

Stratigraphic and Structural Setting of the Rock and Roll Deposit, Northwestern British Columbia (NTS 104B/11)

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KEYWORDS: volcanic-hosted massive sulphide, sulphide, replacement sulphide, Rock and Roll, Stikine assemblage, Stuhini Group, Iskut River, Craig River, Bronson, Monsoon Lake, Hoodoo Mountain

INTRODUCTION

Precious-metal-rich polymetallic massive sulphide deposits are attractive exploration targets because of the high value of the ore and economic resilience from individual commodity price volatility. Precious-metal-rich polymetallic massive sulphide (PMPMS) mineralization at the Rock and Roll deposit (BC Geological Survey, 2009; MINFILE 104B 377), located within the Coast Belt of northwestern British Columbia, is stratiform and is interpreted as volcanogenic. However, the PMPMS mineralization is spatially associated with a diorite sill and dike complex, which is locally characterized by wispy veinlets and disseminations of the same sulphide mineral assemblage. Resolving the primary control on mineralization is imperative for successful targeting of exploration efforts, both on the property and regionally. To this end, geological mapping and sampling was conducted around the Rock and Roll deposit in mid-October 2009. This one-week reconnaissance program in the Iskut River area of northwestern BC (Figure 1) is the initial phase of a partnership between the University of Victoria; the BC Ministry of Energy, Mines and Petroleum Resources; and Pacific North West Capital Corp (and field representatives, Equity Exploration Consultants Ltd). Our aim is to establish the mode of occurrence and to determine the stratigraphic and structural setting of the Rock and Roll deposit. Our longer term goal is to evaluate the potential for similar PMPMS mineralization within the Iskut and adjacent regions (Figure 1).

LOCATION AND ACCESS

Access to the region around the Rock and Roll deposit is via the Bronson airstrip, located 300 km north-northwest of Terrace, 330 km northwest of Smithers and 75 km east-northeast of Wrangell, Alaska. Both Terrace and Smithers

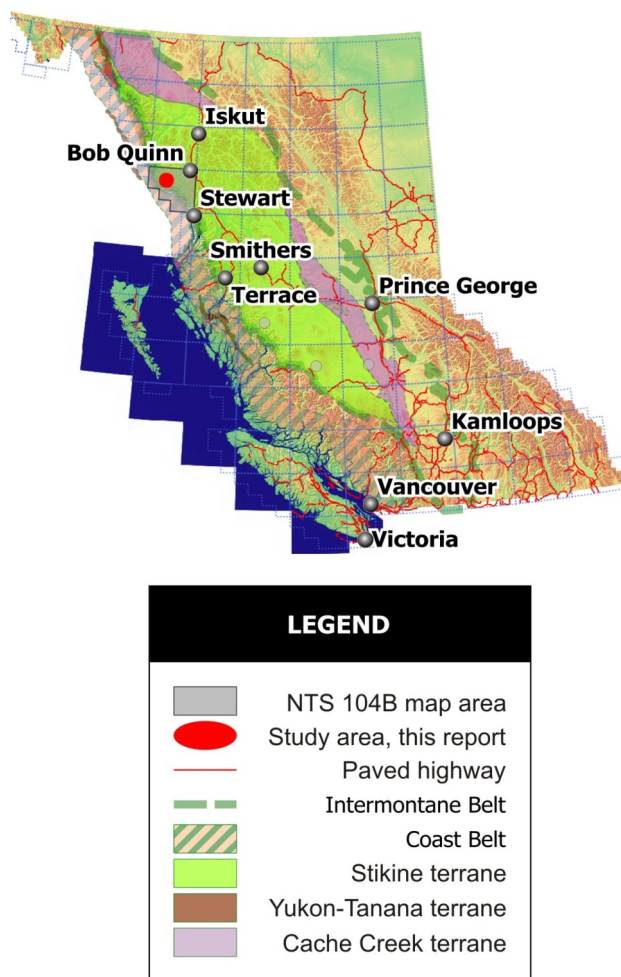


Figure 1. Location of the study area within the Iskut NTS area (104B) near the boundary of the Coast Belt and western Stikine terrane.

are serviced by scheduled commercial flights from Vancouver and both are approximately 400 km by road (~5 hour drive) from Bob Quinn airstrip. A 60 km flight southwest from Bob Quinn brings you to the Bronson airstrip, located on the south bank of the west-flowing Iskut River, at its confluence with Bronson Creek. The main showing on the Rock and Roll property, the Black Dog occurrence, is 10 km west of Bronson camp. Helicopter landing spots are limited to riverbanks, a few swampy openings and newly cut pads; old helicopter pads are overgrown and unserviceable.

The Iskut River valley is a U-shaped glacial valley; it has a relatively flat bottom and steep sides. Alpine glaciers,

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relicts of the once extensive Cordilleran Ice Sheet, extend down to treeline at approximately 1000 m elevation. Our work focused near the Rock and Roll property, beneath the dense hemlock-fir-spruce canopy between 60 m and 300 m elevation, east of the confluence of the Craig and Iskut rivers. Outcrop is plentiful, but is covered in moss and an understory of devil's club. Work in this rainy coastal region benefitted greatly from logistical support provided by a well-provisioned base camp at Bronson airstrip and daily helicopter set-outs for drilling crews overseen by Equity Exploration Consultants Ltd.

REGIONAL GEOLOGY AND PREVIOUS WORK

Rocks between the west-flowing Iskut and Craig rivers have not been mapped as part of a systematic regional program since fieldwork done in the late 1920s by Kerr (1935, 1948; Figure 2). Thus, the most recent compilation map (e.g., Massey et al., 2005; Figure 2) reproduces the geological contacts presented by Kerr, with slight modification of unit assignments. Accordingly, the area is underlain by a northwestward-tapering wedge of Stuhini Group arc volcanic and sedimentary rocks. On the northeast side of the

wedge, Stuhini Group rocks are shown in contact with a unit of Permian limestone, minor chert, argillite and metamorphosed equivalents. Mineralization at the Rock and Roll property is apparently located within Stuhini Group rocks along this contact. On the west side of the wedge, Stuhini Group rocks are shown in contact with a unit of 'pre-Permian' quartzite, argillite, limestone, tuff, intrusive and metamorphosed equivalents. Both Permian and pre-Permian units have been assigned to the Devonian to Permian Stikine assemblage by Massey et al. (2005). Along the Craig River, the wedge is intruded by an arcuate diorite body of the John Peaks stock or Unuk metadiorite (Massey et al., 2005).

The area is peripheral to later regional mapping by Grove (1986), Lefebure and Gunning (1989; NTS 104B/10W, 11E; Figure 2), Alldrick et al. (1990; NTS 104B/06E, 07W, 10W, 11E), Kirkham et al. (1991; NTS 104B/08) and Kirkham (1992; NTS 104B/08, 09). Fillipone and Ross (1989) mapped immediately north of the Iskut River in the Twin and Hoodoo glaciers areas (NTS 104B/14S; Figure 2). Logan and Koyanagi (1994) mapped the Galore Creek area ~30 km to the north (NTS 104G/03, 04) and Logan et al. (2000) mapped the Forrest Kerr–Mess Creek area ~15 km to the east (NTS 104B/10, 15, 104G/02, 07W; Figure 2). Edwards et al. (2000) produced a map of the Quater-

