Yukon Exploration and Geology 1997

PREFACE

This is the 20th volume in a series known to many of its regular readers as "the YEG." Directed toward the mineral exploration industry, ***Yukon Exploration and Geology*** has been the main publication of the Exploration and Geological Services Division of Indian and Northern Affairs Canada (or DIAND). It is a public record of industry activity, and captures some Yukon geoscience research that is not published elsewhere. For a complete list of technical articles from the previous editions, see page 161.

The 1997 volume has four parts. The first is the **Mining and Exploration Overview — 1997**, which is as current as our January 1998 publication deadline would allow. This article expands upon the keynote presentations made previously at the Yukon Geoscience Forum (Whitehorse, in November) and repeated at the Cordilleran Exploration and Geology Round-Up (Vancouver, in January). The second part outlines the activity of the **Yukon Geology Program**. The third part – **Geological Fieldwork** – contains regional reports from new government mapping, geophysical surveys and rock studies. The last part – **Property Descriptions** – is a collection of reports by industry and government geologists on new discoveries and the continued assessment of selected mineral deposits. Two synthesis papers are included: one on the Finlayson Lake district (volcanic-hosted massive sulphide occurrences) and one on the Mount Nansen camp (gold-silver veins).

For the information in this volume we depend upon prospectors, exploration geologists, mining companies and students who are willing to collectively benefit the Yukon's mineral industry. Their assistance is sincerely appreciated.

Charlie Roots

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Photos front cover

Gary Lee in the rehabilitated portal of the Tally-Ho mine, southern Yukon. Photo by Mike Power.

Strained granite of the Simpson Range plutonic suite, with edge of Canadian penny at lower right. Photo by Julie Hunt.

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Modern mining on Mount Stevens, above the cloud-filled Wheaton valley, southern Yukon. Photo by Mike Power.

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The Fyre Lake project 1997: Geology and mineralization of the Kona massive sulphide deposit

Ian Foreman
Columbia Gold Mines Ltd., 1500-675 West Hastings St., Vancouver, B.C. V6B 1N2. e-mail: corpdev@columbiagold.com

ABSTRACT

Columbia Gold Mines' Fyre Lake project is located immediately to the east of Fire Lake, approximately 160 km north of Watson Lake in the Yukon Territory. The 1997 program, consisting of 44 diamond drill holes, doubled the known size of the Kona deposit. Mineralization within the Kona deposit has a defined strike length of 1500 m and a width of 250 m.

The Kona deposit is hosted within a strongly deformed and metamorphosed mafic to intermediate volcanic succession of chlorite-quartz and chlorite-actinolite-quartz schists. This volcanic package is overlain by a metasedimentary succession composed primarily of finely laminated carbonaceous phyllite that locally contains 1 to 20 m thick beds of micaceous volcanic-derived sediments. An intercalated unit of quartz-biotite schist and chlorite-mica-quartz schist marks the base of the metasedimentary succession.

The Kona deposit consists of two parallel northwest trending zones of copper-cobalt-gold volcanogenic massive sulphide mineralization: East Kona and West Kona. East Kona is made up of two distinct horizons: the Upper Horizon and the Lower Horizon. The Upper Horizon occurs immediately below the contact of the metasediments and the metavolcanics while the Lower Horizon occurs 40 to 70 m deeper, within the mafic volcanics. The mineralization of East Kona consists primarily of pyrite with lesser amounts of pyrrhotite and chalcopyrite occurring as massive to banded sulphides with local lenses of massive magnetite. The mineralization across West Kona changes from magnetite, pyrite, and chalcopyrite hosted within a grey siliceous matrix in the east, or down dip, through massive pyrite and lesser chalcopyrite into massive pyrrhotite in the west. The mineralization of West Kona occurs immediately below the metasedimentary and metavolcanic contact; the same stratigraphic position as the Upper Horizon of East Kona. All of the mineralized zones that make up the Kona deposit have an eastern dip and plunge to the southeast.

The Kona deposit, as defined to date, consists of a 15 million tonne mineralized container with the northern, near-surface portion amenable to open pit extraction. The last two holes of the 1997 program intersected mineralization 450 m along strike from previous drilling. The deposit remains open for expansion to the southeast.

RÉSUMÉ

Le projet de Fyre Lake, de la société Columbia Gold Mines, est situé immédiatement à l'est du lac Fire, à environ 160 kilomètres au nord du lac Watson au Yukon. Le programme de 1997, qui comportait 44 trous de sondage, a permis de doubler la taille connue du gisement de Kona. Les minéralisations de ce gisement s'étendent sur une longueur de 1 500 mètres le long de la direction indiquée par forage et sur une largeur de 250 mètres.

Le gisement de Kona est inclus dans une succession métavolcanique mafique à intermédiaire intensément déformée et métamorphisée de schistes à chlorite-quartz et à chlorite-actinote-quartz. Cet ensemble volcanique est recouvert par une succession métasédimentaire composée essentiellement de phyllades carbonés finement laminés renfermant par endroits des couches de 1 à 5 mètres d'épaisseur de sédiments micacés d'origine volcanique. Une unité intercalée de schistes à quartz-biotite et de schistes à chlorite-mica-quartz matérialise la base de la succession métasédimentaire.

Le gisement de Kona comporte essentiellement deux zones parallèles de direction nord-ouest de minéralisations de cuivre-cobalt-or dans des sulfures massifs volcanogènes : East Kona et West Kona. East Kona comprend deux horizons distincts : l'Horizon supérieur et l'Horizon inférieur. L'Horizon supérieur est situé immédiatement sous le contact des métasédiments et des métavolcanites, l'Horizon inférieur étant situé 40 mètres plus bas, au sein des volcanites mafiques. La minéralisation d'East Kona se compose essentiellement de pyrite et, en quantités moindres, de pyrrhotine et de chalcopyrite se présentant sous forme de sulfures massifs à rubanés renfermant localement des lentilles de magnétite massive. La minéralisation de West Kona passe de magnétites, de pyrites et de chalcopyrites incluses dans une matrice siliceuse grise à l'est, vers l'aval-pendage, à des pyrites massives et, en quantités moindres, des chalcopyrites, et enfin, à l'ouest, à des pyrrhotines massives. La minéralisation de West Kona est située immédiatement sous le contact métasédimentaire et métavolcanique, c'est-à-dire dans la même position stratigraphique que l'Horizon supérieur d'East Kona. Toutes les zones minéralisées qui composent le gisement de Kona ont un pendage vers l'est et plongent vers le sud-est.

Le gisement de Kona consiste en une masse minéralisée d'environ 15 millions de tonnes dont la partie nord, en subsurface, se prête à l'extraction à ciel ouvert. Les deux derniers trous de sondage du programme de 1997 ont recoupé des minéralisations à 450 mètres des sondages antérieurs le long de la direction. Le gisement reste propice à l'expansion vers le sud-est.

INTRODUCTION

Columbia Gold Mines' Fyre Lake project is located immediately to the east of Fire Lake, which in turn, is approximately 160 km north of Watson Lake in the Yukon Territory (Fig. 1). The Fyre Lake project is within the Finlayson Lake district of the Yukon-Tanana Terrane. This portion of the Yukon-Tanana Terrane has undergone a resurgence of exploration activity in the past four years. During the 1997 field season, Columbia Gold Mines drilled 44 diamond drill holes totaling 13 598.98 m. In total, Columbia Gold Mines has drilled 115 diamond drill holes for a combined total of 23 266.91 m. All but 8 holes have been drilled within the Kona grid area (Fig. 2).

Columbia Gold Mines currently has an 80% interest in the main claim block surrounding the Kona deposit and wholly owns the rest of the claims that make up the property. In total the property consists of 415 Yukon Quartz claims that cover approximately 85 square km.

REGIONAL GEOLOGY

The Fyre Lake project area is underlain by an Early to Late Paleozoic metamorphosed volcano-sedimentary assemblage of the Yukon-Tanana Terrane. The Yukon-Tanana Terrane is an exotic terrane that was accreted to the North American continent during the Late Triassic and is regionally bounded to the southwest by the Tintina Fault and to the northeast by the Finlayson Lake fault zone (Mortensen and Jilson, 1985). The strongly deformed and metamorphosed lithologic units as described by Tempelman-Kluit (1977) and Mortensen and Jilson (1985) include:

1) a penetratively deformed Layered Metamorphic Sequence;

2) a group of Paleozoic plutonic and metaplutonic rocks;

3) a sheared mafic-ultramafic igneous assemblage; mapped as the Anvil-Campbell Allochthon (Tempelman-Kluit, 1977) and now included in the Late Devonian to Late Pennsylvanian-Early Permian Slide Mountain Terrane (Monger, 1984); and

4) various Cretaceous to Tertiary sub-volcanic and plutonic rocks.

Previous work (Mortensen and Jilson, 1985) had identified the rocks within the area of the Fyre Lake project as belonging to the middle unit of the Layered Metamorphic Sequence (LMS). The LMS is composed of three units with a estimated total thickness of 3 km (Mortensen and Jilson, 1985). The lower unit is dominantly micaceous and feldspathic quartzite, with carbonate beds in the upper portion of the unit. The middle unit

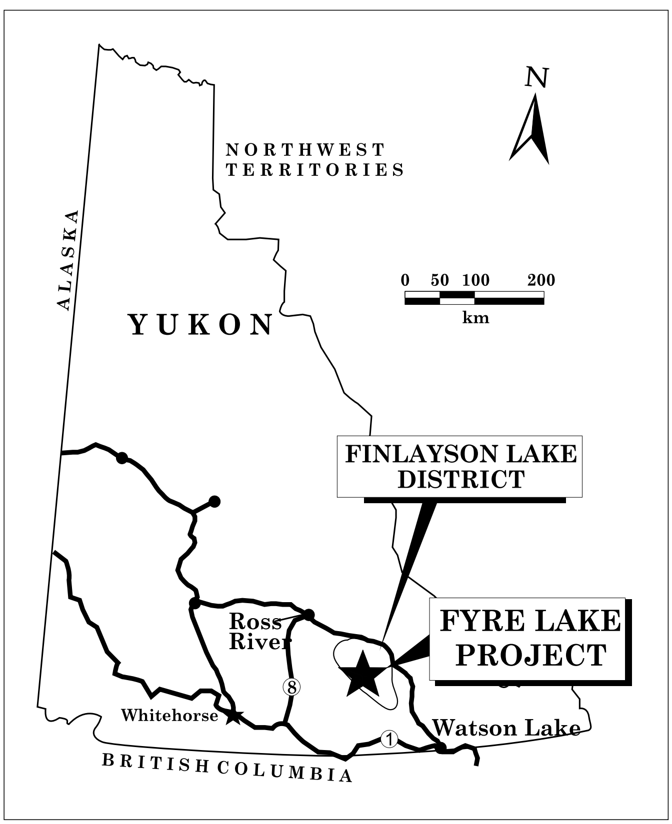

Figure 1. Location of the Fyre Lake Project in the Finlayson Lake District.

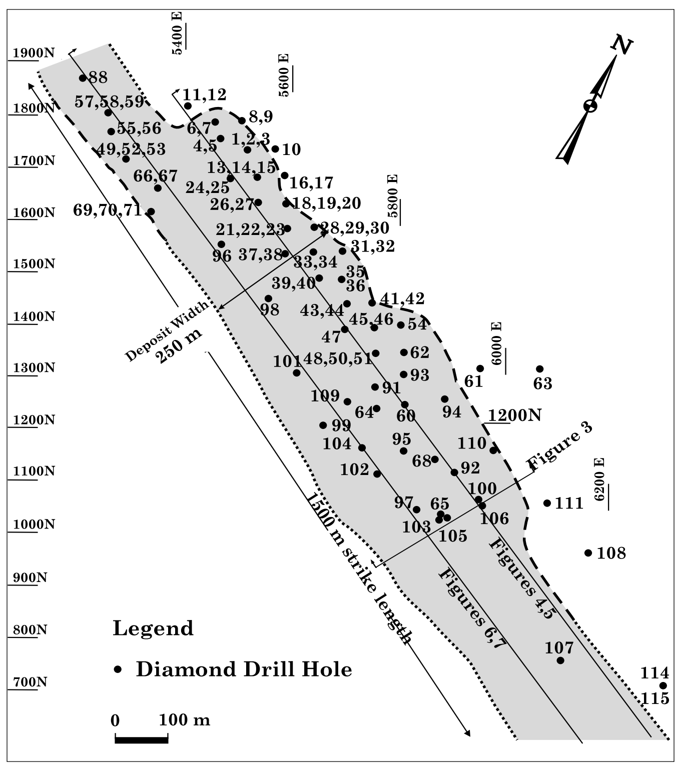

***Figure 2.** Plan of the Kona deposit (shaded) showing the location of drill holes, the positions of the longitudinal projections in (Figs. 4, 5, 6, and 7), and the position of the schematic cross section (Fig. 3).*

consists of interlayered metavolcanic and metasedimentary rocks and is distinguished by the presence of carbonaceous material. The predominant rock type is grey carbonaceous siliceous siltstone. The metavolcanic rocks include mafic beds of green schist composed primarily of chlorite and commonly biotite, epidote and actinolite. The upper unit of the LMS, consisting of light grey limestone interbedded with calcareous quartzite, is of Early Pennsylvanian to Early Permian age. Mortensen and Jilson (1985) state that primary features within the LMS have been obliterated by the intense ductile deformation that occurred during Late Triassic to Early Jurassic time.

Sheared mafic and ultramafic volcanic and plutonic rocks of the Slide Mountain Terrane overlie the Layered Metamorphic Sequence and are preserved as klippen to the north and east of Fire Lake. This allochthonous assemblage has been interpreted as a dismembered ophiolite sequence comprised of massive greenstone with associated sediments, mafic and ultramafic gabbroic rocks and serpentine matrix melange (Stroshein, 1991).

There are three suites of metamorphosed mid-Paleozoic plutonic rocks in the region. The Simpson Range plutonic suite is composed of quartz monzonite to quartz diorite in a large fault-bounded stock. The second and third suites of metamorphosed plutonic rocks include the Hoole augen orthogneiss and Grass Lakes orthogneiss (Murphy, pers. comm., 1997) which outcrop in the Fire Lake area. The youngest rocks in the area are Late Cretaceous (112 ± 1 Ma) biotite-muscovite granitic plutons (Murphy, 1997).

As a result of recent 1:50 000 mapping of the Grass Lakes area, Murphy (1997) has reinterpreted the stratigraphy of the Finlayson Lake area into four distinct units which are summarized below. Murphy (this volume) provides a more complete description of these units.

Unit 1: Layered strongly to moderately metamorphosed sediments,

Unit 2: Metamorphosed intermediate to mafic volcanics with lesser phyllite and quartzite,

Unit 3: Metamorphosed sediments (predominately phyllite) overlain by metamorphosed felsic volcanics,

Unit 4: Layered metamorphosed quartz-rich clastic sediments and lesser mafic and felsic volcanics.

Unit 1 is equivalent to the Lower unit of Mortensen and Jilson's (1985) Layered Metamorphic Sequence; while units 2, 3 and 4 are the equivalent to the Middle unit (Murphy, pers. comm., 1997). Murphy (1997) stated that deposition of unit 1 occurred during the lower to middle Paleozoic and that units 2, 3, and 4 were deposited between latest Devonian and mid-Pennsylvanian time. He proposes that the mafic volcanism and associated mafic and ultramafic intrusions which make up unit 2 occurred in a marine basinal setting with the Kona deposit occurring proximal to synvolcanic, basin-bounding faults. Note that the Kudz ze Kayah and Wolverine deposits occur within the meta-rhyolites that form the upper portion of Unit 3.

PROPERTY GEOLOGY

Volcanogenic massive sulphide mineralization of the Kona deposit is hosted within a strongly deformed succession of chlorite-quartz and chlorite-actinolite-quartz schists. These schists represent a series of mafic, to possibly intermediate, flows, tuffs, and fragmentals. The mafic schist is typically medium green in colour and very fine grained. The modal mineralogy is generally quite simple throughout: chlorite, biotite, and quartz have been identified from hand samples and drill core. Chlorite, which makes up a bulk of the groundmass, is rarely seen in crystals greater than 2 mm. Biotite most commonly occurs as 1 to 5 mm lenses that are concentrated to form 2 to 5 cm wide rough bands. Preliminary petrographic studies (Lietch, 1996) identified tremolite, plagioclase, potassium feldspar, muscovite, carbonate, and apatite crystals up to 1 mm long throughout the groundmass. The same study also noted that some of the biotite is green. One sample studied was composed predominately of fine grained amphibole suggesting that field descriptions locally overestimated the modal percentage of chlorite.

This volcanic package is overlain by a thick metasedimentary succession composed primarily of a finely laminated black to grey carbonaceous phyllite. In hand sample and drill core the fine grained minerals other than biotite and quartz are difficult to identify. The biotite commonly occurs as < 1 to 3 mm brown crystals that are concentrated into 1 to 4 mm wide irregular bands. The quartz occurs throughout as creamy to frosty white 1 mm to 5 cm wide bands. A preliminary petrographic study (Lietch, 1996) states that the rock is composed primarily of mica (muscovite and/or phlogopite), quartz, chlorite, and fine grained opaques (possibly carbon).

The phyllite contains 0.5 to 20 m thick sections of metamorphosed sandstones, volcanically derived sediments, cherts, and rare limestone. Volcanic-derived sediments differ from the mafic schists that host the mineralization because they contain 20 to 40% fine grained mica which gives the foliation surfaces a characteristic silvery to waxy green colour and can be scratched by a finger nail.

An intercalated unit of quartz-biotite +/- chlorite schists and chlorite +/- biotite +/- quartz schists marks the base of the metasedimentary succession. This has been termed the 'transition zone' (Fig. 3) as it is interpreted to represent an inter-fingering of terrigenous sediments and volcanically derived sediments and/or flows. In general, the thickness of the transition zone changes dramatically from east to west. It averages 6 -15 m thick over East Kona whereas it is between 10 and 200 m thick over West Kona (Fig. 3).

The entire hanging wall sedimentary sequence is at least 705 m thick in drill core but the thickness of the mafic volcanic package is unknown. Three drill holes within the Kona cirque were terminated within sediments — below the mafic schists. It is unclear whether these are structurally juxtaposed or represent a sedimentary sequence within the mafic volcanics.

The Finlayson Lake district has regionally undergone greenschist grade metamorphism. Throughout the Fyre Lake project area there is evidence that the rocks have undergone the same, if not a higher degree of metamorphism. In general, white quartz boudins, products of metamorphic segregation, make up 15 to 20% of the rock. Biotite is a common constituent in the volcanics and sediments where it is often concentrated in foliation parallel bands. Garnet occurs locally in the phyllite with quartz and epidote. Typically, the garnets are 1 to 4 millimetres in size, are sub- to anhedral and have a decrepit appearance. The presence of biotite and garnet indicate that P-T conditions reached the upper greenschist grade. Garnet porphyroblasts

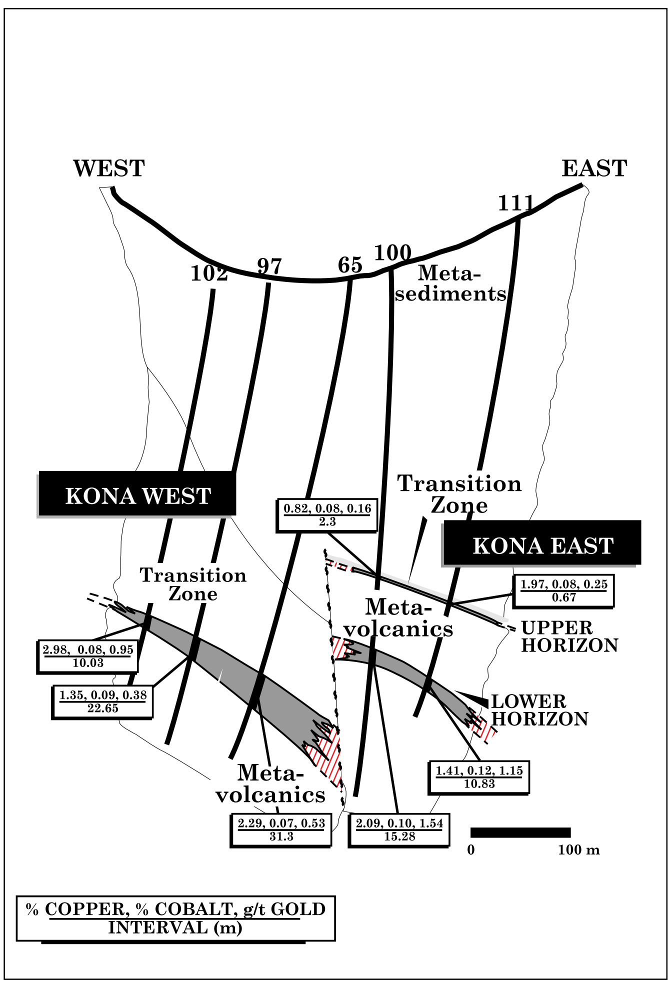

***Figure 3.** Schematic cross section, looking northward, based upon drilling as shown. Shaded areas are volcanogenic massive sulphide layers.*

rimmed by chlorite suggest that later retrograde greenschist metamorphism overprints an earlier higher-grade phase (Sebert, 1997). Mortensen and Jilson (1985) observed that locally, metamorphism reached middle amphibolite facies because sillimanite was identified within the mafic volcanic rocks belonging to the middle unit of the Layered Metamorphic Sequence.

THE KONA DEPOSIT

The mineralization and geological setting of the Kona deposit has many similarities to that of 'Besshi-type' volcanogenic massive sulphide deposits. According to Franklin et al. (1981), the 'Besshi' group of massive sulphide deposits occurs in strata consisting of sub-equal amounts of clastic sedimentary rocks and basalt and their setting is commonly close to a tectonic boundary. The Kona deposit is located at a similar stratigraphic position. The Kona deposit is also similar to many Besshi-type deposits in that the mineralization is predominately pyrite, chalcopyrite and pyrrhotite with lesser sphalerite.

The Kona deposit is divided into two parallel trends of copper-cobalt-gold mineralization: East Kona and West Kona. Both trends have a moderate (20-40°) dip to the east and a shallow (5-15°) plunge to the south. East Kona and West Kona are separated by an inferred steeply dipping fault (Fig. 3). The horizontal separation of East and West Kona is inconsistent and increases towards the northern end of the deposit. At no point does there appear to be any overlap of the two zones. The vertical offset appears consistent along strike and averages approximately 100 m with the west side dropped, suggesting a reverse sense of movement. This measurement is based on the relative elevations of the metasediment/metavolcanic contact.

The geometry and geology of East Kona remains very similar to the interpretation in Blanchflower et al. (1997), whereas West Kona was interpreted during the off-season and expanded during the 1997 drill program.

EAST KONA

East Kona is made up of two distinct horizons: the Upper Horizon and the Lower Horizon (Fig. 4). The Lower Horizon is consistently 40 to 70 m below the Upper Horizon. The Upper Horizon has been drill-tested over a strike length of 630 m (between DDH's 96-21 and 97-100, see Fig. 2) and has an indicated width between 100 and 150 m. The Lower Horizon has been shown to be at least 870 m long (between DDH's 96-6 and 97-100, see Fig. 2) and has an indicated width of between 100 and 150 m. The Upper Horizon has been up-lifted to surface by a cross-cutting fault. Although massive sulphide of the Upper Horizon is not exposed, the underlying banded magnetite forms resistant outcrops. Grey to frosty white siliceous boulders with a sponge-like boxwork texture cover the ground in the immediate area of the magnetite-rich outcrops.

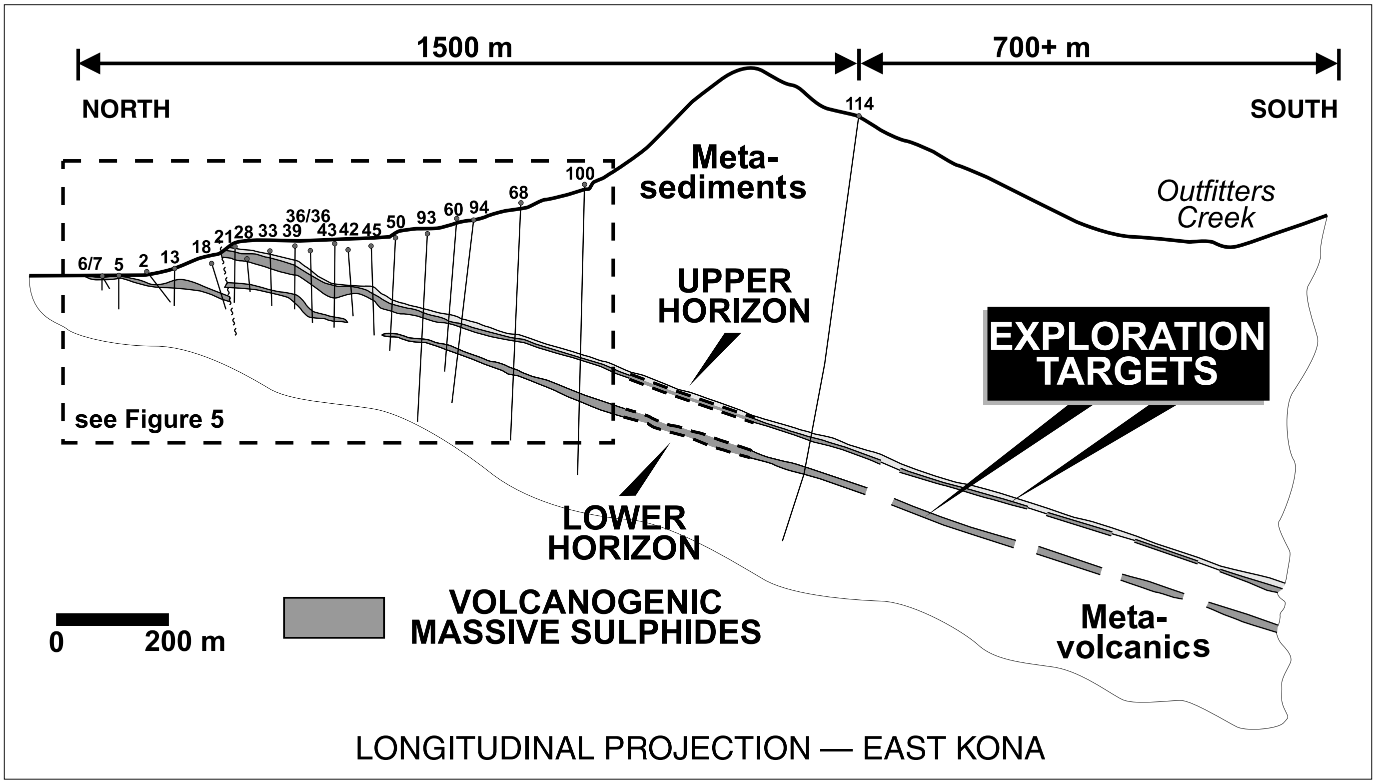

Figure 4. *Longitudinal projection of East Kona outlining the drill-defined mineralization (heavy shading) as well as the exploration potential. The inset area is shown as Figure 5.*

This material has been interpreted to represent the groundmass of the massive sulphides. The Lower Horizon does not outcrop but rather subcrops in the vicinity of the massive sulphide boulders of the original discovery.

The mineralization of the Upper Horizon is the more consistent of the two along most of its length. It has a thicker central portion that thins to the western and eastern margins. The mineralization of the Lower Horizon does not have a thickened central core and is locally open east of its thickest intervals. Through the northwestern and central portions of the deposit, the Upper Horizon is considerably thicker than the Lower Horizon, but it thins towards the southeast. In comparison, the Lower Horizon is more variable with regard to mineralization and thickness. Through its 900 m drill-indicated strike length, the Lower Horizon appears to actually thicken through its central axis (Fig. 5).

UPPER HORIZON

Mineralization belonging to the Upper Horizon has consistent characteristics throughout most of its strike length. The upper portion consists of 1 to 4 m of massive sulphides composed primarily of fine- to medium-grained pyrite with 2 to 7% very fine grained chalcopyrite and minor amounts of pyrrhotite and sphalerite. This, in turn, is underlain by 1 to 25 cm bands of sulphides and quartz within the strongly foliated dark green metavolcanics. This portion of the mineralization varies between 3 to 8 m and contains approximately 30 to 60% sulphides and 10 to 20% frosty white to grey quartz. Chalcopyrite is the dominant sulphide throughout this section and locally makes up 50% of the mineralization. Associated pyrite and pyrrhotite form irregular wisps and blebs about and within the chalcopyrite. Subhedral to euhedral magnetite porphyroblasts (0.5 to 1.0 mm) occur throughout the surrounding metavolcanics. The volume percent of metavolcanics gradually increases down-section as the amount of sulphides decrease. This change is also coincident with the increase in the amount of magnetite. Eventually, sulphide content drops below 10% and magnetite becomes more abundant than the sulphides. Throughout this lower portion of the Upper Horizon, magnetite occurs predominately as aphanitic to <1 mm grains concentrated into 1 to 10 mm wide bands. The magnetite also occurs within 2 to 20 mm wide grey siliceous bands. The sulphides throughout this section of banded magnetite occur predominately as <1 to 4 mm irregular wisps and elongated blebs. The banded magnetite consistently underlies the Upper Horizon and averages 6 to 8 m thick; locally it thickens to 17 m.

The southeastern (or thinned) portion of the Upper Horizon (south of DDH 96-60, Figs. 2, 5) contains little, if any, massive sulphides. The mineralization southeast of this point is primarily banded sulphides within the chlorite-quartz schist. Through these banded intervals, the majority of the mineralization is pyrrhotite, which makes up 40 to 70% of the sulphides. The pyrrhotite occurs as individual 2 to 8 mm long irregular blebs or as 1 to 3 mm thick bands. Chalcopyrite makes up 1 to 10% of the rock and occurs with the pyrrhotite. Throughout the mineralized intervals, magnetite occurs as 1 to 3 mm sub- to euhedral crystals. As with the rest of the Upper Horizon, the southeastern portion is also underlain by banded magnetite. The banded magnetite is much thicker than the sulphide-rich interval and locally thickens to approximately 24 m.

Drill hole 97-114 was collared 450 m to the southeast of 97-100 (Figs. 2, 4) and intersected 2.56 m of banded semimassive sulphides. This mineralization has been interpreted as belonging to the Upper Horizon as it occurs immediately below the intercalated volcanics and sediments of the transition zone. When combined with previous drilling (Fig. 6), the strike length of the Upper Horizon would be 1060 m.

LOWER HORIZON

In longitudinal projection, the mineralization of East Kona (Fig. 5) has an apparent ‘gap’ between the lower intersections in drill holes 96-43 and 96-50. Previous interpretations (Blanchflower et al., 1997) named mineralization north of the gap as ‘Lower Horizon’ and mineralization south of the gap as ‘Middle Horizon.’ Although there are distinguishable differences in the mineralization, the two are now believed to be joined and have been collectively termed the Lower Horizon. The ‘gap’ represents an apparent local eastward shift in the mineralization and the local appearance of a small magnetite-rich horizon.

The northern portion of the Lower Horizon is 4 to 16 m thick. It is comprised predominately of massive sulphides with the central core containing layers of massive magnetite mineralization. The uppermost massive sulphide layer, the thickest of the layers, averages 7 m thick. The sulphides are typically fine- to medium-grained and dominantly pyritic. Chalcopyrite content averages between 3 and 5%.

The massive magnetite layers are typically fine grained and magnetite makes up more than 90% with pyrite and chalcopyrite combining to make up approximately 5%. White carbonate and/or quartz forms the groundmass throughout and also occurs as 2 to 5 mm laminae and irregular clusters. The alternating massive magnetite layers that combine with the massive sulphide layers to form the base of this portion of the horizon tend to be thin and average only 1.0 m thick. The ratio of massive sulphide mineralization to massive magnetite mineralization is approximately three or four to one. The

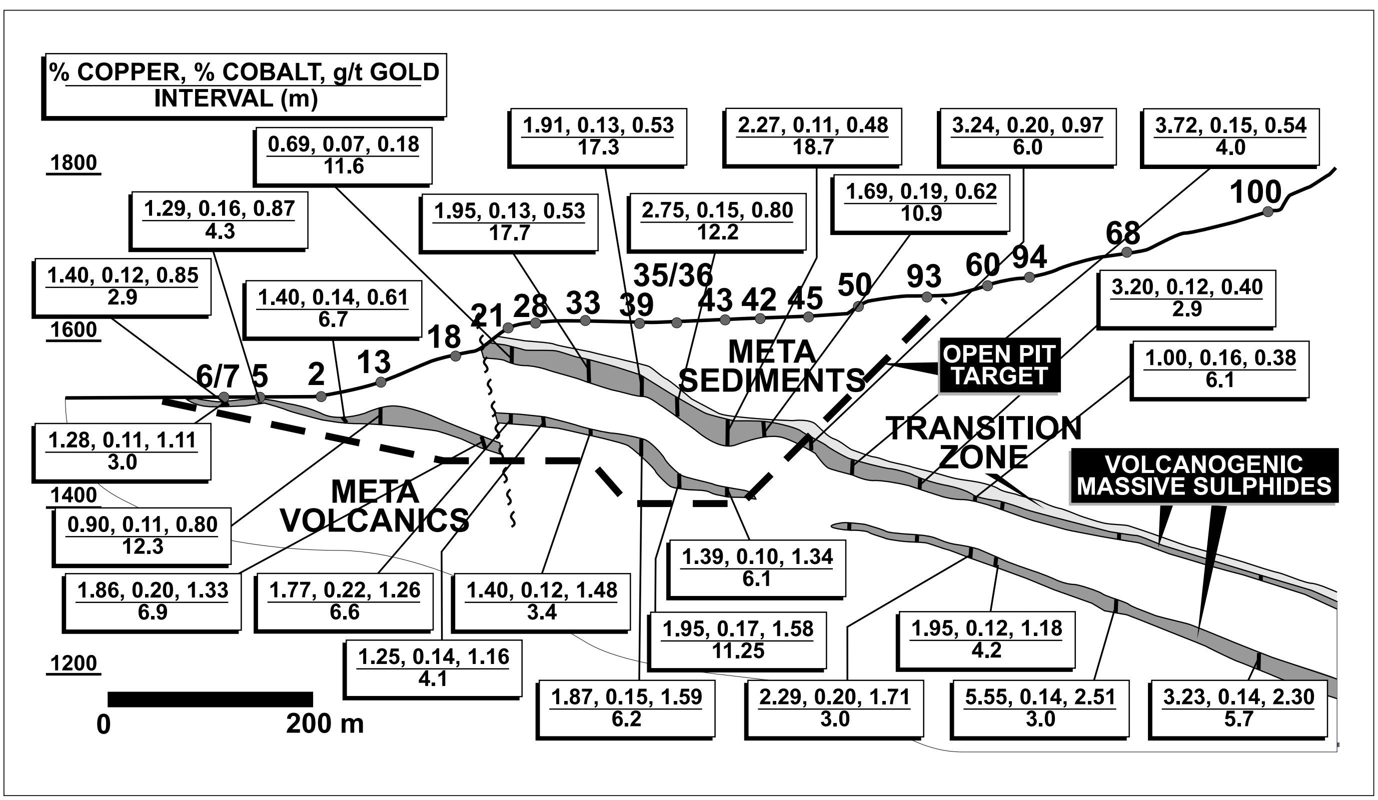

Figure 5. *Longitudinal projection of East Kona showing the geological units, VMS mineralization and drill-hole assays of the Upper and Lower horizons.*

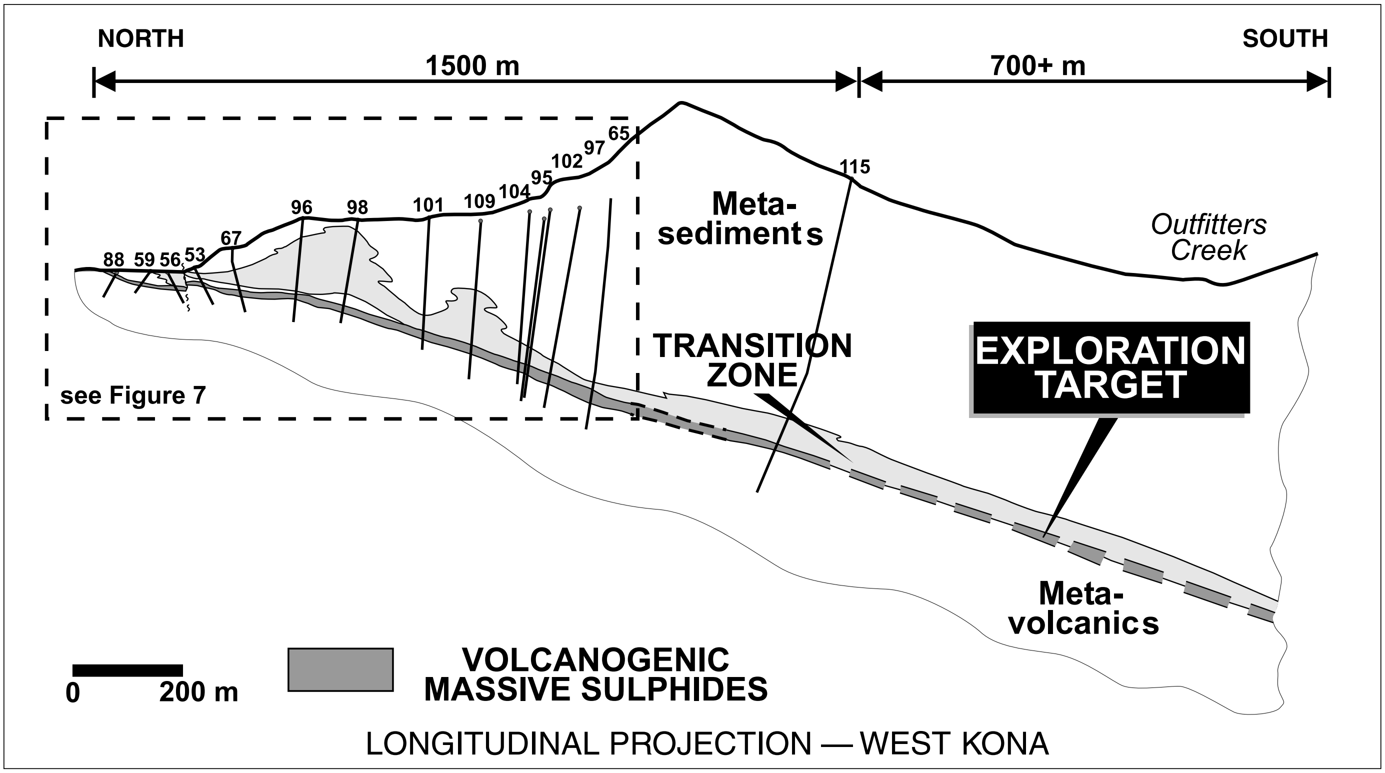

Figure 6. *Longitudinal projection of West Kona outlining the drill-defined mineralization (heavy shading) as well as the exploration potential. The inset area is shown as Figure 7.*

individual layers of massive magnetite do not correlate between drill holes and have been interpreted to be boudinaged lenses.

The styles of mineralization of the southern portion of the Lower Horizon are similar to that to the north of the 'gap' but disseminated to semi-massive banded magnetite overlie the sulphide mineralization. The upper 0.5 to 1.5 m of this portion of the Lower Horizon is typically 80% < 1 to 2 mm subhedral pyrite with 2 to 6% sphalerite as interstitial reddish-purple crystals that are locally concentrated into bands 1 to 2 cm thick. The underlying sulphides comprise layers of fine- to medium-grained, locally recrystallized, pyrite with local 3 to 6 m thick sections in which chalcopyrite and pyrrhotite are concentrated into 2 to 10 cm thick bands. The mineralization occurs over a thickness of 8 m and locally thickens to greater than 11 m. This portion of the Lower Horizon locally contains 0.5 to 3 m thick sections of banded semimassive sulphides. Laterally, the massive sulphides may grade into banded massive to semi-massive sulphides at the eastern margin of the mineralization.

WEST KONA

West Kona has been drill-tested over a strike length of 1420 m (between DDH's 97-88 and 97-115, see Figs. 2, 6) and has an inferred width of 75 to 125 m. A complete section has not been drilled through West Kona, hence information on the lateral characteristics of the mineralization has been drawn from sectional projections (see Fig. 3).

In general, the mineralization within West Kona is distinct from that within East Kona. The primary difference being that a majority of the mineralization of West Kona is hosted within a grey siliceous matrix. Laterally, the mineralization of West Kona changes from siliceous-hosted mineralization in the east to true massive sulphides in the west. The nature of this change is not understood and is assumed to be gradational.

The thickness of the mineralization within West Kona varies considerably across its width (Fig. 3) from 43.9 m in the east to less than 1 m thick at the western margin. Additionally, the thickness of mineralization within West Kona is also quite variable along its strike.

The siliceous-hosted style of mineralization, which makes up > 80% of West Kona, also changes from east to west. The mineralization throughout this portion of West Kona is predominately fine grained magnetite and pyrite. Magnetite occurs as disseminated subhedral to euhedral aphanitic to 1 mm crystals that are locally concentrated into 2 to 15 cm wide bands. Pyrite and chalcopyrite with lesser accessory pyrrhotite together generally make up 15 to 20%. The pyrite typically occurs as < 1 to 2 mm sub to euhedral crystals throughout and when concentrated into bands, locally form 1 to 8 mm long irregular blebs that are aligned with the dominant foliation. The chalcopyrite typically occurs as irregular < 1 mm to > 2 cm elongated blebs, while the pyrrhotite forms 1 to 5 mm long wisps. Locally in the magnetite-rich sections, chalcopyrite is the dominant sulphide in concentrations up to 30%. The percentage of sulphides increases to the west until the sulphide content exceeds that of magnetite. In general, the sulphide-rich portions are a mirror image of the magnetite-rich sections but with the oxide and sulphide portions interchanged. Through the sulphide-rich portions of West Kona, pyrite makes up 75 to 85% of the total volume of sulphides. Chalcopyrite occurs as 1 to 9 mm wide irregular blebs that are locally elongated parallel to the dominant foliation. Through these sections, sphalerite locally occurs as <1 to 5 mm irregular reddish-purple crystals and/or aggregates.

