The setting of volcanogenic massive sulphide deposits in the Finlayson Lake district

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Hunt, J.A. The setting of volcanogenic massive sulphide deposits in the Finlayson Lake district. *In:* Yukon Exploration and Geology 1997, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p.99-104.

ABSTRACT

The definition of regionally extensive stratigraphy in deformed and metamorphosed rocks of the Yukon-Tanana Terrane in the Finlayson Lake district allows the recognition of at least three mineralized horizons. They are: a Lower horizon in chlorite schist of unit 2 close to the contact with overlying carbonaceous phyllite of unit 3; a Middle horizon in felsic meta-volcanic rocks of unit 3; and an Upper horizon in pillowed mafic volcanic rocks of the Campbell Range belt. The lower horizon hosts the Fyre Lake deposit. The Kudz Ze Kayah deposit and probably the deposits near Wolverine Lake are in the Middle horizon. The Upper horizon hosts the Money deposit.

RÉSUMÉ

La détermination de la stratigraphie d'échelle régionale dans les roches déformées et métamorphisées du terrane de Yukon-Tanana dans la région du lac Finlayson a permis la distinction d'au moins trois horizons minéralisés. Un horizon inférieur dans le schiste chloriteux de l'unité 2; à proximité du contact avec le phyllade carboné sus-jacent de l'unité 3; un horizon médian dans les roches métavolcaniques felsiques de l'unité 3; et un horizon supérieur dans les roches volcaniques mafiques en coussins de la ceinture du chaînon Campbell. L'horizon inférieur renferme le gisement de Fyre Lake. Le gisement de Kudz Ze Kayah et, probablement, celui de Wolverine sont inclus dans l'horizon médian. L'horizon supérieur contient le gisement de Money.

INTRODUCTION

An emerging volcanogenic massive sulphide (VMS) mining district in the Finlayson Lake area of southeast Yukon includes the Kudz Ze Kayah deposit discovered by Cominco in 1993 (Schultze, 1996) and deposits in the Wolverine Lake area (Tucker et al., 1997) where significant mineralization, first discovered in 1995, continues to be added to (Fig. 1). Other newly discovered mineralization includes Expatriate Resources Ltd.'s Ice deposit and new reserves at the Fyre Lake deposit owned by Columbia Gold Mines Ltd.

Bedrock geological mapping in the Finlayson Lake district (Murphy and Timmerman, 1997; Murphy, this volume; Hunt and Murphy, this volume) has defined a regionally continuous stratigraphy which can be used as a framework for interpreting the setting of VMS deposits in this area (Figs. 1, 2). The zinc-lead-copper and precious metal-rich Kudz Ze Kayah and Wolverine deposits are in Mississippian felsic meta-volcanic rocks of the Yukon-Tanana Terrane. Stratigraphically beneath is the copper-cobalt-gold bearing Fyre Lake deposit in ?Devono-Mississippian mafic meta-volcanic rocks also of the Yukon-Tanana Terrane. Believed to be stratigraphically higher than Wolverine is the copper-bearing Ice deposit hosted by mafic volcanic rocks of the Campbell Range Belt (interpreted by some as Slide Mountain Terrane; Fig. 2). Gossanous pyritic felsic meta-volcanic rocks of unit 1 of the Yukon-Tanana Terrane in the Finlayson Lake district may constitute a fourth mineralized horizon (Murphy, this volume).

In this short paper the stratigraphic details and mineral characteristics of each of these key horizons is described. These features are distilled from two seasons of investigation, during the early stages of evaluation of these deposits, in consultation with the respective company geologists. The settings are addressed from oldest to youngest.

VMS DEPOSIT SETTINGS

1. LOWER HORIZON - FYRE LAKE DEPOSIT

The Fyre Lake deposit (Foreman, this volume; Yukon Minfile 105G 034) is in chlorite and chlorite-actinolite-quartz schist (unit 2) near the contact with overlying carbonaceous phyllite (unit 3; Figs. 1, 2; Blanchflower et al., 1997). Protoliths for the chloritic schist and phyllite were likely mafic to intermediate flows, with interlayered tuffs and fine-grained sedimentary rocks.