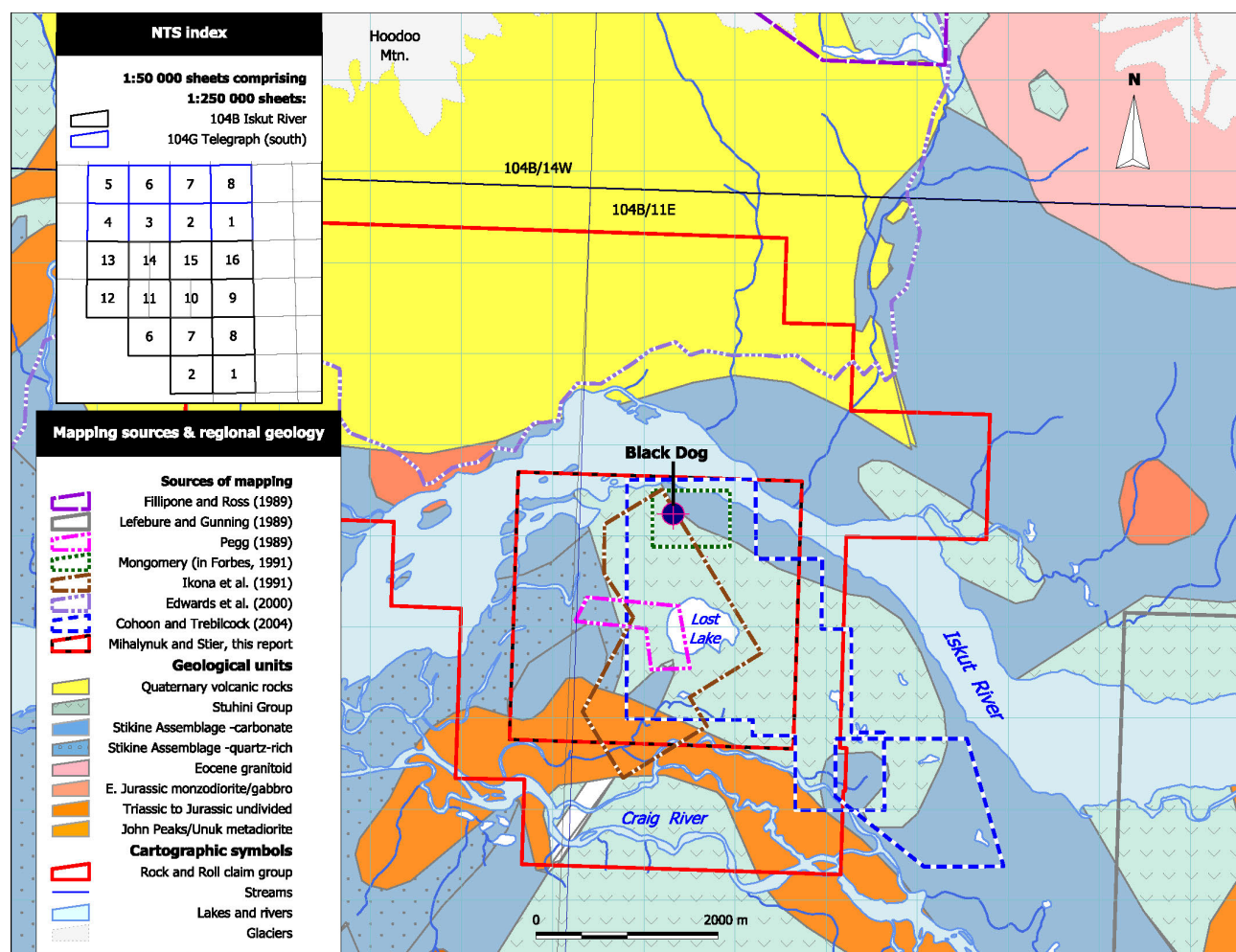


Figure 2. Location of the Rock and Roll property, NTS areas and sources of geological map data. The regional geology shown is after Kerr (1935) as compiled by Massey et al. (2005).

nary Hoodoo Mountain volcano, including the immediately surrounding basement rocks previously mapped by Phillipone and Ross (1989). Many other parts of the Iskut map area (NTS 104B) were mapped as part of Geological Survey of Canada projects (e.g., Anderson, 1989; Anderson and Thorkelson, 1990), culminating in a program under the direction of Anderson in 1991 (Anderson, 1993).

Property-scale mapping reported by Montgomery et al. (1991) covers about 3.25 km² around and west of Lost Lake (Figure 2), including much of a ~0.5 km² area previously mapped by Pegg (1989). Montgomery (*in* Forbes, 1991) covered ~0.5 km² around surface mineralization at the main Black Dog trenches. Much of the Rock and Roll property (~6.5 km²) was mapped at 1:2500 scale as reported by Cohoon and Trebilcock (2004b), as was the adjacent Phiz property (Rob claims; Cohoon and Trebilcock, 2004a). Reconnaissance mapping reported here aims to test and extend the available historical mapping in order to provide a structural and stratigraphic setting for the Rock and Roll deposit and evaluate regional potential for this deposit type.

Exploration Work at Rock and Roll

Exploration at the Rock and Roll property began with staking the Rob and Rock and Roll claims in 1986 and 1988. From 1987 to 1989, preliminary assessment work was done on the claims, including reconnaissance geological mapping, soils and silt sampling (Todoruk and Ikona, 1988a, b; Montgomery and Ikona, 1989; Pegg, 1989). In 1990, the program was expanded to include petrographic work and ground geophysical surveys (Montgomery et al., 1991), all of which contributed to the discovery of polymetallic Ag-Au-Zn-Cu-Pb massive sulphide mineralization at the Black Dog zone. This discovery was immediately followed up with a trenching program (110 m) and in late 1990, a nine hole, diamond-drill program totalling 675 m, which tested the mineralization over a strike length of 50 m (Montgomery et al., 1991).

Work in 1991 focused on a major drill program of at least 86 drillholes (10 525 m) on the Rock and Roll property and five drillholes (373 m) on the Rob claims. Additional line cutting, plugger soil sampling, mapping, prospecting and petrographic work was done. Most of this early exploration work was conducted by the Prime Resources Group ('Prime') and was not filed for assessment. Fortunately, drill logs have been recovered (Dunning and Scott, 1997), but reports documenting other aspects of exploration at the Rock and Roll and the Rob claims in 1991 have apparently been lost.

In 1997, a third drill campaign was conducted by Redstar Resources Corp. Preparatory work combined a comprehensive review of previous work including a re-examination of old drillcore and lithogeochemical and petrographic analyses, followed by a ten drillhole program (2203 m) that tested along strike and downdip extensions of the known mineralization (Dunning and Scott, 1997). By the end of this campaign, sulphide mineralization had been intersected for over 650 m along strike and between 40 and 200 m downdip. Based on 104 holes completed on the Black Dog and adjacent zones, Redstar Resources Corp calculated a pre-43-101 resource of 675 000 t grading 1.75 g/t Au, 233.8 g/t Ag, 0.40% Cu, 0.50% Pb and 2.20% Zn (Becherer, 1997; *in* Dunning and Scott, 1997).

In 2004, a program of geological mapping, mobile metal ion and conventional soil sample geochemistry, and minor rock sampling was conducted (Cohoon and Trebilcock, 2004). Exploration efforts were renewed in 2009 with a 350 line km airborne electromagnetic and magnetic survey and drilling campaign (five holes totalling 540 m) by Pacific North West Capital Corp (Jones, 2009).

PROPERTY GEOLOGY

We report here on the results of a six day reconnaissance field mapping program. Units were defined during the course of mapping (Figure 3) on the basis of distinctive lithological characteristics. They are described here, ordered by their presumed age. They apparently young towards the northeast, from carbonate units near Craig River, through volcanic units near Lost Lake, to sediment-dominated units nearer to the Iskut River (Figure 3). However, both depositional and structural interleaving has occurred and neither fossils nor direct isotopic age determinations are available to conclusively constrain the ages of any of the units.

Carbonate Units

Carbonate outcrops extensively in the southwestern part of the mapped area. There are at least three variants: homogeneous relatively pure limestone/marble, well-bedded limestone with or without tuffaceous interlayers and sooty- and flaggy-weathering limestone. Macrofossils are conspicuously absent, possibly having been destroyed during deformation and recrystallization.

MARBLE

White crystalline marble is the most common carbonate. It is typically strongly foliated and buff-weathering. However, colour changes with the degree of recrystallization—with less intensely foliated limestone, it is more commonly medium to dark grey. Compositional layering tends to be strongly transposed. Where relict bedding is well displayed, massive carbonate beds range from 5 to ~100 cm thick.