In the western portion of West Kona, the mineralization consists of true massive sulphides. The mineralization is made up of greater than 80% fine- to medium-grained subhedral to euhedral pyrite with 8 to 12% fine grained interstitial chalcopyrite. There is a noticeable lack of pyrrhotite in this portion of West Kona. Throughout the massive sulphides are 1 to 10%, 1 to 6 mm subrounded to rounded clear to grey quartz blebs. Locally, the massive sulphides appear to have a siliceous groundmass as the pyrite and chalcopyrite are surrounded by aphanitic white quartz. This style of mineralization appears to be isolated to the area surrounding drill holes 97-102 and 97-104 (Fig. 2) as massive pyrite and chalcopyrite has not been intersected. Intersections even further to the west consist of massive pyrrhotite. These intersections are typically less than 1 m wide and contain less than 5% pyrite and chalcopyrite that occur as rounded blebs and fracture fillings.

EXPLORATION POTENTIAL

The Kona deposit remains open for expansion, particularly to the southeast. The 2.6 m intersection in drill hole 97-114 (Fig. 4) is very significant in that it confirms that the mineralizing system deposited copper-rich ‘East Kona’-style mineralization 450 m along strike to the southeast beyond previous drilling. Within the Kona cirque, the Lower Horizon occurs in every section in which the Upper Horizon has been intersected. This provides reason to believe that the Lower Horizon also occurs 450 m southeast of current drilling. This projected portion of the Lower Horizon combined with the 16.3 m thick intersection of West Kona in drill hole 97-115 (Fig. 6), indicate that the true size of the Kona deposit has yet to be fully realized. The weak coincident geophysical anomalies that are believed to define the deposit in the area of drill holes 97-114 and 97-115 continue 700 m further to the southeast.

Columbia Gold Mines has outlined a mineralized container of approximately 15 million tonnes for the Kona deposit. This mineralized container is 1500 m long and 250 m wide (Fig. 2) and encompasses all of the massive and semimassive

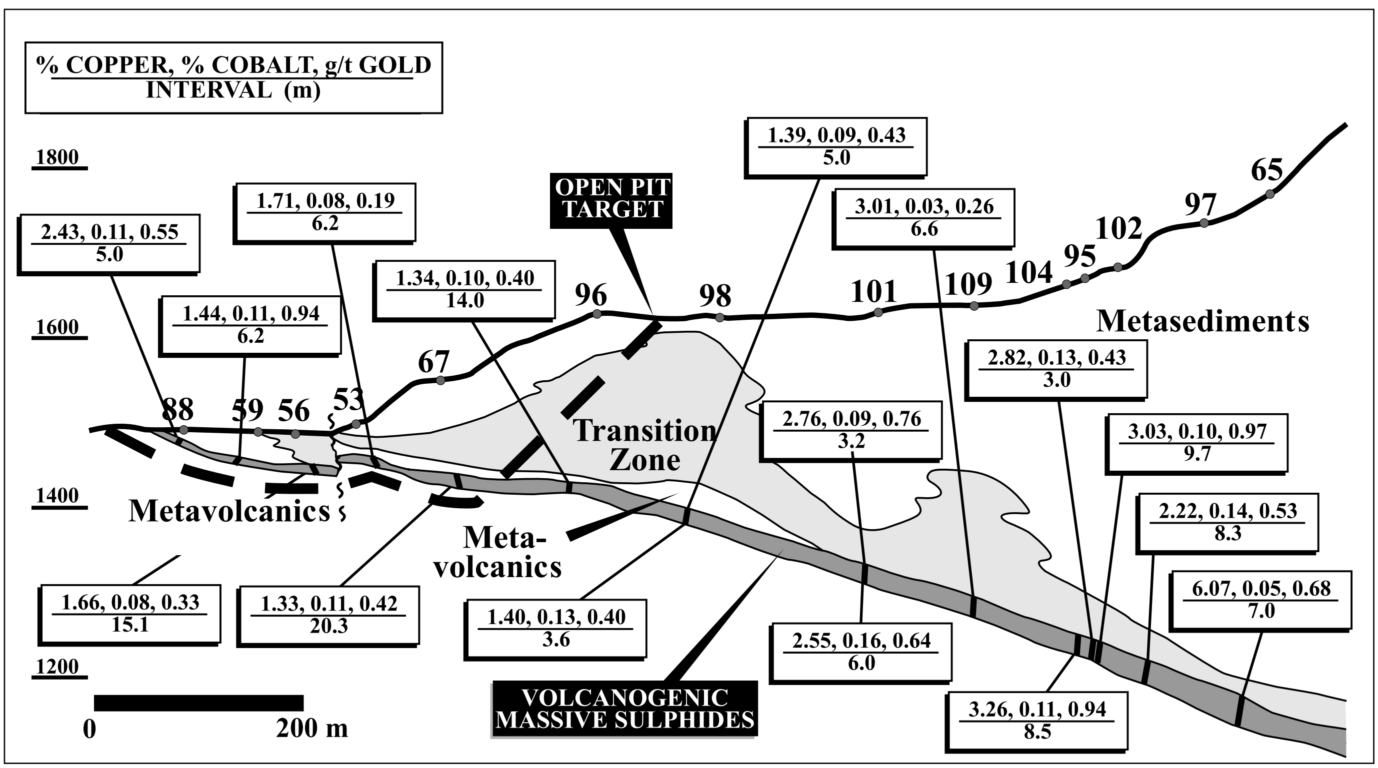

Figure 7. *Longitudinal projection of West Kona showing the spatial association of the geological units and the mineralization.*

mineralization intersected to date. Within this container, there is a near-surface, open pit target and a deeper underground target. The underground target is made up of 3.0 to 8.3 m thick enriched portions of the mineralization. Consistently throughout West Kona (Fig. 7) there are chalcopyrite-rich sections that generally have associated higher grade cobalt and gold values. These intersections, combined with the high-grade central portions of East Kona, form a target that is potentially mineable by modern underground methods. The northern, near-surface, portion of both East and West Kona (Figs. 4, 5) form the open pit target.

ACKNOWLEDGEMENTS

The author would like to thank all the staff that worked at Fyre Lake this past season. In particular special thanks to John Deighton, Chris Sebert, and Willem Zantvoort for their tireless work which made the six months so productive. Stephen Soubliere spent countless hours flying Trans North's new 206 Long Ranger and proved to be an invaluable member of the team. In his absence, Jim Tarnowski filled the role admirably. The author's understanding of the regional geology of the area has been aided by many conversations with Don Murphy and Julie Hunt. Finally, careful editing by Charlie Roots and Wayne Roberts greatly improved the content and flow of the paper.

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The Wolf Discovery: A Kuroko-style volcanogenic massive sulphide deposit hosted by rift-related, alkaline felsic volcanic rocks

P.M. Holbek and R.G. Wilson

Atna Resources Ltd., 1550 - 409 Granville Street, Vancouver BC, V6C 1T2

Ph (604) 684-2285, Fax (604) 684-8887; e-mail: atna@atna.com; www.atna.com

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Abstract

The Wolf property is situated approximately 90 km south of Ross River, Yukon, within the St. Cyr Range of the Pelly Mountains. The Pelly Mountains are bounded to the northeast by the Tintina Fault, the northern extension of the Rocky Mountain Trench.

Mineralization consists of a tabular body of massive sulphide, commonly with subordinate amounts of ferro-dolomite, and more rarely, barite. Sulphide minerals consist of pyrite, sphalerite and galena. Textures vary from very fine-grained massive pyrite with bands of amber sphalerite and steely-gray galena (zebra ore), to medium-grained botryoidal sphalerite and galena within a gangue of buff-coloured Fe-Mg carbonate. Chalcopyrite is conspicuous by its absence. The deposit has been intersected by nine drill holes over a strike length of 500 metres and a down-dip length of 250 metres. Thickness of the sulphide deposit varies from 2, to more than 25 metres. The deposit and host stratigraphy strike northwesterly and dip at 45 degrees to the southwest.

The deposit is hosted by a sequence of high-K trachyte flows, lapilli and crystal tuffs with minor epivolcaniclastic rocks. Sulphide mineralization and/or massive barite occurs in at least three separate stratigraphic levels within a 300- to 1000-metre-thick pile of felsic volcanic rocks.

Résumé

Le projet de Wolf est situé à environ 90 km au sud de Ross River, dans le chaînon Saint-Cyr des monts Pelly, au Yukon. Les monts Pelly sont limités au nord-est par la faille de Tintina, extension nord du sillon des Rocheuses.

La minéralisation consiste en un corps tabulaire de sulfures massifs renfermant fréquemment des quantités mineures de ferro-dolomite et, plus rarement, de barytine. Les minéraux sulfurés sont la pyrite, la sphalérite et la galène. La texture varie de celle d'une pyrite massive à grain très fin renfermant des bandes de sphalérite ambrée et de galène gris acier (minerai zébré) à celle d'une sphalérite botryoïde et d'une galène à grain moyen au sein d'une gangue de carbonate à Fe-Mg couleur chamois. La chalcopyrite brille par son absence. Le gisement a été sondé au moyen de neuf trous de forage sur une longueur de 500 m parallèlement à la direction et de 250 m en aval-pendage. L'épaisseur de ce gisement de sulfures varie de 2 à plus de 25 mètres. Le gisement et les roches encaissantes sont de direction nord-ouest et plongent à 45 degrés vers le sud-ouest.

Le gisement est inclus dans une séquence de coulées trachytiques très potassiques, de lapilli et de tufs cristallins, outre des roches épivolcanoclastiques peu abondantes. Des minéralisations sulfurées et/ou de la barytine massive sont présentes dans au moins trois niveaux stratigraphiques distincts, au sein d'un empilement de 300 à 1000 mètres d'épaisseur de roches volcaniques felsiques.

INTRODUCTION

The Wolf property is located approximately 90 km southeast of Ross River, Yukon, within the Watson Lake Mining District. The property includes the summit of Mt. Vermilion and lies within NTS map sheets 105G/ 5 & 6. Geodetic coordinates for the centre of the property are latitude 62° 20'N and longitude 131° 20'W. Access is by helicopter from Ross River or from the Hoole airstrip located on the Hoole River, 22 kilometres north of the property (Fig. 1).

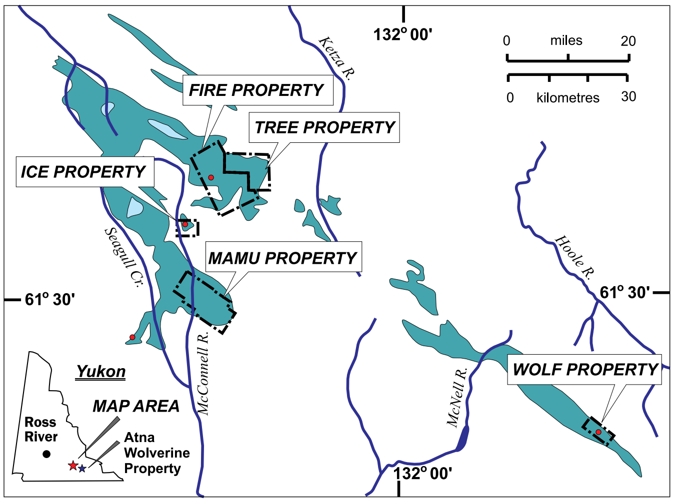


Figure 1. *Location of the Wolf (lower right) and other VMS occurrences in the Pelly Mountains of southeast Yukon. The shaded area is Devono-Mississippian volcanic and sedimentary rocks.*

The Wolf property consists of 18 contiguous mineral claims covering an area of 378 hectares (Fig. 2). Claims are owned by YGC Resources Ltd. and are under option to Atna Resources Ltd. The claims have been explored by Atna since 1995. The option agreement allows for Atna to earn a 65% interest in the claims for expenditures of $1.5 million over a five-year period.

The property is located within the moderately rugged St. Cyr Range of the Pelly Mountains, within the Yukon Plateau physiographic region of the northern Cordillera. The northeastern boundary of the Pelly Mountains is formed by the Tintina Trench, located just north of the property area. Elevations on the property range from 1400 to 1970 metres above sea level.

The Yukon Plateau was covered by McConnell glaciation from approximately 27 000 to 10 000 years before present time. This glaciation has produced rounded mountain peaks and broad valleys. Valley bottoms are typically underlain by glaciofluvial sediments, which are vegetated by grassy wetlands, “buckbrush” and stands of black spruce. The lower slopes of the valleys are commonly covered with aprons of colluvial sediments. Higher slopes are often talus covered, rising to exposed bedrock on cliff faces.

HISTORY

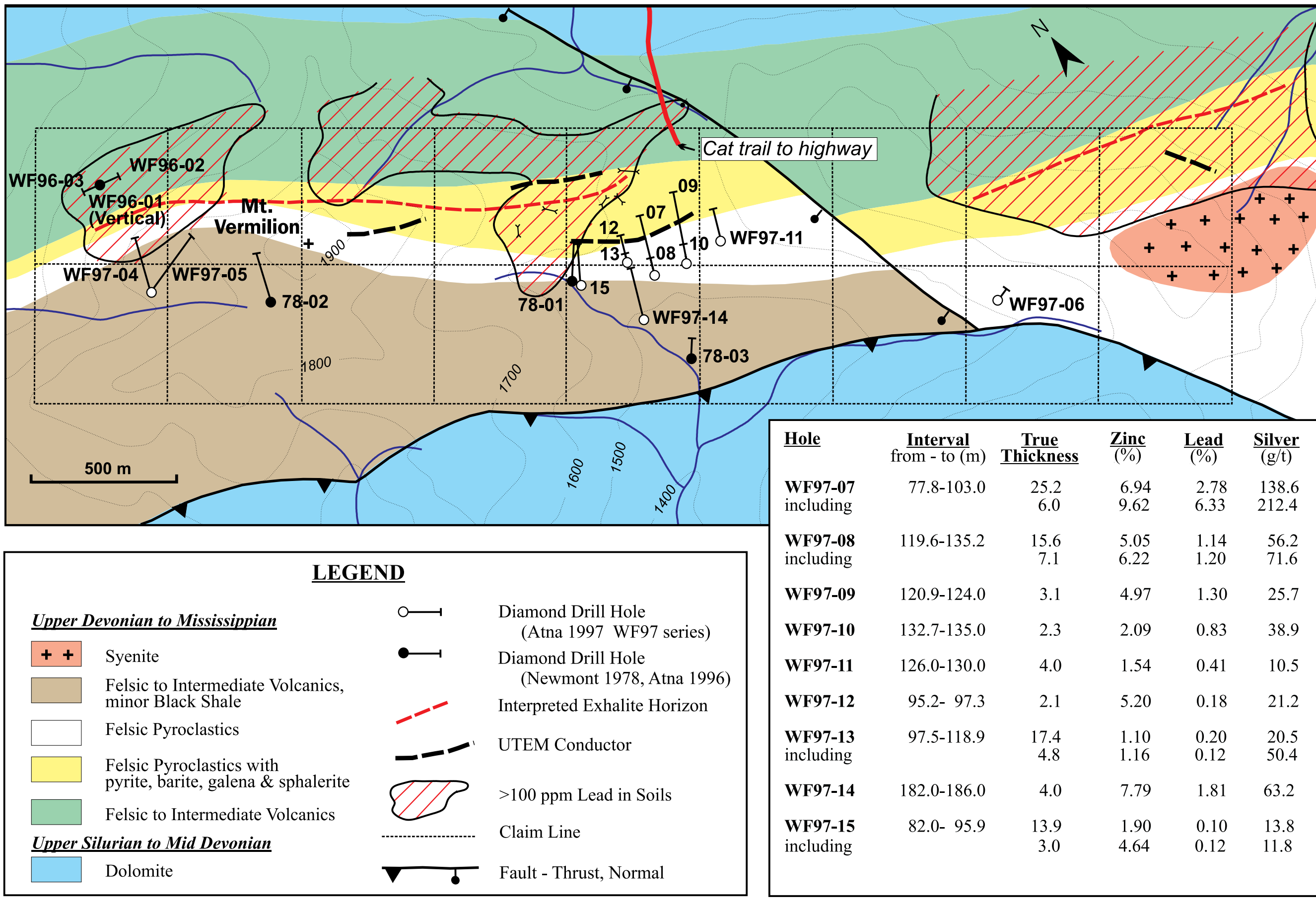
The area covered by the Wolf Claims has been explored intermittently for the last 40 years. The first recorded discovery of mineralization in the area was made by Newmont Mining Corp. in 1955 but claims were not staked until 1966. A tote road was pushed into the property area from the Robert Campbell Highway in 1967. The area was restaked in 1972 by Hesca Resources Ltd. who drilled two “x-ray” holes totalling 61 metres. These holes did not meet with the desired results and the claims were allowed to lapse. Newmont restaked the area in 1976 and conducted an exploration program consisting of a soil geochemical survey, EM and magnetometer geophysical surveys, bulldozer trenching, and three diamond drill holes totalling 528 metres. Newmont’s first drill hole intersected 1.4 metres grading 5.6% zinc and 27.4 g/t silver, however, the claims were again allowed to lapse.

The area was next staked by Amax in 1982 and explored with a program of geological mapping and geochemical sampling (Harris, 1982). YGC Resources restaked the area in 1990 and conducted a geochemical survey (Carne, 1991). The property was optioned to Cominco who carried out more detailed studies than were done previously. This included rock and soil geochemistry, geological mapping, and UTEM geophysical surveys (MacRobbie, 1992; Holroyd, 1993). Cominco concluded that, although the area had all the earmarks of a productive VMS environment, the tonnage potential was limited and the location too remote and returned the property to YGC. Atna Resources Ltd. optioned the property in 1995 and conducted reconnaissance evaluation in 1995 (Kallock, 1995) and a program of soil sampling, hand trenching and diamond drilling in 1996 (Schmidt, 1997). Three holes were drilled in 1996 and intersected significant, but sub-economic zinc, lead and silver mineralization in a horizon below that which was previously explored. Following geological mapping by G. Belik in 1997, a drill program to geochemically evaluate the favourable volcanic stratigraphy was initiated. Significant massive sulphide mineralization was intersected during this program. The discovery hole (WF97-07) intersected a true thickness of 25.2 metres grading 6.94% Zn, 2.78% Pb and 138.6 g/t Ag.

GEOLOGY

REGIONAL SETTING

The region containing the Wolf property area is underlain by Early to Middle Paleozoic volcanic and sedimentary rocks of the Pelly-Cassiar Platform (Gordey, 1977), which is considered to be part of ancestral North America. Recent studies have suggested that the Pelly-Cassiar Platform contains strata which is similar, coeval, and possibly correlative to rocks within the Yukon-Tanana Terrane (Hunt, 1997).



Hole	Interval from - to (m)	True Thickness	Zinc (%)	Lead (%)	Silver (g/t)
WF97-07	77.8-103.0	25.2	6.94	2.78	138.6
including		6.0	9.62	6.33	212.4
WF97-08	119.6-135.2	15.6	5.05	1.14	56.2
including		7.1	6.22	1.20	71.6
WF97-09	120.9-124.0	3.1	4.97	1.30	25.7
WF97-10	132.7-135.0	2.3	2.09	0.83	38.9
WF97-11	126.0-130.0	4.0	1.54	0.41	10.5
WF97-12	95.2- 97.3	2.1	5.20	0.18	21.2
WF97-13	97.5-118.9	17.4	1.10	0.20	20.5
including		4.8	1.16	0.12	50.4
WF97-14	182.0-186.0	4.0	7.79	1.81	63.2
WF97-15	82.0- 95.9	13.9	1.90	0.10	13.8
including		3.0	4.64	0.12	11.8

Figure 2. *Simplified geological map of the Wolf Property, showing drill hole locations. The accompanying table gives significant intersections from the 1997 drilling,*

The Wolf property is underlain by Devonian to Mississippian volcanic rocks, including felsic tuffs, pyroclastic flows, trachyte flows, mudstones, and carbonates which form an arcuate belt nearly 5 km wide and 130 km long (Tempelman-Kluit, 1977). The felsic volcanic rocks are characterized by extremely high potassium geochemistry, bedded barite, and volcanogenic massive sulphide showings. The Wolf property is centered on one of the more prominent showings in the southern part of the belt. The MM property, located 60 km west of the Wolf claims, is underlain by similar strata and contains another prominent showing. The alkalic geochemistry of the volcanic rocks is compatible with formation in a continental rift-type setting (Mortensen, 1979); a setting not normally considered favourable for the formation of volcanogenic massive sulphide deposits (Mortensen and Godwin, 1982).

PROPERTY GEOLOGY

The mineralized volcanic-sedimentary rock sequence on the property occurs between two thrust faults which separates the sequence from underlying and overlying carbonate units (Fig. 3). Immediately to the northeast of the northeastern claim boundary, the favourable volcanic sequence is thrust onto, or possibly, disconformably overlies Upper Silurian to Devonian carbonates. Along the southwestern edge of the property Upper Cambrian to Ordovician dolomite is over-thrust upon the favourable stratigraphy (MacRobbie, 1992). This thrust appears to dip moderately to the southwest. Apparent thickness of the favourable stratigraphy within the claim area is approximately one kilometre.

It is not yet known whether the mineralized volcanic-sedimentary sequence is right-side-up or overturned and whether it contains fold, and/or thrust repetitions. Locally, a penetrative cleavage parallel to bedding is present and isoclinal minor folds are rarely observed, but no larger scale folds have been observed or delineated by mapping. For the sake of description here, the mineralized volcanic rock sequence will be assumed to be an upright monoclinal package.

The volcanic rock sequence is overlain, probably along a thrust fault, by a predominantly coarse clastic unit consisting of carbonate fragment conglomerate, chert pebble conglomerate, angular polymictic conglomerate (sharpstone breccia), dolomite, argillite and interlayered basaltic flows or sills. The clastic units are unmetamorphosed, undeformed and remarkably fresh in appearance. The volcanic sequence consists of lapilli tuffs (pyroclastic flows), crystal and lithic ash tuffs, feldspar phyric trachyte flows, debris flows, greywacke and argillite/mudstone layers. In general, sedimentary units are thicker and more prevalent lower in the sequence. The trachyte flows are the most conspicuous units in the sequence due to 5 to 20% finely disseminated pyrite within the matrix which weathers to produce prominent gossans. The trachyte flows typically contain from 10 to 50% fine- to medium-grained euhedral feldspar phenocyrsts within an aphanitic light to dark gray matrix and are locally amygdaloidal. Trachyte flow units can attain a thickness of 120 metres, although they are commonly from 40 to 60 metres thick and laterally extensive. A single flow has been traced at least 8 kilometres to the northwest of the Wolf property. Locally, the trachyte flows are brecciated, and more rarely form crackle breccias with a fluorite matrix. Lapilli tuffs are volumetrically the most significant lithology within the sequence. The lapilli fragments are commonly from 10 to 20 mm in size, elongate and fairly well sorted. In the upper part of the sequence the lapilli tuffs tend to be well sorted and monomictic with white aphanitic lapilli fragments set in a feldspar-crystal, lithic ash matrix. Lower in the sequence the lapilli tuffs are more polymictic and poorly sorted becoming more like debris flows and volcanic conglomerates. A distinctive unit with lapilli-sized fragments of fine grained massive pyrite and wisps of barite, occurs at approximately the same stratigraphic position as the massive sulphide mineralization but is regionally extensive. Quartz crystals are rare within the volcanic rocks with the exception of a thin quartz crystal tuff unit which occurs in the proximal footwall of the massive sulphide mineralization. A coarse-grained syenite plug intrudes the upper part of the volcanic package on the eastern end of the claims.

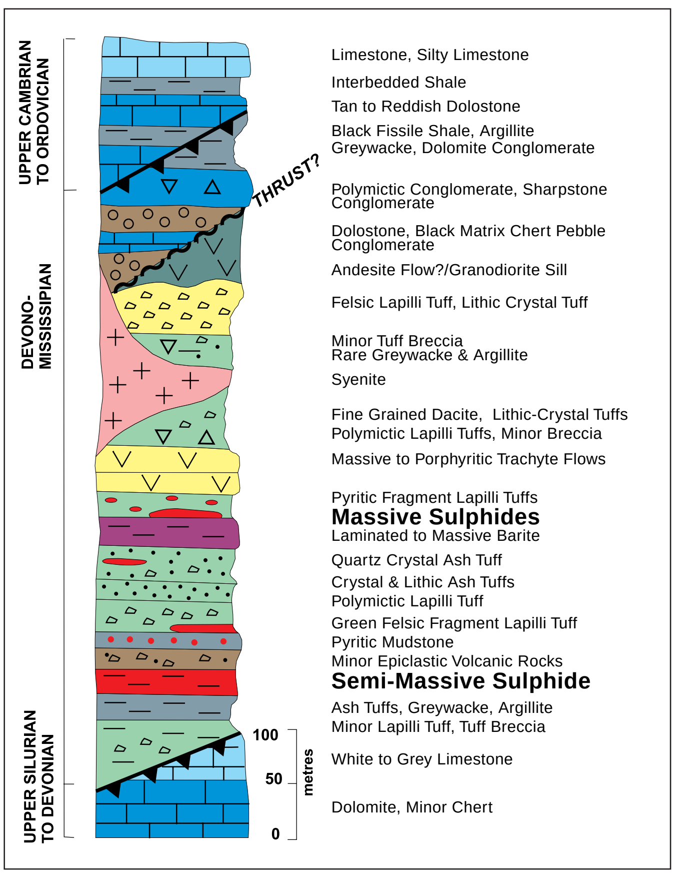


Figure 3. *Wolf property stratigraphic coloum.*

The felsic volcanic rocks and associated sediments are invariably pyritic, typically containing from 2 to 20% pyrite, which has resulted in extensive supergene alteration and formation of gossans. Drainage within the volcanic package is acidic which could have serious implications for exploration geochemistry. Alteration includes extensive pyritization, local but weak quartz-sericite alteration peripheral to the massive sulphide mineralization, and extensive ferro-magnesium carbonatization. A localized, black, chlorite-rich unit was observed during mapping but it is not known at this time if it is associated with sulphide mineralization.

MINERALIZATION

The Wolf deposit was discovered by the fourth drill hole of a four-hole program to determine to stratigraphy and lithogeochemistry of the property. The discovery hole (WF97-07) intersected a true thickness of 25.2 metres grading 6.94% Zn, 2.78% Pb and 138.6 g/t Ag. An additional 8 holes have defined a tabular massive sulphide deposit over a 500 metre strike length and approximately 250 metres in the down-dip direction. Drill hole intersections on the southeastern side of the deposit are narrow (2 metres) with sub-economic grades suggesting a southeastern boundary. The deposit, however, remains open to expansion in all other directions and is not exposed at surface.

The massive sulphides are primarily very fine grained pyrite with bands of amber colored sphalerite and fine grained, steely-grey galena. This form of mineralization has been termed zebra ore. Also present is medium grained botryoidal sphalerite and galena within a gangue of buff coloured Fe-Mg carbonate, and more rarely, barite. Chalcopyrite has only been observed within possible stringer mineralization intersected below the upper massive sulphide horizon in the most northwestern drill hole.

In general, the massive sulphides occur immediately below a feldspar phyric, locally amygdaloidal, trachyte flow, within a pyritic lapilli tuff unit (Fig. 4). The sulphides are underlain by a thin ash tuff containing quartz phenocrysts. Muscovite alteration is weakly developed in both the hangingwall and footwall. Carbonate alteration is distinctly more intense in both the hanging wall and footwall of the sulphide deposit but is also regional in extent. Three sulphide-bearing horizons have been intersected by drilling but potentially ore-grade mineralization

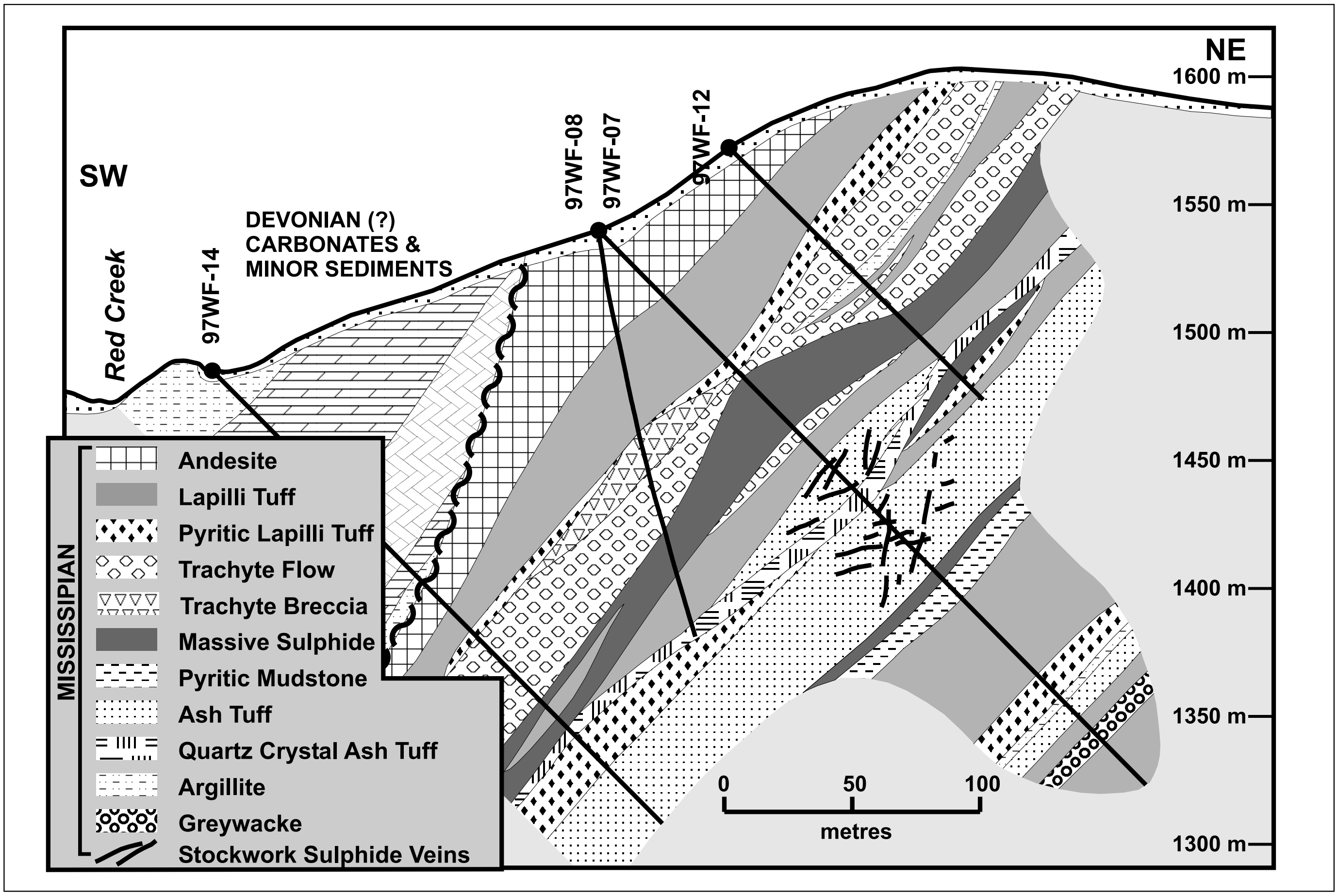


Figure 4. *Geologic cross-section of Wolf property, based upon the four drill holes and surface investigations.*

has only been intersected in the structurally uppermost horizon to date. The barite beds which Newmont trenched in 1978 correlate with the middle sulphide horizon and barite appears to occur laterally peripheral to sulphide mineralization.

WHOLE ROCK GEOCHEMISTRY

Representative core samples were collected from all diamond drill holes and analyzed by whole-rock geochemistry for major and trace elements. Preliminary interpretation of the results indicate that the rocks are of a trachyte composition and comparable to samples collected by Mortensen and Godwin (1982). Mortensen suggested, based upon whole rock geochemistry, that the Pelly Mountains Mississippian volcanic suite is the product of intracratonic rifting. The Wolf property is thus an example of a volcanogenic massive sulphide associated with highly alkaline rocks in an extensional tectonic setting.

CONCLUSIONS

Massive sulphide mineralization discovered on the Wolf property is stratabound and hosted by felsic volcanic rocks, probably of the Earn Group of the Pelly-Cassiar Platform but similar to, and possibly correlative with, strata of the Yukon-Tanana Terrane.

Whole-rock geochemistry indicating regionally extensive, anomalously high sodium content of the Devono-Mississippian volcanic stratigraphy of the Pelly-Cassiar Platform suggests that these rocks formed in an intercontinental rift setting. These types of rocks are relatively rare in the geological record and have not traditionally been considered a favourable location for VMS exploration. Work to date on the Wolf property and elsewhere in the belt clearly demonstrates that these rock are indeed favourable for hosting volcanogenic massive sulphide mineralization.

The Wolf deposit is open to expansion and the property has excellent potential to host an economic volcanogenic massive sulphide deposit.

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Geology and mineralization on the Dromedary property, central Yukon

Brian P. Butterworth[1] and Murray Jones[2]
[1]Blackstone Resources Inc., 501-675 West Hastings St., Vancouver, B.C. V6B 1N2
[2] Equity Engineering Ltd., 207-675 West Hastings St., B.C. V6B 1N2
http://www/canvest.com/blackstone/

Butterworth, B.P. and Jones, M. 1998. Geology and mineralization on the Dromedary property, central Yukon. *In:* Yukon Exploration and Geology 1997, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p.121-124.

ABSTRACT

The Dromedary property consists of 344 claims on Dromedary Mountain, Kalzas Mountain, and the intervening Macmillan River valley, all immediately northeast of Tintina Trench and 240 km northeast of Whitehorse. The property lies within Selwyn Basin geological terrane, and the following rock units are present: Proterozoic-Cambrian Hyland Group, Kechika phyllite and limestone, minor Road River shale and siltstone, Earn Group conglomerate, limestone, black silty shale and baritic chert, and overlying Permian shelf sediments. South Fork subvolcanic intrusions and Cretaceous granitic plugs have induced local biotite- and calc-silicate hornfels and skarn.

The area was staked by Anaconda in 1980 and four areas of interest identified: Dromedary Creek, Dromedary Mountain, François and Kal-Cave. Blackstone Resources Inc. optioned the property in 1996 and has drilled the Dromedary Creek and François areas, encountering massive sulphide mineralization in all five holes. Economic grade Pb-Zn and massive pyrrhotite with significant gold occur on the François grid.

In 1997 the magnetic signature of the pyrrhotite on the François grid was traced 5 km, and soil anomalies were detected further to the west. In the Kal-Cave area a 7.5 km long lead-zinc soil anomaly was refined and numerous new occurrences of iron-sulphide mineralization, carbonate porphyroblasts, manganese and iron oxide were detected. Best samples from this area contain 5.53% Pb and 5.83% Zn.

RÉSUMÉ

Le terrain de Dromedary se divise en 344 claims sur Dromedary Mountain et Kalzas Mountain et dans la vallée mitoyenne de Macmillan River, immédiatement au nord-est du sillon de Tintina et à 240 km au nord-est de Whitehorse. Le terrain repose sur le terrane géologique du bassin de Selwyn. On y trouve les unités rocheuses suivantes : Groupe protérozoïque-cambrien de Hyland; phyllades et calcaires de Kechika; shales et siltstones de Road River peu abondants; conglomérats, calcaires, shales silteux noirs et cherts baryteux du Groupe d'Earn; et sédiments épicontinentaux permiens sus-jacents. Les intrusions subvolcaniques de South Fork et des culots granitiques crétacés ont engendré la formation localisée de cornéennes et de skarns à biotite et calco-silicatées.

La région a été jalonnée en 1980 par la société Anaconda. Quatre régions d'intérêt ont été identifiées : Dromedary Creek, Dromedary Mountain, François et Kal-Cave. La société Blackstone Resources a obtenu une option pour le terrain en 1996 et réalisé des sondages dans les régions de Dromedary et François; les cinq trous de sondage ont traversé des minéralisations sulfurées massives. La région quadrillée de François contient du Pb-Zn à teneur économique et de la pyrrhotine massive renfermant de l'or en quantités importantes.

En 1997, on a retracé dans la région de François, sur une longueur de 5 km, la signature magnétique de la pyrrhotine; des anomalies pédologiques ont été détectées plus loin vers l'ouest. Dans la région de Kal-Cave l'étude d'une anomalie pédologique de plomb-zinc de 7,5 km de longueur a été affinée et de nombreuses occurrences nouvelles de minéralisations de sulfures ferrifères, de porphyroblastes carbonatés et d'oxydes de manganèse et de fer ont été détectées. Les échantillons les plus prometteurs de la région contiennent 5,53% de Pb et 5,83% de Zn.

INTRODUCTION

The Dromedary property is a sedimentary exhalative lead-zinc-silver prospect located east of the Tintina Trench in the Selwyn Basin, 240 kilometres north of Whitehorse in the central Yukon (Fig. 1). The property is situated on the slopes of Kalzas and Dromedary Mountains and covers a portion of the low-lying MacMillan River valley between these two mountains. The property consists of 344 claims in the Whitehorse and Mayo Mining Districts. Blackstone Resources Inc. has an option to earn a 100% interest in the property.

HISTORY

The Dromedary property was staked by Anaconda Canada Exploration Ltd. following a regional exploration program in 1980. Anaconda conducted extensive exploration, including EM, magnetometer and gravity surveys in 1981 and 1982. They identified, from east to west, four areas of interest: Dromedary Creek, Dromedary Mountain, François Grid and Kal-Cave area. Drilling was completed on the Dromedary Mountain and Dromedary Creek claims by Anaconda. The next period of exploration, 1988-1990, was conducted by Dromedary Exploration Company Ltd., culminating in a two-hole drilling program.

In 1996, Blackstone Resources Inc. conducted a 939 metre drilling program to test geophysical anomalies at Dromedary Creek (one hole) and François Grid (four holes). This drilling intersected syngenetic massive sulphide mineralization in all holes, with the most significant results from the François Grid area. Here, narrow intervals of economic grade zinc-lead massive sulphide mineralization, as well as massive pyrrhotite mineralization containing significant gold concentrations were intersected. Minor mapping, prospecting and sampling was done in the Kal-Cave area where a number of showings were known to occur along a 7.5 kilometre long, lead-zinc-silver soil geochemical anomaly.

In 1997, Blackstone granted an option to 523148 B.C. Ltd. whereby 523148 B.C. Ltd. could earn up to a 60% interest in the Dromedary property. In July, 1997, 523148 B.C. Ltd. undertook an exploration program consisting of magnetometer and gravity geophysical surveys in the François Grid area and mapping and sampling in the Kal-Cave area.

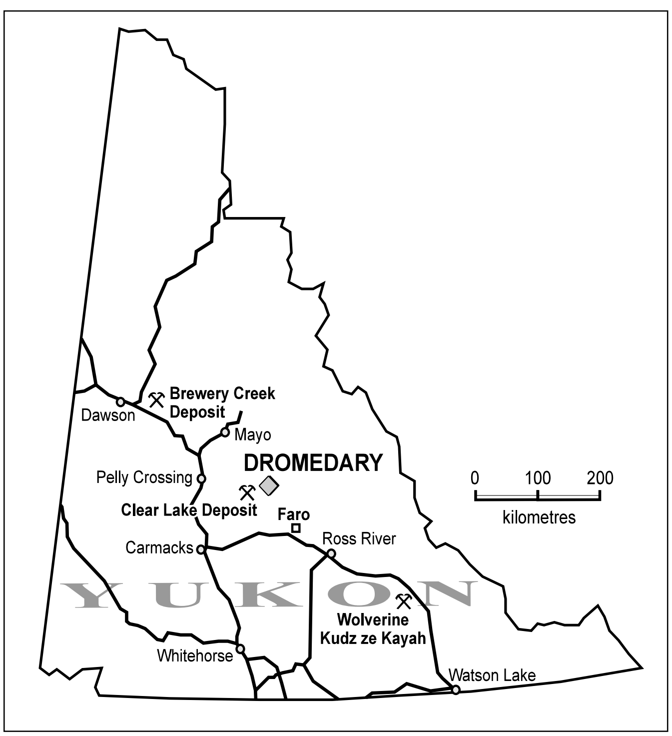


Figure 1. *Dromedary Property location map.*

GEOLOGY

The property is located within the Selwyn Basin geological terrane near the boundary with the Cassiar Platform. The oldest units exposed in the area are Proterozoic-Cambrian Hyland Group, and extensive areas of Cambro-Ordovician Kechika Group phyllite and limestone (Fig. 2). Minor exposures of Ordovician Road River Group shale and siltstone are also present. The most extensive unit in the area of interest is the Mississippian Earn Group. Earn Group lithologies include chert pebble conglomerates of the Crystal Peak Formation, fossiliferous limestone of the Kalzas Formation, black silty shale, argillite and an unnamed middle Mississippian chert-siltstone containing massive barite. A Permian-Triassic sandstone-shale-limestone unit blankets earlier Paleozoic strata. Middle Cretaceous subvolcanic intrusions of the South Fork Formation and quartz monzonite-granodiorite of Cretaceous age (99-120 Ma) intrude the above stratigraphy resulting in local biotite and calc-silicate hornfels and skarn.

In the François Grid area, widespread, locally massive, pyrrhotite mineralization is associated with a strong magnetic trend, with numerous associated gravity high anomalies (Fig. 3) which strikes across the François Grid area for over 5 kilometres. This pyrrhotite mineralization is associated with significant lead-zinc mineralization in at least two areas of the grid, including massive galena-sphalerite mineralization intersected in the 1996 drilling (Fig.4). Gold is apparently enriched in the massive pyrrhotite mineralization, as well as lead and zinc. Extensive overburden has prevented more detailed examination of the mineralized trend on the François Grid.