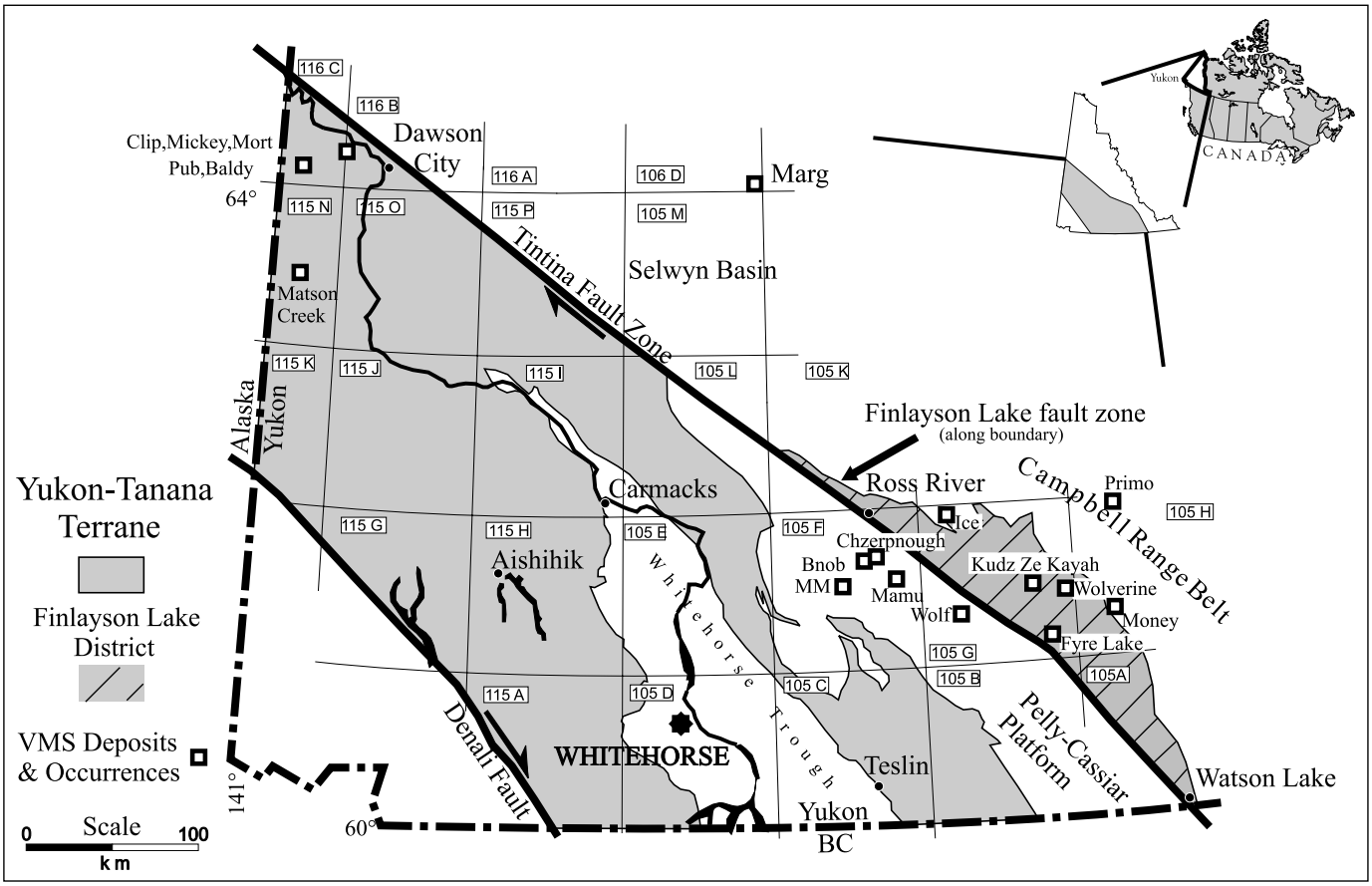

Figure 1. *Location of VMS deposits in the Finlayson Lake district.*

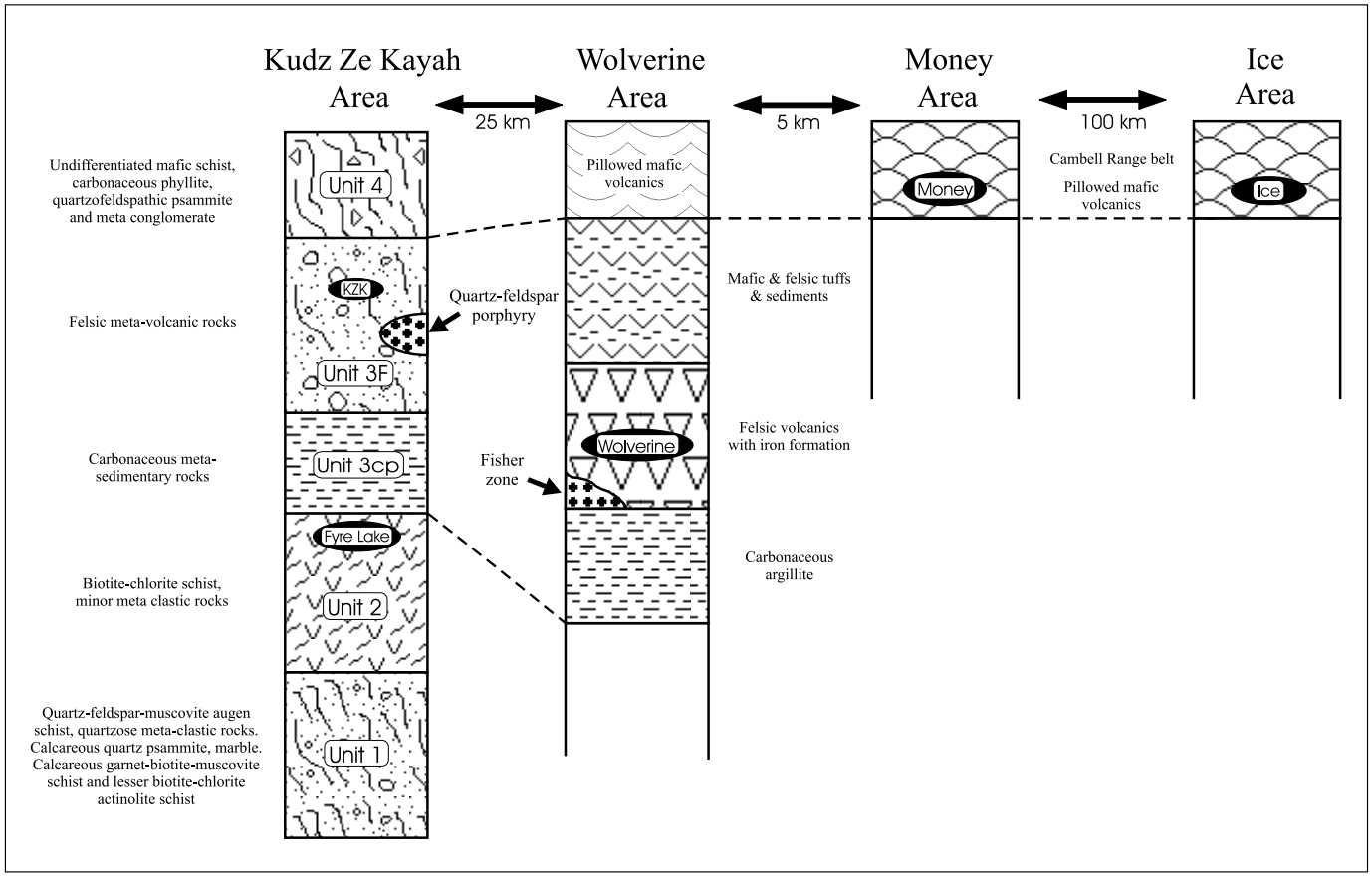

Figure 2. *Schematic stratigraphic sections for the Finlayson Lake district. Unit descriptions for the Kudz Ze Kayah (KZK) area are from Murphy (this volume).*