TUFFACEOUS CARBONATE

Tuffaceous carbonate is green, rust or, less commonly, brown-weathering. Tuffaceous layers tend to be more competent and resistant to weathering than the enclosing carbonate, but pyritic tuff layers can weather recessively (Figure 4). Volcanic clasts vary in proportion from a few percent to packed with a carbonate matrix. In one tuffaceous horizon, quartz grains were identified in hand specimen. This volcanic material is suspected to be of dacitic composition and was sampled for U-Pb age determination.

Open to isoclinal folds are outlined by compositional layering caused by variations in tuff content. In regions of high strain, folds are preserved only as hinges of rootless isoclinal folds.

Tuffaceous carbonate is sporadically exposed and, as a result, is not represented as a separate map unit in Figure 3.

TUFF-QUARTZITE UNIT

Beneath root masses of trees blown down near the Craig River, outcrops of decimetre-thick beds of alternat-

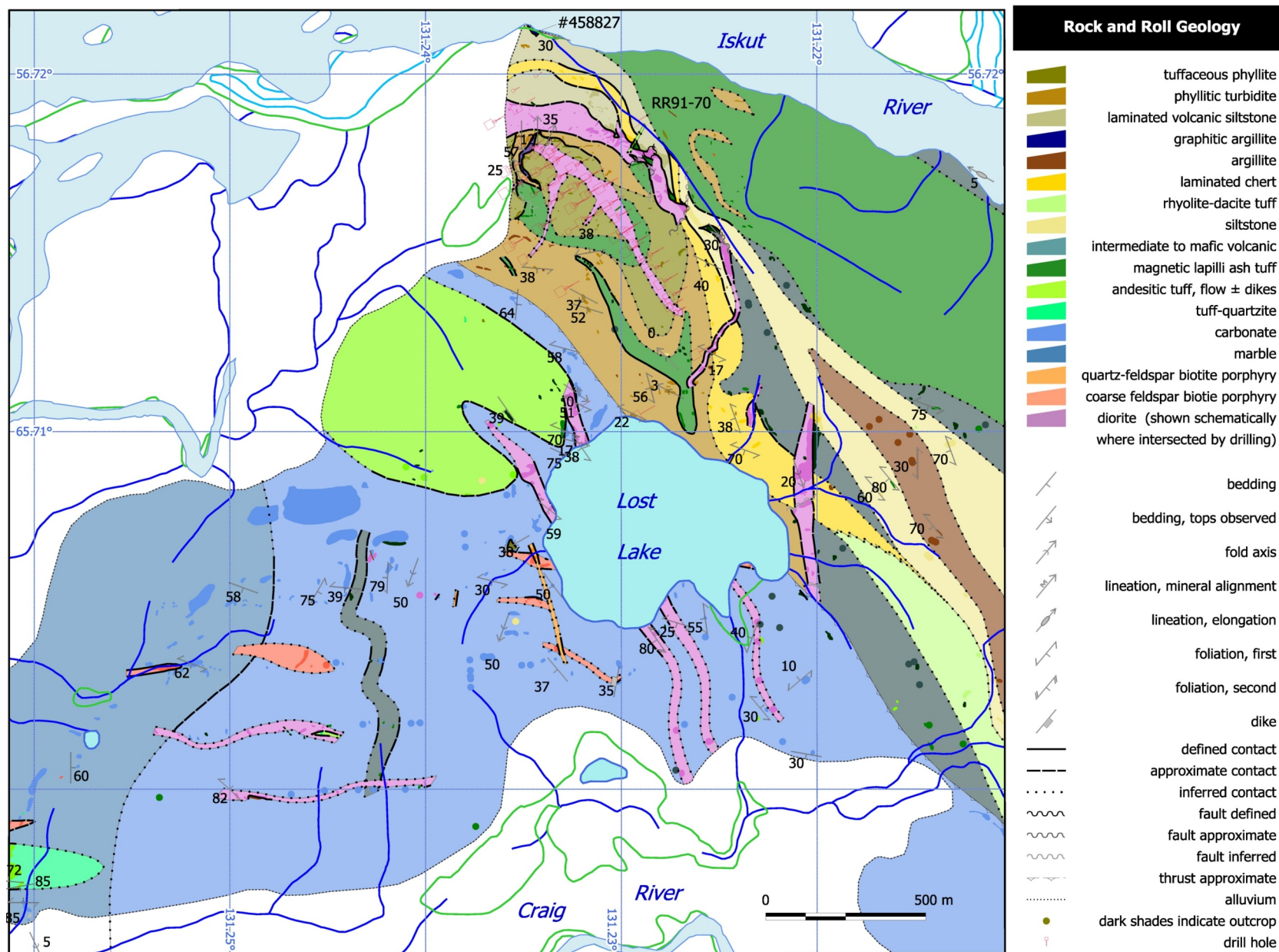


Figure 3. Geology between the Iskut and Craig rivers, based on reconnaissance map ping during this study and a compilation of mapping by Montgomery (*in Forbes*, 1991), Montgomery et al. (1991) and Cohoon and Trebilcock (2004a, b).

ing green tuff and ‘quartzite’ are freshly exposed over several hectares. This unit passes across strike into more typical tuff-carbonate interbeds and the ‘quartzite’ is interpreted as a product of carbonate replacement. Silicification and the occurrence of grossular garnet and abundant epidote within the tuff-quartzite are interpreted as the product of contact metamorphism. This metamorphism is attributed to a several square kilometre intrusive body, which is incorrectly shown on compilation maps (e.g., Massey et al., 2005) as underlying the same area, but the main mass of intrusion must lie farther to the south. No significant base-metal mineralization was observed.

SOOTY LIMESTONE

Black, sooty limestone was mapped at two localities equidistant from the southern and western shores of Lost Lake. Relict beds or folia form continuous layers of uniform thickness. These layers are typically 1–2 cm thick (and up to 15 cm). Slaty parting and sooty black weathering are characteristic. This unit is combined with the main carbonate unit in Figure 3.

Volcanic and Volcaniclastic Units

MAFIC VOLCANIC ROCKS

Light green- to rusty-weathering mafic volcanic rocks are exposed in rounded, glaciated outcrops. Fresh surfaces are dark green, predominantly due to pervasive chlorite and minor epidote alteration. Iron oxides are not as abundant as is to be expected in a mafic volcanic rock. This is reflected in the magnetic susceptibilities, which are approximately 0.5×10^{-3} SI. Volcanic clasts are rarely visible on the outcrop surface, but ash-sized, microporphyritic grains are evident in hand sample. Compositional layering can be observed locally. Outcrops of this unit appear massive and featureless, or rarely, display vague breccia textures. These rare outcrops are interpreted as autobrecciated flow units. Intercalated sedimentary layers point to submarine deposition, although pillows were not conclusively identified. Fragments and layering are obscured by the typical moderate to strong foliation developed within this unit. Gradational contacts with sediment-dominated units may be due to both sedimentary and structural interleaving.

TUFFACEOUS PHYLLITE

Light to dark green-grey-weathering, platy outcrops of phyllitic tuffaceous siltstone crop out on the forested ridge along which most exploration has been conducted (herein called ‘Sulphide ridge’). Tuffaceous phyllite interfingers with phyllitic turbidite (see below), but can be resolved into a mappable unit as shown on Figure 3. Although this unit tends to be recessive, it underlies much of ‘Sulphide ridge’ where it is extensively intruded by diorite dikes. Volcanic siltstone with argillaceous partings and quartz-poor, thin greywacke beds are locally well preserved.

Protolith textures in both units are commonly obscured by moderate to intense foliation and cataclasis. Both units probably grade into cherty siltstone and graphitic argillite.

MAGNETIC LAPILLI ASH TUFF

Light green and rust-weathering, strongly foliated, fine feldspar crystal (20%) lapilli ash tuff is exposed in the Iskut River bed about 450 m northeast of the Black Dog trench. Feldspar and light green-grey ash fragments are elongated towards 120° . Scattered, flattened and elongated

light-coloured felsic lapilli contain 20% fine- to medium-grained feldspar phenocrysts and sparse quartz eyes. A dusting of 1–2% fine-grained magnetite (probably metamorphic) generates a moderately high average magnetic susceptibility of $26 (\times 10^{-3} \text{ SI})$. This unit is likely responsible for the elevated aeromagnetic response over areas along strike from these outcrops (Jones, 2009). Unfortunately, our mapping did not include tracing out this unit to verify correlation with the aeromagnetic high.

