Geology, geochemistry, and lead isotopic analysis of mineralization of the Strike property, Campbell Range, southeastern Yukon

Richard K. Mann and James K. Mortensen
Department of Earth and Ocean Sciences, University of British Columbia[1]

Mann, R.K. and Mortensen, J.K., 2000. Geology, geochemistry, and lead isotopic analysis of mineralization of the Strike property, Campbell Range, southeastern Yukon. *In:* Yukon Exploration and Geology 1999, D.S. Emond and L.H. Weston (eds.), Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 237-245.

ABSTRACT

The Strike property is located in the Campbell Range belt in southeastern Yukon. The study area is underlain by a wide variety of mafic volcanic and volcaniclastic rocks, as well as altered mafic intrusions and cherty metasedimentary rocks. Together these rock units are interpreted to comprise several discrete, relatively flat-lying and highly faulted lithologic assemblages. Lithogeochemical analyses of metavolcanic rocks that host mineralization on the property concluded that they are moderately enriched mid-ocean ridge basalts (E-MORB) to normal basalts (N-MORB) that likely formed in an ocean basin and/or back-arc/marginal basin setting. Diamond drilling intersected minor syngenetic, massive pyrite-chalcopyrite mineralization associated with hematitic chert/exhalite, as well as quartz-pyrite-chalcopyrite veining in a rubbly fault zone. Lead isotopic compositions of the mineralization are consistent with it being syngenetic Cyprus-type volcanogenic (VMS) mineralization. The results of the study highlight the potential for more Cyprus-type VMS mineralization in the Campbell Range in addition to the previously discovered Ice deposit and Money occurrence.

RÉSUMÉ

La propriété Strike est située dans la ceinture de Campbell Range dans le sud-est du Yukon. La région à l'étude est sous-tendue par une grande variété de roches volcaniques et volcanoclastiques mafiques, de même que par des intrusions mafiques altérées et des roches métasédimentaires cherteuses. On interprète cet ensemble d'unités rocheuses comme représentant plusieurs assemblages lithologiques distincts, relativement horizontaux et fortement faillés. L'analyse lithogéochimique des roches métavolcaniques qui contiennent la minéralisation sur la propriété mène à la conclusion que ce sont des basaltes modérément enrichis (de type E-MORB) à normaux (de type N-MORB), qui ont probablement été formés dans un environnement de bassin océanique et/ou un environnement d'arrière-arc ou de bassin marginal. Des forages au diamant ont intersecté de petites quantités de minéralisation massive de pyrite-chalcopyrite syngénétique associées avec un chert/exhalite hématisé ainsi que des veines de quartz-pyrite-chalcopyrite dans une zone de faille non consolidée. Les rapports isotopiques du plomb de la minéralisation correspondent à ceux d'une minéralisation en sulfures massifs volcanogènes syngénétiques de type Chypre (Cu-Zn). Les résultats de cette étude indiquent qu'il y a potentiellement d'autres minéralisations en sulfures massifs volcanogènes de type Chypre dans la ceinture de Campbell Range, en plus du gisement Ice et de l'indice Money déjà mis à jour.

[1]*Department of Earth and Ocean Sciences, University of British Columbia, 6339 Stores Rd., Vancouver, British Columbia, Canada V6T 1Z4, jmortensen@eos.ubc.ca*

INTRODUCTION

The Strike property is located in the Campbell Range belt (CRB) in southeastern Yukon. The study area is underlain by several metabasalt units with intercalated metachert, and is intruded by a leucogabbro body. The presence of a brecciated and sheared serpentinite unit suggests significant faulting in the area. The volcanic package has been interpreted to be part of the Slide Mountain Terrane (SMT) by Plint and Gordon (1997), but this is still under debate. Alternatively it may represent a stratigraphically higher unit of the Yukon-Tanana Terrane (YTT; Murphy, 1999).

The study area is centred on the Strike property (Fig. 1), which was the focus of base metal exploration in 1998 by Cominco Exploration Ltd. The 1998 work followed up on previously identified gossanous zones with strong associated Cu soil anomalies. The area is believed to be broadly on strike with mafic-volcanic-hosted volcanogenic massive sulphide (VMS) mineralization on Expatriate Resources' Ice property 80 km to the northwest, and possibly with the Money occurrence to the south (Fig. 1).

This contribution is based on 1:5000 scale mapping conducted in the study area in 1998 by the senior author and P.A. MacRobbie of Cominco Exploration Ltd. Geochemical, petrographic and Pb isotopic studies were also undertaken, and are discussed in this paper. A total of seven samples were analyzed for major, trace and rare earth element (REE) geochemistry. Four samples of pyrite/chalcopyrite mineralization were analyzed for trace Pb isotopic compositions. Sixteen thin sections along with five polished sections were examined petrographically.

The purpose of the study was to better understand the geology of the Strike property and, if possible, to determine the nature and origin of the mineralization on the property.

