4	>50000	35.71
07MM13-13 01C	543083	6023645	Highly silicified quartz-sericite schist with a lens of disseminated to massive galena (2 x 25 m zone)	212.8	4439	3107	18324	275.1	>50000	33.7
07MM12-01	542901	6022437	Float sample: quartz-sericite schist with abundant pyrite	70.19	103.3	18.35	237	7.2	1063	0.35
07MM13-13 07	543083	6023645	Magnetite skarn	25.02	70.6	46.78	1364	3.9	116	1.85
07MM14-01	542162	6022812	Quartz vein within quartz-sericite schist near granodiorite; mineralization is related to the intrusion	46.45	312.2	406.7	3428	2988	852	95.44

Analysis of steel-milled crushed rock prepared by ACME Analytical Laboratories Ltd.; duplicate on crushed rock

Abbreviations: ACM, ACME Analytical Laboratories Ltd., Vancouver, BC; ARMS, aqua regia digestion followed by inductively coupled plasma – mass spectrometry (15 gram sample); LMB, lithium metaborate fusion followed by inductively coupled plasma – emission spectroscopy / inductively coupled plasma – mass spectrometry

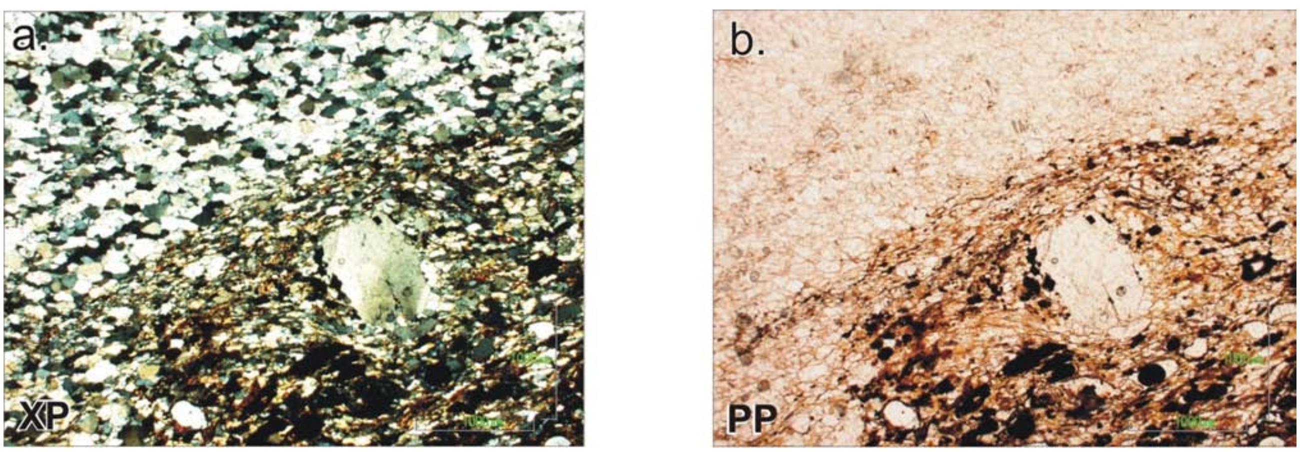

Figure 9. Photomicrograph of barite vein in a) cross-polarized and b) plane-polarized light. Large (pretectonic) barite porphyroblast within finer-grain barite (Sample 07MM13-13 01A).

CONCLUSIONS

Through regional and local mapping, the stratigraphy of Paleozoic and Jurassic volcanic rocks in the area southeast of Terrace has been clarified and a new unit that is prospective for VHMS deposits has been identified. The hostrock age, lithology, alteration and mineralization styles identified on the Gazelle property are characteristic of other pre-Permian VHMS deposits within Stikinia. The results of U-Pb, assay and whole-rock samples that are pending will further test this correlation. Possible extensions of the favourable belt to the southwest require further study to evaluate their stratigraphic age and potential for hosting significant VHMS deposits.

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