A mineralized horizon of similar extent exists in the Kal-Cave area where several showings have been located along the length of a 7.5 kilometre-long lead-zinc soil anomaly. Here, stringers of galena and sphalerite occur in a bedding parallel zone hosted by siliceous siltstones and quartzites as well as fossiliferous shale. Pyrrhotite is not as common in this zone although

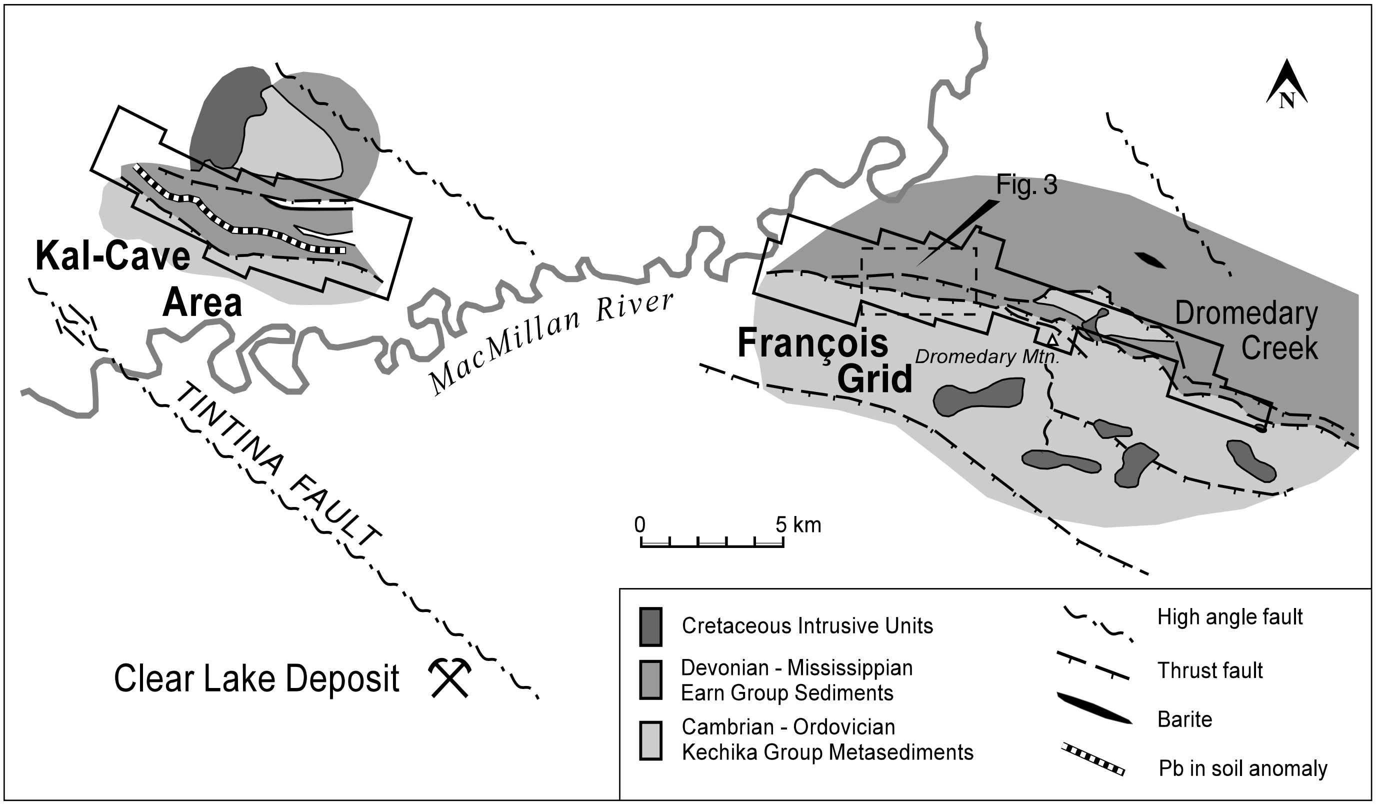


Figure 2. Geological outline map of the Dromedary area.

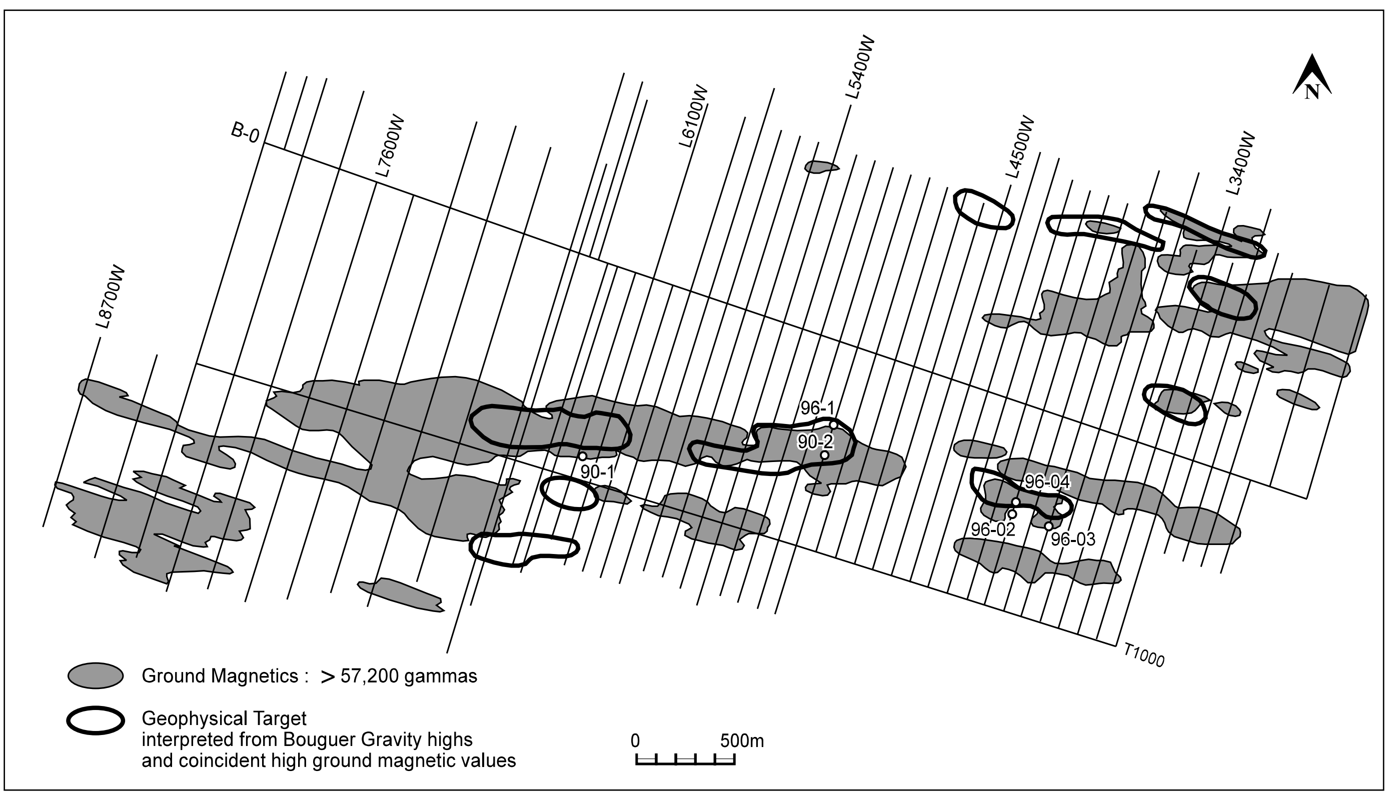


Figure 3. Geophysical compilation of the François Grid.

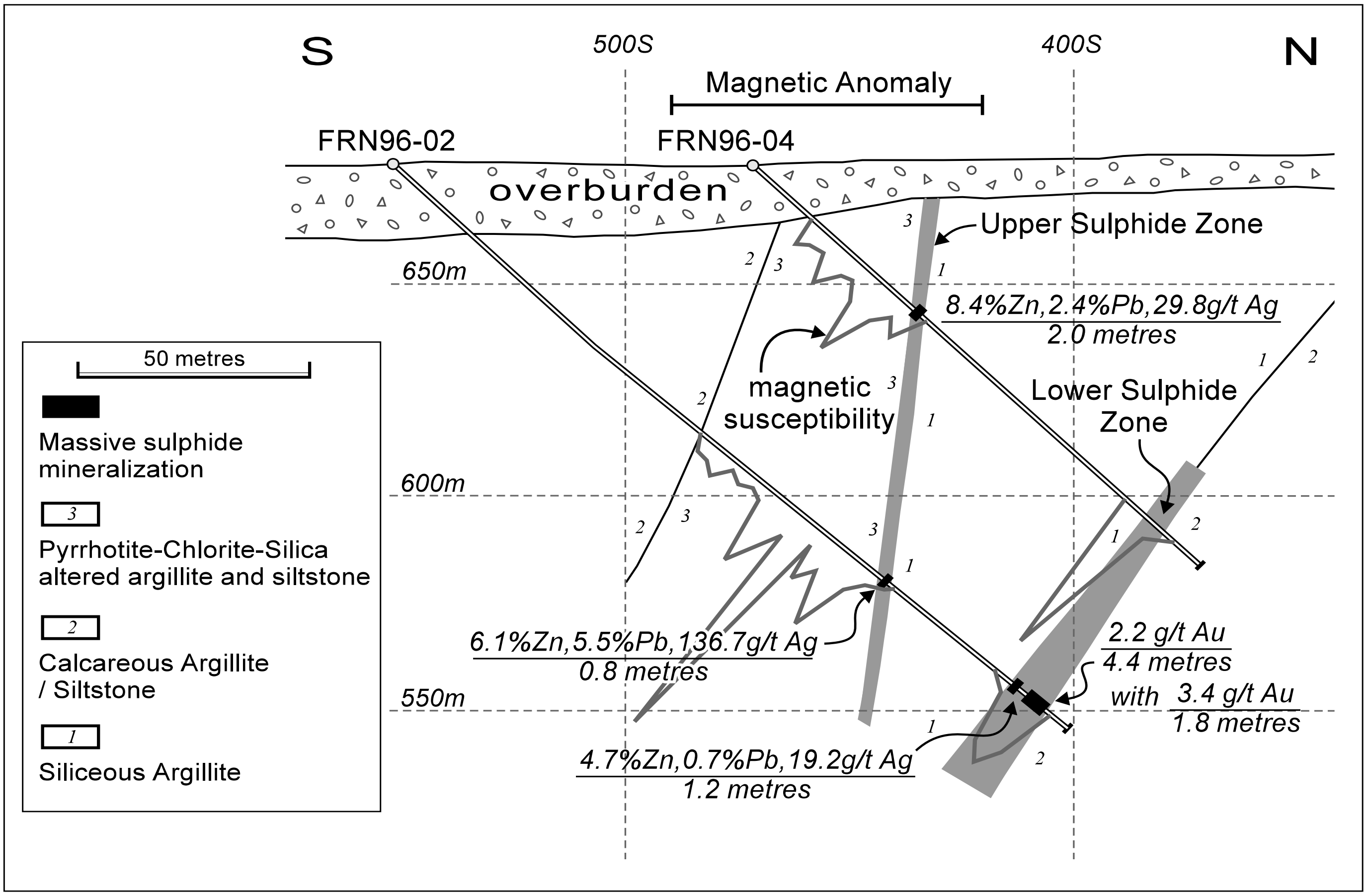


Figure 4. *Cross-section 40+00W on the François Grid.*

abundant ferricrete development suggests that iron sulphides are common. The zone ranges from several metres wide in eastern exposures to a discontinuous section of anomalous rocks almost 100 metres wide at the Cave showing in the west part of the property.

CURRENT WORK AND RESULTS

Exploration activity on the Dromedary Property in 1997 consisted of 33 line-kilometres of gravity surveying, 71 line-kilometres of magnetometer surveys in the François Grid area and mapping and sampling along a 7.5 kilometre-long, lead-zinc soil anomaly in the Kal-Cave area. The geophysical surveys in the François Grid have provided important refinements of the geological trends related to the mineralization. A strong magnetic signature associated with massive pyrrhotite mineralization has been traced over 5 kilometres and numerous coincident gravity and magnetic anomalies detected along this trend are attractive exploration targets. As well, mapping, sampling and prospecting in the Kal-Cave area led to the discovery of several new showings that warrant further investigation.

A comprehensive drilling program to test several of the geophysical anomalies in the François Grid is proposed for 1998. As well, work in 1998 will focus on specific targets in the Kal-Cave area. The exploration program in this area will consist of detailed mapping and trenching as well as magnetometer and electromagnetic geophysical surveys.

Taiga property: A stratiform Ni-Zn-PGE target in north-central Yukon

Brian P. Butterworth[1] and David Caulfield[2]

[1]Blackstone Resources Inc., 501-675 West Hastings St., Vancouver, B.C. V6B 1N2

[2] Equity Engineering Ltd., 207-675 West Hastings St., B.C. V6B 1N2

http://www/canvest.com/blackstone/

Butterworth, B.P. and Caulfield, D. Taiga Property: A stratiform Ni-Zn-PGE target in north-central Yukon. *In:* Yukon Exploration and Geology 1997, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p.125-127.

ABSTRACT

The Taiga property consists of 1043 claims located 95 km northeast of Dawson and 6 km east of the Dempster Highway. Ordovician to Silurian Road River Group dolomite and black calcareous shales overlain by Devono-Mississippian Earn group siliceous shales, chert and conglomerate underlie the property, and comprise the Taiga Basin, an off-shelf outlier on the Mackenzie Platform.

The area was explored by UMEX in 1976 and 1977 with a large silt and soil sampling program to evaluate shale-hosted lead-zinc-barite potential. In 1994 Blackstone Resources Inc. acquired the database, and discovered a thin pyrite-vaesite horizon which assayed 2.06% Ni with elevated Mo, Au and PGE. Geological mapping in 1996 resolved thrust faults and distinguished three members in the Lower Earn Group. The lowest member is a rhythmic, carbonate-rich section of argillite, shale, siltstone, limestone, with a distinctive siliceous shale containing limestone balls at the top. The middle member, of lower Middle Devonian age, contains thick bedded barite, baritic and carbonaceous shale and the nickel-sulphide mineralization. The upper member comprises chert, cherty argillite and minor barite. In addition to the discovery (TB) showing, mineralization is located 450 m south at the DM showing, and 4 km east (MM showing).

In 1997, 12 holes tested the lateral and down-dip extent of nickel-sulphide mineralization at the DM and TB showings, as well as the MM grid area. Significant results from drilling at the MM grid include 25.5 m of 0.51% Ni and 0.41% Zn within which a 5.3 m interval graded 1.42% Ni and 0.70% Zn.

RÉSUMÉ

Le terrain de Taiga comprend 1043 claims situées à 95 km au nord-est de Dawson et à 6 km à l'est de la route de Dempster. Le terrain repose sur des dolomies et des shales charbonneux noirs du Groupe ordovicien à silurien de Road River, lesquels sont sous-jacents à des shales siliceux, des cherts et des conglomérats du Groupe dévono-mississippien d'Earn. Il comprend également le bassin de Taiga, lambeau d'érosion océanique sur la plate-forme de Mackenzie.

La région a été explorée en 1976 et 1977 par la société UMEX, qui a mis en oeuvre un important programme d'échantillonnage de silt et du sol afin d'évaluer le potentiel de barytines plombifères et zincifères incluses dans des shales. En 1994, la société Blackstone Resources Inc. a acquis la base de données et découvert un mince horizon de pyrite-vaesite titrant 2,06% de Ni et présentant des teneurs élevées en Mo, en Au et en éléments du groupe du platine. Des travaux de cartographie géologique réalisés en 1996 ont permis de localiser les failles de chevauchement et de distinguer trois membres dans le Groupe Lower Earn. Le membre inférieur est une section rythmique riche en carbonates composée d'argilite, de shale, de siltstone, de calcaire et d'un shale siliceux distinctif contenant des boules calcaires au sommet. Le membre médian, datant du début du Dévonien moyen, contient des shales à lits épais carbonés, bariteux et à barite ainsi que la minéralisation de sulfures nickelifères. Le membre supérieur se compose de chert, d'argilite cherteuse et de barytine peu abondante. Outre la venue de découverte (TB), des minéralisations sont présentes à 450 m vers le sud, à la venue DM, et à 4 km vers l'est (venue MM).

Le forage en 1997 de 12 trous a permis de déterminer, aux venues DM et TB ainsi que dans les zones quadrillées MM, l'étendue latérale et en aval-pendage des minéralisations de sulfures nickelifères. Parmi les résultats importants fournis par les sondages dans la zone MM figure la présence d'un intervalle de 25,5 m contenant 0,51% de Ni et 0,41% de Zn, au sein duquel un sous-intervalle de 5,3 m titre 1,42% de Ni et 0,70% de Zn.

INTRODUCTION

The Taiga property lies within the Taiga Shale Basin, some 95 kilometres northeast of Dawson City in north-central Yukon. The property is situated within gentle to moderate terrain of the Puddingstone Range, Ogilvie Mountains. The Dempster Highway passes within six kilometres of the western claim boundary (Fig. 1). The Taiga property consists of 1043 claims located in the Dawson and Mayo Mining Districts. Major General Resources Ltd. has a 25% interest in 16 of the claims with the remainder owned 100% by Blackstone Resources Inc. and under option to Glenhaven Resources Inc.

HISTORY

The Taiga property and surrounding area was explored by UMEX in 1976 and 1977 for shale-hosted lead-zinc-barite deposits. As part of their overall program, UMEX completed detailed silt sampling (5836 samples) and soil sampling (4540 samples) on the Taiga property and surrounding area, identifying extensive Zn geochemical anomalies and hydrozincite-coated shales, limestone and chert. In 1994, Blackstone Resources Inc. acquired UMEX's database, sample pulps and an option to purchase a 75% interest in 16 claims dating from 1976. Prospecting led to the discovery of the TB Showing, a thin bed of pyrite-vaesite which assayed 2.06% nickel with elevated molybdenum, gold and platinum group elements (PGE). In 1995, Blackstone re-analysed 2915 soil pulps from the area and staked 178 claims to cover the TB Showing as well as several strong, coincident, stratigraphically-controlled Ni-Mo-Zn-As soil geochemical anomalies.

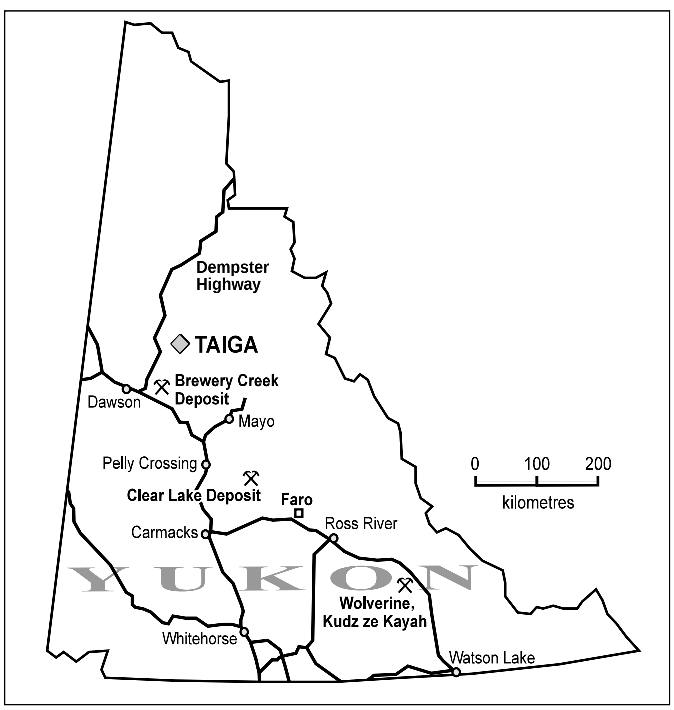


Figure 1. *Taiga property location map.*

In 1996, a program of geological mapping, prospecting and soil sampling was carried out. New occurrences of nickel-sulphide mineralization were found 450 metres south of the TB Showing at the DM Showing and in two thrust panels of the MM grid, located some 4 kilometres east of the TB showing (Fig. 2). Soil sampling in the MM grid area identified a nickel-in-soil geochemical anomaly 2.5 km long and 300 m wide.

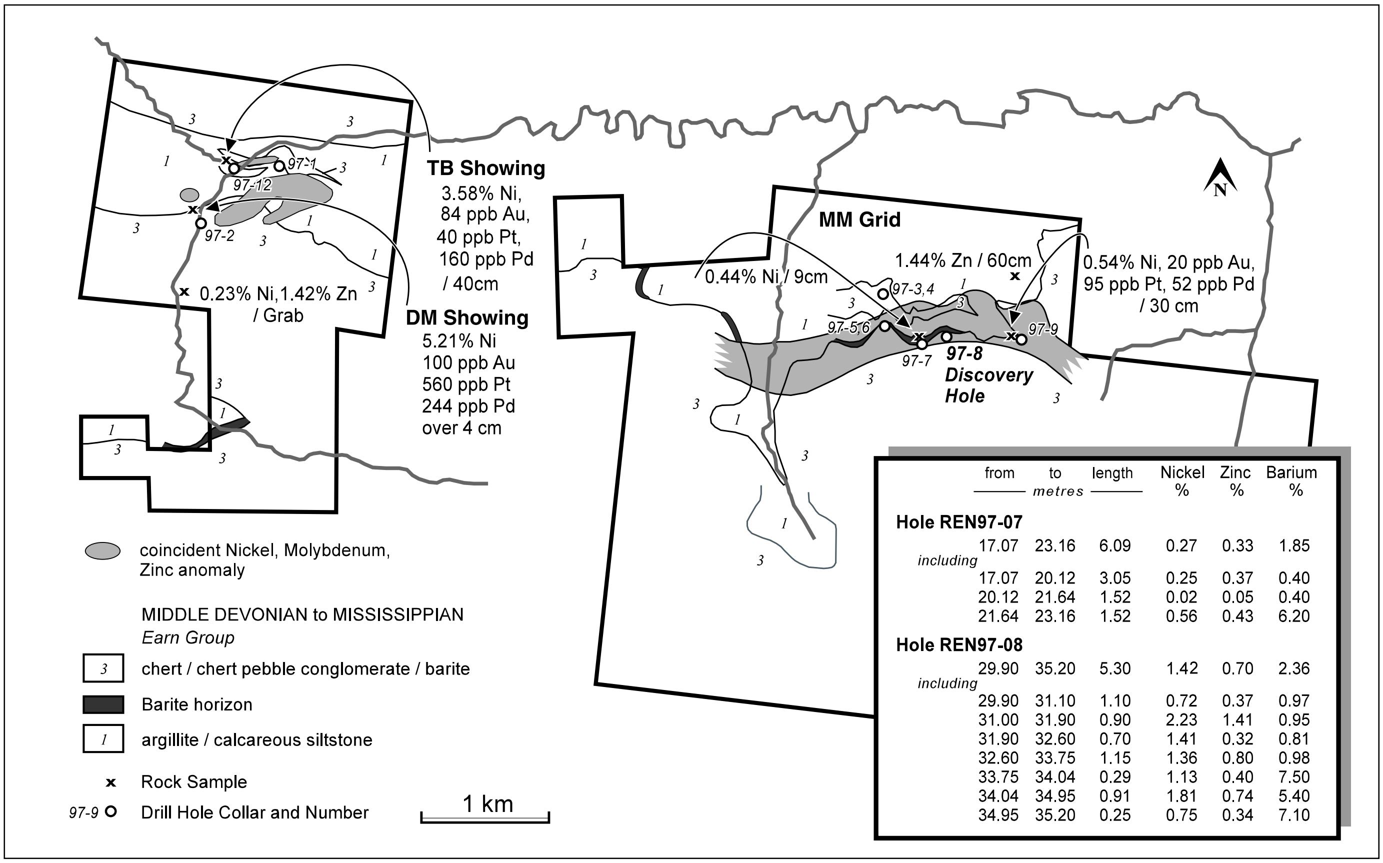
In 1997, Blackstone granted an option to Glenhaven Resources Inc. whereby Glenhaven could earn up to a 60% interest in the Taiga Property. In August, Glenhaven undertook a 12-hole diamond drilling program to test the lateral and down dip extent of nickel-sulphide mineralization exposed at the TB and DM showings as well as to test a laterally extensive nickel-in-soil geochemical anomaly in the MM Grid area. Successful results from the 1997 drilling program led to the staking of an additional 1274 claims within the Taiga Basin before year's end.

GEOLOGY

The Taiga Basin consists of Ordovician to Silurian Road River Group dolomite and black calcareous shales overlain by Devono-Mississippian Earn Group siliceous shales, chert and conglomerate with minor carbonate units near the lower contact. It lies within an off-shelf sequence of the Mackenzie Platform, underlain and overlain by shallow water carbonates and forming a sub-basin north of the main Selwyn basin. To the south, the Taiga Basin is bounded by the northerly-directed Dawson Thrust Fault. Cambrian to Devonian mafic volcanics are spatially related to the Dawson Fault.

The oldest rocks exposed on the property are carbonaceous and calcareous, graptolitic shales of the Road River Group. They are conformably overlain by an interbedded unit of argillite, calcareous shale and siltstone, limestone and chert-siliceous shale of the Lower Earn Group. Limestone and baritic limestone balls up to 1.0 metre in diameter form a distinctive marker that lies at the top of this sequence. A chert and chert pebble conglomerate unit caps the entire succession.

A nickel-bearing horizon lies at the contact between the limestone ball unit and overlying chert. At the TB and DM showings, near the western part of the property, the nickel-bearing horizon is represented by a thin (<40 cm) layer of massive pyrite-vaesite (Fig. 2). The mineralization is exposed along creek banks where samples have returned assay values up to 5.21% nickel and 904 ppb combined gold, platinum and palladium over thicknesses ranging from 6 to 50 centimetres. In contrast, at the MM Grid, lithologies directly overlying the limestone ball unit consist of a calcareous barite horizon and overlying carbonaceous, fossiliferous, baritic and phosphatic black shale. The nickel mineralization is concentrated in two zones that are separated by a brecciated and stockwork-veined



	from	to	length	Nickel %	Zinc %	Barium %
	metres					
Hole REN97-07						
	17.07	23.16	6.09	0.27	0.33	1.85
including						
	17.07	20.12	3.05	0.25	0.37	0.40
	20.12	21.64	1.52	0.02	0.05	0.40
	21.64	23.16	1.52	0.56	0.43	6.20
Hole REN97-08						
	29.90	35.20	5.30	1.42	0.70	2.36
including						
	29.90	31.10	1.10	0.72	0.37	0.97
	31.00	31.90	0.90	2.23	1.41	0.95
	31.90	32.60	0.70	1.41	0.32	0.81
	32.60	33.75	1.15	1.36	0.80	0.98
	33.75	34.04	0.29	1.13	0.40	7.50
	34.04	34.95	0.91	1.81	0.74	5.40
	34.95	35.20	0.25	0.75	0.34	7.10

Figure 2. *Geological/geochemical compilation map of the Taiga property.*

bedded barite horizon (Fig. 3). The higher grade nickel mineralization in the upper zone is hosted in a fossil-rich bed containing baritic limestone balls.

CURRENT WORK AND RESULTS

In 1997, Blackstone Resources and joint venture partner Glenhaven Resources spent $220 000 on the Taiga Property. The program consisted of 616 metres of diamond drilling in 12 holes that were positioned to test 3 target areas, namely the TB Showing, DM Showing and MM Grid, that occur over a lateral extent of 10 kilometres. The most significant results were obtained from the MM Grid area where drill hole 97-08 intersected 25.5 metres of 0.51% nickel and 0.41% zinc. This interval included a 5.3 metre section that graded 1.42% nickel and 0.70% zinc.

A comprehensive drilling program to test over one kilometre of coincident barite and nickel-zinc soil anomalies in the MM Grid area is proposed for 1998. As well, mapping, sampling and drilling is planned to test several other areas of coincident barite and nickel-zinc soil anomalies. Follow-up exploration consisting of mapping, soil and rock sampling is planned for newly staked areas north of the Taiga Property.

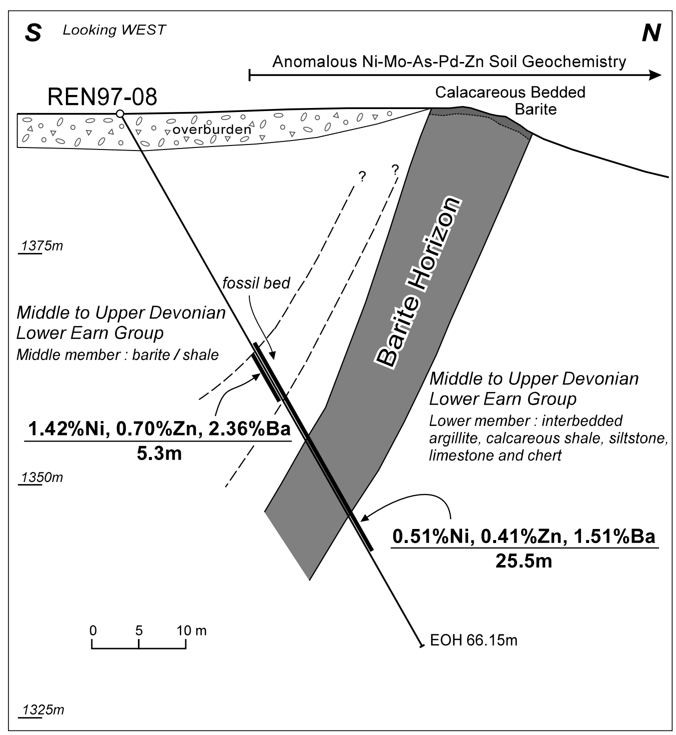


Figure 3. *Cross-section based upon drill hole 97-08 in the MM Grid area.*

Geology and mineral deposits of the Mount Nansen camp, Yukon

Craig J.R. Hart[1] and Mark Langdon[2]
[1]Yukon Geology Program (F-3), Box 2703, Whitehorse, Yukon, Y1A 2C6, e-mail: craig.hart@gov.yk.ca
[2]Mineral Resources, DIAND, 325-300 Main Street, Whitehorse, Yukon, Y1A 2B5

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Abstract

The Mount Nansen camp hosts approximately 30 mineral occurrences of epithermal and porphyry origin. The largest occurrence is the Brown-McDade with approximately 600 000 tonnes of drill-indicated reserves at 6.1 g/t Au and 55.5 g/t Ag. The majority of the northwest-striking, steeply dipping epithermal quartz/sulphide veins are found within a 12 km long by 3 km wide northwest-trending corridor called the Nansen trend. The precious-metal-bearing veins occur in all lithologies within the Nansen trend and contain (in order of decreasing abundance) pyrite, arsenopyrite, galena, sphalerite, chalcopyrite, stibnite and tetrahedrite. Two types of epithermal veins are recognized: an early “cherty” quartz-sulphide vein with fine-grained pyrite and arsenopyrite; and a later coarse-grained quartz-sulphide vein with pyrite, galena and sphalerite and higher precious metal values. Within the trend is the Mount Nansen porphyry complex which hosts two cores of potassic alteration. The character of mineral occurrences varies with increasing distance away from these Central Porphyry Zone and are here recognized as the Peripheral Porphyry, Transitional and Epithermal zones. Together, they comprise a porphyry-to-epithermal transition. Placer mining is predominant on creeks draining from the porphyry complex, implying a porphyry source for the placer gold.

Résumé

Le camp minier de Mount Nansen contient plus de 20 filons sulfurés aurifères dont celui de Brown-McDade (600 000 tonnes à 6,1 g/t d’Au et 55,5 g/t d’Ag), où l’on a récemment extrait 3800 kg doré. La majorité des occurrences sont des filons sulfurés quartzeux à grain fin et de direction nord-ouest contenant (par ordre décroissant) de la pyrite, de l’arsénopyrite, de la galène, de la sphalérite et de la stibine. La majorité des occurrences filoniennes se trouvent dans un corridor granitique de direction nord-ouest de 12 km de longueur et de 3 km de largeur; ce corridor jouxte deux compartiments affaissés de volcanites du Groupe de Mount Nansen. La région contient en outre d’importantes occurrences de cuivre-molybdène porphyrique dans un porphyre quartzofeldspathique de 6 km sur 3 km injecté dans le corridor granitique. Bien que les filons soient inclus dans des roches de compositions diverses, ils sont spatialement associés aux intrusions de haut niveau de porphyre quartzofeldspathique.

INTRODUCTION

The Mount Nansen camp (62°05'N, 137°10'W) is located approximately 42 km west of Carmacks and 160 north of Whitehorse (Fig. 1). The region is accessible along the recently upgraded, 62 km Nansen Road which departs from the village of Carmacks. The Mount Nansen area has had a long but intermittent history of exploration and mining starting with the discovery of the first lode gold vein in 1917. The Brown-McDade, Heustis and Webber veins were discovered in 1946 and saw brief production in 1967 and 1976. Considerable exploration over the past decade resulted in several discoveries. Presently, the Mount Nansen area hosts approximately 30 mineral occurrences — the majority are sulphide-bearing quartz veins — although there are also important porphyry occurrences.

Despite these discoveries, there is relatively little information available to the public. This paper documents a number of occurrences that are not currently listed on government maps and databases, accurately locates them and introduces the nomenclature in use by the exploration community. In addition, salient information from current exploration efforts is presented, with special attention to the gold-bearing veins. We also introduce a new interpretation for the geology of the region and a genetic concept for vein mineralization.

Prior to current mining operations (commenced in Nov. 1996) a combined ore reserve (in all categories) of approximately one million tonnes of 7.4 g/t Au and 148 g/t Ag was calculated from five different deposits within a two-kilometre radius (BYG, 1995). This included all that is minable by both open pit and underground methods. Approximately 450 000 tonnes is considered oxide ore. Processing of approximately 140 000 tonnes of oxide ore from the Brown-McDade open pit and Webber and Brown-McDade stockpiles from November 1996 to December 1997 yielded approximately 3800 kg of doré (Andersen and Stroshein, this volume). Currently the Dickson, Flex and Heuestis zones are in various stages of stripping in preparation for mining. The Flex zone is planned as the next open pit (see Andersen and Stroshein, this volume).

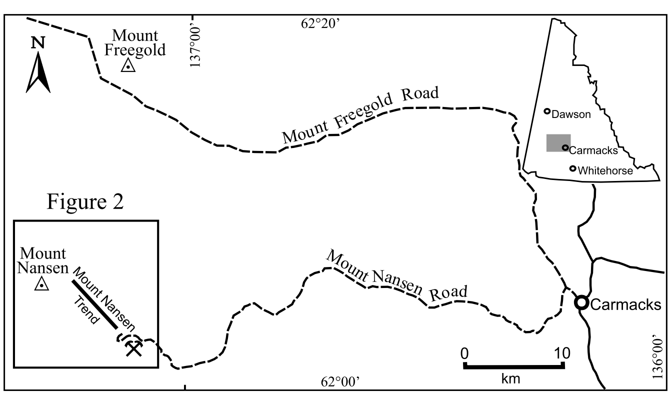

Figure 1. *Location map of the Mount Nansen area.*

Several factors have changed the economics of the Mount Nansen camp: 1) Land tenure is essentially consolidated (through ownership or joint venture agreement with Aurchem Exploration Ltd.) by a single company – namely BYG Natural Resources Inc. This has allowed the aggregation of numerous properties and small ore bodies to be the focus of a single exploration effort and more efficient mine development; 2) Gold recovery has been significantly improved with the utilization of a cyanide circuit. Previous operations failed due to poor recovery of gold and silver using floatation technology on a mixed oxide and sulphide ore. This led to the belief that gold mineralization in the Mount Nansen camp was refractory in nature. Recovery of gold has been significantly enhanced (90%) using a cyanide circuit on an oxide-only ore. Silver recovery remains poor (~50%); 3) Milling capacity was increased to 700 tonnes per day with the recent addition (Sept. 1997) of a semi-autogenous grinding mill (SAG); 4) The opening of the BYG mine, mill and associated permitting and infrastructure enhances the viability of defining a new ore body.

REGIONAL GEOLOGY

The regional geology of the Mount Nansen area has been described by Cairnes (1916), Bostock (1936) and Tempelman-Kluit (1984). The most recent study, by Carlson (1987), describes, in detail, the geology of the area. Although outcrop in this largely unglaciated region is sparse, geological mapping is continually upgraded by ongoing exploration, geophysical surveys and trenching.

The Mount Nansen area is within the Yukon-Tanana Terrane which is composed of variable amounts of Devonian and older meta-igneous and metasedimentary rocks. In the Mount Nansen area, the metamorphic rocks are dominated by chlorite schist and felsic orthogneiss, with lesser quartz-rich metasedimentary rocks and amphibolite.

The metamorphic rocks are intruded by several plutonic suites. The Early Jurassic suite includes the *Big Creek batholith* which is notable for its coarse grain-size, megacrystic alkali feldspars and its variable, but generally quartz-poor, composition. Quartz-rich, alkali feldspar megacrystic plutonic rocks which outcrop in the area are also considered to be Early Jurassic but may be part of the *Granite Mountain batholith*. The most prominent mid-Cretaceous plutonic rock is biotite-hornblende granodiorite of the *Dawson Range batholith*. This batholith intruded Yukon-Tanana Terrane rocks as an extensive sheet-like sill and is more or less continuous from Carmacks northwest to the Alaska. Another notable lithology, but of uncertain age, is sucrosic alkali-feldspar quartz syenite which forms a pluton in the Bow Creek drainage north of the upper Klaza River (Unit 8c of Carlson, 1987). The youngest suite forms a lithologically variable, irregular-shaped pluton composed of mafic syenites and alkali-feldspar-rich porphyry near Victoria Mountain (Unit 9e of Carlson, 1987).

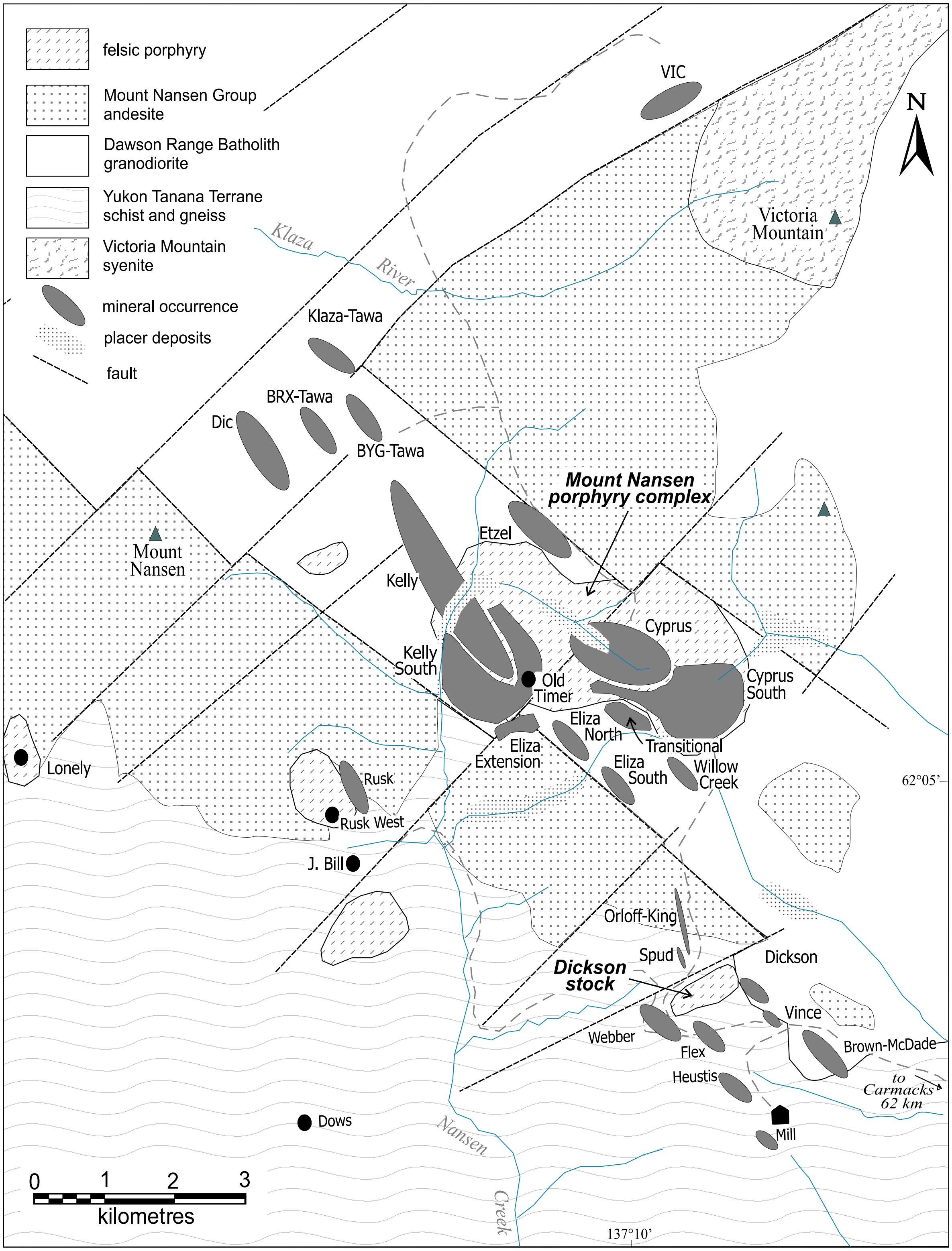

Figure 2. *Generalized geological map of the Mount Nansen trend. The white area includes granitic rocks of all ages and types, but is dominated by the mid-Cretaceous Dawson Range Batholith. The Tawa occurrences collectively comprise the Essansee occurrence (Yukon Minfile 115I 067) and the Eliza and Willow Creek occurrences comprise the Goulter occurrence (Yukon Minfile 115I 093).*

There are two volcanic suites. The mid-Cretaceous (*circa* 108 Ma) *Mount Nansen Group* volcanic suite forms nested caulderas composed primarily of andesitic fragmental units and flows. These rocks have a late phase of hypabyssal quartz-feldspar porphyry and quartz monzonite stocks, dykes, sills and minor pyroclastic flows. The Late Cretaceous *Carmacks Group* comprises extensive, and locally stacked, flows of shoshonitic basalt which unconformably overlie a pre-70 Ma surface which locally preserves sedimentary rocks.

LOCAL GEOLOGY

Mineral occurrences in the Mount Nansen camp are hosted by various rock types within a 3-kilometre wide, northwest-trending corridor, known as the Mount Nansen trend (Fig. 2). The geology of the trend is largely controlled by northwest-trending faults; two are located on the flanks and several more are within the corridor. The gentle, rolling topography of the corridor is largely underlain by granodiorite with less abundant metamorphic rocks, and lies between steep and rugged relief comprising Mount Nansen Group volcanic rocks. Pendants of volcanic rock within the corridor indicate that volcanic rocks originally spanned the region but now remain as two distinct, nested volcanic packages.

The corridor is essentially a horst which also hosts a 5 x 3 km porphyry complex, a number of smaller satellite stocks and a swarm of northwest-trending porphyry dykes. The felsic intrusions may have assisted uplift of the horst. A satellite porphyry body, located near the Dickson and Flex occurrences (the Dickson stock), is notable by its proximity to the mineralization there (Fig. 3). Detailed descriptions of rocks in the Mount Nansen trend are given by Sawyer and Dickinson (1976).

STRUCTURES AFFECTING MINERALIZATION

Three dominant structural orientations, which vary in character and sense of displacement, are recognized from air photos, geological discontinuities, geophysical images, topographic expression and bedrock exposures (mainly exploration trenches). The interaction of these structures are important in the formation of mineral deposits. The three main structural orientations are: 1) a northwesterly trend; 2) an 020° series; and 3) an east-northeasterly trend.