Two parallel zones of copper-cobalt-gold mineralization, East Kona and West Kona, make up the Fyre Lake deposit. The east zone has a strike length in excess of 900 m and consists of upper and lower horizons with average thicknesses of 8 to 12 m and average widths of 100 to 125 m (W. Roberts, pers. comm., 1997). The upper horizon occurs immediately below the contact between units 2 and 3. The lower horizon occurs approximately 40 to 70 m deeper. Upper horizon mineralization consists of massive pyrite with lesser pyrrhotite and chalcopyrite overlying banded sulphides; the lower horizon consists of massive pyrite with lesser pyrrhotite, chalcopyrite and sphalerite locally surrounding lenses of massive magnetite (W. Roberts, pers. comm.; Fig. 3). The west zone, defined during the 1997 program, has a strike length of 1500 m, is at least 125 m wide and varies in thickness from 9 to 40 m. The mineralization is predominantly pyrite, magnetite and chalcopyrite with lesser pyrrhotite in a siliceous matrix (Fig. 4). West Kona mineralization also occurs directly below the contact between units 2 and 3.

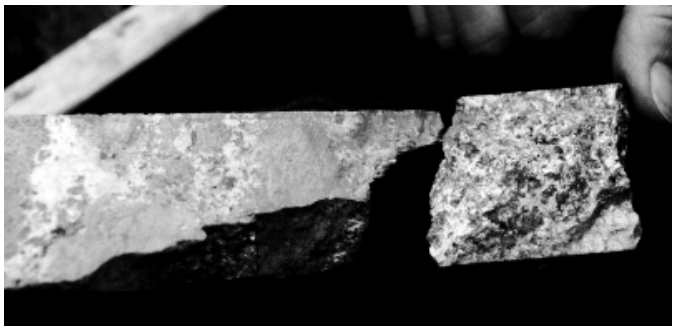

Figure 3. *Copper-rich massive sulphides from the East Kona zone, Fyre Lake deposit.*

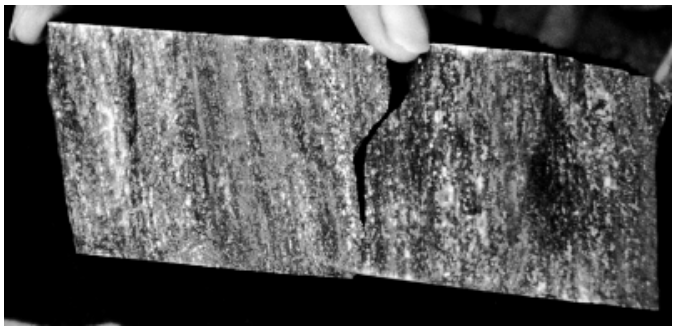

Figure 4. *West Kona zone mineralization, Fyre Lake deposit.*

Figure 5. *Pillowed mafic volcanic rocks at the Money occurrence.*

Grades in the Kona deposit average 1.5 to 2.0% Cu, 0.1 to 0.14% Co and 0.5 to 1.0 g/t Au where tested by drilling (W. Roberts, pers. comm., 1997).