Fine-grained Sedimentary Rocks

PHYLLITIC TURBIDITE

Low, platy outcrops of grey to brown and rust-coloured argillaceous siltstone are widespread on the flanks of ‘Sulphide ridge’. Thin, graded siltstone to laminated siliceous argillite couplets (0.5–3 cm thick) are interpreted as AE turbidite beds. Coarser layers of medium sand to rare volcanic pebble conglomerate have been intersected in drillcore (e.g., DDH RR97-103, 0.5 m sampled for detrital zircons), but were not observed in outcrop. Thin quartz-feldspar tuff layers (1–3 cm thick; Figure 5) occur within the turbiditic siltstone at one locality where they were sam-

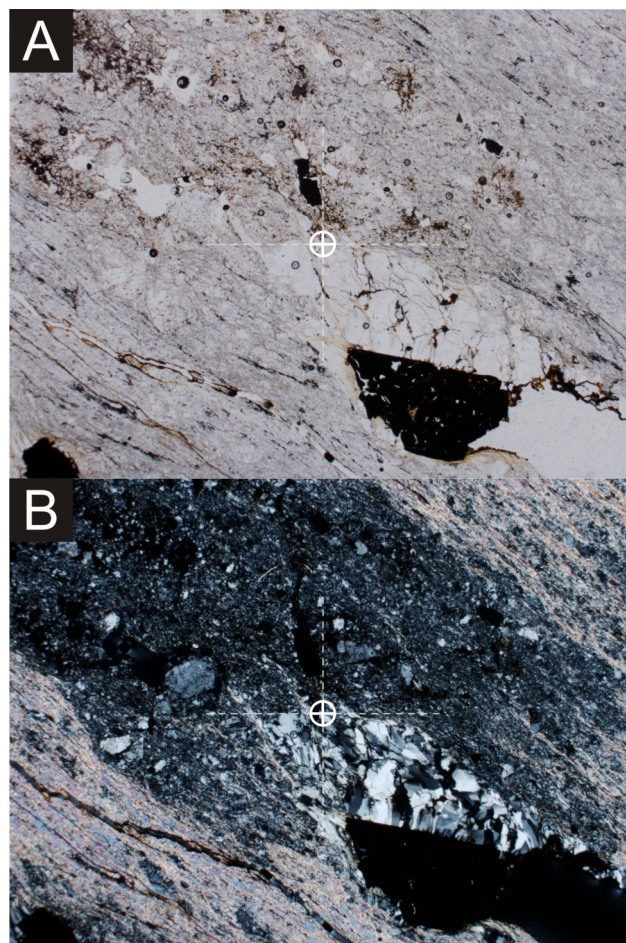


Figure 4. Thin section of tuffaceous carbonate schist, northwestern British Columbia in: **A)** plane-polarized light and **B)** cross-polarized light. Feldspar and quartz grains dominate the central 40% as a diagonal domain, extending from the top left to the bottom right. Secondary quartz fibres have grown in the pressure shadow of a rotated pyrite grain (opaque, bottom right).

pled for U-Pb age determination. Phyllitic turbidite is commonly interleaved with tuffaceous phyllite.

RIBBED CHERTY SILTSTONE/ARGILLITE

Resistant, laminated argillaceous to cherty siltstone beds 0.5–2 cm thick alternate with recessive, featureless silt-poor argillaceous beds 1–5 cm thick to produce the conspicuous ribbed appearance of this unit. It is siliceous and translucent, with a conchoidal fracture. It is best exposed near the north end of ‘Sulphide ridge’ where clean exposures are light green to green-grey weathering. Rhythmic layering within this unit is interpreted as stacked AE turbidite beds.

Locally the unit is chaotically folded and beds are segmented. Such disruption may be due to soft-sediment deformation and the formation of rip-up clasts. Elsewhere, folding caused by regional strain is well developed, except where the primary layering is obscured by strong foliation. This unit has been included with the phyllitic turbidite unit in Figure 3.

GRAPHITIC ARGILLITE (± SILTSTONE)

Dark grey to black, commonly rusty, moderately siliceous to friable graphitic argillite and siltstone is calcareous in many localities. It generally contains up to several percent disseminated pyrite and pyrrhotite and may be bleached as a result of sulphide weathering. This unit grades into the ribbed cherty siltstone-argillite unit, with feathery intercalations observed in drillcore.

Near the Black Dog showing, graphitic argillite is the layered rock most commonly associated with massive sulphide mineralization. It is also the unit in which Zn-Cu mineralization was observed along the bank of the Iskut River about 330 m north of the Black Dog trenches (Table 1, Figure 3).

LAMINATED VOLCANIC SILTSTONE

Dark to light green and locally orange, indurated volcanic siltstone forms the upper northeast flank of ‘Sulphide ridge’. Very well displayed, disrupted laminae are characteristic, although some outcrops are massive. Microporphyrific ash fragments can be observed in hand sample. The unit grades into laminated chert, which lacks volcanic clasts.

LAMINATED CHERT

Creamy white- to rusty-weathering, very well laminated chert occurs in at least one layer >3 m thick on the north side of the ‘Sulphide ridge’. However, multiple exposures closer to the Iskut River suggest structural repetition or a total composite thickness on the order of 100 m. Locally the unit appears flow banded, with sparse, very fine grained feldspar phenocrysts. However, synsedimentary faults with displacement of several millimetres can be observed and a volcanic flow or pyroclastic texture could not be verified petrographically. Instead, it appears to be a siliceous argillite with less than 1% silt grains that are subround and not angular as would be expected of ash content. Fine- to very fine grained white crystals that were interpreted as feldspar microlites in hand sample could be metamorphic minerals.

This unit is interpreted as sedimentary in origin, but may include a significant dust tuff component. It probably grades to the southeast into a felsic lapilli tuff unit (Fig-