NORTHWEST-TRENDING STRUCTURES

Numerous parallel, northwest-striking fault zones are continuous throughout the Mount Nansen region and define a regional structural trend of 130° to 150°. These structures are continuous, form wide zones with numerous faults that host porphyry dykes, and contain mineralized quartz veins. Although significant vertical displacements (normal sense) are known on the faults that bound the granodiorite corridor, right-lateral movement is also recognized. Mineralization largely post-dates the vertical motion but slickenslides on veins and dykes in these faults indicate subsequent strike-slip motion.

020° STRUCTURES

A secondary structural trend approximating 020° (varies between 005° to 045°) is characterized by their discontinuity and a general lack of intense shearing. The structures are typically fractures occupied by narrow mineralized quartz veins and porphyry. Many 020° structures terminate at their intersection with a northwest structure or curve sharply into the northwest trend. Consequently there is generally little or no offset of the northwest structures and the 020° series; instead

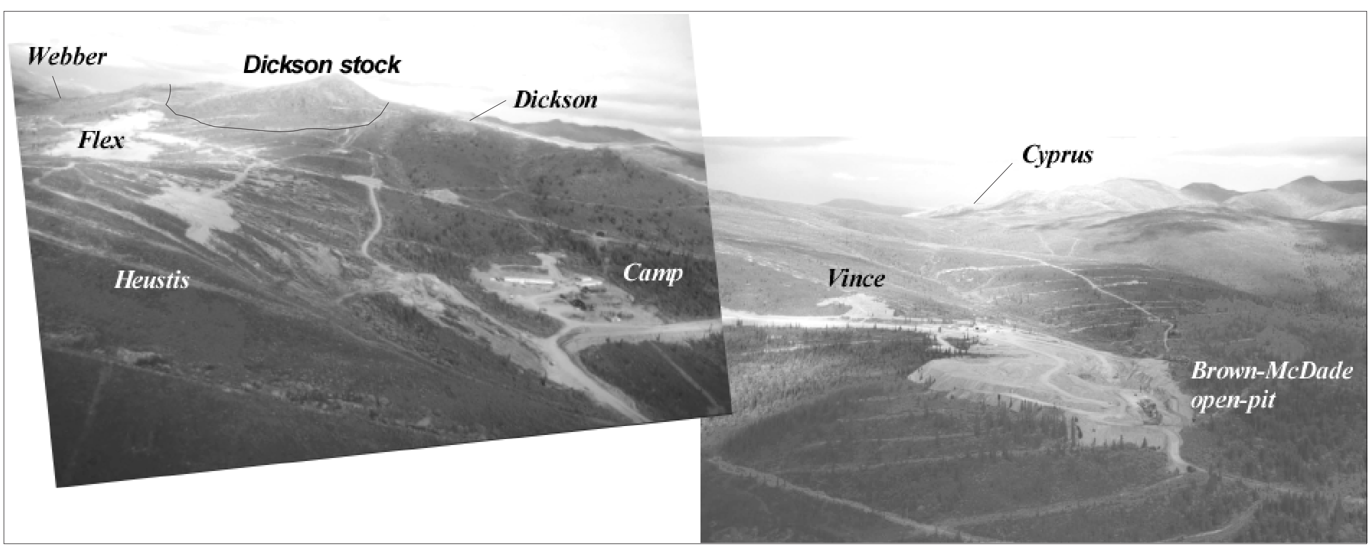

Figure 3. *View northwesterly of the mineral occurrences near the Dickson porphyry stock. The Mount Nansen porphyry stock is in the background low-lying hills near the Cyprus occurrence.*

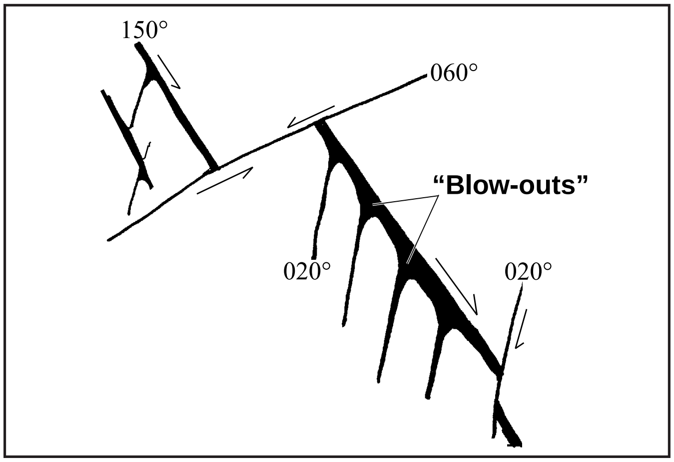

Figure 4. Schematic diagram of the interactions of vein structures. Black indicates mineralization.

they create a network of discontinuous interconnections between them. This has important implications for vein formation, discussed later in this paper. Although the strike of both the 020° series and the northwest-trending structures varies, the angular relationship between them does not. In most cases, a consistent angular relationship of approximately 60° is apparent. Observed fault offsets are typically sinistral, with offsets of less than 15 m although a right lateral offset of about 12 m was recognized cutting the **Vince** vein.

The intersection of numerous 020° veins with the main northwest veins appears to be the structural recipe required to form larger, and wider, ore-bodies (Fig. 4). In the Brown-McDade open pit, a series of six to ten 020° series veins intersect and join the main northwest structure over an interval of about 300 metres. The 020° veins vary from 0.2 to 3.0 m in width and their intersection with the main vein creates ore pods or "blow-outs" which increases the tonnage of the Brown-McDade deposit.

EAST-NORTHEAST-TRENDING STRUCTURES

A third regional set is expressed as faults, fractures and joints that trend northeasterly between 050° and 080°. The faults are continuous but many have not been previously identified through mapping because their offsets are not very large. The structures are apparent on air photos and airborne magnetics surveys however, and have been recognized in trenches. Displacements are sinistral. Most of these cross-faults do not contain mineralization except for minor faulted blocks of earlier veins. An exception is a fault within the Eliza Creek Extension where a 10 to 30 m wide, 065/80°S shear zone contains sheared and highly oxidized fragments of argillic-altered andesite, mineralized by a quartz-pyrite stockwork. A trench excavated along the shear yielded 21.3 metres of 1.5 g/t Au and 11.3 g/t Ag.

In summary, epithermal mineralization is dominantly hosted by the northwest and 020° structures, and intersection of these structures creates a "blow-out" where vein thickness increases considerably. Mineralization largely post-dates the large vertical displacement of these structures. The 020° fractures become dominantly extensional near the intersection. These extensional blow-outs, when filled with vein material, add considerable tonnage of ore-grade material to the veins. In three dimensions, the blow-outs probably have the general form of steeply plunging cylinders. The 020° structures are interpreted to have originated as oblique extension to the strike-slip motion of the northwest-trending system.

THE PORPHYRY TO EPITHERMAL TRANSITION

There are approximately 30 mineral occurrences in the Mount Nansen camp (Table 1). Most occurrences in the Mount Nansen trend are adjacent to porphyry stocks — specifically the sulphide-bearing quartz veins near the Mount Nansen porphyry complex and the Dickson stock. Mineralization associated with the Mount Nansen porphyry complex displays notable changes in metal ratios, vein character and alteration-style outward from two central zones. Four mineralized zones defining a porphyry to epithermal vein transition are recognized – the Central Porphyry Zone, a Peripheral Porphyry Zone, a Transitional Zone and an Epithermal Vein Zone (Fig. 5).

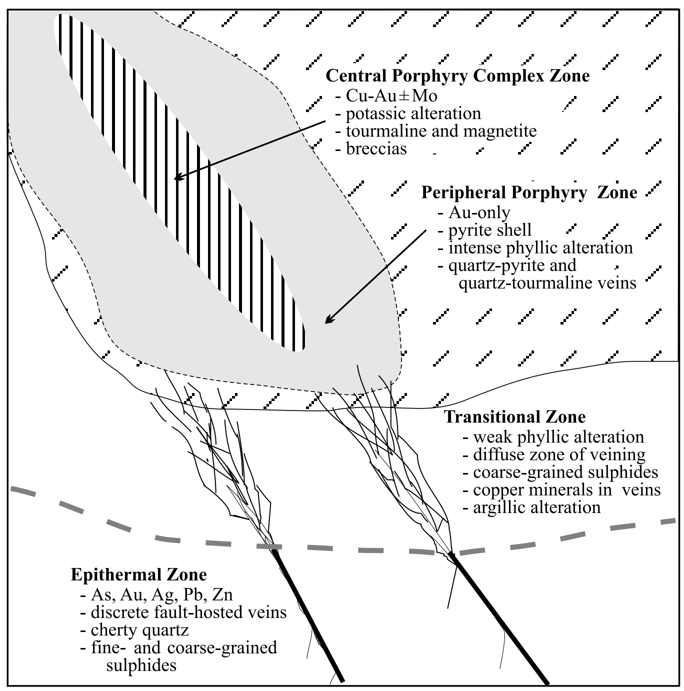

Figure 5. Characteristics that define porphyry to epithermal transitions. The diagram schematically represents the relationships of mineralization observed on the southwest side of the Mount Nansen porphyry complex. See text for discussion.

Table 1. *Summary of characteristics of mineral occurrences in the Nansen trend.*

Yukon Minfile	Name	Host lithology	Vein attitude	Description
Epithermal Vein Mineralization near the Mount Nansen Mine				
064	Brown-McDade	Granodiorite in north, schist and gneiss in south	1° 160/65SW 2° 020	Total reserve 600 000 tonnes of 6.1g/t Au and 55 g/t Ag; open-pit oxide reserve 201 600 of 7.1 g/t Au 69 g/t Ag; production (11/96 to 10/97) 16 000 oz Au, 83 000 oz Ag produced from 124 000 tonnes of ore; a 500 m long strike length; complex veins formed by intersection of two trends
065	Webber	Schist and gniess	155/70SW	Underground reserve of 85 000 tonnes of 9.4 g/t Au and 560 g/t Ag; 600 m strike length; four narrow (0.3-2.0 m) sub-parallel veins
065	Heustis	Schist and gniess	140/80NE	Underground reserve of 123 800 tonnes of 14.1 g/t Au and 291g/t Ag; 530 m long; narrow sulphide-rich high-grade veins with galena and sphalerite; deep drill intersection at 425 m of 5.25 m of 4.1 g/t Au and 74 g/t Ag
065	Flex	Schist and gniess	170/70W	Total reserve 109,000 tonnes of 5.9 g/t au and 269 g/t Ag; open-pit oxide reserve of 67 507 tonnes of 4.9 g/t Au, 182 g/t Ag; 650 m long; veins complicated by offsets along northeast-trending faults
065	Dickson	Granodiorite	140/SW	A 660 m long zone of 5 to 6 Au-Ag-Pb-Zn-Sb veins; 3 m of 17.6 g/t Au, 80 g/t Ag; sulphide>oxide
	Vince	Schist and Gneiss	110/80S	A 50 m long zone averaging 2.5 m wide; best trench sample 3.0 m of 21.1 g/t Au and 74.7 g/t Ag; drill intersection of 14.4 m (~7 m true width) of 3.6 g/t Au and 20.9 g/t Ag
065	Orloff King	Andesite	150/45SW	Reserve of 84 500 tonnes of 2.1 g/t Au, 52 g/t Ag; single 280 m long, 3 m wide vein
	Spud	Andesite	NW	One vein partially explored by trenching
	Mill	Schist and gniess		A few narrow low grade veins in a zone next to the mill; no drilling
Central Porphyry Zone				
066	Cyprus	Quartz monzonite porphyry		Early 1970s drilling explored the central porphyry complex Cu-Mo zone; hypogene Cu grades 0.1% to 0.15% which doubles in the supergene zone; anomalous but erratic Au
	Kelly	Quartz monzonite porphyry and qfp	NW	A 275 m wide, 2.5 km northwest-trending potassic alteration zone with coincident Cu-Mo-Au soil geochemical and geophysical anomalies; trench sample of 8.0 m of 0.86 g/t Au and 0.25% Cu
Peripheral Porphyry Zone				
066	Cyprus South	Granodiorite and qfp	NW	Several sulphide-bearing quartz veins and stockworks within the phyllic zone of the porphyry complex; wide drill intersection of low grade gold, 65 m of 0.31 g/t Au
	Oldtimer	Granodiorite and qfp		Sulphide-poor quartz veins and silicified; Free gold identified in polished sections, grab sample values up to 9 g/t
	Kelly South	Granodiorite and qfp		Gold values associated with pyrite shell in phyllic-altered zone peripherial to potassic zone
Transitional Zone				
	Eliza Creek Extension	Granodiorite and andesite	1° 150/80W 2° 020 mineralized shear zone at 065/80S	Northernmost extension of Eliza Creek veins and stockworks strongly associated with porphyry stocks, breccia and argillic/phyllic alteration; drill intersections of 48.8 m of 4.3 g/t Ag and 5.3 g/t Ag including a few high grade zones including 6.0 m of 17.5 g/t Au and 27.13 g/t Ag
	Transitional	Granodiorite	150/75W	Four main veins and stockworks, similar vein character to Eliza Creek Extension argillic alteration zone

Yukon Minfile	Name	Host lithology	Vein attitude	Description
Epithermal Vein Zone				
093	Eliza Creek South	Quartz diorite, schist and gneiss, minor andesite	1° 150\75SW 2° 020	Two main Au-Ag-Pb-Zn veins with a number of other sub-parallel veins, extensive clay alteration; trench samples 3 0m of 1.0 g/t Au; 7.9 m of 3.4 g/t Au
093	Eliza Creek North	Quartz diorite and andesite		Northern continuation within the argillic alteration zone of the porhyry complex, veins have higher Cu values; 1.5 m of 10.3 g/t Au
	Etzel	Andesite, granodiorite and qfp sill	NW	A zone of Au, Ag, Pb and Zn veins along the edge of the porphyry complex near the volcanic-granodiorite contact
	Willow Creek	Granodiorite and quartz diorite	1° 150/75W 2° 130	Three Au-Ag-Pb-Zn veins with 60 to 90 m strike lengths; contain sulphosalts; 8.5 m of 5.1 g/t Au and 7.0 m of 3.5 g/t Au; veins terminated by 000° faults
067	Tawa - BRX	Granodiorite		Several 1-2 m wide, 825 m long Au-Ag-Pb-Zn veins; values to 43 g/t Au, 102 g/t Ag over 1.1 m
067	Tawa - Klaza	Granodiorite	NW	An anastomosing vein system (at least three veins) exposed for over 300 m by trenching; 8.0 m of 4.2 g/t Au and 47 g/t Ag including 11.1 g/t Au and 216 g/t Ag over 1.0 m
067	Tawa - BYG	Granodiorite	NW	Two trenches 180 m apart expose 1.5-4 m wide Au-Ag-Pb-Zn veins; possible extension of Klaza
117	Dic	Andesite	NW	Mineralized zone associated with the volcanic-granodiorite contact; westernmost of the Tawa veins
Other mineral occurrences				
096	Rusk	Andesite	NW	Several Au-Ag-Pb-Zn veins within a 100 m wide zone of argillic alteration; high silver values to 3000 g/t, and associated Sb
096	Rusk West	Quartz feldspar porphyry (qfp)		Disseminated and fracture-filled mineralization found within and around a rhyolite stock, associated Cu, Mo, Pb, Zn and Au soil geochem anomalies peripheral to stock; single drill hole (1970) intersected 3.0 m of sphalerite stringers
096	J.Bill	Andesite and qfp		A 2-8 m wide jarositic weathering, silicified breccia; Au, Ag, Pb and Zn mineralization; the breccia is adjacent to a qfp sill and has Au-in-soil anomalies
119	Dows	Schist and gniess	040°	A >350 m long quartz-sulphide vein, locally chalcedonic, locally stibnite-rich; extensive clay alteration; drilling results includes 2.43 g/t Au over 7.5 m and 1 0.2 g/t Au over 1.5 m
084	Lonely	Quartz feldspar porphyry		Pyritiferous and altered rhyolite plug with quartz stringers, minor chalcopyrite
122	Grizzly	Andesite		Quartz-arsenopyrite vein up to 6 m wide traced for 150 m; vein float assayed 42.5 g/t Au and 59.94 g/t Ag
068	VIC	Syenite	080°	Several steeply-dipping, narrow high grade gold veins; a newly uncovered quartz-gold stockwork remains untested (grab sample 17.4 g/t Au)

Data are compiled from Langdon (1995), Yukon Minfile (1997), BYG (1995), Melling (1995) and observations made by the authors.

CENTRAL PORPHYRY ZONE

Copper-molybdenum-gold mineralization is found in two locations within the porphyry complex — each centred on a core of potassic-alteration. The eastern potassic zone (**Cyprus**) was explored in the late 1960s and early 1970s with approximately 4500 m of drilling in 26 holes. Average hypogene grades of 0.12% Cu and 0.01% Mo below 60 to 90 m depth were found to approximately double in the supergene oxide enrichment zone above. Local higher grade zones of 0.6% Cu and 0.06% MoS_2 and rare precious metal grades are associated with extensive fracturing (Sawyer and Dickinson, 1976). These were centred on zones of weak potassic alteration which included tourmaline breccia, quartz veining, and lesser biotite enrichment within the dominantly phyllic-altered porphyry.

The western potassic zone (**Kelly**) was explored during 1994-97. It is approximately 275 metres wide and its northwest-trend has a potential strike length of 2.5 kilometres, as defined by coincident geochemical and geophysical anomalies, including: 1) Au, Cu and Mo soil geochemical anomalies; 2) high chargeabilities with moderate resistivities; 3) a distinct high magnetic anomaly observed in both ground and airborne surveys. Trenching and diamond drilling confirmed the potassic alteration zone that is manifest mainly by biotite enrichment and has associated quartz-pyrite stringers that locally include chalcopyrite, chalcocite, molybdenum, rare bornite and minor fluorite. Magnetic anomalies result from magnetite veins and quartz-magnetite stringers which also occur within the potassic alteration zone.

A drill hole in the Kelly zone intersected sub-economic copper and molybdenum mineralization throughout the entire 229 m of core. The strongest mineralization was in a 19 m intersection of the potassic-altered quartz monzonite porphyry breccia. This zone also yielded the highest gold grades including 8.0 m of 0.86 g/t Au and 0.25% Cu.

PERIPHERAL PORPHYRY ZONE

Peripheral portions of the porphyry complex are characterized by a pyrite halo with strong phyllic (pyrite-sericite) alteration enveloping the potassic cores. Gold is the only ore mineral. Quartz flooding and associated quartz, quartz-pyrite and quartz-tourmaline stringers and stockwork with extensive brecciation overprint the phyllic-altered rocks. This zone is also typified by high chargeability with very low resistivity, a very low and flat magnetic response and widespread gold-in-soil anomaly. The anomalies also suggest a strong northwest structural control of mineralization and alteration. Arsenic, which is commonplace throughout most of the sulphide-bearing quartz veins, is noticeably absent from the entire porphyry complex.

The **Cyprus South** mineral occurrence is within a phyllic-altered northwest-trending porphyry dyke which is about 150 m wide. The dyke contains quartz-pyrite stockworks up to 60 m wide. Gold values over these widths average 0.3 g/t. The **Old-Timers** showing is a northwest-trending zone of silicified and phyllic-altered quartz monzonite and granodiorite. Quartz veining and breccia with a low pyrite content are exposed in old hand-dug pits. Free gold has been panned from the rubble within the pit and has been observed in polished sections. Sampling yielded values of up to 9.0 g/t Au. Drill holes, collared on the western edge of the **Kelly** occurrence in 1997, intersected a 4.0 m wide zone of 1.34 g/t Au and another of 3.7 m of 18.9 g/t Ag with elevated tungsten values.

At least five active placer mines are located on streams that drain the Peripheral Porphyry Zone. It was reported that the gold recovered from one creek became finer-grained and that the silver content of the electrum decreased from the normal 20% as placer mining progressed further into the porphyry complex (T. Fraser, pers. comm. 1996).

TRANSITIONAL ZONE

The Transitional Zone outside of the porphyry complex is characterized by sulphide veins which overprint porphyry-style mineralization and alteration. The zone has less intense phyllic alteration and brecciation than described in the Peripheral Porphyry Zone. Veins generally contain coarse-grained pyrite and minor chalcopyrite and lack the "cherty" quartz and fine-grained sulphide veins typical of more distal veins. Veins are generally confined to faults, but where they cut previously brecciated stockworks and phyllic-altered rocks associated with the porphyry mineralization they tend to become diffuse and permeate wide areas.

Strong northwest-trending Au, Ag, Pb, Zn, Cu and As soil geochemical anomalies form numerous zones that are coincident with the quartz-sulphide veins subsequently discovered by trenching and drilling. Gold anomalies are typically wider in the Transition Zone than in the Epithermal Zone because they reflect elevated gold values contained in the pyrite shell associated with the porphyry complex. Weak to moderate chargeability and resistivity anomalies from the veins are distinguishable from a background of elevated sulphide content associated with porphyry mineralization.

The **Eliza Creek Extension** is an example of mineralization in the Transitional Zone. Six sub-parallel veins strike northwest for about 300 metres into the Peripheral Porphyry Zone where they become diffuse and the mineralization dissapates. Free gold was observed in cuttings from six reverse-circulation drill holes in this area of the Transitional Zone. Drill assay results include:

Vein 1
- 48.8 m of 4.25 g/t Au and 5.30 g/t Ag (RC94-5)
- 8.3 m of 1.78 g/t Au and 16.5 g/t Ag (DDH97-4)
- 1.9 m of 4.29 g/t Au and 1.0 m of 2.7 g/t Au (DDH97-3)

Vein 2
- 15.2 m of 3.62 g/t Au and 50.08 g/t Ag (RC94-7A)
- 18.4 m of 3.82 g/t Au and 43.28 g/t Ag including
- 4.6 m with 6.8% Zn, 0.8% Pb and 0.2% Cu (RC94-21)

Vein 3
- 11.6 m of 3.63 g/t Au and 27.8 g/t Ag (Trench sample)

EPITHERMAL VEIN ZONE

Vein mineralization is extensive throughout the Mount Nansen camp and is the current focus of mining activity. There are literally hundreds of veins, varying in width and degree of mineralization, across the Nansen trend but they are stronger and more abundant within 3 or 4 main northwest-trending structural zones. There are two types of veins: an early “cherty” quartz-sulphide vein and a later coarse-grained sulphide vein. The “cherty” veins are composed of very fine-grained disseminated pyrite and arsenopyrite with blue, grey and white cryptocrystalline quartz. The coarse-grained veins are dominated by pyrite and include abundant sphalerite and galena, and locally chalcopyrite and tetrahdrite. The quartz is clear, milky or light grey and locally crystalline. Stringers and banded varieties of this mineralization occur locally where they cut and upgrade the “cherty” quartz-sulphide veins. Hydrofracting in both vein types has resulted in brecciated sulphide minerals.Many veins are overprinted by white to yellow chalcedonic quartz.

Most veins occupy brittle fractures and shears that also locally contain variably altered felsic dykes. Strike lengths up to 900 m have been confirmed, although several may be discontinuous for many kilometres. Vein widths vary to 8.0 m, although mineralized zones up to 25 m have been determined at the **Brown-McDade** system. Most of the veins are confirmed to depths of 50 to 100 m by drilling, but a single deep drill hole on the **Heustis** vein confirms its continuity of character to a depth of at least 425 metres.

Structure of epithermal veins

The majority of the larger veins are northwest-trending and dip steeply to the west. The hanging wall is typically a fault. Fault zones host as many as four veins which typically contain brecciated wall-rock and brecciated quartz fragments. Some veins are simple, narrow and continuous whereas others form complex, anasotamosing systems. As mentioned previously, the intersections of veins are important features in defining ore shoots and increasing the tonnage of the deposits. Ore shoots typically occupy 30-50% of individual veins (R. Stroshein, pers. comm., 1998).

Mineralogy

Ore mineralogy varies between the veins but most are dominated by pyrite, arsenopyrite, galena and sphalerite with lesser stibnite, chalcopyrite, bornite, tetrahedrite and later sulphosalts. Acanthite, electrum, argentite and chalcopyrite have been reported from the **Willow Creek** occurrence (Bremner, 1991). Bindheimite, jamesonite, bouronite, freibergite have been reported from the **Webber** (Melling, 1995). Jamesonite bournonite have been reported from the **Brown-McDade** (Lamb, 1947). Calcite and gypsum typically form late, fracture-filling minerals, but are usually leached from near-surface outcrops.

Gold grains or electrum are associated with pyrite, chalcopyrite and arsenopyrite but most commonly occur as grains within quartz. Most of the Mount Nansen epithermal ore contains between 10% and 25% of the total gold as free gold or electrum. High gold and weak silver values tend to be associated with the arsenopyrite. Silver grades correlate well with galena. Silver to gold ratios average about 20:1 but vary from vein to vein from 10 to 200:1. Gold grades decrease away from the hanging wall.

Alteration of epithermal veins

Most veins are enveloped by bleached alteration zones that are up to 10 m wide. The extent and width of the alteration is dependent on the host rock. Granodiorite host rocks are the most extensively altered; andesite is less altered. Argillic alteration is predominant, indicated by kaolinite and illite, with lesser montmorillonite. Phyllic alteration is common but is less extensive and much less well developed in the metamorphic rocks than it is in the granitic rocks. Phyllic alteration is characterized by alteration to sericite, silicification and suphidization with disseminated pyrite. Dykes associated with veins are intensely argillically altered (Smuk et al., 1997). Metamorphic rocks are most resistant to alteration but become bleached.

The depth of oxidation varies considerably, from as little as 5 m on north-facing slopes, to as deep as 150 metres within faults and shear zones. Scorodite, limonite and melanterite staining is typical in oxidized veins. Manganese wad is extensive along the vein perimeters. In many cases, the alteration zones are extensively oxidized, but the quartz vein may not be. Secondary cerussite is reported from the **Willow Creek** occurrence (Bremner, 1991).

EXPLORATION CONSIDERATIONS

Recommended exploration methods include time-domain IP surveys, soil geochemistry with Au, Ag, Pb, Zn, As, Sb and Cu, airborne and ground magnetic and VLF-EM surveys, and air photograph interpretation followed up with trenching and drilling. Exploration success also requires a geological understanding of the structural and other mineralizing controls within the porphyry-to-epithermal transition. In addition, exploration should focus on the main structural zones within and on the margins of the corridor.

The intense alteration, brecciation and oxidation of mineralized zones in the Mount Nansen camp makes core recovery, logging and sampling difficult. Recognition of rock types in the ore zones can be difficult and core recovery of rubbly or clay-rich vein material is sometimes poor. In a recent exploration program at Brown-McDade, ore versus host-rock was determined by a cutoff assay of 4 g/t Au. However, clay-rich materials were often washed out during drilling. Since the fine-grained ore fractions contain a considerable percentage of the contained gold, the grades of the recovered core were less than those encountered during mining. As a result, ore reserve calculations may be underestimated.

Gold grades within the vein material may also be difficult to deduce with confidence because of the presence of high-grade stringers and patches, and free gold. For this reason, as well as those mentioned previously, the correlation of grades within a deposit, or even between twinned holes, can be extremely variable.

CONCLUSIONS

Most of the mineral occurrences that comprise the Mount Nansen trend occur in a horst which represents the exposed sub-volcanic zones of Mount Nansen Group volcanism. Very few occurrences are in the andesite, thereby suggesting that mineralization is preferentially emplaced at lower structural levels.

Much of the mineralization in the Mount Nansen trend can be placed in a zoned porphyry to epithermal transition framework which is centered around potassic alteration cores. The proximity of the epithermal veins to the Central Porphyry complex, the Dickson stock and porphyry dykes promotes a model that links ore genesis with the magmatism.

The formation of large epithermal ore bodies relies on the structural interaction of the northwest and the 020° fracture systems. The intersection of these structures creates a “blow-out” where the vein thickness increases considerably. The 020° fractures become entirely extensional at the points where they intersect the stike-slip motion of the northwest-trending series. These extensional blow-outs, when filled with vein material, add considerable tonnage to the veins. Although the third dimension is incompletely known, the blow-outs probably form steeply plunging cylindrical ore shoots.

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Geology of the Flex gold-silver vein system, Mount Nansen area, Yukon

Farrell Andersen and Robert Stroshein
BYG Natural Resources Inc. General Delivery, Carmacks, Y0B 1C0

Andersen, Farrell and Stroshein, Robert, 1998. Geology of the Flex gold-silver vein system, Mount Nansen area, Yukon. *In:* Yukon Exploration and Geology 1997, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p.139-143.

ABSTRACT

The Flex Gold-Silver deposit is a multiple vein epithermal system found within the Mount Nansen precious metal trend. High-grade gold and silver values are associated with north-northwesterly trending, sulphide-rich quartz veins that infill structures associated with regional shearing. BYG has stripped and mapped the deposit to prepare advanced exploration and mining design plans.

The mineralization is typically epithermal with extensive wall rock alteration including argillic and phyllic zones. Gold - silver values occur with sulphide-rich quartz veins, breccia veins, and silicified zones. Gold values up to 34 grams per tonne and silver values up to 1416 grams per tonne were obtained from the sulphide-rich veins.

INTRODUCTION

The Flex gold-silver deposit is located approximately 63 kilometres along the Mt. Nansen road west of Carmacks, Yukon Territory (Fig. 1). The deposit is within two kilometres of the Mount Nansen gold mill. BYG Natural Resources Inc. has produced gold and silver at the Mount Nansen gold mill since November 1996 and refined 156 silver-gold bars weighing approximately 3 800 kg. Past production has been from the Webber and Huestis veins in 1975-76 and current production is from the Brown-McDade deposit. Future production will be from the Flex and other gold-silver rich zones on the property, including the Webber and Huestis veins.

A network of north-northwesterly trending veins is the host to the Flex deposit. The deposit was discovered in 1985 between the Huestis and Webber vein systems (Fig. 2). Forty-four diamond drill holes (1877 metres) and 33 trenches (excavated between 1985 and 1995) define the deposit. The deposit area has been completely stripped in preparation for deposit modelling because the vein distribution is complex. Earlier interpretations of the vein distribution (Eaton and Archer, 1989; Melling, 1995) did not include fault offsets and applied only a general northwesterly trend, consistent with the nearby Webber and Huestis veins.

REGIONAL GEOLOGY

The Mount Nansen gold-silver property is located in the Dawson Range of the Yukon Tanana Terrane. The Dawson Range is underlain by Early Mississippian and older metamorphic rocks intruded by several plutonic suites (Carlson, 1987).

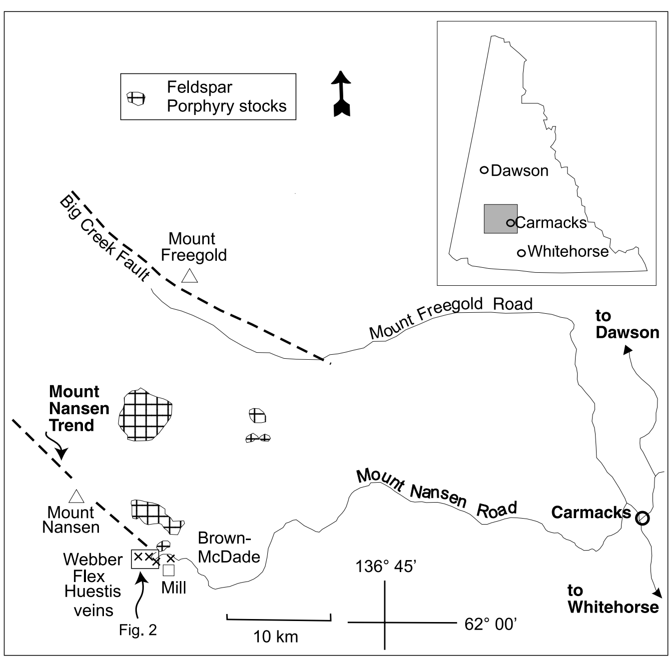

Figure 1. *Location of the Mount Nansen Project, BYG Natural Resources Inc.*

The metamorphic rocks are separated into two suites, meta-sedimentary and meta-igneous. Micaceous quartz-feldspar gneiss, schist, and quartzite of the Nasina assemblage form the meta-sedimentary rock suite. The meta-igneous package includes biotite-hornblende feldspar gneiss and coarse-grained granodiorite orthogneiss with lesser amphibolite.

The metamorphic rocks are intruded by Mid-Cretaceous felsic plutonic rocks of the Coffee Creek Plutonic Suite and capped by the coeval mafic to intermediate volcanic flow and tuff rocks of the Mount Nansen Volcanic Suite (Johnston and Mortensen, 1994). Genetically related sub-volcanic feldspar porphyry dikes and plugs intrude all rock types (Sawyer and Dickinson, 1976).

The Late Cretaceous Carmacks Volcanic Suite, although lacking in the immediate Mount Nansen area, is voluminous in the region where relatively flat lying pyroclastic tuffs and flow units form prominent ridges capping the basement rocks (Carlson, 1987). The Carmacks Volcanic Suite is magmatically related to the Prospector Mountain Plutonic Suite (Johnston and Mortensen, 1994).

Mineralized structures on the Mount Nansen property consist of fault-shear-hosted veins and associated clay-rich and bleached alteration zones (Fig. 3). The vein zones range from narrow, simple quartz veins to complex, anastomosing and braided systems that crosscut all rock types. They trend northwest to north-northwest, and are generally steeply dipping across a two-kilometre wide corridor called the Mount Nansen Trend. The Mount Nansen Trend is sub-parallel to the Big Creek Fault, an apparent control to mineralization in the Dawson Range (Carlson, 1987; Hart; presentation at Geoscience Forum, 1997). The structures are interpreted as dilational fracture systems peripheral to the Middle Cretaceous porphyry intrusive bodies.

Geochronological and lead-isotope studies are being conducted to determine an appoximate time of the mineralizing event (V. Meyer, B.Sc. thesis in progress).

The Mount Nansen area was beyond the limit of the most recent continental glaciation although earlier incursions moved up the valley bottoms. Weathering extends to depths of up to 75 metres below surface which is accompanied by leaching and oxidation in the mineralized zones, and sulphides are commonly altering to limonite or other oxides (Melling, 1995).

CURRENT WORK

The overburden stripping at the Flex deposit exposed an area 80 metres wide by 350 metres long, encompassing the mineralization defined by previous exploration. Excavator trenches have been cut within the stripped area to test for potential supergene enrichment and vertical variation in the mineralization. Geological mapping and systematic sampling of the veins and alteration zones, from both the surface and in the shallow trenches, has been completed. Additional multi-element lithogeochemical analysis of the 1140 rock-chip channel samples is planned.

An indicated resource estimate has been calculated at 90 000 tonnes grading 5.8 g/t gold and 200 g/t silver.

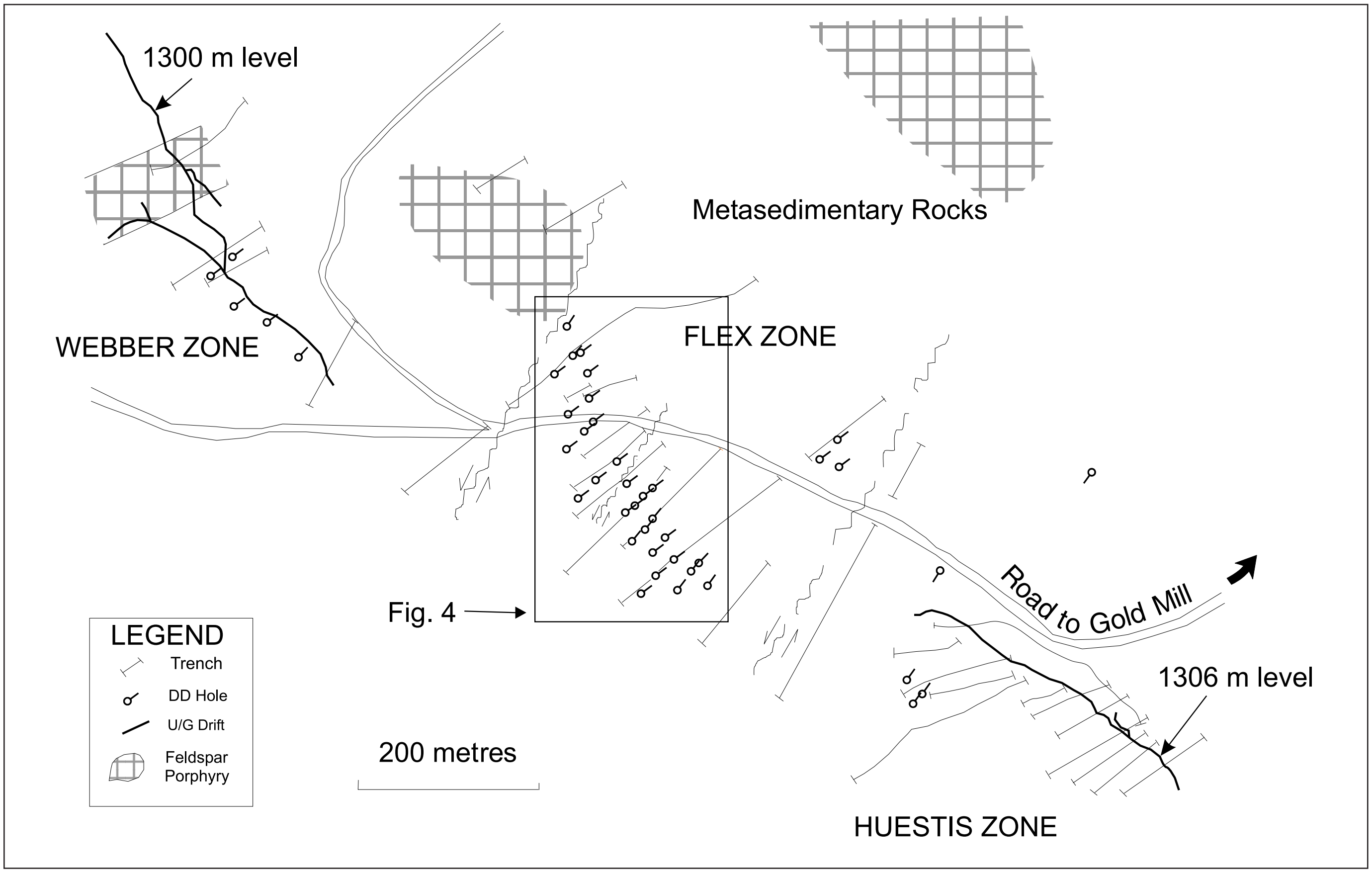

Figure 2. *Recent exploration of the Flex, Huestis and Webber vein systems.*

DEPOSIT GEOLOGY

Host rocks for the Flex veins are predominantly plagioclase-hornblende to amphibolite gneiss, minor quartzite, and micaceous felsic schist. The dark green mafic rocks are prominent in the central and northern part of the deposit while the light-coloured felsic schist is most abundant in the south half. Feldspar porphyry dikes do not occur within the deposit, although two large porphyry plugs outcropping along a ridge immediately north of the deposit may be genetically related to the mineralization (Fig. 2). This contrasts with other deposits at Mount Nansen in which feldspar porphyry dikes are common.

Near-surface weathering has caused the leaching of iron and magnesium from the rocks resulting in a bleached appearance. Strong weathering of feldspar causes clay-rich segregated layers in the gneiss. Mafic minerals are weakly to moderately chloritized below the weathering cap.

In the metamorphic rocks, foliation strikes northeast with dips of 30° to 50° northwest. Cleavage trends north to northeast, with 50° to 80° northwest dips, except where folding is present.

At least one episode of post-mineralization faulting has been identified. Faults trend approximately 040° with moderate to steep northwest dip. The vein structures exhibit left-lateral offset along the faults. On the property scale this set of faults may offset the major deposits, creating disjointed and differential movements across major structures. Differential movement

Figure 3. *Part of the stripped Flex zone, showing drag-folded main vein with an envelope of bleached white clay. Looking southeast from section 3+10 N. The standing pickets are about one metre high.*

along the faults results in varying vein attitudes between the different fault-bounded blocks as between the Huestis veins trending northwesterly and the Flex veins which trend north-northwesterly.

THE FLEX VEIN SYSTEM

Two semi-continuous bleached clay zones enclosing intermittent quartz-sulphide veins and vein breccia cross-cut metamorphic rocks in the Flex deposit. The veins are sub-parallel, trending between 340° - 010° and dip steeply to the west. The two

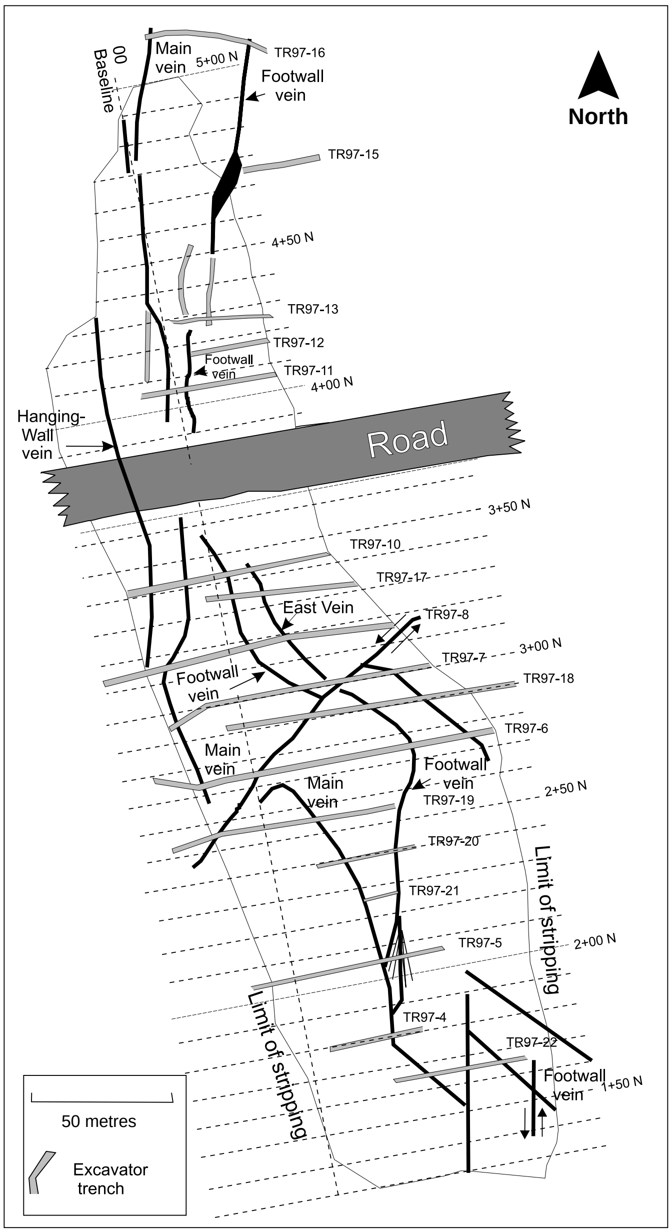

Figure 4. Plan view of the Flex vein system as exposed at surface. The four veins dip steeply west. The survey grid, by BYG Natural Resources, is in metres.

zones, named the Main and Footwall veins in Figure 4, are approximately 30 metres apart but converge near section 2+00 N and section 3+75 N. Additional discontinuous veins have been mapped in the hanging wall of the Main vein and in the footwall of the Footwall vein and are lettered on Figure 4. The Hanging Wall vein is poorly exposed near the west side of the stripped area and has been intersected in several drill holes. The East vein occurs from 10-12 metres east of the Footwall vein in the central portion of the deposit.