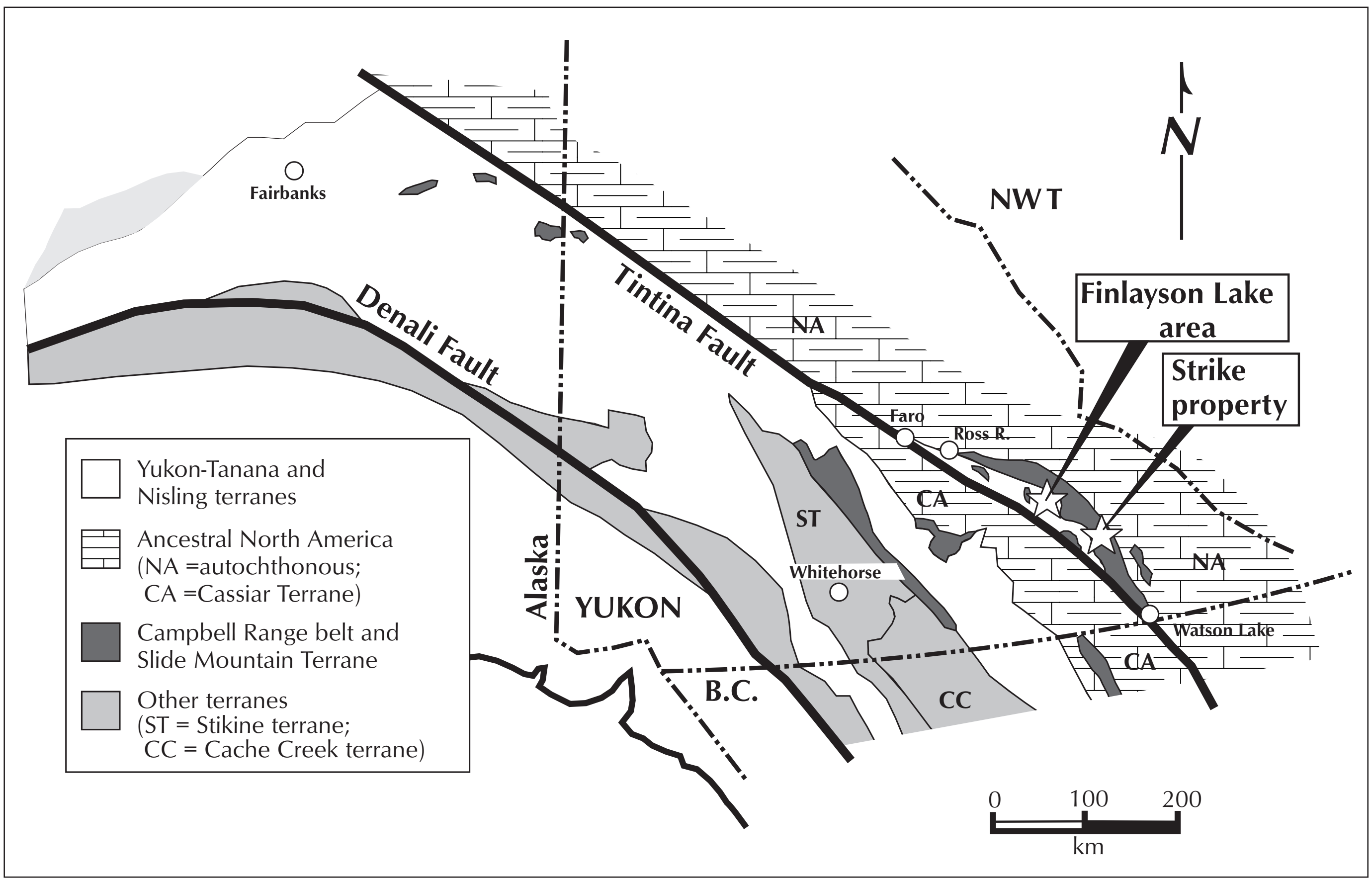


Figure 1. *Location map for the Strike property showing Yukon regional terranes (modified from MacRobbie et al., 1998).*

LOCATION AND ACCESS

The Strike property is located in the CRB in southeastern Yukon Territory (Fig. 1). The study area lies approximately 17 km east of the north end of Wolverine Lake, and 5.5 km west of the Robert Campbell Highway. It is centred at UTM coordinates 446500 E, 6819200 N, and covers approximately 3 km^2. The area is a semi-mountainous zone of 1420-1700 m elevation with small scrub conifers and alpine vegetation. There is moderate to good bedrock exposure on steeper slopes, but much poorer exposure (<2%) on flatter areas in the lower and western part of the study area.

The 1998 program was helicopter supported and based out of the Kudz Ze Kayah exploration camp located approximately 30 km to the west, although the Robert Campbell Highway 5.5 km to the east would also be a viable base for helicopter pick-up.

PREVIOUS WORK

The Strike property was initially staked in 1995 by Cominco Exploration Ltd. to cover multi-element RGS stream silt anomalies on strike with Atna Resources' Money property. Fieldwork in 1996 located a strong Cu (>2300 ppm; locally up to 3436 ppm), Ni and Cr silt anomaly in a creek near the northern edge of the Strike property. In 1997, geological mapping upstream of the 1996-silt anomaly identified a large gossanous/ferricrete area, mafic volcanic rocks and minor malachite-stained talus. Contour soil lines identified >250 ppm Cu-in-soil anomalies (locally up to 9300 ppm) centred over the gossanous zone. The property was re-staked in 1997.

These past results, and the announcement in late 1996 of significant Cu-rich mineralization in mafic-volcanic-dominated stratigraphy on the Ice property by Expatriate Resources, prompted a program of geological mapping, geophysical surveys and diamond drilling by Cominco Exploration Ltd. in 1998. A 12.5-km grid was cut over the area of the gossanous/ ferricrete zone, which was the focus of the 1998 exploration and this study on the Strike property.

REGIONAL GEOLOGY

The Strike property is underlain predominantly by rock units assigned to the SMT by Plint and Gordon (1997). These rocks make up much of the CRB and consist of the following units defined by Plint and Gordon (1997).

- massive to foliated *greenstone*, including pillow breccias and tuffs, heterolithic breccias, maroon metasiltstone and argillite, metagabbro, metadiorite, metagreywacke and various coloured metacherts;
- coarse-grained, ophitic, plagioclase-pyroxene *leucogabbro* with fine-grained and pegmatitic phases;
- green to black, magnetic, locally brecciated, massive, sugary-textured to well foliated *serpentinite*;
- varicoloured *metachert* interbedded with *metasiltstone/ argillite* and minor chert breccia and chert quartz conglomerate; and
- pink, orange, tan, white or green/grey *metachert* and *phyllite* with argillaceous partings of white argillite or minor phyllite beds.