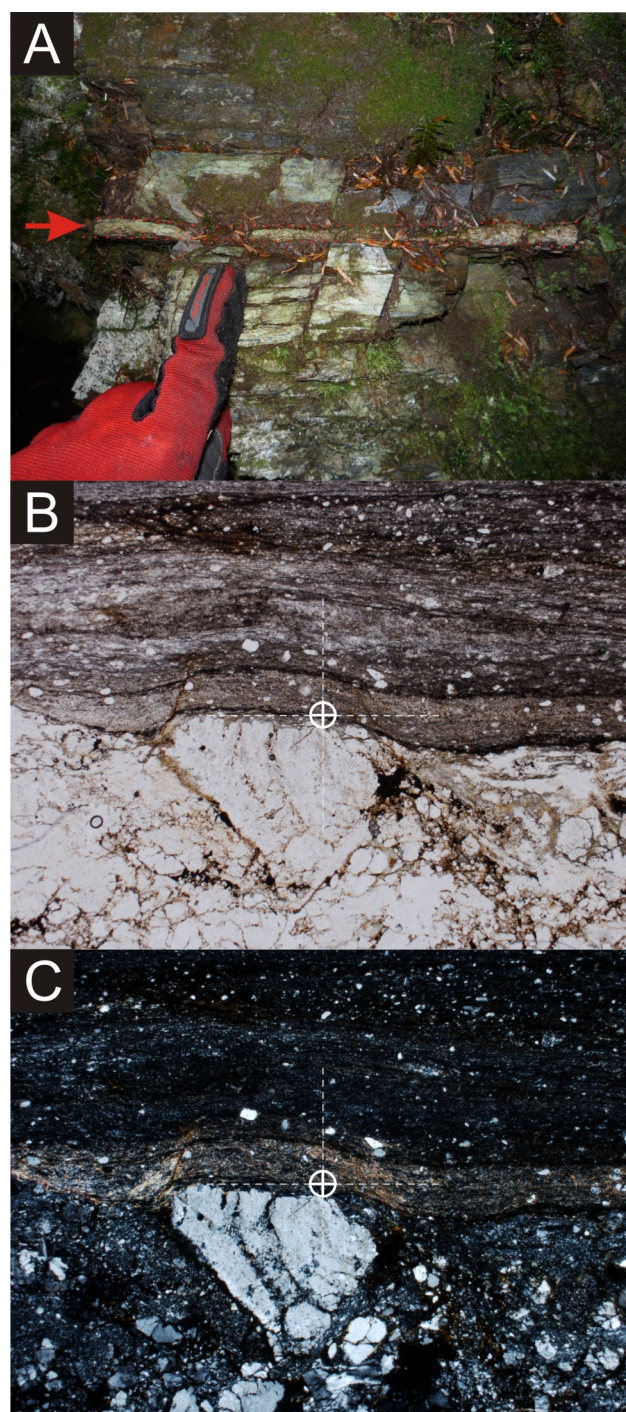


Figure 5. Layers of quartz-feldspar crystal-ash tuff within phyllitic turbidite, northwestern British Columbia: **A)** the outcrop habit of light to dark grey-weathering, well-bedded and moderately to weakly foliated silty argillite turbidite with a 2 cm thick tuff band (red arrow); dotted lines highlight the contacts of the tuff band; **B)** plane-polarized light view of contact between medium-grained felsic tuff and silty argillite; the circle at the crosshairs has a radius of 100 μ m; **C)** cross-polarized light view of contact between medium-grained felsic tuff and silty argillite; note angular crystal fragments produced by cataclasis of original angular feldspar and quartz crystal pyroclasts within the tuff band; the circle at the crosshairs has a radius of 100 μ m.

ure 3) on the adjacent Phiz property where it forms a distinctive marker horizon containing up to 50% subrounded felsic lapilli-sized clasts (Cohoon and Trebilcock, 2004a).

Rhyodacitic flows were intersected by drilling in hole RR91-70. A 5 m sample of split core (sample TST09-7-01) was collected for U-Pb age determination. Possible age equivalence of tuffaceous layers sampled from carbonate and turbiditic argillite will be tested.

Intrusive Rocks

DIORITE

Dark green, rounded to blocky and resistant diorite sills and dikes up to 50 m in width are common. Most are steeply dipping and trend perpendicular to or parallel with the dominant northwest-trending structural grain within the country rocks (Figures 3, 6). Texture is variable on a hand-sample scale, ranging from coarse grained holocrystalline and equigranular, to fine grained and porphyritic. A typical diorite outcrop is medium grained, with felted pyroxene, hornblende and feldspar and <5% interstitial quartz. The dikes are altered everywhere: hornblende is strongly chloritized and feldspar grains are turbid with epidote-calcite alteration (Figure 7). Leucoxene is a common alteration product after titanium oxides (rutile, sphene). Embayed magnetite (Figure 7) can range up to several percent by volume, although measured magnetic susceptibilities are comparatively low, between 0.8 and 0.95 ($\times 10^{-3}$ SI). There is no apparent relationship between magnetic susceptibility and degree of fabric development.

The holocrystalline plagioclase-rich diorite matrix can be used to distinguish this unit from andesite and basalt, except where this texture is obliterated by foliation and local mylonite development. Dike margins can be difficult to define where the foliation is produced by slip and cataclasis, which causes structural interleaving over a metre or more.

POSTDEFORMATIONAL INTRUSIONS

Potassium-Feldspar Biotite Porphyry

Resistant, blocky, reddish-weathering, porphyritic quartz monzonite is medium grey on fresh surfaces. Coarse feldspar phenocrysts are characteristic and appear to be orthoclase and minor plagioclase, ranging in size up to 25 mm. Medium-grained, euhedral, strongly chlorite-altered biotite booklets comprise 5% of the intrusion. Clots of chlorite may replace fine-grained prismatic to interstitial hornblende in the feldspar-quartz matrix. Quartz content is variable, but is generally less than 10% of the fine-grained matrix.

Quartz Feldspar Biotite Porphyry

Orange, blocky weathering, quartz-feldspar porphyry crops out west and south of Lost Lake. It contains 40% medium-grained, subidiomorphic, white feldspar crystals in a fine-grained to aphanitic orange matrix. Quartz eyes may be present up to 5% and are typically embayed square - quartz <5 mm in diameter. Sparse, fine- to medium-grained biotite booklets are chloritized. At one locality, about 300 m southwest of Lost Lake, the unit can be mapped as a north-trending, near-vertical dike cutting carbonate rocks.

Table 1. Analysis performed on a ~4 m chip sample (#458827) collected oblique to the strike of a foliated outcrop (~1.5 m true width) along the southern bank of the Iskut River, northwestern British Columbia. Analyses performed at ALS Chemex Laboratories (Vancouver) by aqua regia digestion and inductively coupled plasma-mass spectroscopy, except for Au, which was analyzed by fire assay atomic absorption spectroscopy.

Element	Unit	Value	Element	Unit	Value
Au	ppm	0.24	Mg	%	3.59
Ag	ppm	14.7	Mn	ppm	1160
Al	%	4.13	Mo	ppm	16
As	ppm	496	Na	%	0.02
B	ppm	<10	Ni	ppm	62
Ba	ppm	140	P	ppm	980
Be	ppm	<0.5	Pb	ppm	571
Bi	ppm	<2	S	%	1.77
Ca	%	1.27	Sb	ppm	11
Cd	ppm	7.9	Sc	ppm	13
Co	ppm	29	Sr	ppm	40
Cr	ppm	93	Th	ppm	<20
Cu	ppm	656	Ti	%	0.24
Fe	%	9.03	Tl	ppm	<10
Ga	ppm	10	U	ppm	<10
Hg	ppm	1	V	ppm	223
K	%	0.05	W	ppm	<10
La	ppm	10	Zn	ppm	1720

MINERALIZATION

During the course of this study, we observed mineralization on the surface at two localities: the main Black Dog occurrence and about 330 m farther to the north, at outcrops along the south bank of the Iskut River. Mineralization at the Black Dog is part of a multi-layered, stratiform zone that has been traced more than 650 m, mainly to the south-east. Representative analyses of massive sulphide where intersected by drilling at the Black Dog are 1.1 and 3.8 g/t Au, 27 and 308 g/t Ag, 0.85 and 2.44% Pb, 4.19 and 9.98% Zn, and 0.01 and 0.24% Cu from intervals 19.4–20.2 m and 18.0–18.3 m in hole RR90-3. Mineralization along the Iskut River bank has not been drill tested; however, we collected a ~4.0 m chip sample oblique to the strike (1.5 m true thickness) of the enclosing graphitic argillaceous strata that yielded 14.7 ppm Ag, 0.24 ppm Au, 0.066% Cu and 0.17% Zn (Table 1).

These two areas of surface mineralization are representative of the two distinct styles of mineralization comprising the Rock and Roll deposit: massive pyrrhotite(+pyrite)–sphalerite–chalcopyrite±galena and stringer and wispy pyrrhotite–chalcopyrite±sphalerite–galena.

Massive pyrrhotite–sphalerite–chalcopyrite forms banded layers (Figure 8) in both outcrop and drillcore that are up to ~10 m thick (e.g., drillhole RR91-037), where they are associated with graphitic argillaceous siltstone. Massive sulphide commonly forms a matrix to clasts of argillite or, as at the main Black Dog showing, diorite (Figure 9). Clasts of apparent felsic volcanic material have also been observed at the Black Dog, but these could be altered diorite fragments (Figure 9), although they lack both mafic minerals and the high degree of alteration typical of diorite



Figure 6. Rose diagram of diorite dike orientations, northwestern British Columbia. The mean orientation is 012° (N = 9).