The veins, which are locally brecciated, range from 5-50 centimetres thick. Silicification of the wallrock extends ore grade widths up to seven metres. Pinching and swelling of the veins and clay alteration zones has been traced more than 400 metres along strike.

The veins have been offset along northeast-trending faults. A prominent fault between sections 2+60 N and 3+00 N (Fig. 3) crosscuts and offsets the veins up to 26 metres left-laterally as indicated by drag-folding.

Vein alteration is primarily patchy silicification and more common in the hanging wall of the vein structures. Pervasive argillic alteration surrounds the sulphide-rich veins and forms hanging wall and footwall haloes up to three metres thick. Manganese oxides occur peripheral to the clay zones surrounding the mineralized veins. The distinctive yellowish-green stain of scorodite accompanies the quartz-sulphide veins and is a visual indicator of high-grade gold value.

PRECIOUS-METAL MINERALIZATION

The mineralization is typically epithermal with extensive wall rock alteration including argillic and phyllic zones. The vein structures appear to be mineralized over approximately 50-60% of the length, which is comparable to the mineralization tested by drifting on the Webber and Huestis vein systems.

Three vein compositions have been identified in the Flex deposit. Dark grey, sulphide-rich, opaque, vitreous quartz carries the richest values of gold, up to 34 grams per tonne and silver values of up to 1416.3 grams per tonne (Fig. 5a). Massive grey, chalcedonic quartz containing angular brecciated wallrock clasts, carries gold values to 3.5 grams per tonne and silver values of 137.5 grams per tonne (Fig. 5b). Pale grey, opaque and vitreous quartz exhibiting open spaces, is barren of sulphide and carries very low grade gold values.

The gold- and silver-rich sulphide consists of pyrite, arsenopyrite, silver sulphosalts, galena, and sphalerite (Figs 5 a,b). Metallurgical studies show that the Flex sulphide ore is amenable to cyanidation with recoveries at 79% and 43% respectively for gold and silver. Detailed testing is in progress to develop an optimum milling process.

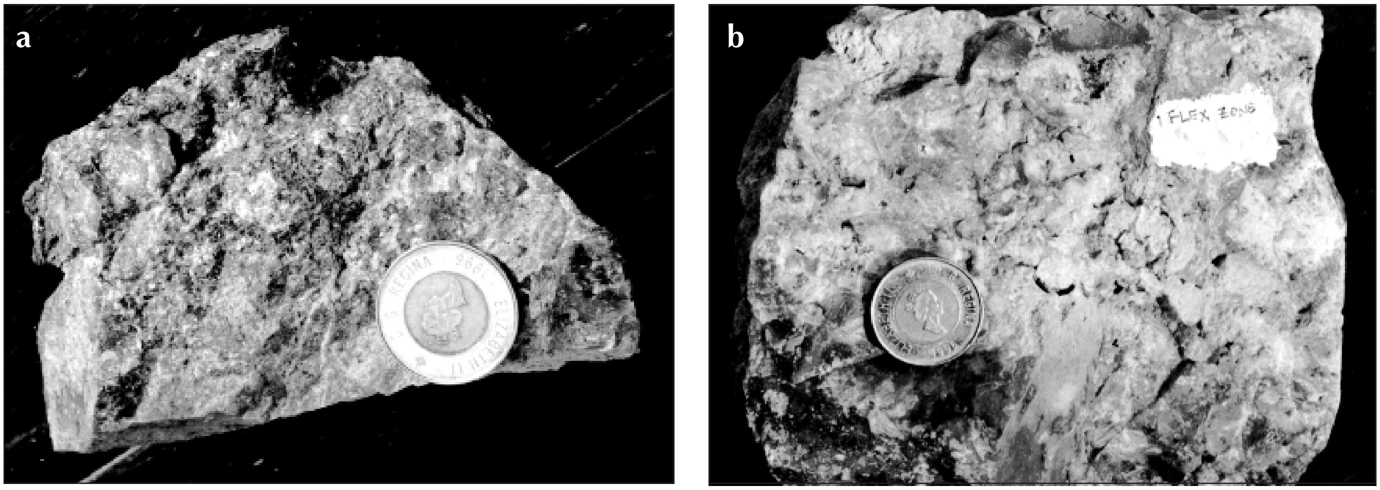

Figure 5. a) *Fine-grained quartz-sulphide from the Main vein near section 5+00 N. Dark patches are sulphide-rich.* ***b)*** *Quartz-sulphide breccia from Footwall vein near section 3+00 N. Two-dollar coin for scale is 2.8 cm across. Light areas are quartz, medium grey areas are orange oxide-stained quartz, and dark grey areas are rich in sulphide minerals.*

CONCLUSIONS

Overburden stripping and geological mapping of the Flex gold-silver vein deposit has revised the distribution and nature of the mineralized veins. The veins were previously modelled as continuous northwest-trending and moderately dipping veins. The stripping revealed that the veins trend north-northwest, dip steeply to the west, and have been offset by cross-cutting northeast trending faults with left-lateral movements of up to 26 metres.

The information derived from the detailed mapping and sampling will lead to a new geological model for the Flex Deposit, with implications for future exploration and development, as well as other areas of the surrounding Mount Nansen property.

ACKNOWLEGEMENTS

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TAD – an unusual porphyry occurrence in the Dawson Range, Yukon

Craig J.R. Hart
Yukon Geology Program, Box 2703 (F-3)
Whitehorse, Yukon, Y1A 2C6, e-mail: craig.hart@gov.yk.ca

Hart, C.J.R., 1998. Tad – an unusual porphyry occurrence in the Dawson Range, Yukon. *In:* Yukon Exploration and Geology 1997; Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p.145-151.

ABSTRACT

The Tad mineral showing is an unusual porphyry-style occurrence in west-central Yukon as it contains zinc as its primary metal. This is unlike the majority of porphyry deposits in the Dawson Range which contain copper and some combination of molybdenum and gold. The Tad occurrence is hosted in a 2 km wide plug that is composed of a crowded plagioclase-quartz-biotite porphyry. A radiometric survey over the Tad property indicates that it has a large area with a low Th/K ratio. This signature is similar to, although larger and slightly less intense than, the Casino copper-molybdenum-gold deposit. The Tad property also contains supergene oxide gold mineralization, and molybdenum mineralization is hosted in the adjacent quartz monzonite country rocks.

RÉSUMÉ

La venue minérale de Tad est atypique parmi les occurrences de type porphyrique du centre-ouest du Yukon en ce qu'elle renferme du zinc comme métal principal. La plupart des gisements porphyriques du chaînon Dawson contiennent en effet du cuivre et, en quantités moindres, du molybdène et/ou de l'or. L'occurrence de Tad est incluse dans un culot crétacé atteignant 2 km de largeur. Ce culot est composé d'un porphyre encombré à plagioclase-quartz-biotite. Un levé radiométrique du porphyre de Tad indique la présence d'une zone étendue caractérisée par un faible rapport Th/K. Cette signature est semblable à celle du gisement de cuivre-molybdène-or de Casino, mais plus étendue et légèrement moins intense. Le gisement de Tad renferme également des minéralisations aurifères d'oxydes supergènes; des minéralisations de molybdène sont incluses dans les roches encaissantes adjacentes de monzonite quartzique.

INTRODUCTION

Since the late 1960s, numerous copper-molybdenum-gold porphyry deposits and occurrences have been discovered in the Dawson Range of west-central Yukon. The majority of these occurrences have copper and some combination of molybdenum and gold as their chief commodities. Most of these deposits occur along a northwest-trending linear belt that forms the Dawson Range mineral belt (Fig. 1). The largest deposit is the Casino copper-molybdenum-gold porphyry (675 million tonnes of 0.25% Cu, 0.02% Mo, 0.48g/t Au; Yukon Minefile 115J 028).

The TAD occurrence (Yukon Minfile115I 031) is an unusual porphyry occurrence as it has zinc as its principal metal, although it has an associated molybdenum zone. In addition, this property has potential for a bulk-tonnage, low-grade oxide gold deposit. The nearby Phelps occurrence hosts copper mineralization.

Much of the Dawson Range lay beyond the limit of continental glaciation. As a result a thick regolith has developed over millions of years leaving little outcrop. To assist mineral exploration efforts approximately 9000 line-kilometres of airborne gamma-ray and magnetics survey (AGMS) was flown (Geological Survey of Canada 1994a,b, 1995a,b,c). These surveys provide a quantifiable indication of rock types and alteration and are particularly useful in unglaciated regions where the surface material (colluvium) approximates the underlying bedrock (i.e., a veneer of glacial drift is absent). These data will improve geological maps in the region (e.g., Johnston and Shives, 1995). In addition, the survey results provide useful exploration tools. The geophysical signature of the Tad property is evaluated in this paper.

LOCATION

The Tad property (62°33'35"N, 137°55'15"W) is located approximately 100 kilometres northwest of the village of Carmacks in the central Dawson Range (Fig. 1) in NTS map area 115I/12. The property is accessible by helicopter from Carmacks. The Casino Trail, a winter tote trail that passes the property, continues west from the end of the upgraded portion of the road near the Cash property. The two airstrips on the property would require upgrading before use, however, the airstrips at Minto and Revenue provide road-accessible staging areas.

GEOLOGY

The regional geology of this portion of the Dawson Range is described by Johnston and Hachey (1993). The region is dominated by metamorphic rocks of the Yukon-Tanana Terrane which are intruded by batholiths of Early Jurassic and mid-

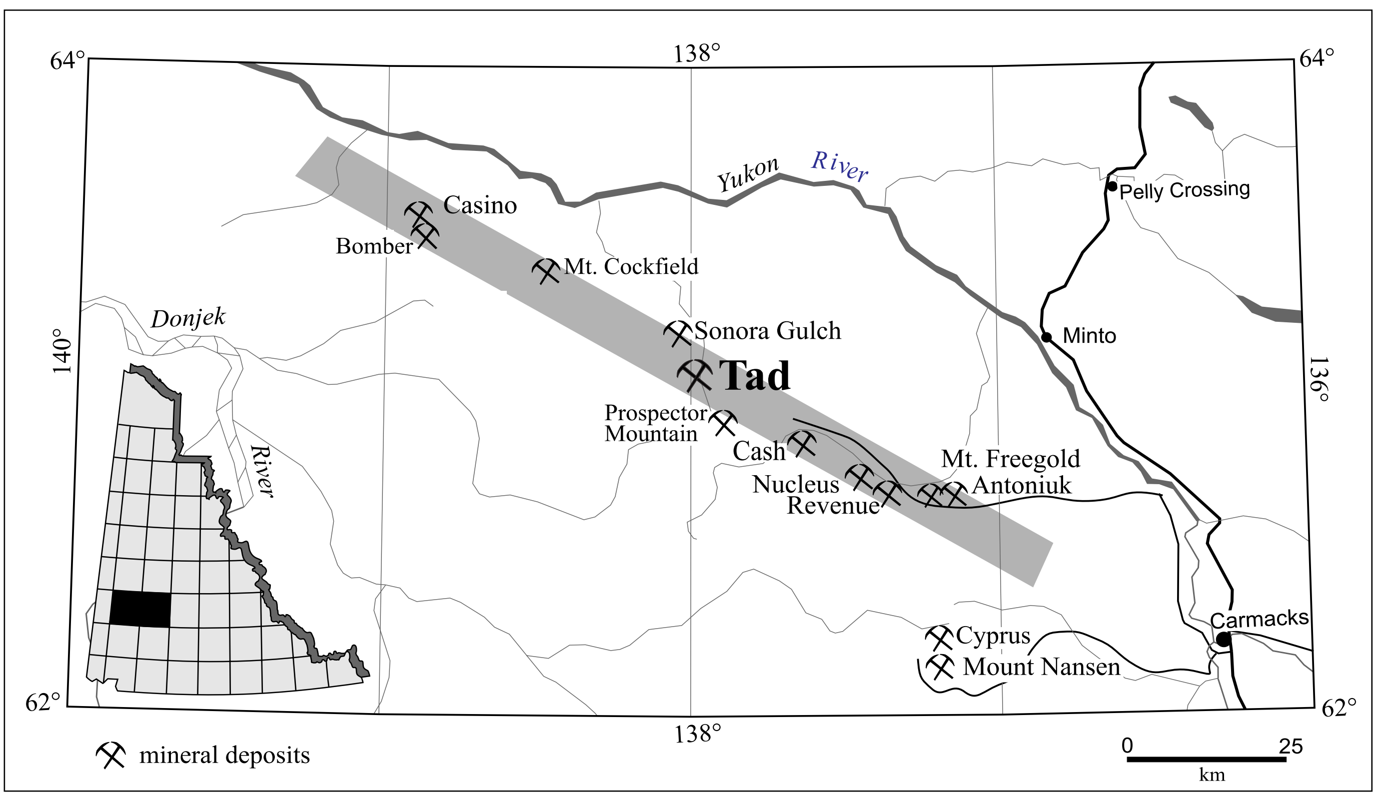

Figure 1. *Location of Tad occurrence within the Dawson Range mineral belt (shaded).*

Cretaceous age. Caulderas of mid-Cretaceous Mount Nansen Group fragmental andesite occur in the eastern part of the Range. The Late Cretaceous Carmacks Group comprise extensive sheets of shoshonitic basalt that locally occur as considerable thickness of stacked flows. Associated intrusive rocks are limited to a few small felsic plugs.

Like most of the porphyry occurrences of the Dawson Range, the Tad porphyry is located immediately southwest of the Big Creek Fault — a prominent structural feature that appears to control the distribution of mineralization in the Dawson Range. A second, north-trending fault is thought to exist beneath the Hayes Creek valley. At least four small northeast-trending faults have been recognized cutting the Tad porphyry.

The geology of the Tad area is apparently simple — although this is based upon the sparse outcrop exposure (Fig. 2). The Tad property is centered on a felsic porphyry stock which is approximately 3 by 2 km and intrudes coarse-grained, pink quartz monzonite that hosts pendants of Yukon-Tanana Terrane metamorphic rocks. The intrusive relationships were observed in drill core (DDH T-10).

The Tad porphyry is composed of a leucocratic, crowded quartz-feldspar-biotite porphyry. Quartz forms clear phenocrysts up to 8 mm in diameter that comprise approximately 20% of the rock. Feldspar forms smaller (2-6 mm), yellowish, euhedral phenocrysts which occupy up to 50% of the rock. Biotite, also euhedral, is smaller and sparser, occupying only 5%. The fine-grained light blue-grey matrix comprises approximately 25% of the rock volume. The porphyry has a granitic or quartz monzonitic composition. Most samples also contain up to 5% disseminated pyrite. Near-surface samples of the Tad porphyry are variably oxidized with limonite staining and dark brown feldspars (Fig. 3).

The quartz monzonite is composed of approximately 30% quartz and 60% alkali feldspar with variable amounts of plagioclase and up to 15% muscovite. It is possible that muscovite is a late alteration mineral as it occurs as replacements, blebs and in quartz veinlets.

The ages of the intrusive rocks are not precisely known. The quartz monzonite is thought to be a late stage intrusive phase associated with the mid-Cretaceous Dawson Range Batholith and is therefore approximately 105 Ma. The Tad porphyry may be a still later phase of the Dawson Range Batholith, or may be a Late Cretaceous (*circa* 70 Ma) intrusion associated with the Prospector Mountain Plutonic Suite (Johnston, 1995).

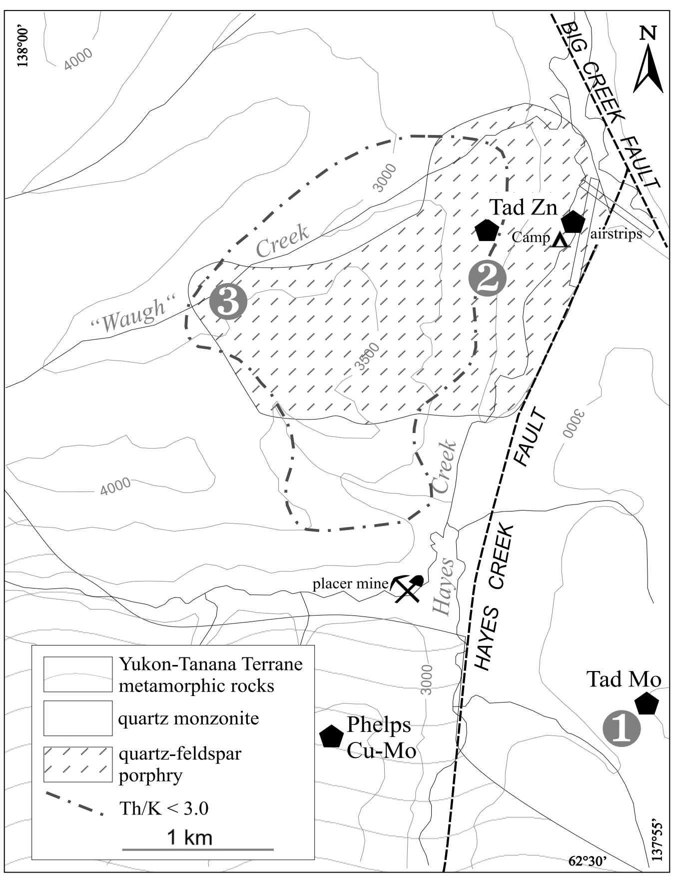

Figure 2. *General geology of the Tad occurrence. Numbers represent anomalous zones from 1970 soil sampling.*

EXPLORATION HISTORY AND RESULTS

Several old cabins built by prospectors around 1898 were noted along Hayes Creek by Bostock (1936). One of these cabins is on the Tad property, near the present site of the exploration camp. It was during this time that placer gold was likely discovered. There have been several modern-day exploration and mining efforts for placer gold in the region.

The TAD mineral occurrence was discovered in 1969 as part of a regional exploration project by International Mine Services (Waugh, 1970). Disseminated sphalerite was recognized in phyllic-altered feldspar porphyry in a gossanous outcrop

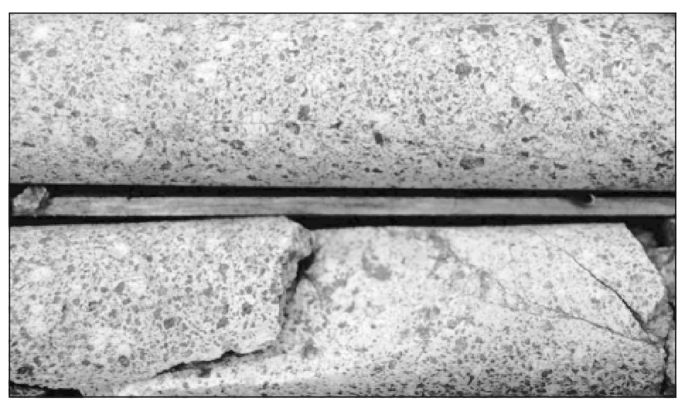

Figure 3. *Diamond drill core (NQ-size) of the Tad porphyry from the oxide zone. Light-coloured phenocrysts are quartz and alkali feldspar; dark specks are altered plagioclase.*

exposed in Hayes Creek. Subsequent soil sampling, trenching and geophysical (mag and IP) surveys were undertaken. Three geochemically anomalous zones were identified: 1) irregular molybdenum values with weak copper values extends two kilometres along a ridge east of Hayes Creek; 2) a broad 1.5 km long Zn-Pb in soil anomaly with coincident IP chargability high and magnetic highs, west of Hayes Creek; and 3) a two kilometre-long Zn-Pb soil anomaly on the southwestern side of the property near "Waugh Creek." All zones were subsequently trenched, and are hereafter referred to by the numbers above.

Mineralization in the anomalous zones was tested with a total of 2708 metres of NQ core drilled in 18 holes during the winter of 1969-70. Most of the holes were sited in the zinc zones, and were drilled to depths of 191 metres; five holes targeted the molybdenum zone and were drilled to depths of 229 metres. Molybdenum mineralization was discovered in hole T-9 in Zone 1.

The best grades from Zone 2 included a 5.6 m section of well mineralized brecciated porphyry that gave 1.83% Zn, 0.36% Cu, 0.04% Cd, 0.04 opt Au and 0.69 opt Ag (DDH T-2), and a 1.5 m wide intersection that gave 1.28% Zn, 0.06% Pb, 0.1 opt Ag (DDH T-12).

In 1986, Noranda undertook a sampling program of on-site drill core from 10 drill holes to assess the oxide gold potential of the property (Hart, 1986). One hundred and fourteen samples, representative of core lengths between 1.2 and 5.0 metres were analysed. Intervals with up to 2080 ppb Au with 7.4 g/t Ag (DDH T-14) were determined. A selected sample gave a result of 3100 ppb Au, 20 ppm Ag and 2.68% Zn over 0.5 metres. Encouraging values were found in three of the holes:

T-2 0.51 g/t Au over 37.0 m (incl. 1.0 g/t Au over 8.2 m);

T-12 1.23 g/t Au over 4.9 m

T-14 1.68 g/t Au over 7.0 m

The highest gold values were found to be coincident with rocks revealing the most intense oxidation, brecciation and alteration. They are easily recognized by abundant limonite or manganese staining. Richest gold values occur at three-quarters the depth from the surface to the base of oxide zone (typically 43-60 m); deeper oxide horizons (75 m) tend to have lower values. Gold grades beneath the base of the oxide horizon, intersected at elevations between 734 and 797 m (2422 and 2613 feet above sea level), were rarely above 100 ppb. The results are therefore considered to relate to a gold-enriched supergene oxide zone.

Samples from one hole were also analysed for base and associated metals. Gold values correlate well with arsenic; As values are 10 x Au if Au>100 ppb. Arsenic also positively correlates with silver but negatively with zinc. Background hypogene gold, silver and zinc values in the Tad porphyry are about 50 ppb, 2.0 ppm and 500 ppm, respectively.

Figure 4. *View southwesterly over the Tad property, showing the location of the gold-in-soil geochemical anomaly identified by Noranda in 1987. This anomaly likely represents the intersection of supergene gold horizon with the present erosion surface.*

These results encouraged Noranda to undertake a soil sampling program in 1986. The 150 samples that they collected yielded values up to 250 ppb Au, 12 ppm Ag and 900 ppm As in three regions. This survey was followed up in 1987 with a new grid which targeted the anomalous regions. Grid lines were ripped with a bulldozer and followed-up with 213 soil samples, and 64 rock samples. The new samples provided higher gold values (up to 815 ppb) and more complete sample coverage on permafrost-covered north slopes. Gold-in-soil anomalies formed a 950 metre long, 100 m wide, northwest-trending region that parallels a weak break-in-slope of the hill that partly overlies the original zinc anomalies of zone 2 (Fig. 4).

Noranda also undertook a short four-hole diamond drill program. Although the original intent of the program was to explore for oxide gold potential, drill holes were sited on coincident gold-in-soil and IP anomalies. As a result, the Noranda drilling intersected moderately altered, but largely unoxidized, pyritiferous rock.

The property was subsequently optioned by Nicholson and Associates who undertook extensive soil sampling and analyses in 1996.

GAMMA RAYS

Porphyry copper deposits are typically associated with a gamma-ray response of elevated K and a low Th/K ratio. This typically represents potassic alteration in the core of the porphyry system.

The Tad porphyry stock does not appear as a distinct feature on most of the AGMS maps, perhaps due to the similar chemistry of the host quartz monzonite. However the Tad porphyry is distinct on the plot of Th/K ratio, indicated by a low ratio of approximately 3.00 to 3.5 over an irregularly-shaped 2.0 x 2.2 km region (Fig. 5b). This is similar to the Casino porphyry which has values of 3.5 to 2.5 over an elliptical region of 1.7 x 1.2 km. Unlike the Casino porphyry which yields K values in the range of 3-3.5%, the Tad porphyry typically gives values of 1.4-1.6%. Actual values are probably higher (geochemical analyses are forthcoming) because the Tad porphyry is poorly exposed and largely covered by forested moss and underlain by permafrost. (In 1994 a forest fire swept through the region underlain by the Tad porphyry and resulted in the melting of the permafrost.) The Casino occurrence yields very high K values due to its position above tree line and greater rock exposure created by extensive trenching, as well as potassic alteration. Thorium values at both porphyries approximate 4.6 to 5.0 ppm.

MINERALIZATION

Mineral showings in the area include the Tad zinc-gold occurrence, the Tad molybdenum occurrence and the Phelps copper occurrence. In the Tad zinc-gold occurrence, pyrite is the most common and abundant sulphide mineral and occurs in veinlets, disseminations and fracture coatings. Sphalerite is coarse-grained (up to 3 mm), crystalline and dark brown. It occurs as disseminations in altered portions of the Tad porphyry and as part of the matrix of breccias developed within the porphyry. A petrographic report (Boorman et al., 1970) noted that marcasite and lesser amounts of pyrrhotite, chalcopyrite, galena, arsenopyrite and bournanite? are also associated with the mineralized zones. Magnetite rimmed by hematite was a common feature in the oxide zones.

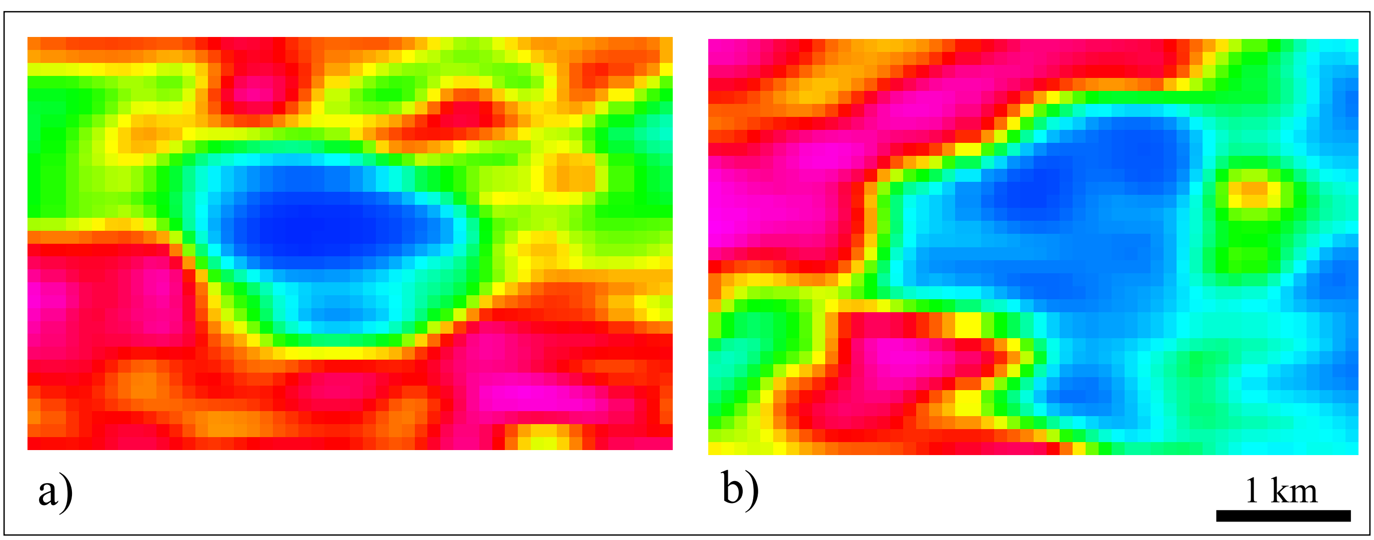

Figure 5. *Detail from the Th/K ratio geophysical survey (Geological Survey of Canada, 1994a,b), centered upon the a) Casino and b) Tad porphyry occurrences. Darker regions in the centre of the figures represent lower ratios. The Casino occurrence yields an elliptical doughnut-shaped anomaly. The Tad Zn occurrence yields a slightly irregular-shaped anomaly that coincides with the Tad porphyry (see Fig. 2).*

Tad molybdenum occurrence is hosted in quartz veins that cut the coarse-grained quartz monzonite and less often occurs as disseminations in the quartz monzonite. The quartz monzonite locally contains zones of coarse-grained muscovite. Much of the drill core from the molybdenum zone is extensively phyllic-altered, with chlorite, epidote and lesser illite on fracture surfaces. The molybdenum occurrence is not spatially, nor likely genetically related to mineralization within the Tad porphyry due largely to different host rocks and the distance between them.

The Phelps occurrence, located 5 km south of the Tad, contains bornite and chalcopyrite in quartz stringers with minor disseminated chalcopyrite.

DISCUSSION

The Tad porphyry is unique in that it has zinc as its primary ore metal and not copper. Although sphalerite was recognized as occurring in approximately 12% of Cordilleran porphyry deposits (Pilcher and McDougall, 1976), it is primarily associated with copper porphyry deposits. Sphalerite, galena and pyrrhotite all typically occur peripheral to the pyrite shell of typical porphyry copper deposits (Guilbert and Lowell, 1974; Drummond and Godwin, 1976). As such, targeting copper mineralization may be possible by recognizing a geometry of the zinc zones with respect to the IP anomalies which typically define the pyrite shell. The Tad molybdenum zone does not appear to be related to the Tad porphyry or the zinc mineralization.

Arsenic in soil anomalies are unusual in typical porphyry copper deposits. Arsenopyrite is recognized in only 3% of Cordilleran deposits (Pilcher and McDougall, 1976). However, arsenopyite and significant arsenic-in-soil anomalies have been recognized at several porphyry-style mineral occurrences in the Dawson Range (e.g., Antoniuk; Hart and Jober, 1997).

A supergene gold deposit may exist at Tad. Noranda’s diamond drill holes were collared at low topographic levels where erosion had already excavated through the supergene zone and exposed the topographically lower hypogene (unoxidized) zone. Attempts to define a supergene gold zone should be initiated higher, in the oxide realm. Although the base of the oxide horizon is undulatory, it appears to approximate the 760 m (2500') contour. Previous drilling and soil sampling suggests that the base of the supergene zone is exposed at the present erosional surface at approximately 745 m (2450') elevation.

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Geology, alteration, and mineralization of the Sato porphyry copper prospect, southwestern Yukon

Jeff Lewis[1,2] and Jim Mortensen[1]

[1] Department of Earth and Ocean Sciences, University of British Columbia, 6339 Stores Rd., Vancouver, B.C. V6T 1Z4, e-mail: jmortens@eos.ubc.ca

[2] Presently at: Homestake Canada Inc., 1000-700 West Pender St., Vancouver, B.C. V6C 1G8

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Abstract

The Sato prospect is located between Aishihik Lake and Long Lake in southwestern Yukon Territory. Low grade porphyry-style copper mineralization was discovered on the property in 1969. The main country rock in the study area is a potassium feldspar megacrystic granite that is correlated with the Early Jurassic Aishihik and/or Long Lake plutonic suite. Mineralization on the property is hosted by a multiphase intrusive complex that is thought to represent a high level intrusive member of the Late Cretaceous Mount Creedon volcanic suite. The complex consists of three distinct phases, medium-grained diorite; coarse-grained diorite; and porphyritic quartz monzodiorite. U-Pb zircon dating of the medium-grained diorite and porphyritic quartz monzodiorite phases gives ages of 78.2 ± 0.1 Ma and 78.8 ± 0.2 Ma, respectively, which supports the correlation with the Mount Creedon Volcanic Suite.

Four alteration zones are recognized on the property. Alteration is mainly developed in the medium-grained diorite and quartz monzodiorite phases. In order of decreasing intensity, these zones include potassic, phyllic, albitic, and propylitic. Copper mineralization consists of chalcopyrite, which occurs as a replacement of earlier-formed magnetite in the potassic and phyllic zones, and malachite which occurs on weathered fracture surfaces.

Alteration and mineralization on the property are thought to be related either to fluids evolved during the latest stages of crystallization of the main phase diorite unit or from a buried, younger phase of the intrusive complex.

Résumé

La zone d'intérêt de Sato est située entre le lac Aishihik et le lac Long, dans le sud-ouest du Yukon. Une minéralisation cuprifère de type porphyrique à faible teneur a été découverte sur le terrain en 1969. La principale roche encaissante de la région prospectée est un granite mégacristallin à feldspath potassique associé à la suite plutonique d'Aishihik et/ou de Long Lake, qui date du début du Jurassique. La minéralisation sur le terrain est incluse dans un complexe intrusif polyphasé, vraisemblablement un membre intrusif de haut niveau de la suite volcanique de Mount Creedon, du Crétacé tardif. Le complexe comprend trois phases distinctes : une diorite à grain moyen, une diorite à grain grossier et une monzodiorite quartzique porphyrique. La datation à l'U-Pb de zircons des phases à diorite à grain moyen et à monzodiorite quartzique porphyrique a fourni respectivement des âges de $78{,}2 \pm 0{,}1$ Ma et de $78{,}8 \pm 0{,}2$ Ma, ce qui corrobore la corrélation avec la suite volcanique de Mount Creedon.

On distingue quatre zones d'altération sur le terrain. L'altération est plus poussée dans les phases à diorite à grain moyen et à monzodiorite quartzique. Par ordre d'intensité décroissante, il s'agit des zones potassique, phylliteuse, albitique et propylitique. La minéralisation cuprifère se compose de chalcopyrite, qui se présente sous forme de remplacement d'une magnétite formée antérieurement dans les zones potassique et phylliteuse, et de malachite, présente sur les surfaces de cassures altérées.

On admet que les phénomènes d'altération et de minéralisation sur le terrain sont liés à une phase souterraine, tardive et de haut niveau du complexe intrusif.

INTRODUCTION

The Sato occurrence (Yukon Minfile 115H 021) is located in southeastern Yukon Territory, between Aishihik Lake and the northern tip of Long Lake (Fig. 1). The host rock is a multiphase, dioritic to quartz monzodioritic intrusive complex that is thought to be the intrusive equivalent of the Late Cretaceous Mount Creedon Volcanic Suite.

The property was discovered and initially explored as a porphyry copper-molybdenum prospect in 1968-1971. The high concentration of magnetite and the mafic composition of the rocks that host the mineralization suggested that the system might be gold-enriched. As the property had not previously been specifically assayed for gold, it was re-examined by Homestake Canada, Inc., during the summer of 1996 for possible gold potential. This paper is based on 1:2 000 and 1:500 scale geological mapping conducted by the senior author and H. Marsden of Homestake Canada during the 1996 field season, as well as petrographic, geochemical, and geochronological studies of samples from the property. A total of thirteen samples were analyzed for 30-element ICP, seven samples were analyzed for major and trace element geochemistry, two samples were dated by U-Pb zircon methods, and thirty-four thin and polished thin sections were examined. In this paper we provide a brief summary of the property geology, report new U-Pb zircon ages for two intrusions on the property, and describe the alteration and mineralization present.

LOCATION AND ACCESS

The property is situated halfway between the villages of Carmacks to the north-northeast and Haines Junction to the south-southwest (Fig. 1). It is located at 61° 29' N and 136° 45' E (UTM Zone 8, 40800E 6817150N) in the Hopkins Lake map area (115H/7). Access to the property is by helicopter from Carmacks or Haines Junction, each about 75 km distant. The Aishihik Road extends to within 15 kilometres of the property.

Exposure in the region is generally less than one percent, and is mainly restricted to ridge tops. Exposure is slightly better on the property, however, and includes abundant local felsenmeer and partially collapsed exploration trenches.

PREVIOUS WORK

Cockfield (1927) carried out reconnaissance-scale mapping in the area immediately south of Long Lake and between Aishihik and Sekulmun lakes to the west. Tempelman-Kluit (1973) conducted a more comprehensive study of the area, including 1:250 000 scale mapping of the 115A, 115F, 115G, 115H, and 115K map sheets. Limited age constraints and poor exposure made regional correlation of units very speculative. Subsequent work in the region focussed on the area immediately surrounding Aishihik Lake (Gordey, 1973; Morin, 1981). S.T. Johnston mapped several 1:50 000 map sheets in the Aishihik Lake map area between 1988 and 1993. His work specifically studied the nature of the Aishihik Batholith in this region (e.g., Johnston et al., 1996). The most recent mapping in the area was carried out by Johnston and Timmerman (1993), who produced revised geological maps and a geological synthesis for the 115H/6 and 115H/7 map sheets.

Only limited work has been done on the Sato property itself. The property was first staked as the KL claims in August, 1969, by the Mitsubishi Metal Mining Co., Ltd., to cover a large soil geochemical anomaly. Geological mapping and geochemical sampling in 1970 produced encouraging copper assays, and subsequent geophysical surveys outlined a large magnetic anomaly on the property. During 1971, a total of eight trenches were dug and seven diamond drill holes, totaling 790 m, were completed (Kikuchi, 1970; Cathro, 1971; Norgaard, 1971). The

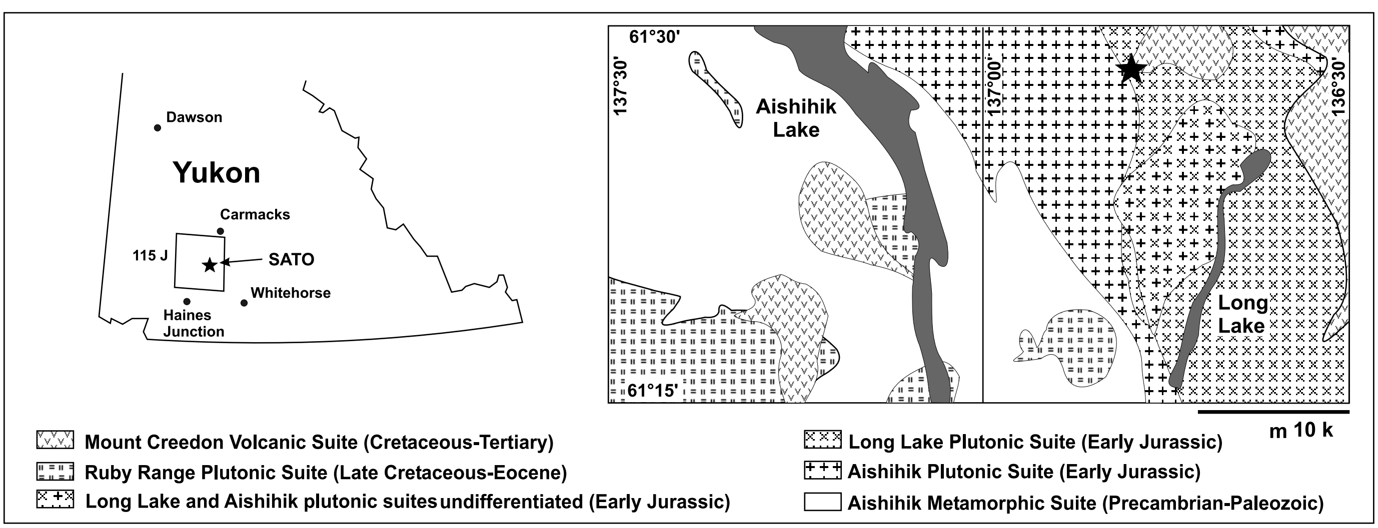

Figure 1. *Location and generalized geologic map of the Aishihik and Hopkins Lake map areas (modified from Johnston and Timmerman, 1993).*

results were generally negative, with copper grades in the 0.1% to 0.2% range, and molybdenum grades mainly at or below detection limits. The property was inactive until 1989, when Golden Quail Resources Ltd. restaked the property as the NICK claims. They performed an airborne geophysical survey in the spring of 1990, and ground VLF magnetic surveys, geochemical work, and geological mapping later in the season. They reported highly anomalous pan concentrates of gold, platinum, and palladium, but the overall results were not sufficiently encouraging enough to warrant further work at that time.

REGIONAL GEOLOGY

A simplified geological map of the 115H/6 (Aishihik Lake) and 115H/7 (Hopkins Lake) map sheets is shown in Figure 1. Johnston and Timmerman (1993) divided the area into five distinct lithotectonic suites. The *Aishihik Metamorphic Suite* comprises penetratively deformed and metamorphosed sedimentary and igneous rocks, and is broadly divided into two sub-suites; a feldspathic quartz-mica-schist lower package, and a black quartzite-marble-metaigneous upper package.

The metamorphic rocks have been intruded by four distinct intrusive suites. The *Aishihik Plutonic Suite* forms the Aishihik Batholith in this area, and consists predominantly of granodiorite with less abundant quartz monzonite and quartz diorite. The rock is generally coarse-grained and equigranular; however large megacrysts of pink potassium feldspar are commonly present. The Aishihik Suite typically displays a weak to stong foliation that is thought to have formed during magmatic emplacement (Johnston, 1993; Johnston and Erdmer, 1994). Johnston et al. (1996) report U-Pb zircon and titanite ages of 186 ± 2.8 Ma for the Aishihik Batholith.

The *Long Lake Plutonic Suite* consists of equigranular to locally porphyritic, leucocratic quartz monzonite and granite plutons that intrude rocks of the Aishihik Suite. Long Lake plutons only locally contain a foliation, and in many areas are clearly intrusive into the Aishihik Plutonic Suite. The Long Lake Suite has given a U-Pb zircon age of 185.6 +2.0/-2.4 Ma (Johnston et al., 1996).

The *Ruby Range Plutonic Suite* comprises the Ruby Range Batholith, a large granodiorite plutonic body that is mainly centered south of the Aishihik Lake map area, as well as several relatively small plutons located north of the batholith. Overall compositions range from granodiorite to less abundant monzonite and diorite. Plutons of the Ruby Range Suite intrude the Aishihik Metamorphic Suite in the westernmost part of the area, but there are no known contacts with either the Aishihik or Long Lake plutonic suites. Recent U-Pb zircon dating on the various members of this suite have given ages between ~78 Ma and 58 Ma (Johnston, 1993).