Assignment of this assemblage to SMT is now under debate. Murphy (1999) has tentatively concluded that the metabasalts of this area of the CRB conformably overlie YTT rocks that host the Wolverine deposit. More work will be needed to resolve this problem.

The CRB also forms part of the Finlayson Lake fault zone (Mortensen and Jilson, 1985; Plint and Gordon, 1997). This complex fault zone contains both thrust and steep transcurrent faults, and separates the YTT from allochthonous North America (Mortensen, 1983; Mortensen and Jilson, 1985). Thrust faulting continued after the formation of the Finlayson Lake fault zone, as indicated by the presence of overthrust sheets of SMT lithologies above the fault zone (Plint and Gordon, 1997).

The age of the volcanic rocks in the CRB is thought to range from Early Mississippian to Permian. This is based on firstly, the premise that there is no unconformity between the YTT (mainly Late Devonian-Mississippian) and the CRB, and secondly, a Pennsylvanian to Early Permian fossil (radiolarian) age for chert from the CRB that was reported by Plint and Gordon (1997).

PROPERTY GEOLOGY AND MINERALIZATION

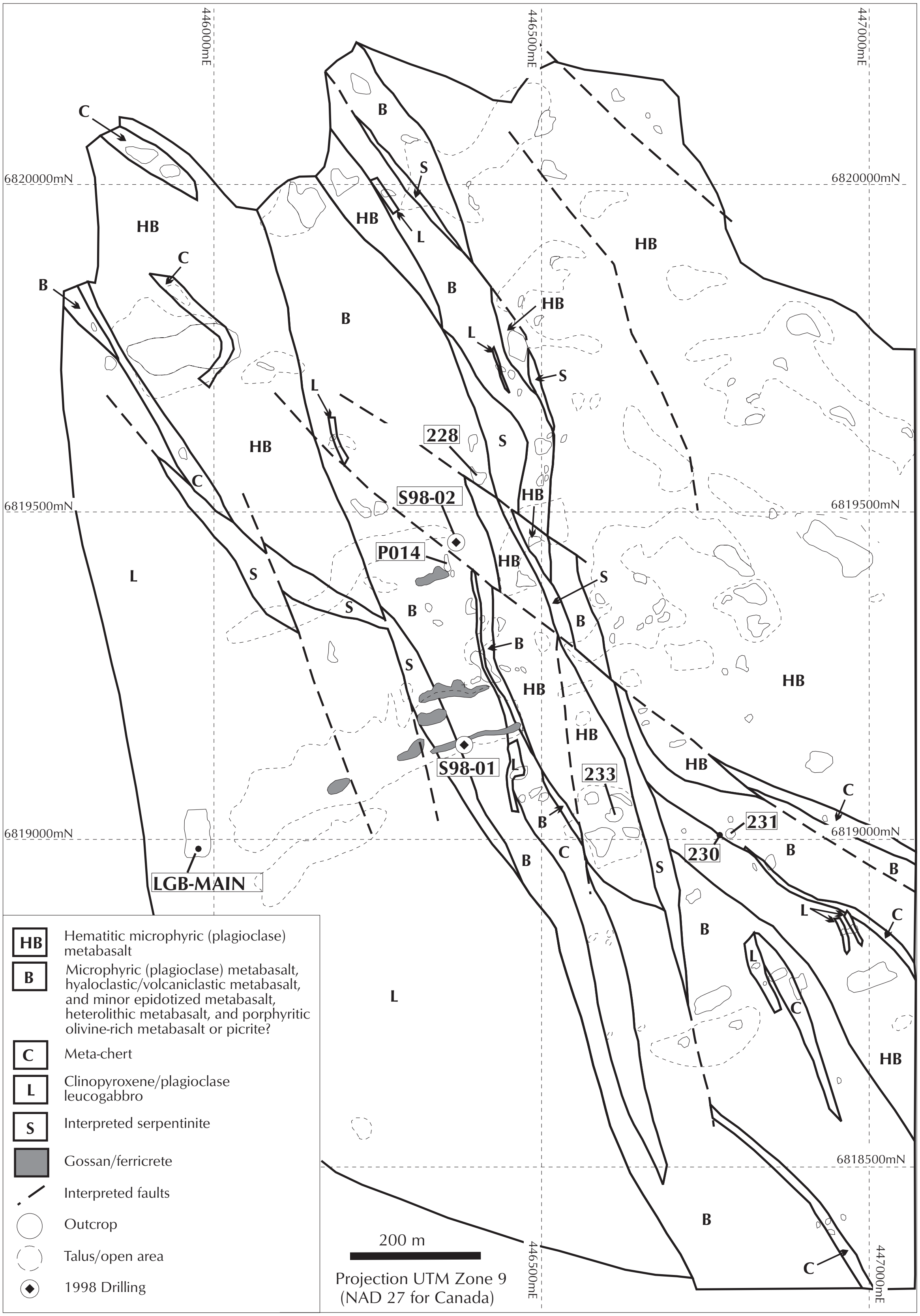
LITHOLOGIC UNITS

Lithologic units in the study area (Fig. 2) have been subdivided based on field relations, petrography, and geochemistry into the following six main units.

Unit 1: Microphyric (plagioclase) metabasalt. This unit consists of greenish brown weathering, massive to pillow-brecciated metabasalt containing abundant plagioclase microphenocrysts up to 0.8 mm in length. Minor pillows, calcite, pumpellyite, and epidote amygdules, and epidote alteration occur locally.