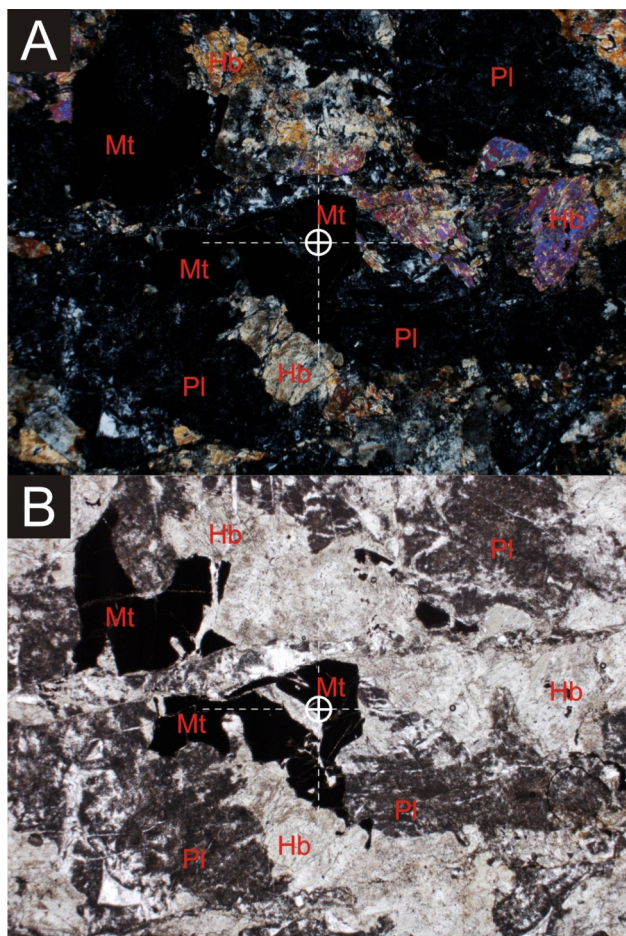


Figure 7. A) Altered, nonfoliated hornblende diorite in cross-polarized light. **B)** The same field of view in plane-polarized light with very weakly pleochroic hornblende (probably low-Fe). Abbreviations: Mt, embayed opaque (resorbed magnetite?); Pl, strongly turbid plagioclase; Hb, hornblende. The circle at the crosshairs has a radius of 100 μm.

(e.g., Figure 7). At the Black Dog occurrence, a diorite dike is cut by moderately to steeply dipping brittle faults to produce blocks several metres long. Graphitic argillite is folded around the blocks and sulphide has flowed between them (Figure 10). Folds in sulphide and argillite are tight and hinges plunge in opposite directions, both north and south, within the 15 m length of the main exploration trench. Veins of sphalerite–pyrrhotite±chalcopyrite extend into the diorite and surround breccia fragments near the faults (Figures 9, 11).

Wispy trains and disseminations of sulphides outline folded foliation within the diorite and graphitic argillite. Mineralization along the Iskut River (Table 1) is of this type. Pyrite–chalcopyrite–galena is most notable within the argillite and pyrrhotite–chalcopyrite–sphalerite is a common assemblage within the diorite. Sphalerite also outlines foliation in a siliceous tuff or sediment where intersected by drilling below the massive sulphide horizon. Wispy and disseminated sulphide predates folding and could be syngenetic; however, a predeformational intrusive-related source cannot be ruled out on this basis, particularly given the occurrence of this mineralization within foliated diorite. Some late stringers of pyrrhotite–chalcopyrite cut the fabric and are likely remobilized.

STRUCTURE

The predominant fabric throughout the ‘Sulphide ridge’ area is south- to southwest-dipping bedding and foliation that is moderately well developed within volcano-sedimentary strata (Figure 12) and variably developed within diorite dikes. In places, the foliation is demonstrably axial planar to overturned folds, which range from open to tight. Rootless isoclinal folds are common where foliation is most strongly developed, particularly within carbonate-rich rock types.

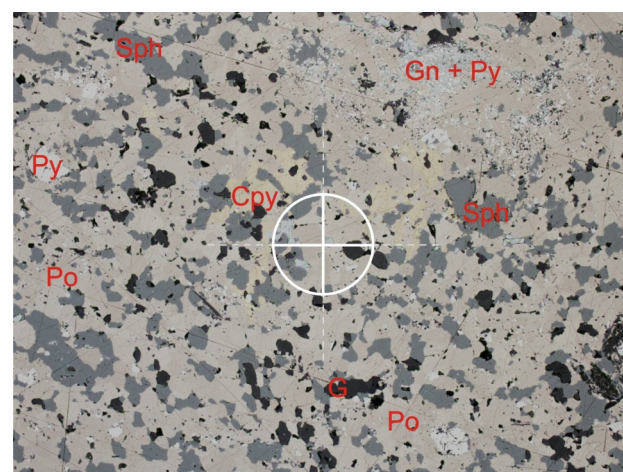


Figure 8. Polished section of a representative sample of massive, pinkish, pyrrhotite-rich (Po) sulphide from interval 19.4–20.2 m of drillhole RR90-3, Rock and Roll deposit, northwestern British Columbia. Yellow chalcopyrite (Cpy) comprises ~10% of the field of view, and medium-grey sphalerite (Sph) comprises ~20%. Bluish-white tabular galena (Gn) is subordinate to granular yellowish-white pyrite (Py), which together comprise ~5%. Dark grey to black gangue (G) is mainly carbonate. The radius of the circle at the crosshairs is 100 μm.

Outcrop to map-scale folds can be traced northwest of Lost Lake where foliated diorite crosscuts mafic volcanic and carbonate rocks. Within one of these fold closures, intrafolial isoclinal folds plunge shallowly towards 120° (Figures 3, 12, 13).

Strain associated with southwest-dipping foliation may have thickened northeast-trending diorite dikes, while dissecting thin dikes not within, or orthogonal to, the flattening fabric.

Repetition of a mineralized horizon is seen in drill sections, with up to four layers observed (M. Jones, pers comm, 2009). This repetition may result from tight to isoclinal folding about shallowly southeast plunging fold axes. Such folding would necessarily predate intrusion of the diorite dikes as they have not been observed to outline isoclinal folds. Moderate to shallow dips in the region of 'Sulphide ridge' (Figure 13) are consistent with the possi-

bility of stratiform sulphide layers repeated by early folds with shallow axial surfaces. This pattern is observed at outcrop scale in other rock types.

DISCUSSION

Interlayered sedimentary and volcanic sequences of Triassic and late Paleozoic age, which are ideal candidates for stratiform mineralization, are regionally extensive in the Iskut area. A volcano-sedimentary succession, including a felsic volcanic marker horizon, hosts the Rock and Roll mineralization. This host stratigraphy may be used to (1) unravel the complex crustal structure in the area and (2) constrain the age of the mineralizing environment through isotopic age determination.

Age of Host Strata

Geochronological constraints on the age of the Rock and Roll deposit host strata are lacking. One unpublished isotopic age determination from a sample of volcanic strata north of the Iskut River is reported by Edwards et al. (2000) as ">190 Ma based on 2 discordant zircon fractions (P. van der Heyden, written communication, 1987)" (see Figure 2) is not reliable. Strata from which the zircons were extracted were interpreted as the oldest Stuhini Group rocks in the immediate area (Phillipone and Ross, 1989).