2. MIDDLE HORIZON - KUDZ ZE KAYAH AND WOLVERINE DEPOSITS

The ABM deposit (Yukon Minfile 105G 117) at Kudz Ze Kayah is a geological resource of 13 000 000 tonnes of 5.5% Zn, 1% Cu, 1.3% Pb, 125 g/t Ag and 1.2 g/t Au including an open pit mineable ore reserve of 11 mt with 5.9% Zn, 0.9% Cu, 1.5% Pb, 130 g/t Ag and 1.3 g/t Au (Schultze, 1996). This deposit lies within a thick complex of felsic meta-tuffs and sills or flows of unit 3 and is overlain by mafic meta-volcanic rocks, carbonaceous phyllite and quartzo-feldspathic conglomerate of unit 4 (Fig. 2; Murphy, this volume; Schultz, 1996).

The Wolverine deposit (Tucker et al., 1997; Yukon Minfile 105G 072) is hosted by Devono-Mississippian carbonaceous meta-sedimentary and meta-volcanic rocks whose correlation with the stratigraphy of Murphy (this volume) is unknown. Nevertheless it lithologically resembles the strata surrounding Kudz Ze Kayah and the following correlations are suggested (Fig. 2). Massive sulphide mineralization at Wolverine is hosted by argillite or aphyric meta-rhyolite (? unit 3). The immediate footwall consists of graphitic phyllite (? unit 3cp) and porphyritic felsic meta-volcanic rocks (? unit 3f). Interlayered carbonaceous phyllite, felsic meta-volcanic, fragmental and tuffaceous units, and magnetite ± barite-iron formation form the hanging wall (Tucker et al., 1997).

Topographically overlying the Wolverine stratigraphy is a thick sequence of pillowed mafic volcanic rocks of the Campbell Range Belt. If this contact is stratigraphic, and not a thrust fault as previously mapped (Tempelman-Kluit, 1977; Mortensen and Jilson, 1985; Plint and Gordon, 1996), the pillowed volcanics may be correlative with unit 4 of Murphy (this volume) in the Yukon-Tanana Terrane.

The published geological inventory at Wolverine is 5 311 000 tonnes grading 1.81 g/t Au, 359.1 g/t Ag, 1.41% Cu, 1.53% Pb and 12.96% Zn (Tucker et al., 1997). In August 1997, the geological inventory at Wolverine was increased with the discovery of the Sable zone 1600 m southeast of the main Wolverine deposit (Westmin Resources Limited and Atna Resources Ltd., 1997).

3. UPPER HORIZON - MONEY OCCURRENCE AND ICE DEPOSIT

The Money occurrence (Yukon Minfile 105H 078; 61°24'57"N, 129°58'44"W) owned by YGC Resources, is located about 5 km east of the Wolverine deposit in rocks which lie structurally and possibly stratigraphically above those at Wolverine (Figs. 1, 2). Mineralization consists primarily of sulphides of copper with lesser zinc, gold and silver within a sequence of mafic flows and breccia and is associated with maroon and oxidized fine-grained sediments (Figs. 5, 6; Baknes, 1997; this study). Drilling has defined a tabular massive sulphide layer with a down-dip length