Unit 2: Hematitic microphyric (plagioclase) metabasalt. This unit is well exposed and is the dominant lithology of the northeastern parts of the study area. It consists of greenish brown to maroon, massive to brecciated metabasalt. The basalt has moderate to strong hematitic alteration of the groundmass, and abundant plagioclase microphenocrysts up to 0.8 mm. Minor subhedral plagioclase phenocrysts up to 8 mm, pumpellyite, chlorite, calcite, and plagioclase amygdules, and variolites up to 3 mm all occur locally.

Figure 2. Strike property study area geology and sample locations.



Units 1 and 2 are similar in appearance and likely have a similar origin, and are shown as HB on Fig. 2. In addition to characteristics already mentioned, feldspars in both units are moderately to strongly saussuritized, and both units locally contain magnetite grains, quartz-epidote veining and relict olivine phenocrysts. The major differences are hematitic alteration, and more common brecciation of the hematitic microphyric metabasalt.

Unit 3: Hyaloclastic/volcaniclastic metabasalt (B on Fig. 2). This unit consists of tan- to light green-weathering, very fine- to coarse-grained, brecciated metabasalt with minor poorly developed banding. Breccia fragments contain rare, strongly saussuritized, relict plagioclase microphenocrysts. This rock appears to have undergone devitrification of a primary glass-rich matrix. This unit was included in Unit 1 at the time of mapping due to variability and graded boundaries.

Unit 4: Clinopyroxene/plagioclase leucogabbro (L). The leucogabbro unit occurs as a large, fine- to medium-grained intrusion in the western part of the study area; whereas it is only seen as pegmatitic and possibly peperitic phases in the better exposed northern portion of the study area. This unit consists of tan- to grey-weathering, white to light green, medium-grained, equigranular to pegmatitic metagabbro. The rock consists mainly of clinopyroxene and highly altered (albitized) plagioclase laths, as well as irregular actinolite pseudomorphs after primary orthopyroxene or clinopyroxene. Subhedral orthopyroxene crystals are also preserved locally.

Unit 5: Serpentinized ultramafic rocks (S). This unit consists of tan-weathering, dark green, strongly magnetic, and massive serpentinite with rounded and fractured magnetite grains to 2.5 mm. The rock is locally highly fractured and contains abundant talc and clay as fault gouge. Relict orthopyroxene, chrome spinel and chromite (?) are present in minor amounts.

Unit 6: Metachert (C). This unit consists of massive, grey to pale green, pink and maroon metachert. An argillaceous component is present in some areas. Poorly developed fine stratification, rare radiolarians to ~1 mm, and fine-grained breccia textures also occur locally. This unit is intercalated with the metavolcanic units.

Three other minor rock units were recognized in the study area (especially within the microphyric metabasalt unit). These include:

- dark green, olivine-phyric metabasalt containing abundant poikilitic olivine and altered plagioclase phenocrysts;
- heterolithic metabasaltic breccias containing fragments of units 1, 2, 3 and 4 above; and
- brown- to green-weathering, strongly epidotized metabasalt.

STRUCTURE

Although exposure is good in the upper and eastern portions of the study area, individual metabasalt and metachert units are difficult to trace along strike. The apparent discontinuous nature of flows and sediment units, along with the overall form of the outcrops, suggest faulting between some of the mapped units (Fig. 2). Ultramafic bodies that are interpreted to cut across geological boundaries also support this. Generally, bedding measurements can only be made from rare, poorly developed banding in the metachert units. Where present, bedding appears to be northwest-trending with shallow (20-45°) southwest dips. Deformation in the area is weak with only locally developed minor foliation. The structure of the study area is poorly constrained due to lack of good bedding indicators, and the highly faulted nature of the rocks.

SURFACE MINERALIZATION AND SOIL GEOCHEMISTRY

Talus in the gossanous/ferricrete area contains minor malachite on fractures in both the metabasalts and leucogabbro. However, no significant sulphides or rocks with significant metal contents were found on surface.

Soil sampling in 50-m intervals was carried out on 12.5 km of grid. Five soil pits, approximately one metre deep, were also dug and sampled in selected areas of the grid to try to outline and source the soil anomalies.

The results defined two highly anomalous areas. The first area coincides with the rusty-weathering, gossanous/ferricrete zones in the centre of the study area (Fig. 2). Samples returned >300 ppm Cu with higher values of 11,610 ppm and 8788 ppm. These anomalies are interpreted to be due to Cu and Fe-rich waters rising up fault zones and periodically flooding the surface. Springs near the up-slope cutoff of the gossanous zones, as well as layering of rusty-weathering soil, support this interpretation. The second anomalous area lies in a non-gossanous area in the northern part of the study area. Samples returned highly anomalous Cu, up to 11,920 ppm. This area is generally gently sloping with grassy and brushy vegetation. Analysis of soil horizons resulted in the highest anomalies being reported from dark brown to black organic-rich soil, which may indicate entrapment and concentration of metals by organic material.

The Cu soil anomalies in both anomalous areas coincide with strong Cr (>100 ppm; maximum 1155 ppm), Ni (>125 ppm; maximum 755 ppm) and weaker Co (>20 ppm; maximum 401 ppm) anomalies. Soil geochemical results from the northern portions of the study area, which are mainly underlain by non-gossanous hematitic metabasalts, were at most weakly anomalous, with a maximum of 611 ppm Cu present locally.

Rock samples of ferricrete returned 14-49% Fe, 1866-3806 ppm Cu, 4-1339 ppm Ni, 61-1533 ppm Cr, and 9-37 ppm Co.