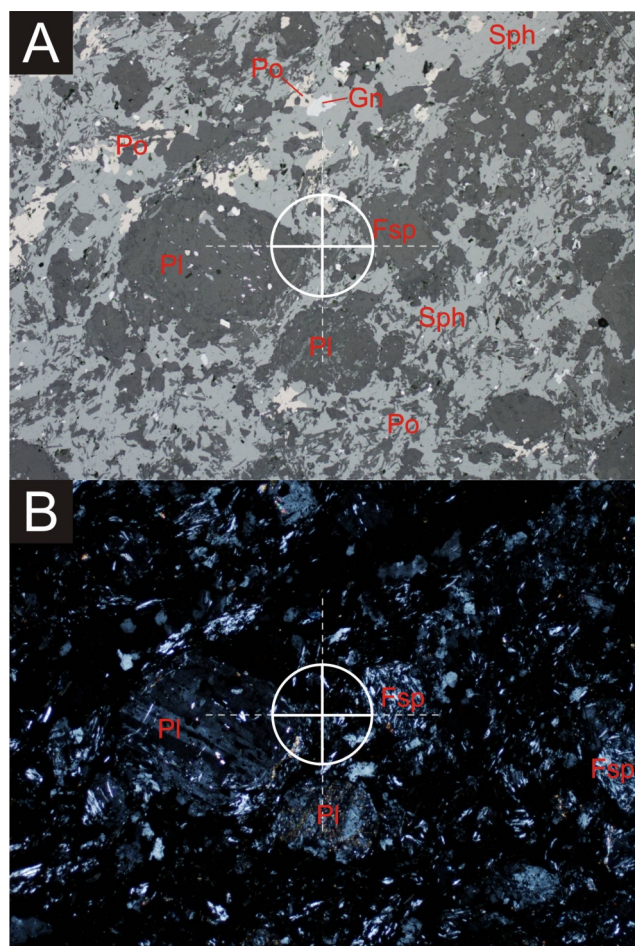


Figure 9. Mineralization from the Rock and Roll deposit, north-western British Columbia: **A)** reflected light view of sphalerite-rich mineralization; **B)** transmitted light view of sphalerite-rich mineralization. Clasts comprised mainly of plagioclase (Pl) and unidentified feldspar (Fsp) float in a matrix of sphalerite (Sph), which is medium grey in reflected light, and minor flesh to light tan-coloured pyrrhotite (Po) and galena (Gn). Some feldspar clasts are relatively fresh plagioclase (Pl); others are much more altered. These clasts might have originated as diorite, and were subsequently fragmented and milled during brittle deformation. However, a lack of mafic minerals and the relatively fresh plagioclase are both inconsistent with this interpretation. The circle at the crosshairs has a radius of 100 μ m.



Figure 10. Massive sulphide at the main trench, Black Dog occurrence, northwestern British Columbia. The view is east-southeast. A very rusty massive sulphide layer appears to have been 'squeezed up' between diorite blocks.

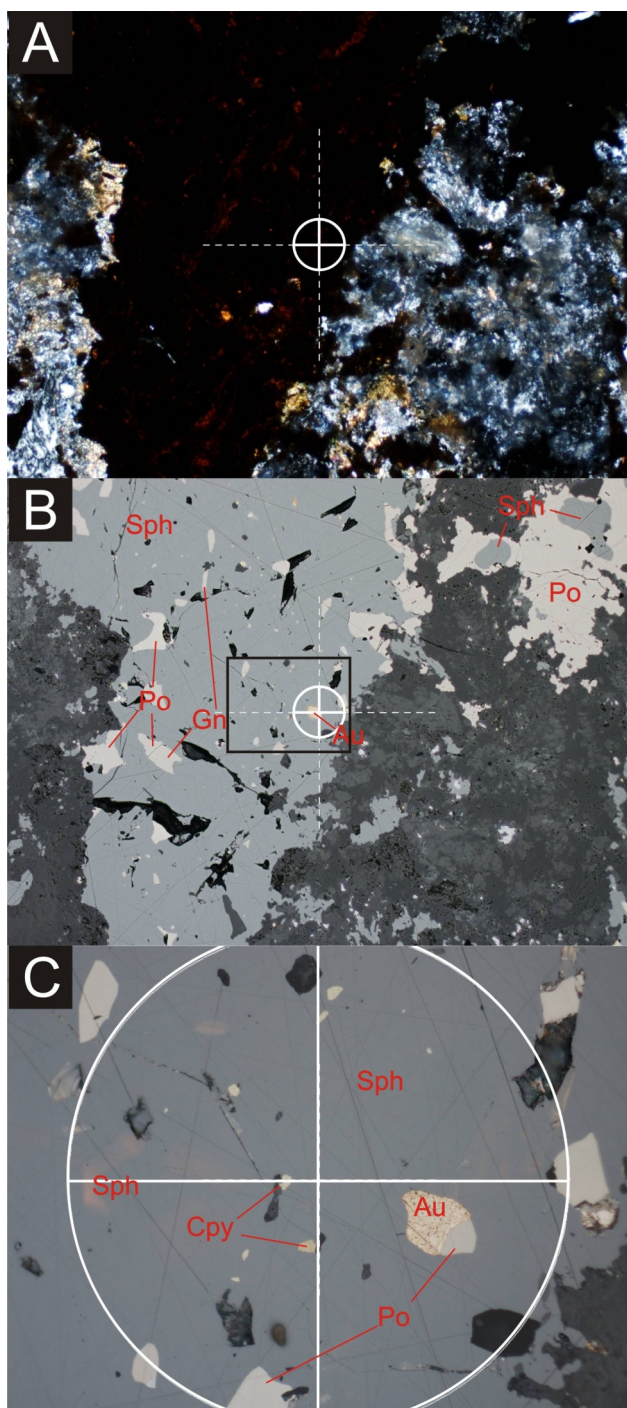


Figure 11. Sphalerite-rich massive sulphide in contact with diorite, northwestern British Columbia; the circle at the crosshairs in A and B has a radius of 50 μm , and in C has a radius of 100 μm : **A)** transmitted plane-polarized view of irregular brown-orange sphalerite vein within altered diorite; **B)** same field of view as A under reflected light; medium-grey sphalerite (Sph) encloses xenomorphic pyrrhotite (Po) and bladed galena (Gn); the highly reflective yellow grain at the crosshairs is gold (Au); top right of photo shows flesh to light tan-coloured pyrrhotite enclosing xenomorphic sphalerite; **C)** higher magnification of gold grain (Au) and less reflective yellow chalcopyrite (Cpy); internal reflections in sphalerite are well displayed.

About 7 km east of Lost Lake, Stuhini Group strata are mapped as intruded by ca. 193 Ma plutons, including the 193.9 ± 0.6 Ma (U-Pb zircon; Lewis et al., 2001) Iskut River stock and the 195 ± 1 Ma Red Bluff porphyry (U-Pb zircon; Macdonald et al., 1992). Near this locality, the Stuhini Group is mapped as overlain by a coeval, discontinuous blanket of dacite-rhyolite flow rocks belonging to the Betty Creek Formation of the Early Jurassic Hazelton Group, dated at 193 ± 1 Ma and 194 ± 3 Ma (Lewis et al., 2001). However, none of these magmatic units are known to extend onto the Rock and Roll property (the John Peaks/Unuk metadiorite body along the Craig River is undated).