The *Mount Creedon Volcanic Suite* includes a variety of high level intrusive rocks and their volcanic equivalents. The suite is widespread in the Aishihik Lake area and the extrusive components typically unconformably overlie all of the previously mentioned rock units. The Mount Creedon Suite includes a wide range of compositions and rock types, making regional correlation of rock units difficult. Tempelman-Kluit (1974) was the first to describe these units in detail. He broadly separated the volcanic rocks west of Aishihik Lake from those that occur to the east and north of Long Lake, but considered both groups of rocks to be Eocene or younger in age. He correlated the "west Aishihik Lake rocks" with alaskitic intrusives found in the Sekulmun Lake area, and suggested their correlation with the Mount Nansen Group. Volcanic rocks east and north of Long Lake rocks were correlated with the Carmacks Group. The Mount Creedon Volcanic Suite is currently considered to be mainly Late Cretaceous to possibly Eocene in age, based on geological mapping and regional isotopic dating studies (Johnston and Timmerman, 1993).

PROPERTY GEOLOGY

The geology of the Sato property is shown in Figure 2. The immediate area of the property is underlain by two of the rock

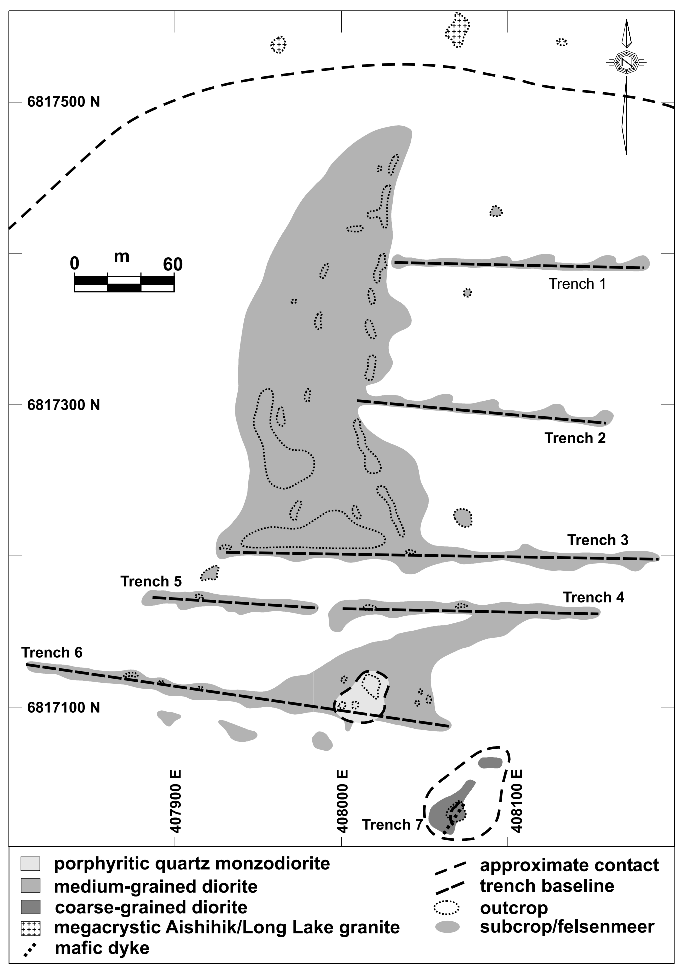

Figure 2. *Geologic map of the Sato property.*

suites described above. Megacrystic granite makes up much of the country rock. This is intruded by a multiphase intrusion that forms the main host to mineralization. Andesitic volcanic rocks crop out at several localities in the vicinity of the property.

K-spar megacrystic granite is the dominant country rock on and around the property. It is unclear whether this unit belongs to the Aishihik or Long Lake plutonic suite. In hand specimen, the rock is characteristically weathered to a pinkish-orange colour due to the abundance of potassium feldspar megacrysts, which are lath-shaped and up to 4 cm long. The other main minerals present include coarse, anhedral quartz grains, and coarse plagioclase laths. Biotite is rare and appears to be the only mafic mineral present. A weak foliation is visible, mainly defined by a preferred orientation of the potassium feldspar megacrysts. Seen in thin section the feldspars are partially altered to sericite, and there are small amounts of hematite and various other opaque minerals present. Johnston and Timmerman (1993) mapped the megacrystic granitic in the area of the property as Aishihik Plutonic Suite; however some of these characteristics of the unit suggest a closer resemblance to the Long Lake Suite.

The intrusive complex that hosts mineralization on the property can be divided into three sub-units; medium-grained diorite, a coarser-grained variety of the diorite, and a more felsic, porphyritic quartz monzodiorite unit. The main phase of the intrusive is a greenish-grey, medium-grained, variably altered rock of dioritic composition that intrudes the K-spar megacrystic granite. Vesicular andesite, which occurs in the vicinity of the property, has been included in the Mount Creedon Volcanic Suite by Johnston and Timmerman (1993). Although these authors do not include intrusive rocks in the Mount Creedon Suite, the diorite is thought to be the intrusive equivalent of the andesite. The surface exposure of the intrusive complex is roughly oval in plan view, and covers an area of approximately 2 km^2. Where relatively unaltered, the diorite is greenish-grey in colour, and is very slightly magnetic. The unit consists mainly of saussuritized plagioclase (70%), mafic minerals (25%), including biotite, hornblende, clinopyroxene and epidote, and minor interstitial quartz and orthoclase. The remaining 5% of the rock consists of opaques, most of which is magnetite, with lesser pyrite and chalcopyrite. An alignment of the plagioclase grains is commonly visible in thin section.

Coarse-grained diorite is exposed only in Trench 7 (see Fig. 2 for trench locations), with a mapped surface area of about 400 m^2. Contacts with the main diorite phase are not exposed, however this unit is geochemically and mineralogically somewhat distinct from the main diorite, and appears to represent a separate intrusive phase. In hand sample, the coarse-grained diorite phase is dark greenish grey, and highly magnetic. The rock consists mainly of light to dark green altered plagioclase laths (55%), together with strongly altered clinopyroxene and hornblende (40%). The remainder of the rock consists of interstitial orthoclase and opaque minerals, including magnetite, pyrite, and lesser amounts of chalcopyrite and hematite.

Porphyritic quartz monzodiorite underlies an area of about 300 m^2, and is wholly contained within the main phase diorite. This is the most felsic and porphyritic phase present in the intrusive complex, and also hosts a significant amount of the copper mineralization. The typical whitish weathering character of this unit is mainly due to sericitic and clay alteration. This unit was not recognized as a separate phase during field mapping, but rather was thought to be represent a strong phyllic alteration overprint on the main phase diorite. Plagioclase occurs as a phenocryst phase and comprises 60% of the rock by volume. Quartz (15%) and orthoclase (10%) occur both as phenocrysts and as interstitial phases. The only mafic minerals present are biotite (up to 5%) and epidote (3-5%), both of which appear to be secondary minerals. Opaque minerals (5%) include abundant chalcopyrite, pyrite, and magnetite. This phase also contains both titanite and zircon as accessory minerals.

Two distinct compositions of dykes occur on the property. A 1.5 m wide, strongly altered plagioclase- and pyroxene(?)-phyric mafic dyke intrudes the coarse-grained diorite phase in Trench 7 (Fig. 2). Several thin (<1 m wide) quartz-feldspar porphyry dykes also intrude the K-spar megacrystic granite.

GEOCHRONOLOGY

A U-Pb dating study of the intrusive phases in the area of the Sato property was undertaken in order to constrain the timing of magmatism and mineralization. Zircons were separated from two samples, the main phase diorite and the porphyritic quartz monzondiorite. Analytical methods are as described by Mortensen et al. (1995). Analytical data is given in Table 1 and the results are shown graphically in Figure 3. Errors are given at the 2σ level.

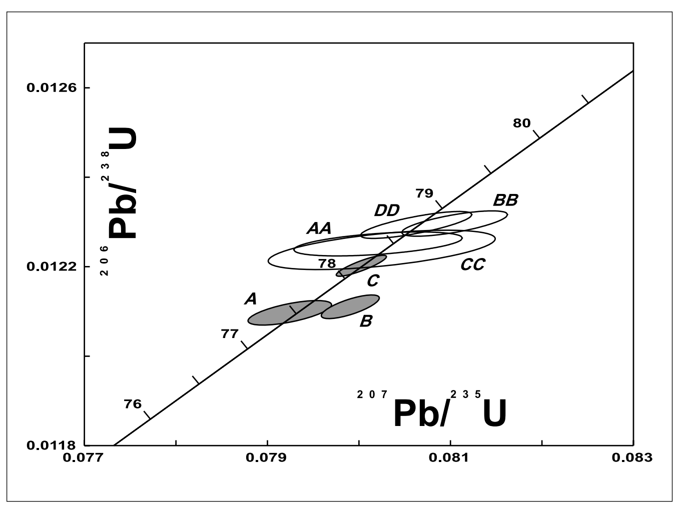

Figure 3. *U-Pb concordia diagrams. Shaded ellipses are analyses from the medium-grained diorite phase and the open ellipses are analyses from the porphyritic quartz monzodiorite.*

The diorite sample consisted of approximately 25 kg of relatively unaltered material. Three fractions of strongly abraded zircon were analyzed. Two of the fractions give concordant analyses; with $^{206}Pb/^{238}U$ ages of 77.6 ± 0.3 Ma and 78.2 ± 0.1 Ma. The third fraction (B) falls slightly to the right of concordia, indicating the presence of a minor inherited zircon component. The spread in $^{206}Pb/^{238}U$ ages is thought to result from minor post-crystallization Pb-loss from fraction A, and best estimate for the crystallization age of the rock is therefore given by the $^{206}Pb/^{238}U$ age of fraction C, at 78.2 ± 0.1 Ma. The porphyritic quartz-monzodiorite sample consisted of a single, fist-sized sample weighing approximately 1 kg. Four fractions of strongly abraded zircon were analysed. All four analyses are concordant or nearly so, and the best estimate for the crystallization age of the rock is given by the $^{206}Pb/^{238}U$ ages of fractions BB and DD, at 78.8 ± 0.2 Ma.

The new U-Pb age data indicates that both phases are Late Cretaceous in age, and supports a correlation with the Mount Creedon Volcanic Suite. It had been expected that the porphyritic phase, being somewhat more felsic and differentiated, would be the younger of the two units dated. Although the two ages are similar, the data indicates that the porphyritic phase is actually slightly older than the main phase diorite. The porphyritic unit is now interpreted to be a slightly earlier phase of the intrusive complex that was entrained as a raft within the main phase diorite as it was being emplaced.

ALTERATION

Four distinct alteration zones have been distinguished on the Sato property (Fig. 4), including potassic, phyllic, albitic, and propylitic. Scarcity of outcrop hampers detailed mapping of the extent of, and possible overprinting relationships between, the different alteration facies.

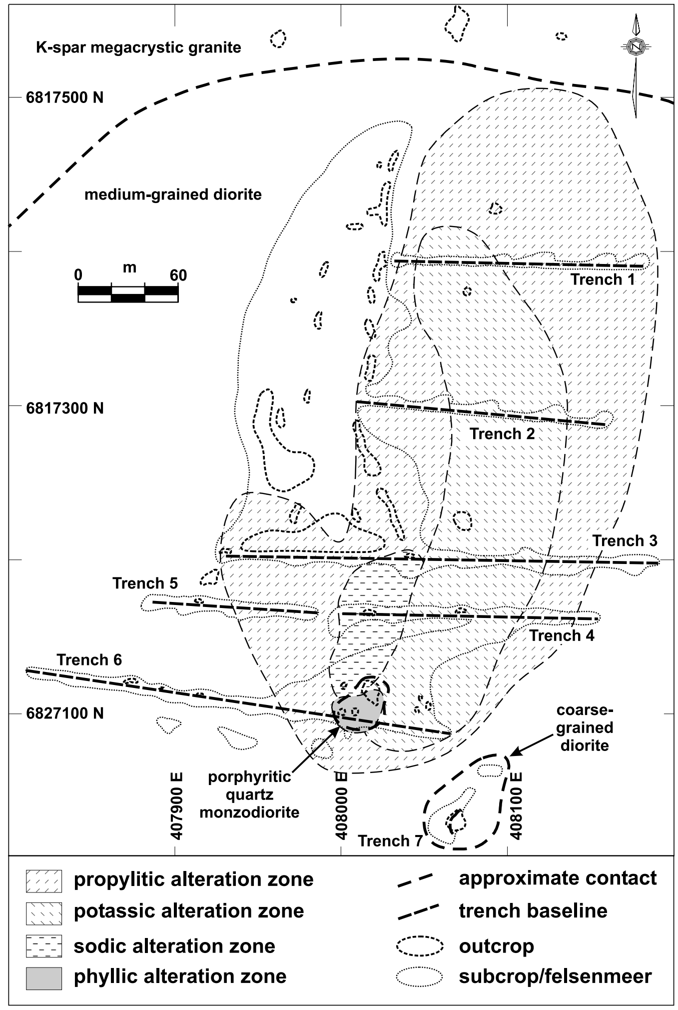

Figure 4. *Alteration zones on the Sato property.*

Description[1]	Wt (mg)	U (ppm)	Pb[2] (ppm)	$^{206}Pb/^{204}Pb$ (meas.)[3]	total common Pb (pg)	% ^{208}Pb[2]	$^{206}Pb/^{238}U$[4] (±% 1σ)	$^{207}Pb/^{235}U$[4] (±% 1σ)	$^{207}Pb/^{206}Pb$[4] (±% 1σ)	$^{206}Pb/^{238}U$ age (Ma, ±%2σ)	$^{207}Pb/^{206}Pb$ age (Ma, ±%2σ)
Sample DIO-UM (medium-grained diorite)											
A: N2,>105	0.092	1058	14.6	1436	51	20.8	0.01210(0.11)	0.07924(0.29)	0.04751(0.23)	77.5(0.2)	75.0(10.9)
B: N2,>105	0.030	797	10.9	2891	6	19.9	0.01211(0.11)	0.07992(0.20)	0.04786(0.13)	77.6(0.2)	92.3(6.2)
C: N2,>105	0.095	1173	16.4	3912	22	21.2	0.01220(0.09)	0.08003(0.18)	0.04760(0.10)	78.2(0.1)	77.9(4.8)
Sample DIO-PORP (porphyritic monzodiorite)											
AA: N2,>105	0.245	108	1.4	683	30	13.1	0.01225(0.11)	0.08021(0.57)	0.04749(0.53)	78.5(0.2)	73.7(25.2)
BB: N2,>105	0.082	136	1.7	770	11	13.0	0.01230(0.12)	0.08105(0.36)	0.04780(0.29)	78.8(0.2)	89.5(13.7)
CC: M2,>105	0.090	125	1.6	393	23	12.2	0.01224(0.18)	0.08028(0.78)	0.04759(0.70)	78.4(0.3)	78.7(33.1)
DD: M2,>105	0.153	150	1.9	648	28	12.8	0.01229(0.12)	0.08063(0.38)	0.04757(0.29)	78.8(0.2)	77.8(14.0)

Analyses done at the Geochronology Laboratory, University of British Columbia
[1] N2 = non-magnetic at one degree side slope on Frantz isodynamic magnetic separator; grain size given in microns
[2] radiogenic Pb; corrected for blank, initial common Pb, and spike
[3] corrected for spike and fractionation
[4] corrected for blank Pb and U, and common Pb.

Table 1. *U-Pb Analytical data*

Potassic alteration is the most intense and pervasive form of alteration on the property. It is best developed in Trench 6, but extends north-northeastward past Trench 1 (Fig. 4). In hand sample, alteration is characterized by an overall darkening of the diorite. This darkening is due to the formation of secondary biotite and the replacement of various primary mafic minerals by magnetite, making the rock strongly magnetic. The zone is also characterized by a suite of quartz and pink potassium feldspar (locally with graphic textures) veins up to 1 cm wide. These veins are themselves cut, and commonly offset, by thinner quartz and potassium feldspar veins that contain secondary biotite. In the areas around Trenches 1 and 2, potassium feldspar-magnetite-actinolite-epidote veins are also common.

Seen in thin section, the felted, feathery masses of secondary biotite occur as rims on corroded hornblende and primary biotite phenocrysts. Magnetite is seen replacing various mafic minerals, including biotite and hornblende. In portions of the potassic zone where the diorite appears to have been hydrothermally brecciated, microfractures are commonly healed by quartz and potassium feldspar veinlets.

Phyllic alteration is only developed within the porphyritic quartz monzodiorite unit in Trench 6. In hand sample, the phyllic zone is characterized by an overall bleaching of the entire rock, destruction of primary textures, as well as strong sericitization of feldspars, replacement of primary magnetite by pyrite, and alteration of early(?) secondary biotite to sericite and/or clay. Fine quartz veinlets are abundant throughout the unit.

Albitic alteration is the least pervasive form of alteration on the property. In hand sample, this alteration zone is characterized by an overall lightening in colour of the affected rock, and the formation of intense albitic envelopes around the microveinlets that are common in this zone. The albitized envelopes are bright white in colour and are up to an order of magnitude wider than the veinlets themselves. This form of alteration is seen only between Trenches 4 and 6 (Fig. 4). In thin section this style of alteration is distinguished by the presence of abundant fine laths of secondary albite, along with minor secondary biotite. Diorite within this zone has been hydrothermally micro-brecciated, and the thin veinlets and their albite envelopes are commonly truncated and displaced slightly by later veinlets. Breccia fragments have not been obviously rotated however, and many veinlets crosscut faulted veinlets, indicating the the veining and brecciation overlapped in time.

Propylitic alteration is the most widespread and least intense of the four recognized alteration facies on the property. It is characterized by the presence of significant amounts of chlorite and epidote, which impart a medium to dark green colour to the diorite in which it occurs. Magnetite is considerably more abundant in propylitic-altered diorite than in unaltered diorite. The "unaltered" diorite actually contains significant concentrations of secondary chlorite and epidote, and it was not until the differing magnetite content was noticed that a clear boundary for the propylitic alteration zone could be defined. The secondary magnetite occurs with chlorite as replacements of primary mafic minerals.

MINERALIZATION

Copper is the only commodity of potential economic interest on the Sato property, as gold and molybdenum are far below economic grades. The main copper minerals present are chalcopyrite, malachite and very rare native copper. Copper mineralization is concentrated in the potassic alteration zone, and to a lesser extent, in the albitic and phyllic zones. Chalcopyrite occurs in veinlets and as fine disseminations within the altered host intrusions. It appears to be intimately associated with pyrite and magnetite. Malachite commonly forms on weathered fracture surfaces, and is especially common in the potassic alteration zone closest to the quartz-monzodiorite porphyry, where the diorite has been hydrothermally brecciated. The malachite appears to be a secondary weathering product. Unlike the Casino porphyry copper deposit 175 km to the northwest, no significant supergene enrichment has been developed on the Sato property, although a trace amount of native copper of possible supergene origin was identified in float in Trench 6.

Examination of polished sections of mineralized samples shows a close relationship between magnetite, pyrite and chalcopyrite. Magnetite occurs as disseminations within all of the alteration facies on the property, and in the potassic, phyllic and albitic alteration zones it occurs both as disseminations and in veinlets. The disseminated magnetite forms as a replacement of mafic minerals such as hornblende and biotite. In the innermost three alteration zones (potassic, phyllic and albitic), disseminated and veinlet magnetite is commonly partially to wholly replaced by pyrite and/or chalcopyrite. The degree of replacement of magnetite by pyrite or chalcopyrite appears to be random, suggesting that the replacement mineralization was controlled by fluids movement along selected microfractures, rather than by wholesale infiltration of the rock.

There is a close relationship between copper grade and alteration facies. The potassic zone, on average, contains the highest copper grades, followed by the phyllic zone and albitic zones.

PROPOSED DEPOSIT MODEL

In the field-based model for copper mineralization on the Sato property, the porphyritic quartz-monzodiorite phase was thought to be the latest and most highly differentiated phase of the intrusive complex, and was considered to be the likely source of the fluids responsible for hydrothermal alteration and mineralization on the property. However the potassic alteration zone, which is typically the most intense and most centrally located within porphyry systems, is not spatially associated with the porphyritic intrusion, which experienced mainly phyllic alteration.

The new U-Pb age data indicate that the main phase diorite was emplaced slightly later than the porphyitic unit, and that the alteration and mineralization post-dates both units. The cause of the brecciation, alteration, and mineralization is therefore unresolved. The coarse-grained diorite unit and either of the two dyke units present on the property represent possible sources of the mineralizing fluids, but these units occur well away from the main area of alteration and mineralization. The mineralization may be related either to fluids evolved during the final stages of crystallization of the main phase diorite, or from a younger intrusive phase that is not exposed at the present level of erosion. The phyllic alteration seen mainly in the porphyritic quartz monzodiorite unit appears to simply result from the interaction between a more felsic rock composition and the mineralizing fluids.

DISCUSSION AND CONCLUSIONS

The Sato property is underlain by K-spar megacrystic granite of the Aishihik or Long Lake plutonic suite, which has been intruded by a multiphase intrusive complex that is the intrusive equivalent of the Late Cretaceous Mount Creedon Volcanic Suite. Porphyry copper-style mineralization is hosted within the Late Cretaceous intrusive complex and is thought to be related to the emplacement of a late phase of the complex.

The Late Cretaceous intrusive complex includes at least three separate phases. The main phase is a medium-grained diorite (U-Pb zircon age of 78.2 ± 0.1 Ma) which makes up approximately 95% of the surface area of the complex. A porphyritic quartz monzodiorite (U-Pb zircon age of 78.8 ± 0.2 Ma) is volumetrically minor, occurring only as one small outcrop in the middle of the property. The age data indicates that it is the oldest phase present and it appears to occur as a raft within the younger diorite. The third phase recognized is a coarse-grained diorite. Contact relationships between this and the two other phases of the intrusive complex are not exposed. Minor mafic and felsic dykes seen on the property may or may not be related to the complex.

Four alteration facies are recognized on the property. Potassic alteration is the most pervasive and intense style of hydrothermal alteration. It affects the main phase diorite and is characterized by the formation of secondary biotite at the expense of primary biotite and hornblende. Also characteristic of this zone are abundant quartz-potassium feldspar-biotite veins and veinlets that locally contain magnetite, epidote, and actinolite. These veins and veinlets appear to heal fractures within a zone of brecciated diorite. The second alteration facies is albitic, and also affects the diorite in the outer edge of the brecciated zone. This alteration is characterized by thin microveinlets of quartz, feldspar and minor secondary biotite that have intensely bleached envelopes. These envelopes are composed of sodic plagioclase and possible sericite. The alteration is generally limited to the area immediately surrounding the veinlets, but a slight wholesale enrichment of plagioclase may be present throughout the zone as a slight lightening in colour of the diorite is recognized. Phyllic alteration is characterized by the formation of quartz and sericite, and bleaching of the rock. This style of alteration is only apparent in the porphyritic quartz monzodiorite unit and is thought to reflect the more felsic primary rock composition. The widespread propylitic alteration is characterized by the presence of significant chlorite and epidote and the formation of magnetite at the expense of biotite and hornblende. Magnetite replacement similar to this is common to the other zones as well, but it can be used as an indicator of the propylitic zone because unaltered diorite contains comparatively little primary magnetite.

Mineralization on the property is intimately associated with the hydrothermal alteration. Copper grades are carried mainly in chalcopyrite, which occurs with pyrite as a replacement of hydrothermal magnetite. Grades are highest in the potassic alteration zone and decrease outwards. Copper grades range from ~0.1 to 0.38% in the potassic zone, from 0.1 to 0.15% in the phyllic zone, and ~0.08% in the albitic zone. Mineralization is thought to have resulted from either fluids evolved during the latest stages of crystallization of the main phase diorite or from a buried intrusion that represents a later, high-level phase of the Late Cretaceous intrusive complex.

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YUKON MINING AND EXPLORATION OVERVIEW — 1997

YUKON MINING AND EXPLORATION OVERVIEW — 1997

Mike Burke
Staff Geologist, Yukon Geology Program
(867) 667-3202 or email: burkem@inac.gc.ca

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INTRODUCTION

Mining remained Yukon's number one industry with production from three operating mines and significant expenditures in mine development and mineral exploration. Development expenditures, estimated at $23 million, were incurred at Yukon's three operating mines: the Faro Pb-Zn-Ag Mine, the Brewery Creek Au Mine, and the Mount Nansen Au-Ag Mine. Development also occurred at the Minto Cu-Au-Ag project which will undergo final construction and begin production in 1998, and a number of other projects which are in the final stages of permitting. Exploration expenditures, estimated at $35 million (Fig. 1), were down from the $54 million spent in 1996, but higher than the ten-year average of $32 million. The exploration season was very successful, highlighted by a combination of new discoveries, positive results from several advanced projects, and a significant amount of claim staking as a result of grassroots exploration programs. The number of claims in good standing climbed to a new historical high of 72,723 (Fig. 2), with 9,628 new claims recorded in 1997 (Fig. 3).

Yukon had three producing mines in 1997. The Brewery Creek Mine was opened by Viceroy Resource Corporation in November 1996, and has proven a technical success producing gold utilizing heap leach technology in the extremes of a cold northern climate. Production from Brewery Creek in 1997 is estimated at 2252 kg (72 400 ounces) and 1998 production should surpass 2644 kg (85 000 ounces) of gold. BYG Natural Resources produced 617 kg (19 829 ounces) of gold and 3068 kg (98 654 ounces) silver to the end of September from its Mount Nansen Mine which also opened in November, 1996. Milling operations at the shear zone hosted vein deposit were temporarily shut down in November 1997, to increase water treatment capacity and rectify water balance problems in the tailings pond. Anvil Range Mining Corporation, shut down in December 1996, resumed production from the Grum Pb-Zn-Ag orebody near Faro and began shipping lead and zinc concentrates in November, 1997. The Grum sedimentary-exhalitive deposit is one of several known orebodies distributed in an arcuate belt along the south flank of the Anvil Range batholith in central Yukon.

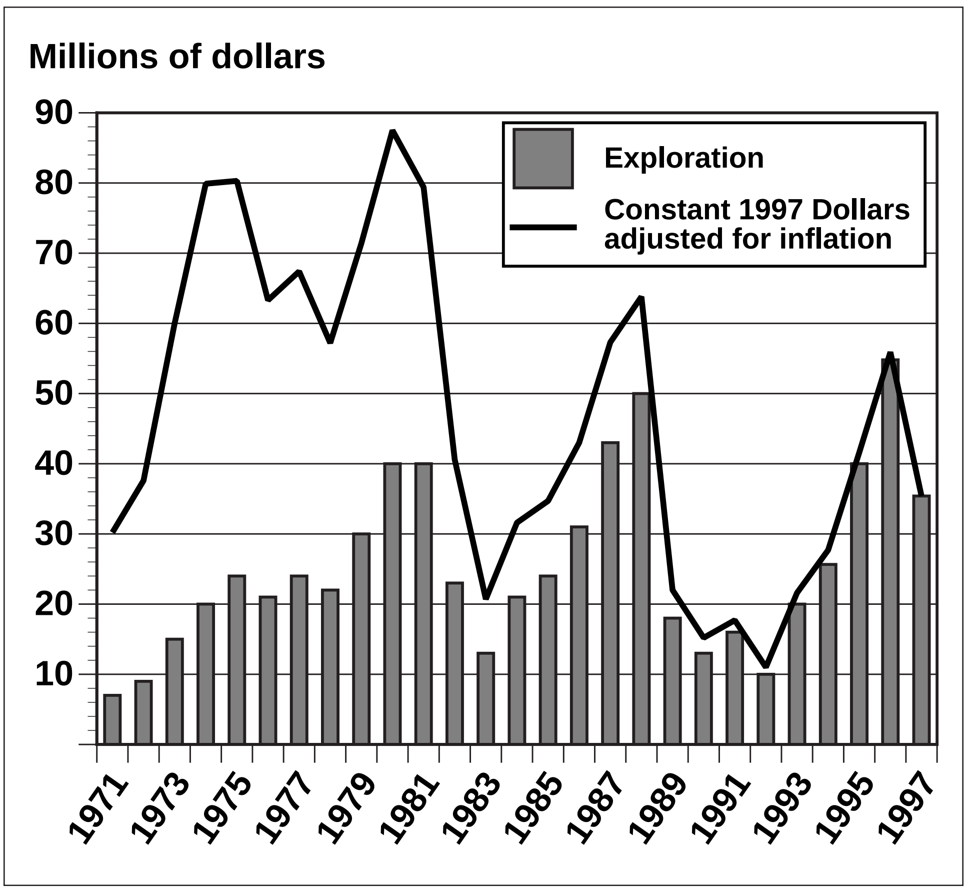
RÉSUMÉ

L'exploitation minière reste la principale industrie du Yukon. Trois mines sont en exploitation, la mine de Pb-Zn-Ag de Faro, de l'Anvil Range Mining Corporation; la mine d'or de Brewery Creek, de la Viceroy Resource Corporation; et la mine d'or-argent de Mount Nansen, de la société BYG Resources. Le territoire a en outre engagé des dépenses importantes pour des travaux préparatoires et pour l'exploration minérale. L'exploration dans le territoire a été extrêmement fructueuse. Elle a en effet débouché sur de nouvelles découvertes, notamment celle, par la société Atna Resources, du gisement de Pb-Zn-Ag Wolf dans des sulfures massifs inclus dans des roches volcaniques, au sein de roches de la plate-forme de Cassiar; celle, au projet de Wolverine, d'un nouveau corps de sulfures massifs à l'ouest du gisement de Wolverine-Lynx, propriété des sociétés Mines Westmin Ltée et Atna Resources; et celle d'un horizon stratoïde à Ni-Zn, à la suite de forages par les sociétés Blackstone Resources et Glenhaven Resources, dans le nord du Yukon. De nombreux projets ont fourni des résultats d'exploration positifs sur tout le territoire, et l'on espère que les nombreux programmes de reconnaissance se traduiront par de futures découvertes. En termes économiques, les dépenses de mise en valeur et pour l'exploration ont diminué par rapport au chiffre imposant de 108 millions de dollars enregistré en 1996. Les dépenses pour des travaux préparatoires, qui ont atteint en 1996 un sommet, en raison surtout de la mise en valeur de la mine de Brewery Creek de la Viceroy Resource Corporation, ont accusé la plus forte diminution; elles ont néanmoins apporté à l'économie du Yukon un montant estimé à 23 millions de dollars. On assistera en 1998 à une augmentation des dépenses de mise en valeur consécutivement à l'aménagement de la mine de Cu-Au-Ag de Minto et à la réouverture possible de la mine de Pb-Zn-Ag de Sa Dena Hes. Les dépenses pour l'exploration sont évaluées à 35 millions de dollars, chiffre inférieur aux 54 millions de dollars dépensés en 1996 mais supérieur à la valeur décennale moyenne de 32 millions de dollars.

Base-metal exploration highlights include the discovery by Atna Resources of volcanic-hosted massive sulphides (VMS) in Mississippian pyritized felsic tuffs of Pelly-Cassiar Platform at the Wolf property. The discovery hole intersected 6.9% Zn, 2.8% Pb and 138.6 g/t Ag over 25.2 metres and resulted in an immediate increase in exploration activity in this belt of rocks. Continuing evaluation of massive sulphide deposits of Yukon-Tanana Terrane in the Finlayson district at the Wolverine project jointly owned by Westmin and Atna Resources, and Columbia Gold's Fyre Lake deposit were successful in expanding reserves. At Wolverine a new massive sulphide body in the Sable zone, approximately 2 km southwest of the Wolverine-Lynx deposit, was intersected by exploratory drilling. Similarly the Ice occurrence owned by Expatriate Resources in the Campbell Range Belt was further delineated by drilling. In northern Yukon, Blackstone and Glenhaven Resources made a significant discovery of stratabound nickel-zinc at the Taiga Project. There the Devono-Mississippian Earn Group argillites and shales host stratabound mineralization which yielded a 5.3 metre drill intersection grading 1.42% Ni and 0.70% Zn.

Gold exploration was conducted mainly in the mid-Cretaceous Tombstone Suite intrusive belt that spans central Yukon from Dawson in the west to MacMillan Pass in the east. Tombstone Suite intrusive rocks host the Fort Knox deposit in Alaska, the Brewery Creek Mine near Dawson and the Dublin Gulch deposit north of Mayo. Focused exploration programs in the belt were included the Brewery Creek minesite, the 66 000-hectare Oki Doki Project of International Kodiak Resources north and east of the Brewery Creek Mine, and the Scheelite Dome project of Kennecott subsequently optioned by La Teko Resources. Several reconnaissance programs also took place in the belt in 1997 and the largest resulted in more than 1100 claims staked by Viceroy Resource Corporation. The largest gold exploration program in the Yukon was conducted on the Goddell Shear property in the Mt.

Figure 1. *Exploration expenditures: 1971-1997*



Skukum area, 85 kilometres south of Whitehorse. Omni and Trumpeter Yukon Gold Inc. each hold a 35% interest in the property and Arkona Resources holds 30%. Exploration on the Goddell shear zone, in the mid-Cretaceous Carbon Hill granite, was investigated by extending of the undergound adit 182 metres and by more than 8500 metres of underground drilling in 37 holes. An indicated reserve of 824 594 tonnes grading 7.15 g/t Au was calculated from drill results. These exploration highlights show that continued confidence in the mineral potential in the Yukon, and illustrate that much of the territory remains under-explored (Fig. 4).

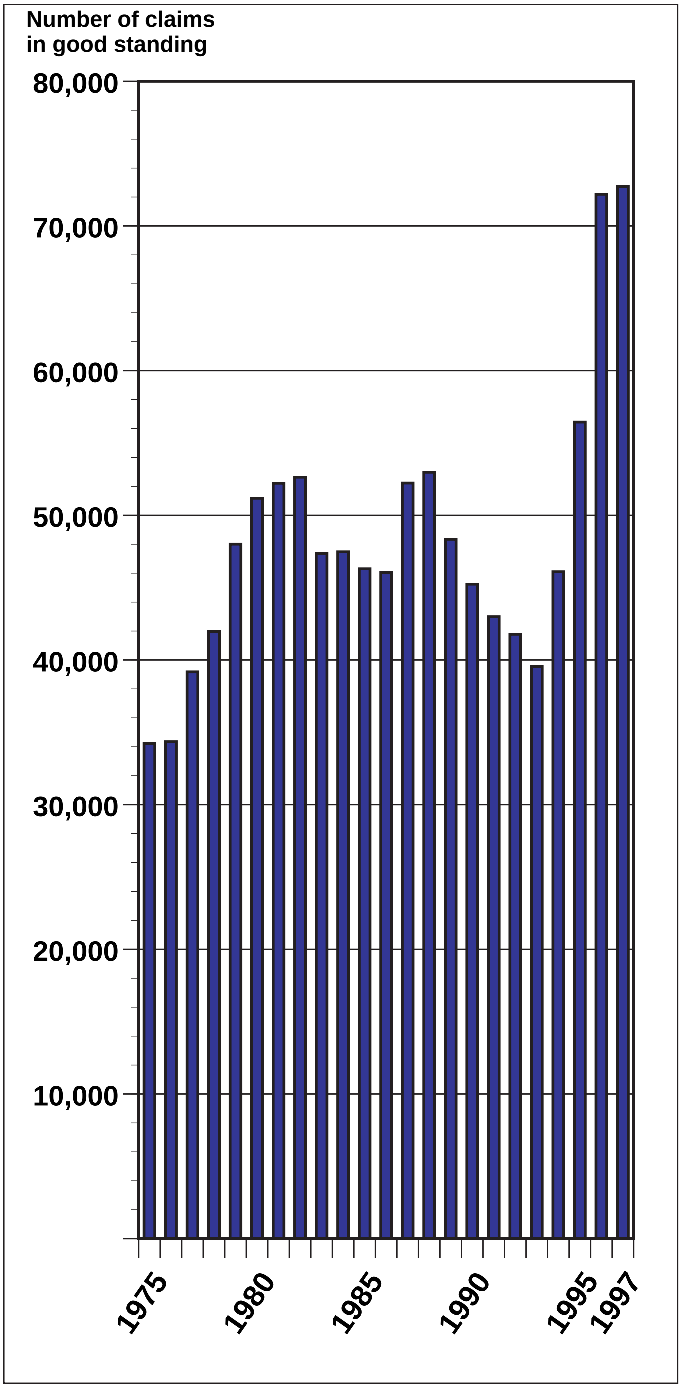


Figure 2. *Quartz claims in good standing: 1975-1997*

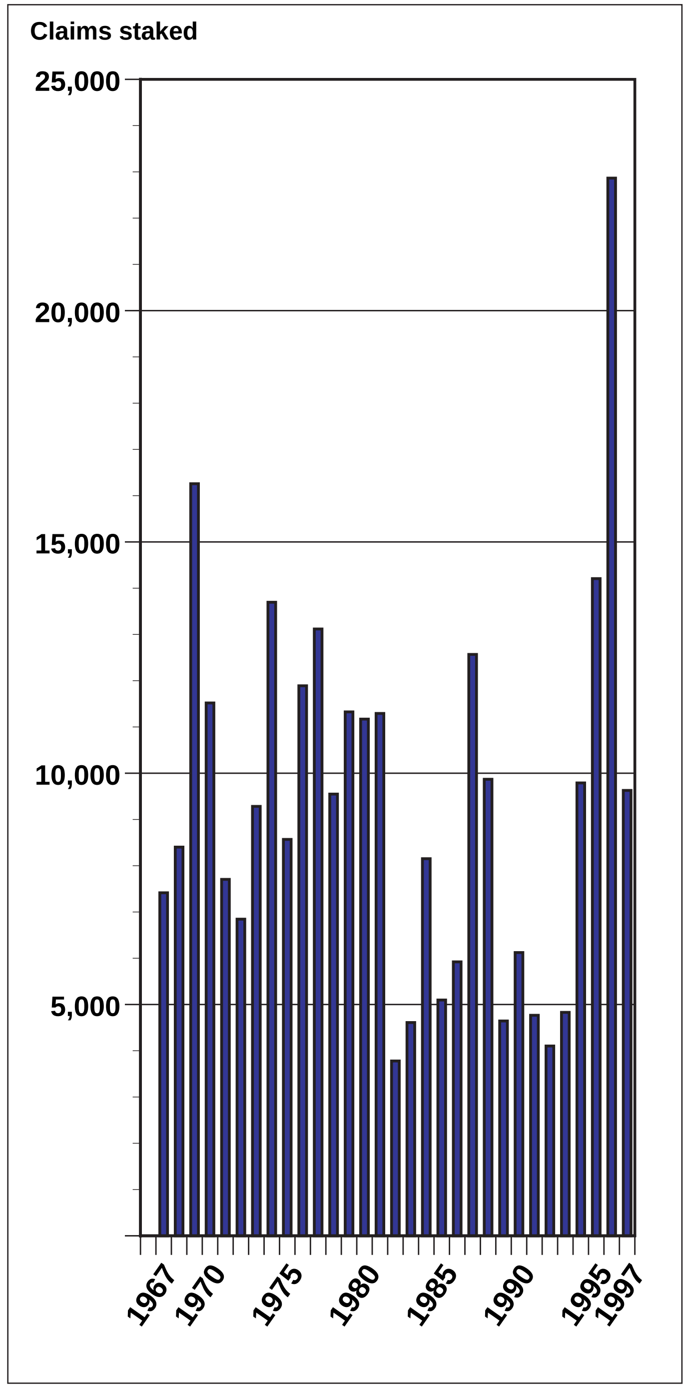


Figure 3. *Quartz claims staked: 1967-1997*

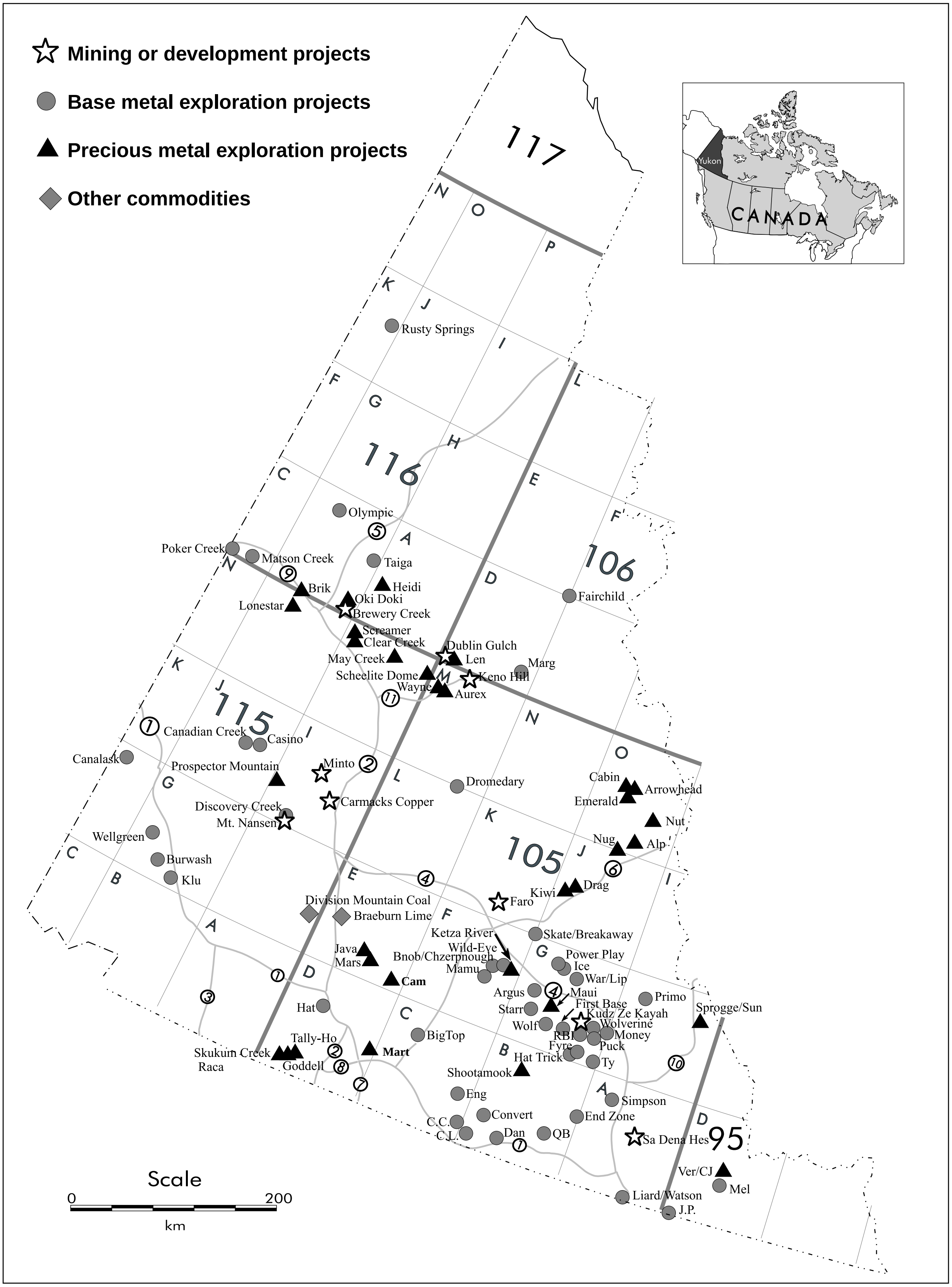


Figure 4. Location of active Yukon mines and exploration projects in 1997. Not all exploration (particularly reconnaissance) can be shown on the map.