DRILL HOLE MINERALIZATION

Minor amounts of pyrite/chalcopyrite mineralization were intersected in DDH-ST98-01 (Fig. 2), including several small rounded pebbles in fault zone wash and one ~5 cm band of massive pyrite/chalcopyrite in an envelope of hematitic chert/exhalite. Three distinct types of mineralization are present:

1) Very fine-grained pyrite (60%) with interstitial remobilized chalcopyrite (12%), quartz (28%), trace sphalerite as inclusions or adjacent to chalcopyrite, and trace hematite (?). Quartz occurs as very fine-grained matrix to the euhedral sulphide grains and is closely associated with chalcopyrite. This mineralization is associated with adjacent strongly hematitic siliceous rock (chert or exhalite). Subtle layering is locally evident macroscopically. Analyses of this material returned 1.9% Cu and 5.7 g/t Ag.
2) Quartz-pyrite-chalcopyrite and quartz-calcite veins. They are comprised of anhedral to euhedral, fine- to coarse-grained, recrystallized and fractured pyrite (20-40%); medium- to coarse-grained, remobilized chalcopyrite (8-20%); and fine- to medium-grained quartz matrix (40-50%). Analyses of the pebble wash from this zone returned 3.1% Cu and 6.4 g/t Ag.
3) Minor disseminated subhedral pyrite grains up to 3 mm found locally in the metachert, hematitic microphyric metabasalt, microphyric metabasalt, and serpentinite units.

Types 1 and 2 (above) are invariably hosted by strongly hematized cherts and/or pale siliceous exhalites. No volcanic rocks were found in contact with these types of mineralization. This may indicate a period of decreased volcanic activity with expulsion of silica- and metal-rich fluids onto the sea floor. Type 1 mineralization is interpreted to be syngenetic because of the fine-grained, massive nature of the sulphides, lack of recrystallized pyrite, and apparent macroscopic layering. Association with hematitic chert/exhalite also supports this conclusion. Type 2 mineralization occurs as veins. Breccia textures in the sulphides and an association in one sample with brecciated hematitic chert/exhalite suggests possible remobilization of syngenetic mineralization in a fault zone.

GEOCHEMISTRY OF METAVOLCANIC AND META-INTRUSIVE ROCKS

A total of seven samples (five metavolcanic and 2 meta-intrusive rocks) were analyzed for major, trace and rare-earth elements (REE) at Chemex Labs Ltd. in North Vancouver, B.C. Major elements were determined by X-ray fluorescence (XRF), whereas trace elements and REE were determined by research-grade, inductively coupled plasma mass spectrometry (ICP-MS). Table 1 summarizes geochemical data for the seven samples. The data set is relatively limited and thus may not be completely representative.

***Table 1**. Major, trace and REE abundances for metavolcanic and meta-intrusive rocks of the Strike property study area.*

Sample	PO14	RKMR-228	RKMR-230	RKMR-231	RKMR-233	RKMR-LGB-MAIN	ST9802-33.4-33.5
Major elements (%)							
SiO_2	47.42	47.96	37.83	47.90	47.78	47.27	46.60
TiO_2	1.42	1.80	1.36	1.55	1.35	0.21	0.23
Al_2O_3	14.79	13.44	14.36	14.85	14.07	16.09	17.52
Fe_2O_3	10.11	12.08	8.79	8.24	9.97	4.85	4.31
MnO	0.15	0.19	0.20	0.15	0.16	0.11	0.09
MgO	7.30	6.29	12.85	8.28	5.69	10.36	9.12
CaO	9.62	11.57	16.55	8.85	11.48	13.01	12.93
Na_2O	3.19	2.30	0.08	3.85	3.73	2.34	1.97
K_2O	0.27	0.25	0.03	0.52	0.16	0.23	0.95
P_2O_5	0.16	0.16	0.19	0.24	0.16	0.01	0.04
Cr_2O_3	0.05	<0.01	0.01	0.03	0.07	0.18	0.14
LOI	4.07	2.78	7.06	4.36	4.02	4.11	4.64
Sum	**98.55**	**98.82**	**99.31**	**98.82**	**98.64**	**98.77**	**98.54**
Trace elements (ppm)							
Ag	<1	<1	<1	1.0	<1	<1	<1
Ba	61.5	101.5	59.5	98.0	43.0	40.0	173.0
Co	40.0	45.5	35.5	36.0	37.0	33.0	29.5
Cs	0.1	<.1	0.3	0.3	<.1	<.1	0.5
Cu	45.0	80.0	65.0	40.0	55.0	85.0	430.0
Ga	15.0	18.0	13.0	15.0	14.0	9.0	11.0
Hf	2.0	3.0	2.0	3.0	2.0	<1	<1
Nb	6.0	6.0	14.0	13.0	5.0	1.0	1.0
Ni	120.0	35.0	115.0	155.0	70.0	230.0	215.0
Pb	<5	<5	<5	<5	<5	<5	<5
Rb	5.0	4.4	<.2	8.2	2.2	1.8	17.2
Sn	<1	1.0	<1	1.0	<1	<1	<1
Sr	21.7	171.0	53.5	35.0	61.1	167.0	66.0
Ta	2.0	2.0	2.0	2.0	1.5	0.5	0.5
Th	<1	<1	<1	<1	<1	<1	<1
Tl	<.5	<.5	<.5	<.5	<.5	<.5	<.5
U	<.5	<.5	<.5	<.5	<.5	<.5	<.5
V	240.0	285.0	200.0	180.0	250.0	Intf	Intf
W	19.0	18.0	10.0	16.0	11.0	7.0	9.0
Zn	75.0	90.0	65.0	55.0	85.0	25.0	40.0
Zr	75.5	96.5	88.0	109.0	67.0	<.5	<.5
REE (ppm)							
Ce	9.5	13.0	18.5	20.5	9.0	0.5	1.5
Dy	5.8	6.8	5.1	4.6	5.5	1.0	1.0
Er	3.8	4.4	3.4	3.0	3.1	0.5	0.7
Eu	1.2	1.5	1.6	1.3	1.2	0.5	0.3
Gd	4.5	5.7	5.0	4.4	4.3	0.9	0.6
Ho	1.2	1.4	1.0	1.0	1.0	0.1	0.1
La	3.0	5.0	8.5	8.5	3.5	0.5	0.5
Lu	0.6	0.6	0.5	0.4	0.5	<.1	<.1
Nd	9.5	13.0	13.0	13.5	8.5	1.5	2.0
Pr	1.7	2.4	2.8	2.9	1.7	0.2	0.3
Sm	3.4	3.8	3.9	4.2	3.1	0.6	0.6
Tb	0.8	1.0	0.8	0.7	0.8	0.1	0.1
Tm	0.5	0.6	0.5	0.4	0.5	<.1	<.1
Yb	3.5	3.9	3.0	2.4	3.3	0.5	0.6
Y	33.0	37.5	29.0	27.0	30.0	5.5	6.0