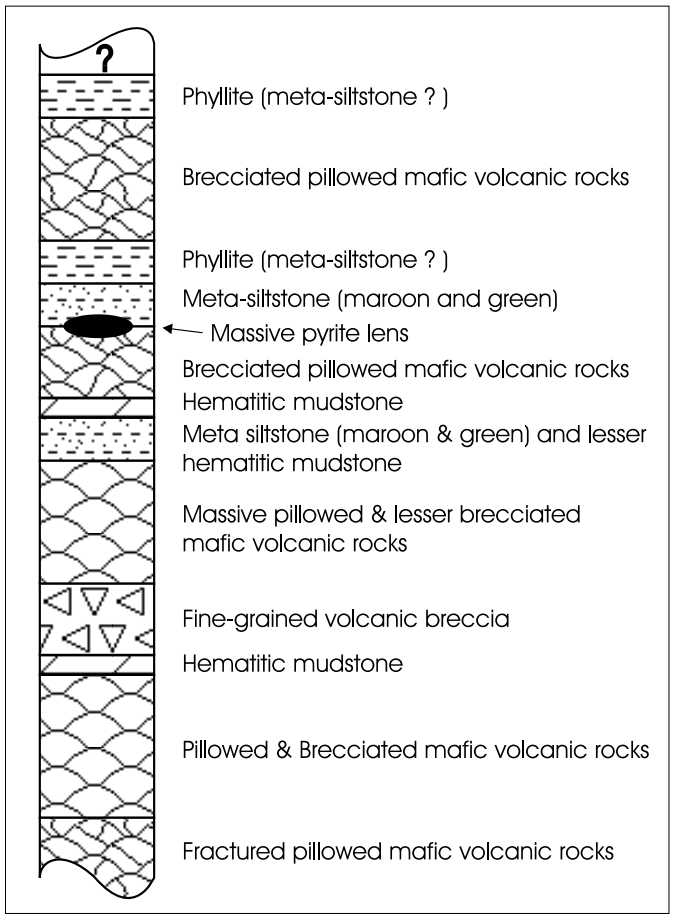

Figure 6. *Schematic stratigraphy, Money claims. Not to scale.*

of at least 130 m, a strike length greater than 53 m and an average thickness of 1.0 m (Baknes, 1997).

The Ice occurrence (61°53'N, 131°25'W) is located about 60 km east of Ross River in an area of subdued topography with limited outcrop (Fig. 1). Copper-gold-cobalt mineralization is hosted by pillowed, massive and brecciated mafic volcanic rocks interlayered with mudstone and chert as shown in Figure 7 (Eaton, 1996; Pigage and Becker, pers. comm., 1997). These rocks resemble, and are on trend with, those which host the Money prospect and likely form a continuation of the Campbell Range Belt (Fig. 2).

The Ice occurrence was first identified by a single 2000 ppm Cu soil geochemical anomaly (Archer, Cathro and Associates (1981) Ltd., internal report); follow-up work led to the discovery of vegetation kill zones with malachite and limonitic boxwork (Eaton, 1996; Pigage, 1996). Subsequent drilling intersected two main sulphide horizons, an upper massive sulphide horizon and a lower stockwork sulphide horizon which contains lenses of semi-massive to massive sulphide (Fig. 8). Both are hosted within the "active" basalt unit, which has been subdivided into four members: a lower massive basalt, a brecciated basalt, a porphyritic basalt and an upper massive basalt (Expatriate

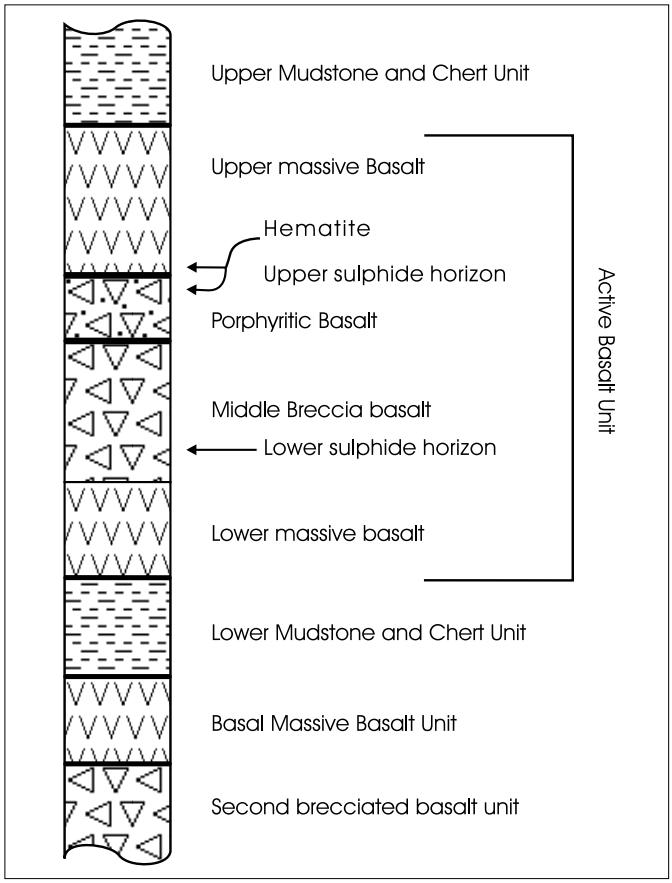

Figure 7. *Simplified stratigraphic section for the Ice deposit. Not to scale. Modified from Pigage (1997).*