LODE MINING AND MINE DEVELOPMENT

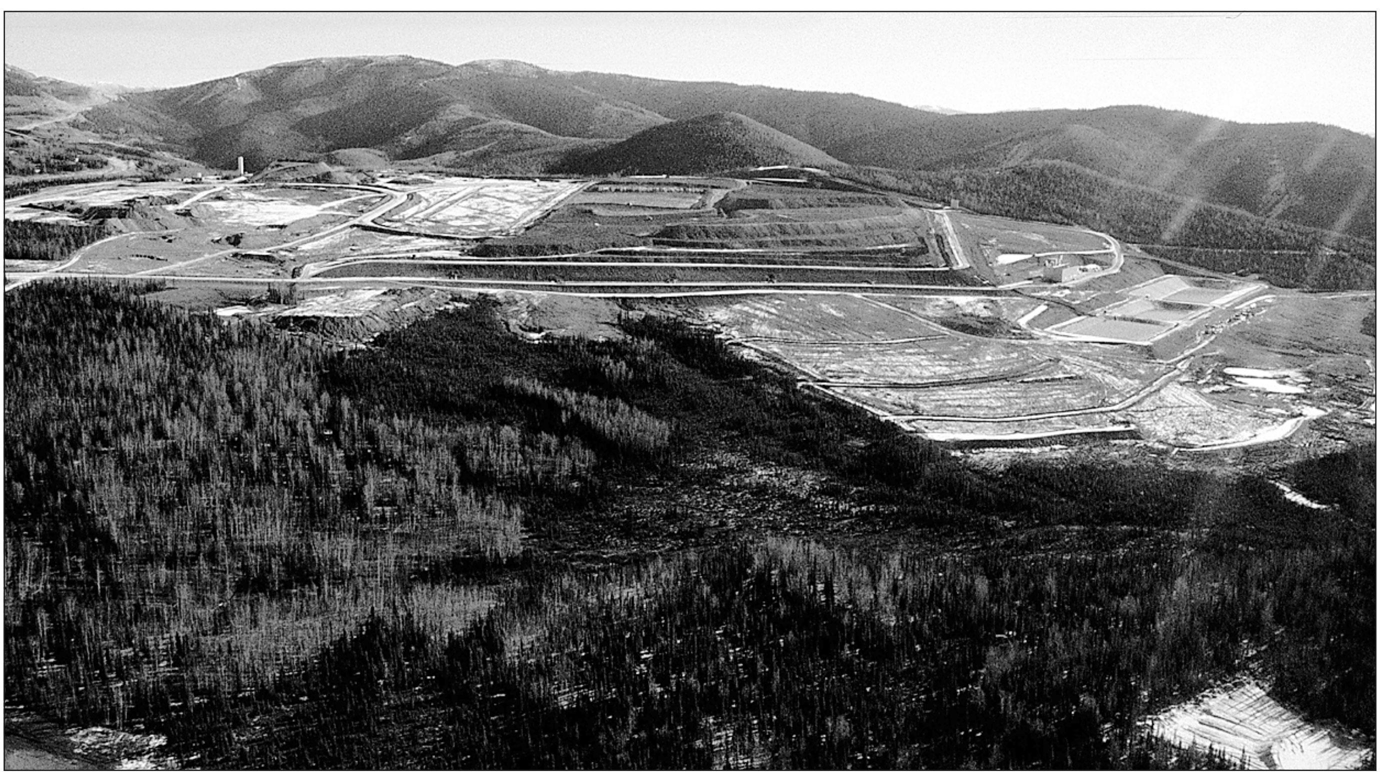
Mining resumed at the **Faro Pb-Zn-Ag Mine** (Yukon Minfile 105K 056) of Anvil Range Mining Corp. after a temporary shutdown. Mining of the Grum sedimentary-exhalative orebody was suspended in December, 1996 due to low metal prices and a number of operational factors, although milling of low-grade stockpiles continued until the end of March, 1997. In August, 1997 Anvil Range started a $15 million stripping program at the Grum deposit which contained open-pit mineable reserves of 16.9 million tonnes (Fig. 5) grading 3.0% Pb, 4.9% Zn, 47 g/t Ag and 0.7 g/t Au prior to mining which began in 1995. Funding for the current stripping program was provided in the form of a $15 million loan at 8.5% interest by Cominco Ltd., Anvil Range's largest shareholder at 27.7%. The loan is fully secured by all of Anvil Range's assets. Cominco has received five million warrants exercisable at $3 per share in conjunction with the loan. Cominco has also provided Anvil Range with sufficient working capital to continue operations until March, 1998 and the Glencore Group has entered into an agreement as the exclusive buyer of lead and zinc concentrates from the mine. Trucking concentrates to Skagway, Alaska (535 km) resumed in November, 1997. When in full operation the Faro Mine is one of the world's largest zinc-lead producers with an annual production of 480 000 tonnes of zinc and lead concentrates. Anvil Range conducted diamond drilling on the northwest side of the Grum pit, proving a model which would expand the pit limits in this direction. The mine is the Yukon's largest private-sector employer with nearly 500 direct employees plus related contractors.

Figure 5. *Production resumed from the Grum open pit at the Faro Mine in December, 1997. Stripping, shown here, began in August.*

Viceroy Resource Corporation successfully produced gold during its first winter of operation at the **Brewery Creek Mine** (Yukon Minfile 116B 160). Previously it was not known how successful heap leach technology would be in a northern climate (Fig. 6). Gold production during the first two months of operation, November and December 1996, totaled 316 kg (10 175 ounces) at a cash operating cost of US$239/oz. 1997 production is estimated at 2252 kg (72 400 ounces) of gold at a cash cost of US$190 per ounce. The ore at Brewery Creek consists of eight low-grade oxide gold deposits. The deposits are hosted by Cretaceous Tombstone Suite quartz-monzonite sills and underlying Devono-Mississippian greywacke of the Earn Group which occur over a linear trend 7 kilometres long. The orebodies will be extracted over an initial eight-year mine life. The unique configuration of the orebodies and the mine plan allows the backfilling and reclamation of the open pits shortly after extraction is completed. Reclamation of the mine therefore began in the first year of full production with the backfilling and reclamation of the Canadian Pit. Open-pit mineable reserves at the onset of production stood at 17.1 million tonnes grading 1.45 g/t Au. The strip ratio is 1.5:1 and gold recovery is 78%. Development in 1997 at the Brewery Creek Gold Mine included expanding the heap leach pad and construction of haulage roads. Two more cells were added to the existing 158 000 m^2 heap leach pad and haulage roads were constructed to orebodies slated for future production. Reserves are being updated and initial analysis indicates a decrease in tonnage and an increase in grade. The mine employs approximately 150 people during active mining in the summer months and 45 during the winter.

Viceroy conducted a $2 million exploration program to expand reserves beyond the main trend. The program covered nine kilometres of untested soil anomalies, using excavator trenching followed by reverse circulation drilling of several targets. In conjunction with the Geological Survey of Canada, an airborne geophysical survey was carried out over the mine property, as well as on adjacent Tr'on dek Hwech'in land claims, adjoining quartz claims and open ground on mapsheets 116B-1 and 115P-13. Within the minesite, trenching and drilling on the Moosehead, Big Rock, Bohemian, Lucky, Schooner, Sleemans zones, as well as the West grids have returned additional ore-grade intersections over mineable widths. The

Figure 6. *Gold-bearing ore, the Adsorption-Desorption Recovery plant and processing ponds can be seen in this photo of the heap leach pad area at Viceroy Gold's Brewery Creek Mine. The mine successfully produced gold during its first winter of operation, proving that heap leach technology can be used successfully in northern climates.*



highlight was the Lucky zone, where infill drilling returned numerous intersections up to 2.54 g/t Au over 22 metres. Drilling to the southwest of the current pit design returned intersections including 14.11 g/t Au over 10 metres, 8.67 g/t Au over 12 metres, 4.82 g/t Au over 16 metres and 7.94 g/t Au over 12 metres. These results illustrate the potential for significant expansion of reserves in and around the deposits in the current mine plan.

Central to the Brewery Creek Mine is the Classic zone, a Fort Knox-style target in potassic-altered syenite and biotite monzonite stocks south of the main reserve trend. Trenching at the Classic has exposed a zone of strong clay, sericite and limonite alteration over a length of one kilometre within a five-kilometre long Au-As geochemical anomaly. Assays from the Classic zone returned up to 1.88 g/t Au over 5.4 metres and 0.7 g/t Au over 20 m. Drilling on the North Slope zone intersected sediment-hosted ore-grade mineralization over a 500 m strike length. Assays include 13.15 g/t Au over 4 metres and 2.56 g/t Au over 16 m but typically range from 1 to 3 grams over thicknesses of 4 to 6 metres. The North Slope zone contains alteration and mineralization similar to Carlin-type deposits. Sulphide zones below the oxide reserves were also tested with drilling in 1997. Results suggest the grade of sulphide mineralization is similar to oxide mineralization. Preliminary metallurgical test work has indicates that bio-oxidation can attain recoveries from the refractory sulphides of up to 90%. Continued exploration on the mine property will add to the reserve base and likely extend the mine life beyond the projected eight years.

BYG Natural Resources Inc. continued production in 1997 from the Brown-McDade open pit (Fig. 7) at the **Mt. Nansen Au-Ag Mine** (Yukon Minfile 115I 064, 065). The Brown-McDade is a vein-fault up to 30 metres wide cutting Lower Cretaceous granodiorite and feldspar porphyry of the Mount Nansen Group. The fault contains lenses of quartz with sulphides. Mining is currently directed at the upper oxidized portion of the vein. A high clay content in the ore created lower production from the crushing and screening circuit of the mill resulting in lower throughputs for the first six months of 1997. A SAG mill was installed and commissioned in late August to replace the crushing and screening circuit. Production for 1997 totaled 617 kg (19 829 ounces) of gold and 3068 kg (98 654 ounces) silver. The

Figure 7. *Brown-McDade open pit at BYG Natural Resources, Mt. Nansen Mine. The upper oxidized portion of the vein system is currently being mined.*

mine shut down on November 12 to upgrade the water treatment system and was slated to resume full production by year-end, meeting water discharge requirements. The mine employs approximately 70 people.

The **Flex zone** (Fig. 8), which hosts possible reserves of 115 000 tonnes grading 7.5 g/t Au and 200 g/t Ag, will supply feed for the Mount Nansen mill after depletion of the Brown-McDade. The Flex zone, a shear zone hosted vein system similar to the Brown-McDade was stripped and trenched for detailed mine planning. The Flex zone contains two parallel veins, the Main and Footwall, that were exposed over a 350 metre strike length. Samples from the Main vein returned values of 7.1 g/t Au, 350.8 g/t Ag over 3.0 metres at the north end and 2.0 metres grading 14.6 g/t Au and 350.4 g/t Ag at the south end of the stripped area. The Footwall vein returned values of 3.0 metres of 9.4 g/t Au and 486.7 g/t Ag at the north end and 2.0 metres of 16.8 g/t Au and 221.2 g/t Ag at the south end of the stripping. B.Y.G also conducted a drilling program on the Eliza Extension vein to the northwest of the minesite on the **Discovery Creek** property. Drilling on the quartz-sulphide vein returned values up to 2.4 g/t Au and 25.7 g/t Ag over 3.8 metres in Hole 97-4 and 1.9 metres grading 4.29 g/t Au and 5.8 g/t Ag in Hole 97-3.

Development occurred at a number of Yukon projects which are in various stages of mine permitting and may see production in the near future. Minto Explorations received a positive Screening Report from the Regional Environmental Review Committee in April 1997 for the **Minto Cu-Au-Ag project** (Yukon Minfile 115I-021, 022), and signed a cooperation agreement with the Selkirk First Nation. A Yukon Water Board Hearing was held in June and the Board is in the process of drafting the water license. The porphyry deposit hosts open-pit-mineable reserves of 6.51 million tonnes grading 2.13% Cu, 0.62 g/t Au and 9.3 g/t Ag at a stripping ratio of 4.9:1. The mill is designed for a throughput of 525 000 tonnes of ore giving the mine an initial 13 year life. The estimated average cash operating cost per pound of copper, including freight, smelting, and refining charges and after gold and silver credits, is US$0.52 for the first five years of production. In anticipation of receiving their license Minto began site construction. The remaining 12.8 kilometres of access road were upgraded, the camp and mill sites excavated, peripheral access roads constructed, and two grinding mills moved to the site. Concrete for the mill footings may be poured as early as March, 1998 and production at the mine could begin as early as November, 1998. Asarco Inc. will acquire a

Figure 8. *Oxide material exposed by stripping of the Flex zone at the Mt. Nansen Mine. Detailed work for mine planning began on the Flex which is slated for production when the ore from the Brown-McDade pit is depleted.*

70% interest in the property by funding development costs up to US$25 million with Minto Explorations remaining the operator with a 30% interest.

Western Copper Holdings Limited continued engineering studies on the **Carmacks Copper Project** (Yukon Minfile 115I 008). The project hosts an open-pittable 14.1 million tonne oxidized porphyry Cu-Au deposit grading 1.01% Cu and 0.51 g/t Au. The project, which is being reviewed under the Environmental Assessment and Review Process, is slated to recover copper using solvent extraction-electrowinning technology. Western cleared and grubbed the access road, leach pad site, and plant site in 1997 (Fig. 9). A bulk sample was also extracted to conduct column tests on run of mine ore which may allow the elimination of a crusher in the mine plan resulting in substantial capital and operating cost reduction.

Cominco Ltd, announced in August that the **Sa Dena Hes Zn-Pb Mine** (Yukon Minfile 105A 012, 013) may reopen by mid-1998 however by mid-December they announced that the current market conditions did not support a reopening of the mine. Preparations for possible start-up included upgrading the haul road, camp renovations, recommissioning of power plants and rehabilatation of mine openings. The mine, formerly operated by Curragh Resources, ceased operation in December 1992 (Fig. 10). At Sa Dena Hes, several high-grade zinc-lead-silver skarn zones occur along contacts between Early Cambrian limestone and phyllite. The former operator mined mainly from Jewelbox Hill while future production will come from reserves in the Burnick Zone. The Sa Dena Hes mine is owned jointly by Cominco Ltd. (25%), Teck Corporation (25%) and Korea Zinc Co., Ltd., (50%), with Cominco the operator of the project.

The **Kudz Ze Kayah project** (Yukon Minfile 105G 117) of Cominco received a positive screening report under the Canadian Environmental Assessment Act in mid-December, 1997. No production decision has been made. The ABM volcanic massive sulphide deposit, the first major discovery in the Finlayson Lake district, hosts open-pit mineable reserves of 11 million tonnes grading 5.9% Zn, 0.9% Cu, 1.5% Pb, 130 g/t Ag and 1.3 g/t Au. Cominco conducted UTEM and magnetic geophysical surveys on the Kudz Ze Kayah property and drilled 17 holes totaling 5360 metres. A regional program consisting of soil sampling, horizontal-loop electromagnetics, magnetics and gravity surveys was also conducted by

Figure 9. *Western Copper Holdings stripped the pad site for the Carmacks Copper Project in 1997. Production of copper from the oxide deposit, using solvent extraction-electrowinning technology, will come from the No.1 zone, marked by trenches at the top right of the cleared pad site.*

Cominco on their numerous properties in the Finlayson Lake district. Six of these were tested with 1050 metres of drilling in seven holes.

The former producing mines of **United Keno Hill Mines** (Yukon Minfile 105M 001) Limited were placed on care-and-maintenance during 1997 while the company focused on renewing their water licence and obtaining financing to reopen. The 30 veins in the Keno and Galena hills have produced over 200 million ounces of silver in the past 70 years. Underground mineable reserves, mostly in the Bellekeno and Silver King veins, stand at 415 000 tonnes grading 1145 g/t Ag, 7.5% Pb, and 5.6% Zn; geological reserves are 944 000 tonnes grading 930 g/t Ag, 4.8% Pb and 3.9% Zn. The veins are hosted in the Mississippian Keno Hill quartzite and Triassic metadiorite intrusions. The Bellekeno vein contains massive sideritic galena-sphalerite while the Silver King ore-body consists of high grade veins with native silver, ruby silver and galena.

Late in 1997, United Keno Hill and NDU Resources announced a binding merger agreement between the two companies. NDU brings two substantial mineral deposits, the Marg (Yukon Minfile 106D 009) and the Blende (Yukon Minfile 106D 064), while Keno Hill brings the mineral deposits outlined above and the mine infrastructure at Elsa. The **Blende**, a large Mississippi Valley-type Zn-Pb-Ag deposit approximately 65 kilometres northeast of Elsa, is hosted by Middle Proterozoic Gillespie Group dolomite. It contains a drill-indicated resource of 19.4 million tonnes grading 2.81% Pb, 3.04% Zn and 55.9 g/t Ag mineable by open pit methods. The deposit was drilled between 1988 and 1994 with the latest results indicating an expansion in the West Zone. Hole 94-81 returned 14.86 m of mineralization which assayed 9.71% Pb, 5.48% Zn, 0.78% Cu and 228.4 g/t Ag. The **Marg** deposit is a polymetallic VMS deposit hosted in Early Mississippian meta-chert and quartz and muscovite schist (coeval with Yukon-Tanana stratigraphy) in the north-central Selwyn Basin approximately 60 kilometres east of Elsa. NDU has drilled the Marg deposit for the last couple of summers and drill-indicated reserves at the end of the 1996 were 5 527 000 tonnes at a grade of 1.76% Cu, 2.46% Pb, 4.6% Zn, 62.7 g/t Ag and 1.0 g/t Au. The 1997 program consisted of seven diamond drill holes outside the existing reserve blocks. Drilling was suspended until access for underground drilling can be established. A winter road to the Marg site was completed in 1997 across Class A (surface and subsurface rights) settlement lands of the Nacho Nyak Dun First Nation to facilitate development of the project.

New Millenium Mining Ltd, whose principal asset is the **Dublin Gulch deposit** (Yukon Minfile 106D 021-029) 51 km north of Mayo announced positive results from a feasibility study on this Fort-Knox style (intrusive-hosted) deposit which hosts open-pit mineable reserves of 50.4 million tonnes grading 0.93 g/t Au. The feasibility study indicates a gold recovery of 78%, a stripping ratio of 0.8:1, with forecast production of 135 000 ounces of gold per year at a capital cost of US$106.7 million and an operation cost of US$230 per ounce. In 1997 the company completed the feasibility study, continued environmental monitoring, baseline studies and underwent a comprehensive review of the project for permitting under the Canadian Environmental Assessment Act (CEAA).

Figure 10. *The Sa Dena Hes Mine underwent preparations for a possible reopening. With the right conditions in the zinc market the mine could resume production with short notice.*

PLACER MINING

William LeBarge, Yukon Geology Program

Yukon's placer mining industry continued to be an important part of the Yukon's economy in 1997. A total of 183 operations, directly employing 700 people, mined in ten major placer mining areas. The unglaciated Klondike (Fig. 11), Indian River, West Yukon (Fortymile, Sixtymile, and Moosehorn Range) and the Lower Stewart River tributaries produced approximately 80% of the total, with the remainder produced from the variously glaciated Clear Creek, Mayo, Dawson Range, Kluane and Livingstone areas.

Figure 11. *Ross Mining (foreground) on Dominion Creek and Teck Corporation (background-across road) on Gold Run Creek are two of the largest producing placer gold mines in the Yukon in recent years.*

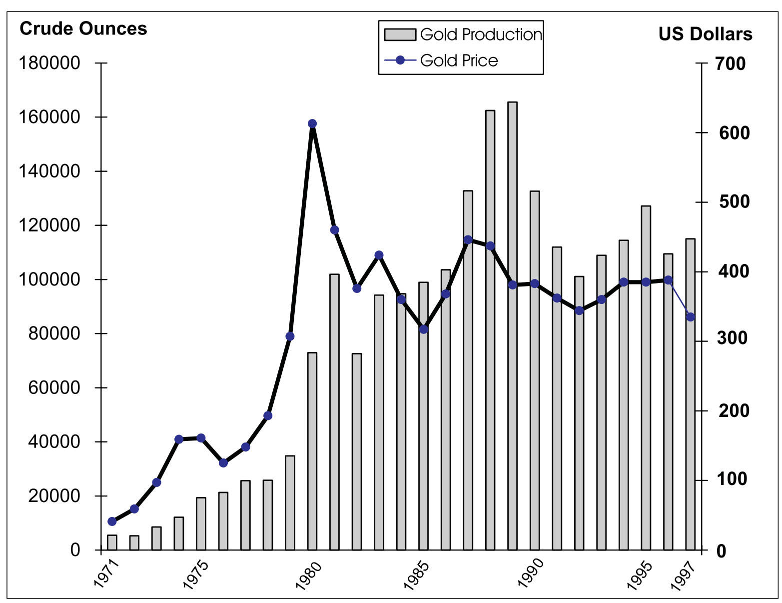
The 1997 Yukon placer gold production total of over 116 000 crude ounces of gold was up approximately 6% over 1996 (Fig.12), however due to the drastic drop in world market gold price, the total value of this gold was just over $42 million compared to nearly $46 million for 1996. The reason for this may be that some producers were forced to sell stockpiles of placer gold to offset its lesser value in order to pay production costs.

The number of placer mining operations in outlying (non-traditional) areas has increased in recent years, with renewed mining on Henderson Creek, Canadian Creek and in other parts of the Dawson Range.

Teck Corporation, which operated on Gold Run Creek in the Klondike, was one of the largest placer mines in the Yukon until it ceased production in September after 10 years of mining. Over 90 000 ounces were credited to this mine over its ten-year production life.

Other recent developments in the industry include the introduction of Mining Land Use regulations on placer claims, which are scheduled to take effect in the 1999 mining season.

Figure 12. *Yukon placer gold production and average US gold price, 1971 to 1997.*



EXPLORATION — BASE METALS

Continued exploratory drilling on volcanic-associated massive sulphide (VMS) deposits in the Finlayson Lake district and the search for additional deposits, dominated the 1997 exploration season. Cominco's initial discovery, in 1994, of the ABM deposit at the Kudz Ze Kayah project hosted in Mississippian felsic meta-volcanic rocks of Yukon-Tanana Terrane, spurred a staking rush and subsequent intensive exploration, resulting in the discovery of the Wolverine deposit jointly owned by Westmin and Atna Resources, the Fyre Lake deposit of Columbia Gold Mines, and the Ice deposit of Expatriate Resources. In 1997, Atna Resources discovered a new massive sulphide body on the Wolf claims 45 kilometres west of Kudz Ze Kayah.

Columbia Gold Mines spent approximately $4 million on a 44-hole, 13 500 metre drill program (Fig. 13) at the **Fyre Lake project** (Yukon Minfile 105G 034) 53 km south of Finlayson Lake and 30 kilometres southwest of Wolverine deposit. The Fyre Lake deposit is located stratigraphically below the ABM and Wolverine deposits at the contact of carbonaceous phyllites and chlorite schist of the Yukon-Tanana Terrane. The extensive exploration program followed up on positive results from 1996, and included detailed mapping around the Kona deposit, reconnaissance-scale mapping at the Lake zone, grid extensions, ground magnetometer and electromagnetic surveys and downhole geophysics (UTEM). The Kona deposit contains two parallel trends of copper-cobalt-gold mineralization: Kona East and Kona West. The east zone has a strike length in excess of 900 metres and consists of upper and lower horizons with an average thickness of 8 to 12 metres and average widths of 100 to 125 metres. The Kona West zone, which has a strike length of at least 1450 metres, a minimum width of 125 metres and varies in thickness from 9 to 40 metres, was the main focus of the 1997 drilling. The strike length of the Kona West zone was increased to approximately 1450 metres with the intersection of 16.3 metres of massive sulphides grading 1.28% Cu, 0.61 g/t Au, and 0.11% Co in the last hole of the season, a 450 metre southeasterly step-out. The entire Kona deposit is estimated to average 1.5 to 2.0% Cu, 0.1 to 0.14% Co and 0.5 to 1.0 g/t Au based on reported drill intercepts. Metallurgical testwork has indicated that copper recoveries of 90% and cobalt and gold recoveries of 70% can be achieved.

Figure 13. *John Dayton (L) and Ian Foreman (centre) of Columbia Gold Mines review core with Julie Hunt (Yukon Geology Program) who is conducting a study of VMS deposits in the Yukon.*

Westmin and Atna Resources conducted a large exploration program in and around the **Wolverine deposit** (Yukon Minfile 105G 032) located approximately 25 km east of Kudz Ze Kayah and 35 km southeast of Finlayson Lake. The Wolverine is hosted in Devono-Mississippian carbonaceous meta-sedimentary and meta-volcanic rocks of Yukon-Tanana Terrane. The deposit was first intersected by drilling in 1995 after an initial geological program identified favourable host rocks and coincident barium-lead-copper-zinc-gold-silver geochemistry. A large program in 1996 outlined a geological inventory of 5.3 million tonnes grading 1.8 g/t Au, 359 g/t Ag, 1.4% Cu, 1.5% Pb, and 13% Zn based on 49 drill intersections. In 1997, Westmin drilled 22 holes with 19 intersecting mineralization outside of the 1996 block model. The program was successful in expanding the Wolverine-Lynx zone deposit in the up-dip direction, and to the east and west along strike. The deposit remains open in the downdip direction which extends across the claim boundary onto ground held by Cominco. Westmin revealed that the deposit contains unusually high levels of selenium which is a metallurgical concern.

Westmin also drilled an additional 20 stratigraphic holes on targets believed to be underlain by stratigraphy similar to that hosting the Wolverine deposit. Favourable stratigraphy extends approximately14 kilometres on their claims. The stratigraphic drilling program intersected numerous areas with alteration and uneconomic mineralization, some of which will require a significant follow-up. Late in the season, massive sulphides in the Sable zone were discovered by a drill intersection 1.6 kilometres east of the Wolverine deposit. Hole WV97-106 (Fig. 14) returned 2.6 g/t Au, 183 g/t Ag, 0.65% Cu, 0.62 Pb and 15.7% Zn over a true thickness of 0.6 metres. The Puck claims, optioned by Westmin from Expatriate Resources, adjoin the Wolverine property to the southeast in the vicinity of the Sable zone. Westmin drilled 10 widely spaced stratigraphic holes on the Puck claims which were successful in intersecting the favourable Wolverine horizon, magnetite horizon, stockwork mineralization and strong alteration, however no economic mineralization was reported.

Figure 14. *Massive sulphides from the Sable zone intersected in Hole WV97-106 at the Wolverine Project. This interval assayed 2.26 g/t Au, 183 g/t Ag, 0.65% Cu, 0.62% Pb and 15.70% Zn over 0.6 metres.*

Expatriate Resources conducted a 7880 metre diamond drilling program (Fig. 15) on the **Ice property** (Yukon Minfile 105G new) 70 kilometres northwest of the ABM deposit and 35 km northwest of Finlayson Lake. The deposit is hosted in basalts of the Campbell Range Belt. Cyprus-type massive sulphide mineralization was intersected on the Ice property in the final

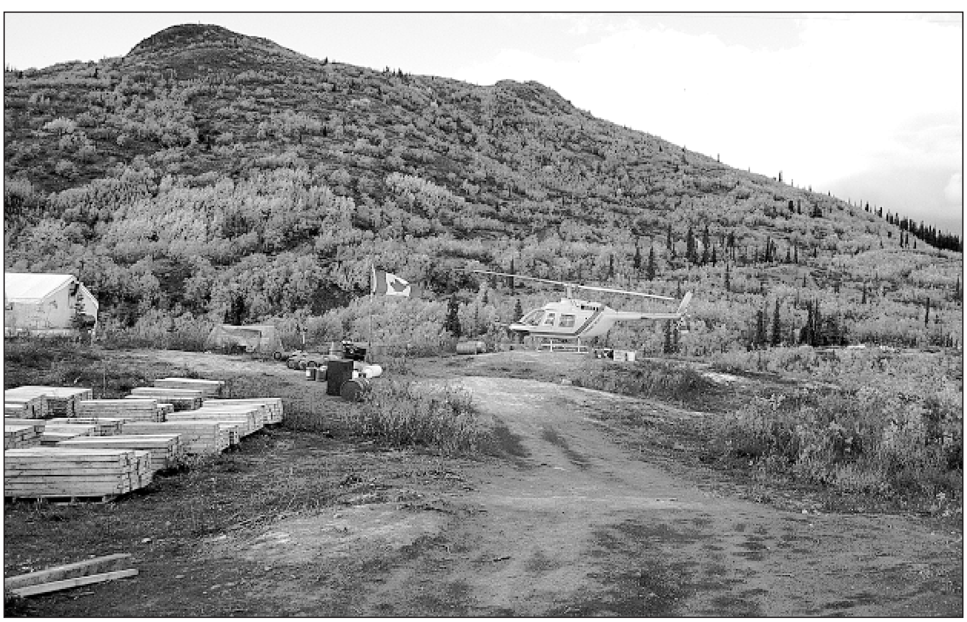


Figure 15. *The Ice deposit of Expatriate Resources lies underneath the hillside behind the helicopter. Over 100 drill holes at 25- and 50-metre spacings have intersected the deposit in the area of this photo.*

Figure 16. *Bright red hematitic chert (grey in this photo) at the upper contact of a massive sulphide intersection (black) on Expatriate Resources' Ice Property in the Finlayson Lake area.*

hole of the 1996 exploration program. Drilling in 1997 intersected sulphides in two horizons, an upper massive sulphide horizon (Fig. 16) and a lower stockwork sulphide horizon which contains lenses of massive to semi-massive sulphides. Mid-way through the program the best intersection was Hole ID97-13 which returned 6.83% Cu, 1.02% Zn, 0.12% Co, 0.56 g/t Au and 24.2 g/t Ag over 10.98 metres. A feeder zone directly underlying the massive sulphides contained an additional 1.53% Cu over 17.57 metres. Expatriate's drilling program outlined a higher grade core to the deposit over a 350 by 50 metre area within a larger 600 by 400 metre area. Copper intersections from the core included, 5.20% over 20.56 metres, 8.56% Cu over 5.92 metres, 3.57% Cu over 28.55 metres and 4.31% Cu over 19.75 metres. Thicker lower grade mineralization surrounding the high-grade core, contains 1.5% to 3.0% Cu and the feeder zone assays in the 0.2% to 1.5% Cu range.

Expatriate also conducted several programs, including mapping, prospecting, geochemistry and hand trenching, on their extensive land package (>100 000 ha) in the Finlayson Lake district. Several areas of new mineralization and favourable stratigraphy for hosting VMS deposits were identified. On the **Goal-Net** property, Pb-Zn mineralization is associated with several intense multi-element geochemical anomalies and felsic metavolcanic rocks. An extensive magnetite horizon has also been identified. Regional mapping by the company indicates that it lies at approximately the same stratigraphic horizon as the magnetite horizon which forms a marker in the hanging wall of the Wolverine deposit. Helicopter-supported diamond drilling was performed on the **Power Play, Skate, Breakaway and Arn** (Yukon Minfile 105G new, 105K 098, 103, 105G 112) (Fig. 17) claims, following up on geochemical anomalies; however, no significant mineralization was encountered.

Nordac Resources conducted drilling programs on the **Convert, Simpson and End Zone** (Yukon Minfile 105B new, 105G new, 105B 101) properties south of Finlayson Lake. Drilling at Convert and Simpson intersected felsic metavolcanic rocks, baritic horizons, and pyrite with minor sphalerite and rare galena and chalcopyrite. At the Simpson property, where previous work had located strataform copper-lead-zinc grading up to 2.17% Cu, 10.5% Pb, 2.26% Zn and 128.6 g/t Ag, a chloritic magnetite horizon was intersected. Drilling at the End Zone failed to intersect stratiform mineralization, exposed in a creek bank, which returned up to 4.67% Zn, 3.17% Pb and 46 g/t Ag over 0.7 metres. Drilling was conducted across the creek from the exposed mineralization. Folding or faulting, indicated in drill core, has probably disrupted the continuity of the mineralization.

Elsewhere in the Finlayson Lake area many other programs were performed. Westmin conducted max-min and magnetometer surveys, soil sampling and geological mapping on the **Ty property** (Yukon Minfile 105G 083) optioned from Pacific Bay Minerals Ltd. The

Figure 17. *Bill Wengzynowski (left) of Archer, Cathro and Associates with his crew of assistants clearing a drill pad on the Arn property in the Finlayson Lake district. Hand trenches by this crew on other Finlayson area properties bear a striking similarity to trenches dug by a Caterpillar 225 excavator.*

program outlined a multi-element geochemical anomaly and coincident EM conductor in volcanic schists that is planned for drill testing in 1998. Pacific Bay conducted a program of geological mapping, grid soil sampling, prospecting and lithogeochemistry on 13 of 19 properties optioned from Cominco in the Finlayson region. Demand Gold Ltd. drilled two holes on the **RBI** (Yukon Minfile 105G new) claims, located three kilometres south of Cominco's ABM deposit, to test EM conductors associated with a weak magnetic anomaly and slightly anomalous soil geochemistry. The drilling encountered highly faulted structures but no economic mineralization. KRL Resources drilled five holes on the **Watson** (Yukon Minfile 105A new) property located at the southern end of the Finlayson Lake district on the BC-Yukon border. The best intersection from the program was 2.67% Zn over 0.9 metres. Arcturus Resouces Ltd, conducted a 3-hole drill program on the **First Base** (Yukon Minfile 105G 031) (Fig. 18) property located 17 kilometres southwest of Cominco's Kudz Ze Kayah Project in early October to investigate an electromagnetic and magnetic anomaly coincident with a lead-copper-zinc soil anomaly. Results of the program are pending. Atna Resources conducted drill programs on the **Money and Argus** (Yukon Minfile 105H 078, 105G 013) properties following up on mineralization intersected in 1996 drilling. Atna also conducted an E-scan (3-D conductivity and resistivity) survey on the Money property (Fig. 19).

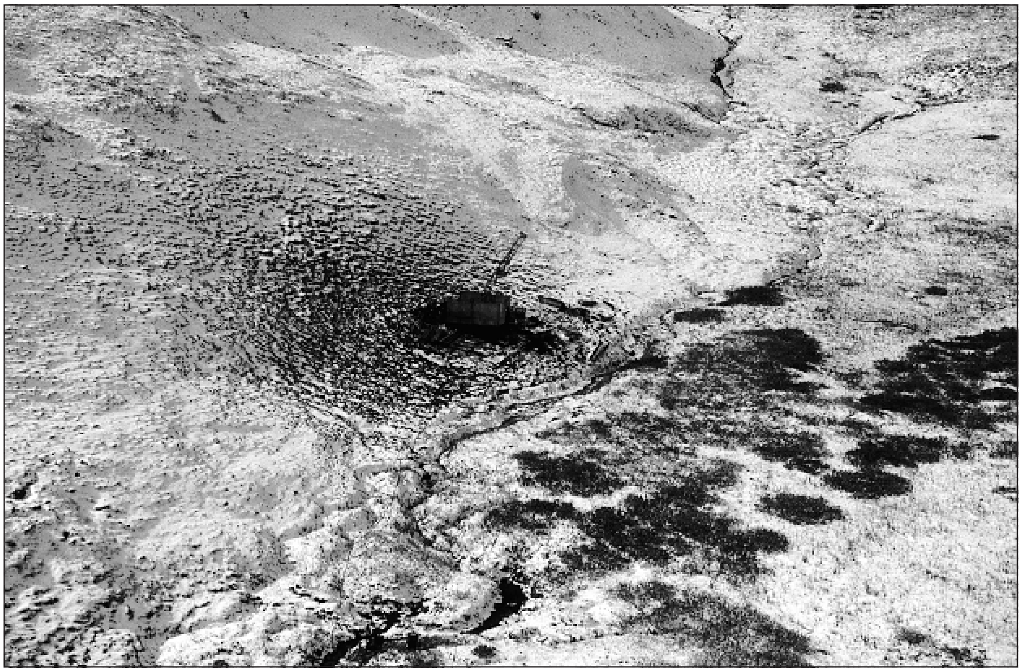


Figure 18. *Arcurus Resources conducted a 3-hole diamond drilling program on the First Base property located 17 kilometres southwest of Cominco's Kudz Ze Kayah Project. Drilling conducted in October targeted coincident electromagnetic, magnetic and Pb-Cu-Zn soil anomalies. The drill is visible in the centre of the photograph..*

Figure 19. *Wayne Pickett of Atna Resources examines 1996 core on the Money property. Atna continued drilling the property in 1997.*

Exploration continued in 1997 for VMS deposits outside the Finlayson Lake district. Exploration in volcanic rocks of Pelly-Cassiar Platform west of the Finlayson Lake area resulted in the discovery of a new massive sulphide body on the Wolf property of Atna and YGC Resources. Prospective occurrences in Yukon-Tanana Terrane north of Teslin and in the Dawson area were the focus of several focused programs and some grassroots exploration programs. The Marg deposit, hosted in Devono-Mississippian felsic volcanic rocks of the Selwyn Basin was explored with a moderate drill program.

The most significant program outside the Finlayson area was operated by Atna Resources on the **Wolf** (Yukon Minfile 105G 008) property. The Wolf property, 45 kilometres west of Kudz Ze Kayah, is on the west side of the Tintina Fault in Pelly-Cassiar Platform strata coeval, and possibly correlative with, Yukon-Tanana Terrane rocks in the Finlayson Lake district. The intermediate to felsic volcanic rocks hosting the mineralization discovered on the Wolf property define a belt approximately 80 kilometres long and up to 25 kilometres wide. Massive sulphide mineralization is hosted by pyritized felsic tuffs and was intersected by all nine drill holes of the program (Fig. 20) over a 500 metre strike length and 250 metres downdip. The property has been drilled by previous operators who intersected narrow sub-economic mineralization. Based on geologic interpretation of previous work and from their 1996 program Atna drilled deeper in the target horizon and intersected mineralization in the first hole of the program. The highest grade intersection, in WF97-07, was 25.2 metres grading 6.94% Zn 2.78% Pb and 138.6 g/t Ag. Atna will be conducting a major drill program in 1998 on the Wolf property.

Subsequent to the Wolf discovery, Atna Resources optioned several properties, including the **Mamu** (Yukon Minfile 105F 013) property of Oro Bravo Resources, and the **Bnob (Ice) and Chzerpnough (Fire)** (Yukon Minfile 105F 071, 073) properties of Eagle Plains and Miner River Resources. These three occurrences hosted in the same 80 by 25 kilometre belt of intermediate to felsic volcanic rocks as the Wolf. Oro Bravo completed a 12 kilometre access road (Fig. 21) to the Mamu property and conducted prospecting, additional claim staking and a 3-hole, 350 metre drill program. Mineralization at Mamu consists of disseminated pyrite in exhalite horizons, massive bedded pyrite, quartz veins and quartz breccias with pyrite +/- sphalerite, tetrahedrite, galena and chalcopyrite. On the **Bnob** and **Chzerpnough** properties, Eagle Plains and Miner River conducted geochemistry, mapping and prospecting. The Bnob hosts two layered barite horizons containing disseminated pyrite, and banded galena and sphalerite (Fig. 22). Select grab samples of the mineralized barite returned up to 12.7% Pb,

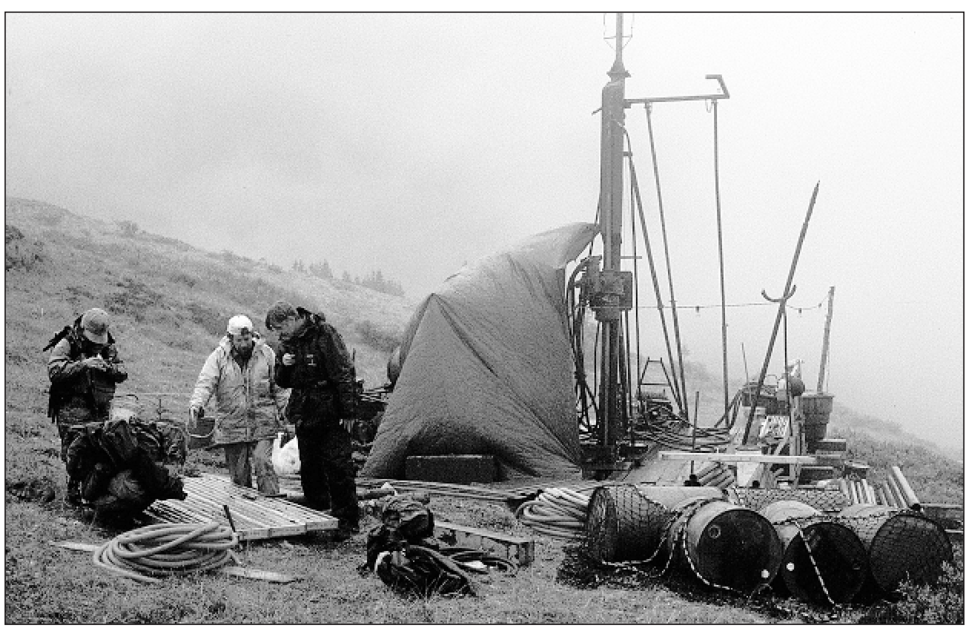


Figure 20. *Atna and YGC Resources geologists examine core at the Wolf massive sulphide discovery.*

Figure 21. *Oro Bravo Resources completed a 12-kilometre access road to the Mamu property. Three diamond drill holes were completed on the project in 1997.*

4.7% Zn and 55 g/t Ag. The Chzerpnough is host to disseminated sphalerite and galena mineralization hosted by lapilli tuff with a carbonate matrix. Peak values of 2.5% Pb, 11.7% Zn, 72.9 g/t Ag, and 1.06 g/t Au have been obtained on the property.

Artemis Ventures Inc, explored the **Wild-Eve** claims (Yukon Minfile 105F 020) with trenching and soil sampling. The claims are located approximately three kilometres south of the Chzerpnough occurrence. Trenching encountered a pale grey, pyritic horizon in Devono-Mississippian shales. The property is also underlain by felsic volcanics. Values up to 10.3 ppm Ag and 1853 ppm Pb were obtained from trenches and soil samples up to 44.1 ppm Ag, 2418 ppm Pb and 5564 ppm Zn were obtained.