Major element discriminant plots (not shown) indicate that the metavolcanic rocks and leucogabbro are generally sub-alkaline basalt in composition. Trace element plots show that the volcanic rocks are of ocean floor affinity, rather than arc-related (Fig. 3). More specifically, trace elements indicate that both enriched (E-MORB) and normal mid-ocean ridge basalt (N-MORB) compositions are present (Fig. 4). The E-MORB group has higher Mg numbers (66.6-74.3%) than those in the N-MORB group (50.8-58.9%), indicating a lesser degree of fractionation in the E-MORB group and also showing the influence of fractional crystallization of olivine in sample RKMR-230.

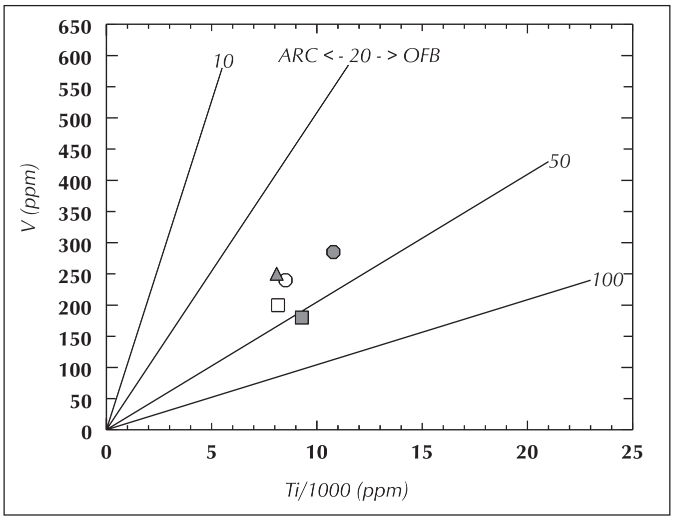


Figure 3. *Trace element plot showing ocean floor basalt (OFB) affinity of metavolcanic rocks from the Strike property (from Shervais, 1982). For symbols, see legend in Figure 4.*

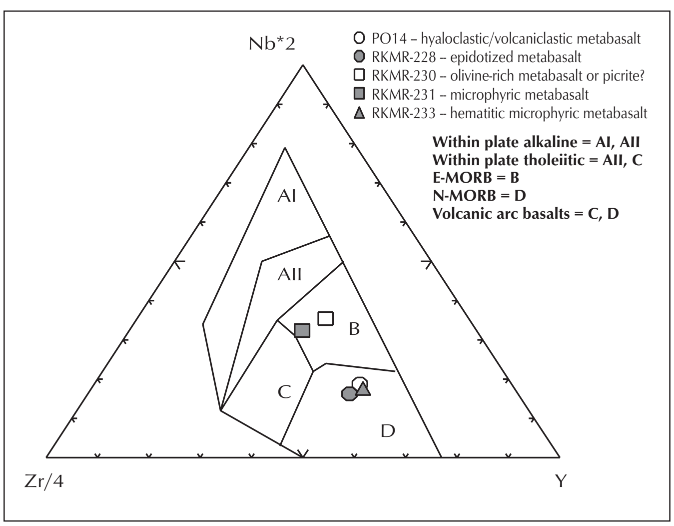


Figure 4. *Trace element plot showing differentiation between E-MORB and N-MORB settings of metavolcanic rocks from the Strike property (from Meschede, 1986).*

Primitive-mantle normalized multi-element plots (Fig. 5) show enrichment in Th, Nb, La, and Ce in samples RKMR-230 and 231 compared to a relatively flat to depleted light rare earth element (LREE pattern) for RKMR-228 and 233, and P014. This supports the separation of samples into E-MORB and N-MORB types. Generally all the metabasalts have relatively flat REE patterns with minor differences in the LREE abundances.

In view of the relatively coarse grain size and heterogeneous nature of the leucogabbro unit in outcrop and hand sample, the relatively small samples that were analyzed are likely not representative. Multi-element patterns for the leucogabbro unit are quite erratic (Fig. 5) and appear to indicate a separate origin from that of the metavolcanic rocks. A positive Eu value may result from plagioclase accumulation, which is consistent with the plagioclase-rich nature noted in outcrop and hand sample.

Metavolcanic rocks from the Strike area are geochemically similar to suites CRB_1 and CRB_2 as defined elsewhere in the CRB by Piercey et al. (1999). CRB_1 is defined by moderately LREE-enriched E-MORB-type compositions, characterized by relatively flat to slightly enriched LREE patterns, and relatively flat primitive-mantle-normalized multi-element plots. These compositions are consistent with generation in an ocean basin and/or back-arc/marginal basin setting (Piercey et al., 1999). The E-MORB samples in the Strike area differ from those described by Piercey et al. in that Strike rocks have somewhat higher Mg numbers and Zr/Y ratios. This may indicate a greater plume influence in the Strike metavolcanic rocks. The CRB_2 suite as defined by Piercey et al. consists of strongly LREE-depleted N-MORB-type rocks that are also consistent with generation in an ocean basin and/or back-arc/marginal basin setting (Piercey et al., 1999). The N-MORB samples from the Strike area are very similar to CRB_2 suite except for higher Nb contents in the Strike area.