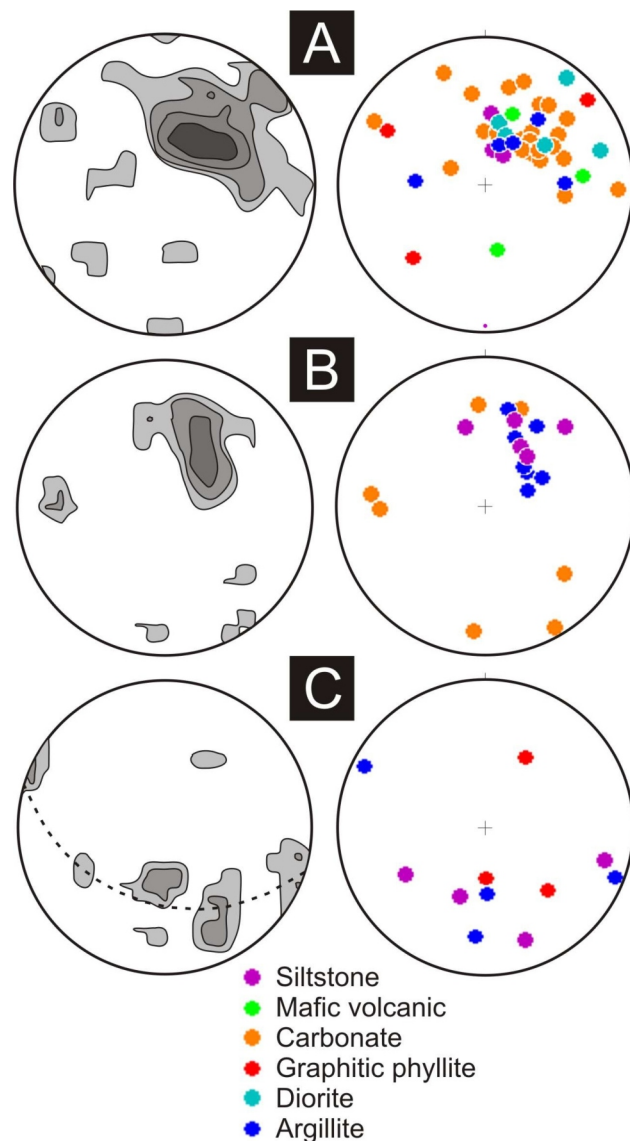


Figure 12. **A)** Poles to foliation, all rock types, Rock and Roll property, northwestern British Columbia. The mean orientation is $130/39$; $N = 46$; contours at 2%, 4%, 8% and 16%. **B)** Poles to bedding, all rock types. The mean orientation is $115/43$; $N = 19$; contours at 5%, 10% and 20%. **C)** Fold hinges, all rock types. Plane of best fit is $107/46$; $N = 13$; contours at 7% and 14%.

Deposit Model and Age of Mineralization

Two models are proposed to explain the origin of massive sulphide mineralization observed at the Rock and Roll deposit: (1) skarn mineralization attributable to metasomatism, coeval with, and generated by, intrusion of dikes and sills of diorite; and (2) syngenetic mineralization attributable to hydrothermal cells, driven by submarine volcanism. Skarn mineralization is consistent with the close spatial relationship between diorite and massive sulphide at the main Black Dog occurrence, with sulphide veins cutting the dikes and with possible diorite fragments within the massive sulphide. In this model, metasomatism and mineralization is attributed to the expulsion of reduced, sulphide and metal-rich fluids from the intruding diorite magmas. Replacement of reactive graphitic argillite layers explains the stratiform nature of the mineralized layers. This model requires that the diorite intrusions were reduced and metal rich, characteristics that can be tested through geochemical analysis.

Syngenetic mineralization is consistent with the spatial association of massive sulphides and graphitic argillite, the occurrence of multiple horizons that can be traced at approximately the same stratigraphic horizon from drillhole to drillhole, the lack of diorite association with mineralization in some drillholes, and the presence of a distal felsic volcanic horizon within the productive part of the stratigraphy. In addition, sparse geochemical data from the sulphide-bearing zones reveal elevated Mn, Co and V typical of other PMPMS deposits of syngenetic origin.

We prefer a model of syngenetic mineralization because of the strong apparent stratigraphic control of the mineralization and evidence for remobilization where the sulphide mineral suite is hosted by diorite. The PMPMS association with graphitic argillite is consistent with a reducing and sulphide-preserving environment (versus oxidizing, sulphide-destroying). The association of felsic volcanic rocks within the section is consistent with a corresponding high Cu-Zn tenor of the mineralization (e.g., Kuroko style). However, the expectation of increased sulphide nearer to an intrusive centre has not been borne out by preliminary drilling on the Phiz property where strata containing the most proximal felsic volcanic rocks in the local area have not yet revealed PMPMS mineralization. Clear evidence for synchronicity of mineralization and host strata is required. Uranium-lead zircon dating of the host strata and the diorite, as well as direct Re-Os dating of the sulphide mineralization, is needed to unequivocally demonstrate whether or not the Rock and Roll deposit is syngenetic.

ACKNOWLEDGMENTS

The authors acknowledge the assistance of our project partners: Pacific Northwest Capital and the University of Victoria (BC Ministry of Energy, Mines and Petroleum Resources Partnership Fund). This project is also funded in part by a Natural Science and Engineering Research Council (NSERC) grant to Stephen T. Johnston. Paul Wojdak provided background information and logistical support.

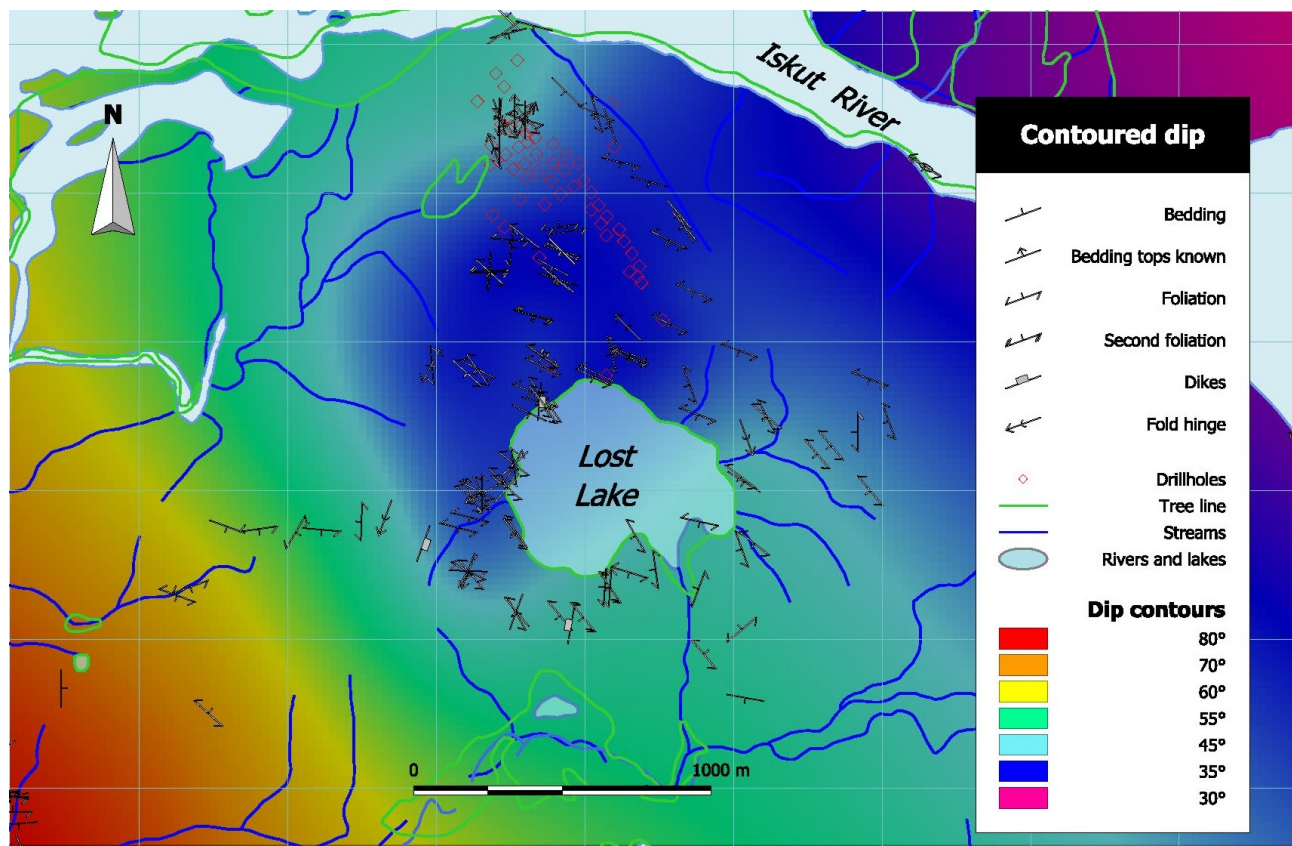


Figure 13. Contoured dips (isogons) for bedding and foliation data collected during this study around the Rock and Roll property. Dike orientations and fold hinges are shown for reference. Dense distribution of drillholes corresponds to mineralization in the subsurface of 'Sulphide ridge'. Grid is 500 m, UTM WGS84.

Pete and Kathy Kossey, proprietors of Bronson Bistro, bestowed warm and inviting camp facilities. Punctual transportation by Lars Helgesen (Quantum Helicopters Ltd), master of the approach, was appreciated. Steve Rowins reviewed an earlier draft of the manuscript.

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