Figure 8. *Bornite and massive sulphide mineralization from the Ice deposit.*

Resources Ltd., 1997; Pigage, 1997). The strata between the two sulphide horizons are generally unmineralized, locally however, feeder zones immediately underlie the upper sulphide horizon.

The upper sulphide horizon occurs at the contact between the porphyritic basalt and the overlying massive basalt (Pigage, 1997). Locally the porphyritic basalt is absent and the massive sulphide mineralization lies on the brecciated basalt. The mineralized horizon commonly lies within an envelope of bright red to maroon, siliceous hematitic mudstone to massive chert up to 0.5 m thick (Pigage, 1997, Fig. 7). Mineralization consists primarily of medium-grained pyrite aggregates disseminated in a gangue of milky white quartz. Chalcopyrite and locally bornite form interstitial grains associated with quartz (Pigage, 1997). The pyritic sulphides frequently display breccia textures.

The lower stockwork sulphide horizon occurs about 35 m below the upper massive sulphide horizon. Locally it contains massive sulphide layers up to 10 m thick although generally the mineralization consists of quartz-sulphide stringers and replacement zones within brecciated basalt (Fig. 9; Pigage,

Figure 9. *Stringer sulphide mineralization from the Ice deposit.*

1997). Specular hematite-quartz-pyrite forms the matrix to the brecciated basalt; the matrix and fragments are cut by quartz-pyrite veins and stringers. These early veins and stringers are cut by quartz-pyrite-chalcopyrite veins (Pigage, 1997).

The pillowed mafic volcanic rocks that host Money and Ice have a similar appearance and lithogeochemical signature (Hunt, in prep.) to those which directly overlie the Wolverine deposit. The age of the Campbell Range Belt is poorly constrained by fossil data raising the possibility that it is older than previously reported (Plint and Gordon, 1997) and forms a stratigraphically continuous sequence with the Yukon-Tanana Terrane. Given the position of the Campbell Range Belt above Wolverine, which likely correlates to unit 3, the Campbell Range Belt most likely correlates to unit 4 of the Yukon-Tanana Terrane. Additional bedrock mapping, geochronology and geochemical analysis of the igneous units are needed to strengthen this correlation.

CONCLUSIONS

New bedrock mapping in the Grass Lakes and Fire Lake areas has defined a general stratigraphy in deformed and metamorphosed rocks of the Yukon-Tanana Terrane that can be extended to the remainder of the Finlayson Lake district. Within this stratigraphy recent VMS discoveries occur in three distinct settings within the Yukon-Tanana Terrane and Campbell Range Belt. In the Yukon-Tanana Terrane, the Kudz Ze Kayah and Wolverine deposits are in Early Mississippian meta-tuffs and flows (unit 3); the Fyre Lake deposit is located at the contact between chlorite schist (unit 2) and carbonaceous phyllite (unit 3) that underlies the felsic meta-volcanic rocks. In the adjacent Campbell Range Belt the Ice deposit and Money occurrence are hosted by pillowed mafic flows and breccia.

ACKNOWLEDGMENTS

Thanks and appreciation are extended to all the companies and individuals working in the Finlayson Lake district and Yukon-Tanana Terrane for their cooperation and support during the 1997 field season, especially Columbia Gold Mines Ltd., Expatriate Resources Ltd. and Atna Resources Ltd. Thanks to Lee Pigage, Ian Foreman, John Deighton, Peter Holbek, Peter Delancey and Don Murphy for interesting discussion and sharing of information. Many thanks to Jason Adams for drafting the figures.

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