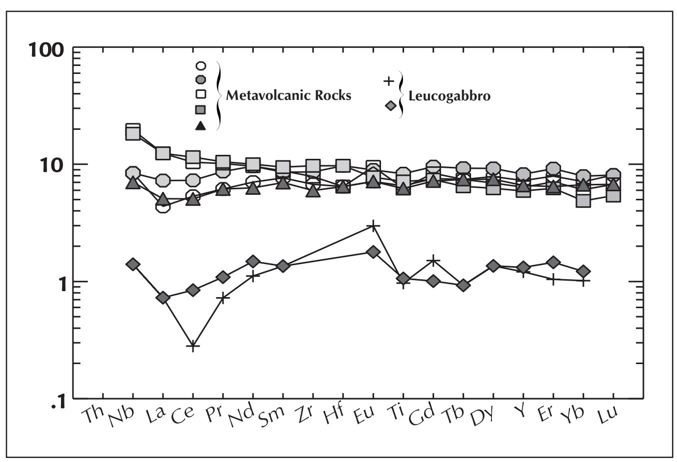


Figure 5. *Primitive-mantle-normalized multi-element plot for metavolcanic and leucogabbro rocks from the Strike property. Primitive-mantle values are from Sun and McDonough (1989).*

LEAD ISOTOPE STUDIES

Trace Pb isotopic compositions were determined for mixed pyrite/chalcopyrite samples from massive (Type 1) and vein (Type 2) mineralization in drill hole ST98-01 (31.1-38.1 m). The goal of this part of the study was to determine the source of metals and to help characterize the paleotectonic setting in which the host rocks formed. The main goal of this part of the study was to determine whether the sulphides represent syngenetic Cyprus-type volcanogenic massive sulphide (VMS) mineralization or epigenetic vein-type mineralization with no association with syngenetic targets. Lead isotopic data are given in Table 2 and shown graphically in Figure 6.

The data show a tight cluster, suggesting a similar Pb source for types 1 and 2 mineralization. The samples are all slightly more radiogenic than the "Model Mantle Growth Curve" (Fig. 6), but fall far below the "Shale Curve" on which most VMS mineralization in the YTT plots (Mortensen, unpublished data). The analyses are also significantly less radiogenic than Pb's from the Chu Chua mafic-volcanic hosted deposit in the SMT in east-central British Columbia (Aggarwal and Nesbit, 1984). This suggests a syngenetic origin for the mineralization with most Pb being derived from a MORB-type, mantle source, and a minor contribution from a more radiogenic source. This causes the analyses to plot on a mixing line between the "Mantle" and "Shale" curves. This enrichment may be explained by the fact that the host metabasalts themselves have slightly geochemically enriched signatures. Another possible explanation is that they may reflect isotopic mixing by fluid circulation through the metabasalts and more radiogenic sedimentary units that are interlayered with the volcanic rocks. Some of the cherts in the study area contain an argillaceous component, and it is possible that this material is continentally derived, which may account for the radiogenic enrichment.

Table 2. *Trace Pb isotopic analysis data.*

Sample	Type	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$	$^{207}Pb/^{206}Pb$	$^{208}Pb/^{206}Pb$
RKM-33	2	18.2744	15.5380	37.6593	0.85027	2.0608
RKM-35.4	2	18.3306	15.5260	37.7250	0.84700	2.0580
RKM-35.6a	2	18.3380	15.5469	37.7859	0.84780	2.0605
RKM-38.1	1	18.2273	15.5419	37.8457	0.85267	2.0763

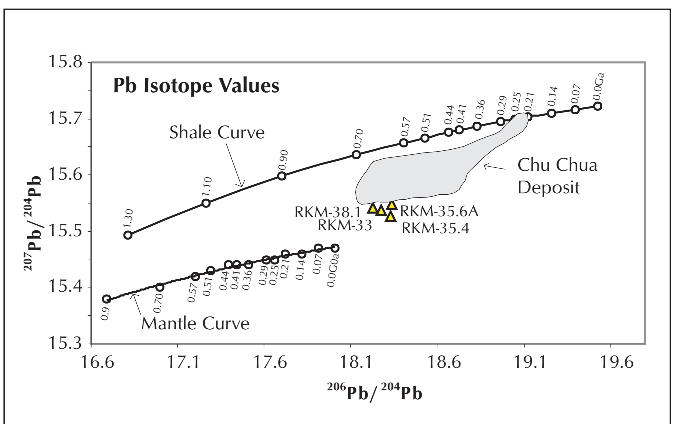


Figure 6. *Lead isotope compositions of Strike mineralization compared with data from the Chu Chua deposit, the "Model Mantle Growth Curve" and the "Model Shale Curve" (curve data from Godwin et al., 1988).*

INTERPRETATION AND DISCUSSION

As has also been concluded by Plint and Gordon (1997) and Piercey et al. (1999), the metavolcanic rocks in the study area are interpreted to have formed in a subaqeous MORB setting such as an ocean basin and/or back-arc/marginal basin. Textures observed vary from highly brecciated to pillowed to massive, which are typical of flow breccia formation. Intercalated chert beds up to 5 m thick also support the subaqeous setting. The geochemistry of the metavolcanic rock units indicates both E-MORB and N-MORB settings for the volcanic units. Given the relative proximity of the volcanic units in the study area, it is likely that the classification of two samples into an E-MORB setting and three samples into an N-MORB setting reflects varying amounts of plume contribution. This may be explained by various amounts of interaction between magmas during their rise to the sea floor. Hematization of the microphyric unit indicates possible formation in a shallow and therefore relatively oxygenated basin. This may support a marginal/back-arc basin setting rather than a deep ocean basin setting.

Epidotized metabasaltic rocks are likely a highly altered form of the microphyric metabasaltic units based on stratigraphic position and the abundance of these rock types. This unit is likely formed in a localized area of high hydrothermal flow indicated by the total epidotization of the rock. This may be significant in that mafic VMS deposits generally are associated with, or form near, areas of high hydrothermal flow. Therefore, large amounts of this unit may be a positive indicator of prospective units.

The gabbroic composition, proximity, and possible peperitic textures of the leucogabbro unit indicate an association with the volcanic units. However, the large differences in trace and REE geochemistry suggest that the leucogabbro and the metavolcanic rocks may be unrelated. A marked TiO_2 depletion, as well as high field strength element (HFSE) depletion, supports a more evolved nature and non-comagmatic relationship with the metavolcanic rocks.

The serpentinized ultramafic unit may have two origins. It may represent fault slices of basement ultramafic rock brought up by faulting, or alternatively it could represent intrusions into pre-existing faults. The unit is recessive and therefore very poorly exposed. It is also highly magnetic and may be a source of local magnetic anomalies.

The metachert unit occurs as intercalated beds within the metabasalt units. The presence of rare radiolarians and minor banding indicates that it is indeed of sedimentary origin, and does not represent hydrothermal jasper. Thicknesses up to 8 m indicate prolonged periods of volcanic inactivity and a period of time suitable to VMS sulphide deposition.

EXPLORATION IMPLICATIONS

The two basaltic suites (CRB_1 and CRB_2) in the CRB defined by Piercey et al. (1999) and the metavolcanic rocks area of the Strike property are all interpreted to have formed at spreading centres. This comes with generic MORB magmatism and abundant fractures and faults that could have formed conduits for hydrothermal fluid flow. The inferred tectonic setting, as well as the presence of the Ice deposit and Money occurrence, indicates a strong potential for mafic-volcanic associated VMS mineralization within the CRB.

The geology of the Ice deposit shares many characteristics with the Strike property, including:

- host rocks of the CRB dominated by metabasalts with interlayered, locally argillaceous metacherts;
- intimately associated chert and/or exhalite as an envelope around mineralization; and
- a large gossanous area with high copper soil anomalies on surface.

These similarities, together with minor, apparently syngenetic Cu mineralization present in DDH-ST98-01, suggest excellent potential for additional discoveries of Cyprus-type VMS mineralization in this area.

ACKNOWLEDGMENTS

This research was done by the first author as part of a directed study at the University of British Columbia. We thank Cominco Exploration Ltd. and especially Paul MacRobbie for supporting the field and lab component of the study. We also thank J. Gabites of the UBC Geochronology Laboratory for assistance in producing the trace Pb analytical data reported here. Thanks also goes to Scott Billows for his help with formatting and reproducing the maps, and Steve Piercey for his invaluable insight into volcanic geochemistry.

REFERENCES

Godwin, C.I., Gabites, J.E. and Andrew, A., 1988. Leadtable: A galena lead isotope database for the Canadian Cordillera, with a guide to its use by explorationists. A contribution to the Canada/British Columbia Mineral Developments Agreement, 1985-1990, B.C. Ministry of Energy, Mines and Petroleum Resources Paper, p. 14-18.

MacRobbie, P.A., Mann, R.K. and Johnston, R.D., 1998. 1998 assessment report, Strike property. Cominco Exploration Ltd., unpublished internal company report.

Meschede, M., 1986. A method of discriminating between different types of mid-ocean ridge basalts and continental tholeiites with the Nb-Zr-Y diagram. Chemical Geology, vol. 56, p. 207-218.

Mortensen, J.K. and Tosdal, R., 1998. Geochronology of mineral deposits. *In:* Mineral Deposits Research Unit, UBC Short Course #23 notes, p. 6-1 to 6-6.

Mortensen, J.K., 1983. Age and evolution of the Yukon-Tanana Terrane southeastern Yukon. Unpublished PhD thesis, University of California, Santa Barbara, California.

Mortensen, J.K. and Jilson, G.A., 1985. Evolution of the Yukon-Tanana Terrane: Evidence from southeastern Yukon Territory. Geology, vol. 13, p. 806-810.

Murphy, D.C., 1999. Yukon-Tanana Terrane and its relationship to Slide Mountain Terrane, Finlayson Lake area, southeastern Yukon. *In:* Lithoprobe: Slave-Northern Cordillera Liothospheric Evolution (SNORCLE) and Cordilleran Tectonics Workshop, report of the 1999 combined meeting, March 5-7, 1999, Lithoprobe Report No. 69, p. 138-141.

Piercey, S.J., Hunt, J.A. and Murphy, D.C., 1999. Lithogeochemistry of meta-volcanic rocks from Yukon-Tanana Terrane, Finlayson Lake region, Yukon: Preliminary results. *In:* Yukon Exploration and Geology 1998, C.F. Roots and D.S. Emond (eds.), Exploration and Geological Service Division, Yukon, Indian and Northern Affairs Canada, p. 125-138.

Plint, H. E. and Gordon, T.M., 1997. The Slide Mountain Terrane and the structural evolution of the Finlayson Lake fault zone, southeastern Yukon. Canadian Journal of Earth Sciences, vol. 34, p. 105-125.

Shervais, J.W., 1982. Ti-V plots and the petrogenesis of modern and ophiolitic lavas. Earth and Planetary Science Letters, vol. 59, p. 101-118.

Sun, S.S. and McDonough, W.F., 1989. Chemical and isotopic systematic of oceanic basalts: Implication for mantle composition and processes. *In:* Magmatism in the Ocean Basins. A.D. Saunders and M.J. Norry (eds.), Geological Society Special Publication 42, p. 313-345.