Figure 22. *Tim Termuende, President of Miner River Resources examines banded galena and sphalerite in a barite horizon on the Bnob (Ice claims) occurrence.*

Pathfinder Resources staked approximately 450 **Starr** (Yukon Minfile 105G new) claims northeast from the Wolf discovery on open ground between the Wolf and the Bnob-Chzerpnough-Mamu properties. The property covers favourable volcanic stratigraphy which, with the recent discovery on the Wolf, has increased significantly in its mineral potential. Pathfinder conducted an airborne electromagnetics and magnetics survey over the claims and plans on conducting extensive exploration in 1998.

In the Teslin area the **BigTop** (Yukon Minfile 105C 021) property was explored by a privately funded Yukon exploration company with an airborne electromagnetic (EM) and magnetic survey, grid geochemistry, mapping, and excavator trenching (Fig. 23). Multi-element geochemical anomalies with up to 8.9 ppm Ag, 351 ppm Cu, 669 ppm Pb, and 3361 ppm Zn with coincident EM and magnetic anomalies were trenched, exposing a package of interlayered carbonaceous shales, argillites, pyritic felsic volcanics and tuffaceous units. Thinly laminated argillite with disseminated sphalerite returned assays of 0.75% Zn from outcrop and 1.2% Zn from float. Results of detailed sampling, whole rock analyses, thin section and polished sections are pending.

Fairfield Minerals Ltd. explored the **Cabin Lake** and **Caribou Creek** properties in the Teslin and Wolf Lake areas with prospecting, mapping, geochemistry and airborne geophysics. The properties were both staked on regional multi-element geochemical anomalies from a 1980's survey. On the Cabin Lake property a 250 ppm copper anomaly 800 metres long and 400 metres wide, with peak values up to 3000 ppm copper with some coincident silver, lead and zinc anomalies was identified. Grab samples up to 6087 ppm copper in quartz sericite schists were obtained from the Caribou Creek property.

Birch Mountain Resources Ltd. explored the **Swift River** (Yukon Minfile 105B 027) property located midway between Teslin and Watson Lake in Yukon-Tanana Terrane. Birch Mountain conducted a horizontal-loop electromagnetic survey in the spring followed by prospecting, trenching, detailed mapping and diamond drilling. Mineralization is associated with limy bands and metavolcanic rocks of the Anvil Allochthon. Detailed mapping of the mineralized showings on the property and subsequent petrographic work identified interlayered tuffaceous volcanics and calcareous sedimentary rocks. Mineralization consisting of massive to semi-massive pyrrhotite and magnetite was drilled at the Dan (Fig. 24) and Lower Crescent Lake showings. At the Dan, values of 14.57% Zn over 1.2 metres and 6.55% Zn over 1.88 metres were obtained. At the Lower Crescent, an intersection of 3.52% Zn over 1.1 metres was obtained. At the Upper Crescent showing, four horizons of interlayered magnetite and sphalerite returned values up to 6.29% Zn over 0.88 metres and 4.67% Zn over 4.85 metres.

Figure 23. *Interbedded black argillites and light coloured felsic rocks can be seen in trenching on the Bigtop property being explored for its VMS potential by a private Yukon exploration company.*

Also in Yukon-Tanana Terrane Atna Resources explored the **Matson Creek** (Yukon Minfile 115N 100) property west of Dawson with an electromagnetic and UTEM geophysical survey. The property is underlain by meta-sedimentary and meta-volcanic rocks of the mid-Permian Klondike Schist. Boxwork textured limonite occurs on surface within a large soil Cu-Pb-Zn geochemical anomaly, suggesting the presence of sulphides. Quartz veins with sulphide selvages identified in core from previous drilling may also explain the source of the geochemical anomaly.

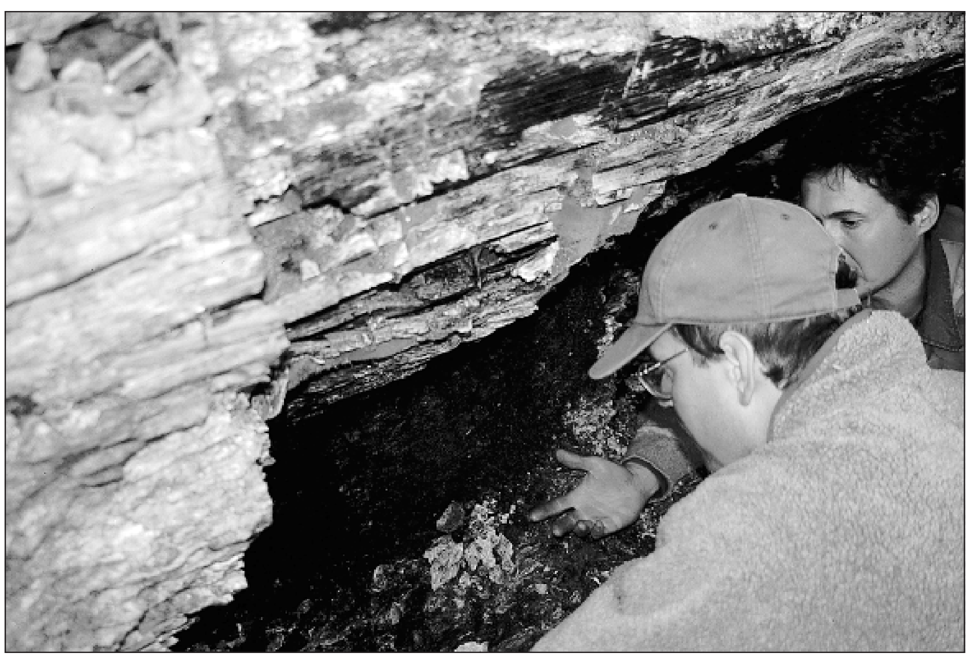
Madronna Mining Limited conducted a program of soil geochemistry on the **Poker Creek** (Yukon Minfile 116C 019, 146) prospect located 75 km west of Dawson in Yukon-Tanana Terrane. The property is being explored for its potential to host a VMS deposit. The geochemical survey was completed over magnetic highs identified in a 1996 airborne geophysical survey.

Exploration for base metals targets other than volcanic-hosted massive sulphides were conducted by several companies. Deposit types explored for included: sedimentary-exhalative Pb-Zn-Ag and sedimentary Ni-Zn in Selwyn Basin strata, Olympic Dam Cu-Co-Au in the Proterozoic rocks of MacKenzie Platform, porphyry Cu-Au in Stikine Terrane northeast of Whitehorse and in the Dawson Range, skarn Cu in the Whitehorse Copper Belt and magmatic Cu-Ni-PGE in Wrangell Terrane of southwest Yukon.

Figure 24. *Geologist Ed Santiago (R) at the Dan showing on Birch Mountain Resources' Swift River Project.*

Figure 25. *Dave Caufield (R) of Equity Engineering and John Robins, Director of Blackstone Resources at the TB showing, a stratiform nickel-zinc horizon on the Taiga Project.*

Blackstone Resources and joint-venture partner Glenhaven Resources, conducted a 12-hole helicopter-supported, reconnaissance scale drill program for stratiform Ni-Zn mineralization at the **Taiga** (Yukon Minfile 116B 128) project. The property is located approximately 100 kilometres northeast of Dawson and seven kilometres from the Dempster Highway. Mineralization consists of stratiform vaesite (nickel disulphide) hosted in silty argillites and shale of the Devono-Mississippian Earn Group (Fig. 25). A distinctive limestone ball unit consisting of limestone spheres up to one metre in diameter occurs in the strata immediately below the mineralization. This stratigraphic setting is similar to that found at the Nick occurrence located 150 kilometres to the east. At Taiga, Ni-Zn-PGE mineralization has been discovered in outcrop in two locations in 1994 and 1996, and the 1997 drill program was designed to test the favourable stratigraphy and coincident geochemical anomalies over a ten-kilometre strike length. Drill hole REN97-08 drilled in the vicinity of the TB showing (3.58% Ni over 40 cm on surface) intersected 25.5 metres of 0.51% nickel with 0.41% zinc starting at 29 metres depth. The intersection included a higher grade 5.3 metre intersection



grading 1.42% nickel and 0.70% zinc (Fig. 26). Drill hole REN97-07, drilled 200 metres east of 97-08, intersected 6.1 metres of 0.27% Ni and 0.33% Zn. Late in 1997, Blackstone staked a further 900 claims to cover 34 kilometres of favourable stratigraphy and coincident Ni-Zn soil and silt anomalies in the Taiga Basin. The discovery area and new areas will be further tested with an expanded program in 1998.

Blackstone Resources continued to evaluate the **Dromedary** (Yukon Minfile 105L 031, 051) property, where sedimentary exhalative mineralization, grading up to 8.42% Zn, 2.43% Pb and 29.8 g/t Ag over 2 metres, was intersected by drilling in 1996. The property, 80 km east of Pelly Crossing, is underlain by northwest-trending, south-dipping thrust panels which repeat Devono-Mississippian Earn Group sediments and Cambro-Ordivician Kechika Group sediments. Sedimentary exhalative mineralization consists of massive pyrrhotite, pyrite, sphalerite, galena and minor arsenopyrite hosted in the Earn Group while stratabound pods, bands and disseminations of pyrrhotite, pyrite, galena and sphalerite with cross-cutting quartz-galena-sphalerite veins occur in Kechika Group sediments. The 1997 program consisted of magnetic and gravity geophysical surveys, trenching, mapping, soil and rock sampling. The geophysical program increased the density and expanded a previous geophysical survey performed by Anaconda. The new data was successful in further delineating the coincident gravity and magnetic anomalies which formed the basis of the 1996 drilling. A better understanding of the geophysical signature of the massive sulphide mineralization encountered in the 1996 drilling has generated 13 anomalies which need to be further tested by drilling. Surface exploration led to the discovery of the Gully showing where selected grab samples returned up to 5.83% Zn and 5.5% Pb. The Gully showing is in the Kal-Cave area west of the 1996 drilling where several showings occur over a five-kilometre strike length.

The Westmin-Newmont joint venture (Fig. 27) conducted a helicopter-supported drill program in the Wernecke Mountains on the **Fairchild** (Yukon Minfile 106C,D,E various) project to test previously outlined geophysical anomalies in search of Cu-Au-Ag-Co mineralization hosted by “Wernecke Breccias.” Similarities to the Olympic Dam deposit (over 2 billion tonnes grading 1.6% Cu and 0.6 g/t Au, 3.6 g/t Ag, 0.06 U_2O_3) include: the hematitic breccia host rocks, the Proterozoic age of both host rocks and the deposit, and a similar mineralogy consisting of approximately 85% chalcopyrite and 15% chalcocite-bornite. The joint venture has 27 properties totalling over 1800 claims in the Bonnet Plume River region and has spent approximately $8.0 million on exploration over six years. Eleven of the properties have been drilled with 14 600 metres of diamond drilling in 105 holes. More than half of the drilling has been on the Hoover-Slab occurrence. Selected results from drilling include: 20.5 metres of 2.0% Cu, 0.21% Co, 0.16 g/t Au from Hole 3 at the Gremlin occurrence, 0.25% Cu over 200 metres including 20 metres grading 0.52% Cu in Hole 94-5 at the Hoover and 18 metres of 0.76% Cu in Hole 97-9 at the Slab.

Figure 26. *Drill core from Hole REN 97-08 at the Taiga property which demonstrates the subtle character of nickel-zinc mineralization. This hole returned a 5.3 metre intersection grading 1.42% nickel and 0.70% zinc.*

The **Olympic property** (Yukon Minfile 116B 099), within the Ogilvie Mountains, 100 kilometres north of Dawson City was explored by Major General Resources with structural mapping, geophysics and

diamond drilling. The property is underlain by a hematitic breccia complex analagous to those in the Wernecke Mountains being explored by the Westmin-Newmont joint venture and both are similar in age and emplacement style to the Olympic Dam deposit in Australia. The program ended in early October and results are not yet public. Previous work identified several areas of fracture-controlled, breccia-hosted copper mineralization which returned values up to 7.0% Cu over 4 metres. Mineralization in a fractured mafic dyke returned 1.97% Cu over 4 metres.

Figure 27. *The Westmin-Newmont joint venture went to great lengths to have a minimal environmental impact with their exploration program in the Bonnett Plume River area. This included flying garbage out of the area to the town of Mayo.*

An eight-hole, reverse-circulation drilling program was carried out on the **Rusty Springs** property (Yukon Minfile 116K 003) of Eagle Plains Resources during 1997 (Fig. 28). The program was funded by CanAustra Resources who can earn a 60% interest by spending two million dollars in exploration and making cash payments over 4 years. A total of 412 metres were drilled over the course of the program, which tested for stratabound base-metal mineralization beneath Mississippian-aged chert and shales in the lower Earn Formation. Four of the eight holes were abandoned with two holes intersecting the siliceous limonitic stratabound unit identified in the 1996 drilling program. Anomalous copper and zinc were obtained over a 36.6 metre limonitic interval in one hole and anomalous copper, lead, zinc and silver over a 59.9 metre interval of limonite in the other. The target siliceous limonitic unit was first successfully recovered in drilling in 1996 which led to reinterpretation of the property geology and setting of stratabound mineralization. The siliceous limonitic unit is host to both oxide and sulphide mineralization on the property, and has been intersected by drill holes up to five kilometres apart. The horizon is everywhere anomalous in base metals and has returned values in oxides up to 15.3 metres of 517.7 g/t Ag, 3.0% Cu and 1.3% Zn. Sulphide mineralization encountered in the horizon has returned values up to 4.54 metres grading 3873.8 g/t Ag, 13.0% Pb and 2.0% Cu.

Figure 28. *Summit Air's Skyvan provides support for the Rusty Springs project in northern Yukon. Drilling equipment, fuel and vehicles are among the supplies efficiently delivered to the project.*

Placer Dome conducted a program of geological mapping, sampling, geochemistry, airborne magnetics and radiometrics and an IP survey on the **Mars** (Yukon Minfile 105E 002) claims optioned from Camdan Exploration Inc. The property is located approximately 60 km northeast of Whitehorse near the Livingstone Creek winter trail. The Cu-Au porphyry target is hosted by the Middle Jurassic Teslin Crossing Pluton, an alkalic monzonite stock which intrudes Jurrasic Whitehorse strata of Stikine Terrane. Intensive potassic alteration and magnetite occur within the stock and mineralization consists of stockwork quartz +/- chalcopyrite.

Camdan Exploration Inc. conducted a program of prospecting, mapping and geochemistry on the **Java** claims located 3 kilometres northwest of the Mars property. The claims cover Jurassic intrusive rocks and a magnetic signature analogous to the host rocks and magnetic signature on the Mars property. Prospecting located a Cu-Au skarn occurrence which assayed up to 900 ppb Au and 1.5% Cu with anomalous zinc and bismuth. The occurrence is associated with a linear magnetic feature tailing off of the magnetic high coincident with the property.

Wildrose Resources Ltd. and joint venture partner Alexis Resources conducted a program of road-building, drill-pad construction, and prospecting on the **Canadian Creek** property (Yukon Minfile 115J 036) 150 kilometres south of Dawson in central Yukon. The property is located in the Dawson Range appoximately 5 kilometres west of the Casino Cu-Au-Mo porphyry deposit and may contain a similar target. Pyritic stockwork mineralization in intrusive subcrop was exposed during road-building and several gossanous areas were stripped in preparation for trenching.

Inco Limited and Fort Knox Gold Resources Inc. explored the **Klu** (Yukon Minfile 115G 003, 084) and **Burwash** (Yukon Minfile 115G 016) properties near Destruction Bay in western Yukon. Inco initially staked the Klu property in 1994 after discovering Ni-Cu mineralization hosted by Triassic mafic-ultramafic sills. Grab samples assayed up to 2.8% Cu, 3.1% Ni, 0.2% Co, 3.1 g/t Pt, and 1.0 g/t Pd. UTEM and ground magnetic surveys were conducted on the Klu property in 1997 following up on electromagnetic conductors identified in an airborne survey conducted in 1996. On the Burwash property, optioned from Nathan Minerals, two showings grading up to 3.6% Ni and 2.0% Cu are located at the base of the Tatamagouche Ultramafic complex. Ground magnetics and UTEM surveys, geological mapping and sampling were conducted on the Burwash property in 1997.

Figure 29. *Chalcopyrite-bearing skarn mineralization from the Hat claims located in the Whitehorse Copper Belt.*

Expatriate Resources drilled the **Canalask** Ni-Cu property (Yukon Minfile 115F 045) with 10 holes totalling 1203 metres. The drilling tested airborne magnetic and electromagnetic anomalies identified in a 1996 survey. The best results from the drilling was 0.35% Ni and 0.12% Cu associated with pyrrhotite concentrations in a gabbro. The geophysical anomalies coincide with fault zones containing pyrrhotite, magnetite and minor native copper.

Northern Platinum Ltd. continued work on the **Wellgreen** (Yukon Minfile 115G 024) deposit which contains reserves of 50 million tonnes of 0.35% Cu, 0.36% Ni, 0.51 g/t Pt and 0.34 g/t Pd in a Triassic layered mafic-ultramafic sill 600 metres thick. The deposit was in production in 1972 and 1973 and a portion of the underground workings were rehabilitated and resampled in the 1997 program. Adjoining are the Linda claims where Northern Platinum sampled a zone of massive to semi-massive sulphides which averaged 4.12% Ni, 0.89% Cu, 1.88 g/t Pt and 1.35 g/t Pd over 1.3 metres.

Local prospector Rob Hamel explored the **Hat** (Yukon Minfile 105D 053) claims located one kilometre north of the former War Eagle Open Pit near the garbage disposal area for the City of Whitehorse. Excavator trenching (Fig. 29) uncovered calc-silicate skarn consisting of garnet, diopside and wollastonite with chalcopyrite and bornite typical of the Whitehorse Copper Belt over a strike length of approximately 200 metres. Several extremely high grade areas of bornite and chalcopyrite mineralization were noted during a property visit. Production in 1970 and 1971 from the War Eagle deposit totaled 900 000 tonnes grading 1.25% Cu, 0.22 g/t Au, 8.57 g/t Ag and 0.038% Mo. Further to the north, in an area slated for expansion of the garbage dump, Hamel conducted limited cat-trenching to expose more porphyry-style mineralization.

EXPLORATION — GOLD

Exploration for precious metals, mainly gold, was active throughout Yukon with the main interest along the Cretaceous Tombstone Suite intrusive belt which stretches across the Yukon from north of Dawson in the west to MacMillan Pass in the east. Several reconnaissance programs were conducted in this belt of rocks, which hosts the deposits at Brewery Creek and Dublin Gulch in the Yukon, and Fort Knox in Alaska. The largest gold exploration program elsewhere in the Yukon was conducted in the Wheaton River district southwest of Whitehorse. In the Wheaton, Omni Resources with joint venture partners Arkona Resources and Trumpeter Yukon Gold continued a successful advanced exploration program on the Goddell and Skukum Creek deposits.

Omni Resources and Trumpeter Yukon Gold Inc, each hold a 35% interest in the **Goddell Shear** (Yukon Minfile 105D 025) property 85 kilometres south of Whitehorse; Arkona Resources holds the remaining 30%. In 1997, the undergound adit was extended 182 metres and over 8500 metres of underground drilling completed in 37 holes (Fig. 30). Based on this drilling an indicated reserve of 824 594 tonnes grading 7.15 g/t Au has been calculated. The shear zone cutting the mid-Cretaceous Carbon Hill granite contains gold and silver with disseminated stibnite, galena, sphalerite and arsenopyrite. Omni also conducted surface drilling near its **Skukum Creek** (Yukon Minfile 105D 022) deposit located 5 kilometres away. The deposit hosts a drill-indicated and inferred reserve of 800 150 tonnes grading 7.6 g/t Au and 275 g/t Ag. Drilling approximately 300 metres west of Skukum Creek intersected 7.66 g/t Au, 234.9 g/t Ag, 0.24% Cu, 5.88% Zn and 2.06% Pb over 11.6 metres in a quartz breccia containing galena-sphalerite-chalcopyrite-arsenopyrite-pyrite mineralization. Access to this new area, called the Ridge zone, can be gained by extending the 1300 level drift at Skukum Creek. Drilling also began on the **Raca** (Yukon Minfile

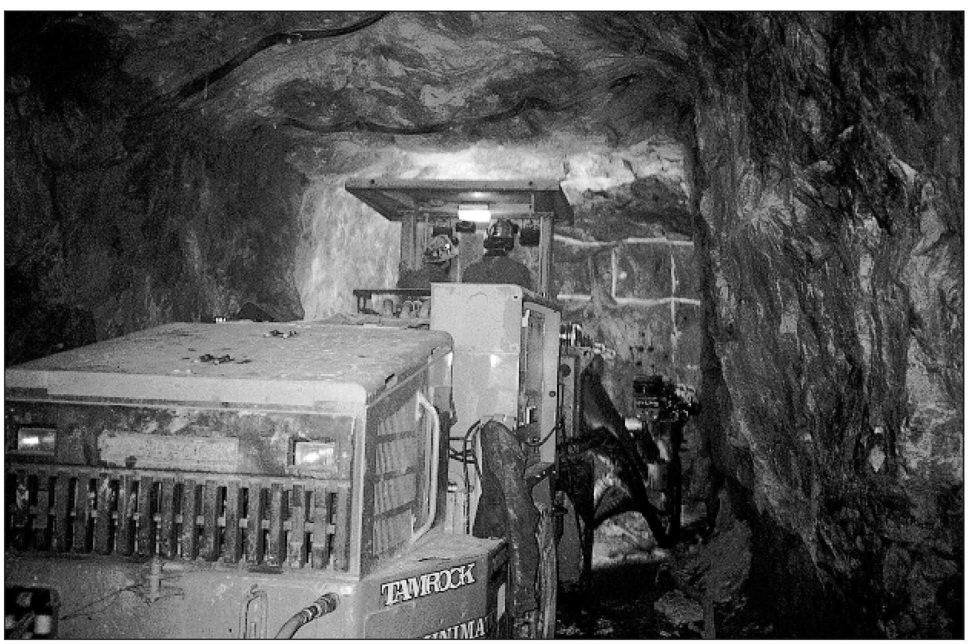


Figure 30. *Omni Resources extended the underground workings at the Goddell project to facilitate underground drilling of the deposit.*

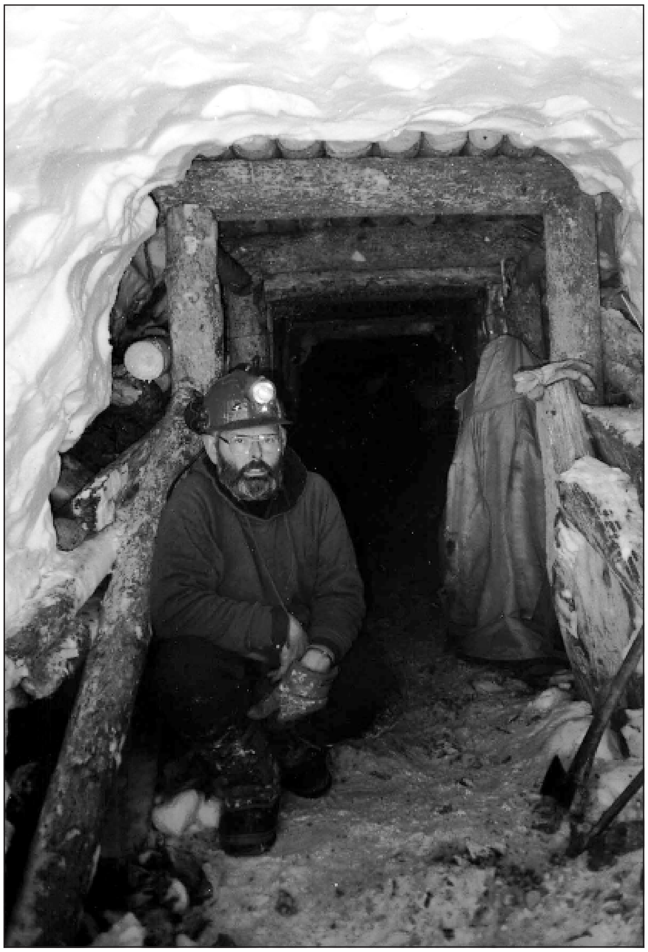


Figure 31. Gary Lee in the rehabilitated underground workings on the Tally-Ho property in the Wheaton River District.

105D 023) claims on strike to the northeast from the Skukum Creek deposit. A mineralized zone was reported in the first hole drilled in October but assay results are not yet available. Several other areas of high-grade mineralization were discovered in the vicinity of the Skukum Creek deposit during the summer.

Gary Lee and Mike Power continued work on the **Tally Ho** (Yukon Minfile 105D 032) property in the Wheaton River District which they have explored since 1994. The property straddles the Tally Ho shear zone between Dickson Hill and the Wheaton River. The pair have conducted extensive geophysical surveys, excavator trenching on 6 showings and rehabilitation of the underground workings on Mt. Stevens (Fig. 31). This work has delineated a series of E-W and NW-SE striking, epithermal quartz-calcite veins which appear to be splays of the Llewellyn Fault. Mineralization consists of pyrite-galena shoots up to 30 metres long over narrow widths returning grades of 6 to 93 g/t in both gold and silver.

Viceroy Resource Corporation conducted an extensive regional exploration program throughout the Yukon, looking for Brewery Creek-type and Carlin-style deposits. This was the largest reconnaissance program conducted in the Yukon in many years; over 80 targets were selected by extensive research and field checked during the summer. Viceroy staked eight new claim groups totalling more than 1100 claims and optioned several properties including two Tr'ondek Hwech'in land claims blocks. In addition the **Sun** and **Sprogge** (Yukon Minfile 105H 034) claim groups in southwestern Yukon were optioned by Viceroy from Battle Mountain Canada and explored with detailed mapping, sampling and hand trenching. Mineralization on these claims consists of skarns and quartz-arsenopyrite vein breccias assaying up to 6.9 g/t Au. Viceroy plans extensive exploration programs in 1998 on their many Yukon claim holdings.

Figure 32. International Kodiak Resources conducted a large stream sediment sampling program on the 66 000 ha Oki-Doki property adjacent to the Brewery Creek Mine. Preliminary results from the program have identified numerous Au-As-Hg-Sb geochemical anomalies.

International Kodiak Resources Inc, conducted a substantial exploration program on the **Oki-Doki** (Yukon Minfile 116B new) Project which consists of over 3300 claims (66 000 ha) at the northern and eastern boundary of the Brewery Creek Mine northeast of Dawson. The property is underlain by rocks of the Ordivician-Silurian Road River Group, the Devonian-Mississippian Earn Group and intrusive rocks of the Cretaceous Tombstone suite. The property contains very little outcrop and an airborne geophysics survey in conjunction with the Geological Survey of Canada, as well as detailed stream-silt geochemical sampling, (Fig. 32) were conducted in the fall of 1997. Nearly 10 000 silt samples were collected at 50-metre spacing on all primary and secondary drainages of the property. In October, with less than one third of the analyses received, 11 multi-element (Au, As, Hg, Sb) anomalies and 25 gold-only anomalies had been identified. Prospecting, mapping, detailed grid- and contour-soil sampling of anomalous areas, followed by trenching and drilling is planned for 1998.

Kennecott Canada conducted mapping, prospecting, excavator trenching (Fig. 33) and a reverse-circulation drill program consisting of 13 holes totaling 1000 metres on the **Scheelite Dome** (Yukon Minfile 115P 033) property located 120 kilometres east of Brewery Creek and 25 km northwest of Mayo. The property was optioned by La Teko Resources after the 1997 program. La Teko's main asset is the True North deposit in the Fairbanks district in Alaska which is optioned to Newmont. Scheelite Dome is underlain by a Cretaceous Tombstone suite granodiorite which intrudes Late Proterozoic Hyland Group metasediments. Several styles of gold mineralization hosted mainly in the metasediments have been identified on the property. Mineralization is more abundant in the competent quartzite units and consists of quartz-arsenopyrite +/- stibnite, galena and pyrite in veinlets and arsenopyrite as disseminations. Previous work by Kennecott defined a gold-in-soil geochemical anomaly which extends over three kilometres along strike and is one kilometre in width. Soils within the anomaly average severel hundred parts per billion, with a peak value of 1640 ppb Au. Trenching within the anomaly has returned values to 84.3 g/t Au over 4 metres and 20.5 g/t Au over 4.5 metres. One trench returned 0.33 g/t Au over its 744 metre length. The 1997 drilling tested two areas within the large geochemical anomaly and intersected

__Figure 33.__ Kennecott Canada conducted an extensive exploration program on the Scheelite Dome property. Trenches excavated during the program were backfilled at the end of the year. La Teko Resources has recently optioned the property and plans more work for 1998.

Figure 34. *Mike Glynn (L) explains the finer points of exploration work to Brenton Keyser (geologist-in-training) at the Len property in central Yukon. Drilling at the Len intersected a consistent gold-bearing quartz-arsenopyrite vein over a 500 metre strike length.*

mineralization in every hole. Selected results include 0.48 g/t Au over 29 metres in Hole 97-4 which was abandoned at a depth of 29 metres and Hole 97-11 which assayed 0.415 g/t Au over its entire 60.1 metre length.

Panamex Resources Inc. completed a six-hole diamond drilling program on the **Len** (Yukon Minfile 106D 020) property located 10 kilometres east of the Dublin Gulch deposit (Fig. 34). Quartz-sulphide veins are hosted by an east-west fracture system in a granodiorite stock, probably of the Tombstone Suite. Six holes were drilled at 100 metre spacings and all intersected quartz-arsenopyrite-pyrite mineralization with grades from 1.1 to 28.5 g/t Au. Intersections included 18.6 metres grading 2.1 g/t Au (including 15.3 g/t Au over 1.83 metres) in Hole 97-1, 4.2 g/t Au over 0.61 metres in Hole 97-5 and 3.1 g/t Au over 6.1 metres in Hole 97-6.

Figure 35. *Midnight Sun Drilling of Whitehorse performed reverse-circulation drilling on the Wayne property of Eagle Plains and Miner River Resources. Viceroy Resource Corporation optioned the property and conducted trenching late in 1997 and plans on further drilling in 1998.*

Miner River and Eagle Plains Resources acquired the **McQuesten** (Yukon Minfile 105M 029, Wayne) property in central Yukon, 17 kilometres south of Dublin Gulch. Mineralization at the Wayne consists of gold-bearing calc-silicate skarn in Proterozoic Hyland Group metasediments. Drilling in the 1980s intersected wide gold-bearing intervals including 0.72 g/t Au over 95.7 metres and 1.4 g/t Au over

40.1 metres. In 1997, a 6-hole reverse-circulation drill program (Fig. 35) tested the mineralized horizon over a strike length of 750 metres. Results included 3.23 g/t Au over 21.3 metres, 1.77 g/t Au over 35.3 metres and 0.92 g/t Au over 45.7 metres. Subsequent to the drilling program, Viceroy Resources optioned the property and began a program of trenching and detailed sampling. Viceroy's trenching program returned values up to 2.23 g/t Au over 22 metres, 1.59 g/t Au over 25 metres and 1.45 g/t Au over 10 metres. Preliminary metallurgical tests indicate that gold occurs as free particles resulting in material that is amenable to low-cost cyanide processing. Viceroy is planning a major drill program for the property in early 1998.

Pacific Galleon Mining Corp. explored the **Screamer** (Yukon Minfile 115P 040) property midway between Dawson and Mayo with prospecting, mapping and geochemistry. The claims cover the sheared contact between a syenite intrusive and metasediments. Sampling of the sheared contact in 1996 returned values up to 2.53 g/t Au from the zone which contains quartz with disseminated and banded pyrite, arsenopyrite, galena, antimony and trace chalcopyrite. The zone is up to 75 metres wide and can be traced over a one-kilometre strike length.

Miner River and Eagle Plains conducted mapping, prospecting (Fig. 36) and detailed sampling on several gold properties in the Tombstone Suite intrusive belt between Mayo and MacMillan Pass. The **Dragon Lake property** (Yukon Minfile 105J 007) located 85 km northeast of Ross River, 10 km west of the North Canol Road, hosts calc-silicate mineralization in Hyland Group metasediments and bears many similarities to the Wayne property located approximately 250 kilometres to the northwest. A program of prospecting and hand trenching at Dragon Lake uncovered several mineralized areas in a 300 by 600 metre area. Chip samples returned values up to 1.87 g/t Au over 9 metres and 1.21 g/t Au over 15.3 metres. The companies also conducted a small program involving prospecting and sampling on the **Nug** (Yukon Minfile 105O 048) property southwest of MacMillan Pass. A weakly silicified and clay-altered granitic stock containing a quartz stockwork returned values up to 1.55 g/t Au. On the **May Creek** (Yukon Minfile 115P 056) property west of Scheelite Dome in the Mayo area, grab samples returned up to 5.7 g/t Au from a granitic intrusion hosting narrow arsenopyrite veins. Actinolite skarn located peripheral to the granitic stock

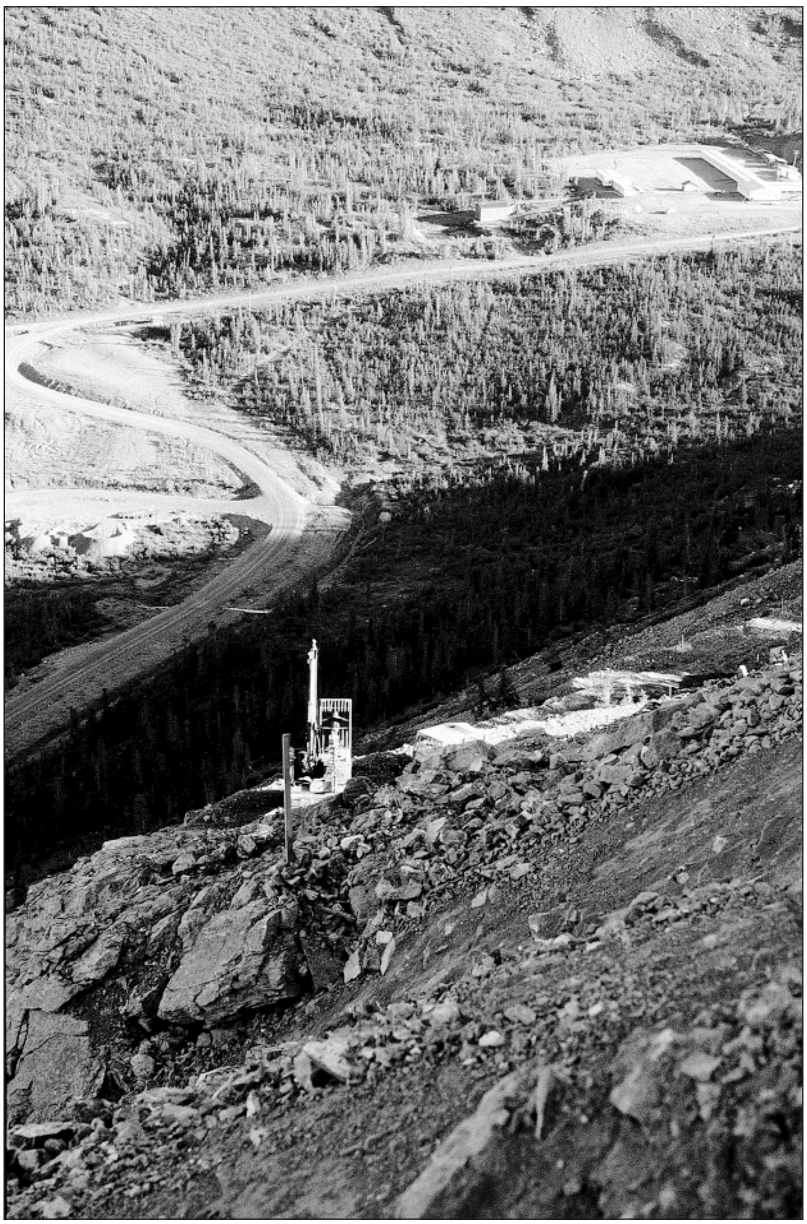
Figure 36. *Bernie Kreft examines an outcrop of gold-bearing calc-silicate mineralization on the Drag Property. The property bears many similarities to the Wayne property.*

returned gold values up to 6.6 g/t Au. The company also staked the **Nut** (Yukon Minfile 105O 044) claims northwest of MacMillan Pass to cover skarn mineralization identified by Amax in the early 1980s. The property is underlain by Proterozoic Hyland Group metasediments intruded by a Tombstone-age intrusion.

Near MacMillan Pass, at the eastern end of the Tombstone Suite intrusive belt, Cyprus Canada Inc. conducted a program of general prospecting, sampling and additional staking on the **Hess River** (Yukon Minfile 105O 009, etc) project, optioned from Alliance Pacific Gold Corp. The option applies to several blocks of claims staked and drilled by Alliance Pacific (formerly Yukon Gold Corp.) in 1995 and 1996, but excludes the Plata Mine property. Mineralization, similar to that at the Fort Knox mine operated by Cyprus in Alaska, has been identified on several of the claim blocks.

YGC Resources (no affiliation with Yukon Gold Corp.) continued to explore the **Ketza River** (Yukon Minfile 105F 019) Mine property south of Ross River. Diamond drilling in the area of the McGiver, Nu, and B-mag zones (Fig. 37) was directed towards demonstrating continuity between the zones. Drill hole KR-97-587 suggested a connecting mineralization between the Nu zone and McGiver, with an intersection of 6.1 metres grading 16.3 g/t Au in oxide mineralization. Drilling also intersected a new zone of oxide mineralization named the McDood. Two intersections 100 metres apart returned assays of 6.7 g/t Au over 4.7 metres and 4.6 g/t Au over 5.8 metres. The 1997 program was aimed at increasing oxide reserves on the former producing mine property in preparation for possible production in 1998. Ore from Ketza River would be trucked 300 km to the Mt. Nansen mill owned by YGC's joint venture partner and major shareholder BYG Natural Resources. YGC also conducted geological work on the Shamrock Zone, a bulk-tonnage low-grade gold target. The Shamrock Zone was tested with widely spaced drilling in 1996 which returned numerous intersections. The 1997 work included detailed mapping, sampling and re-logging of all core drilled by previous operaters.

__Figure 37.__ YGC Resouces drilled for more oxide reserves at the Ketza River property. The access road and campsite of the former producing mine are visible in the background.

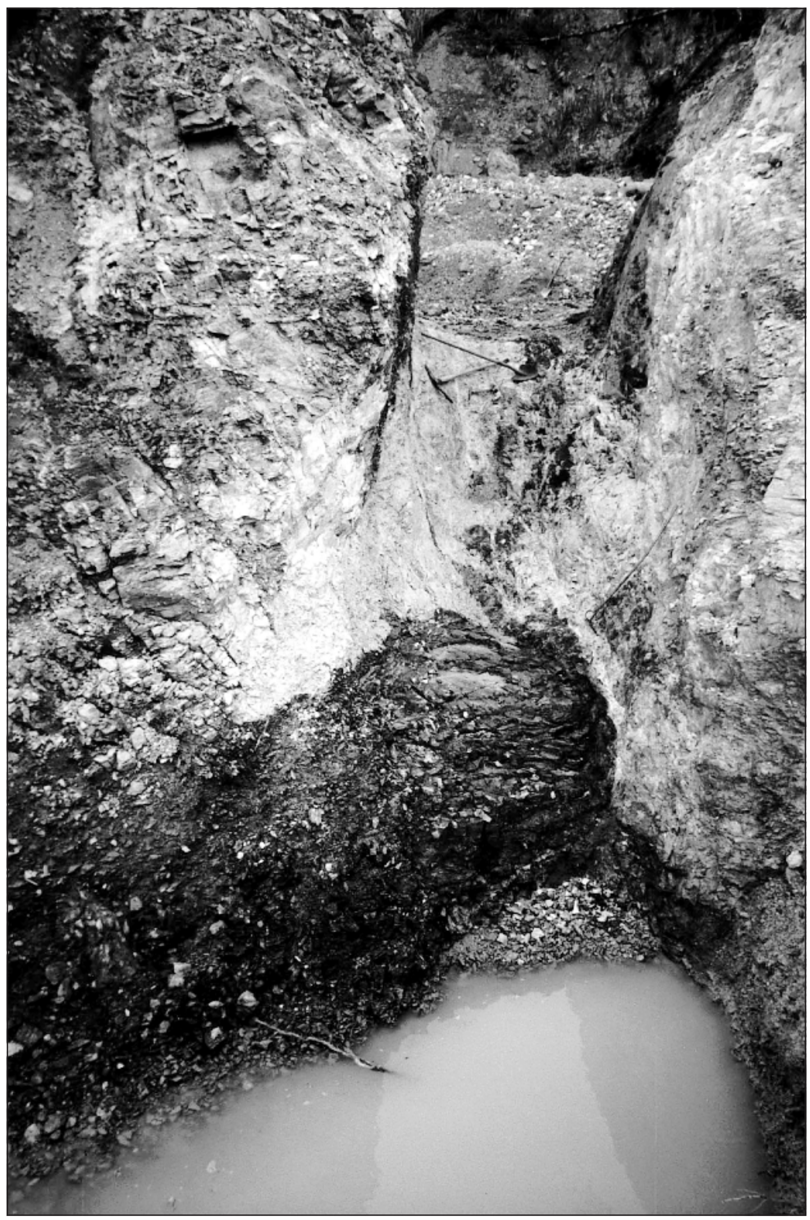


Brett Resources conducted preliminary work on the **Maui** (Yukon Minfile 105G new) claims, approximately 80 kilometres southeast of Ross River. The claims are underlain by Proterozoic metasediments and a Cretaceous intrusion immediately north of the Tintina Fault. Newly discovered mineralization on the property consists of silicification with pyrite, arsenopyrite, sphalerite and bismuthinite. Grab samples graded up to 5.9 g/t Au and 718 g/t Ag and nearly all samples assayed >1g/t Au.

Troymin Resources Ltd. optioned the **Prospector Mountain** (Yukon Minfile 115I 034, 036) from Almaden Resources Ltd. and explored the property with geological mapping, prospecting and trenching. The property, 100 kilometres west of Carmacks, is underlain by schists and gneiss intruded by Early Cretaceous Mt. Nansen volcanics and a subvolcanic syenite intrusive. Grab samples from veining within the intrusive returned values up to 56.0 g/t Au, 52.2 g/t Ag and 0.25% Cu. Anomalous values of mercury, arsenic and antimony were also obtained. The property was expanded and the new areas of mineralization will be investigated in 1998.

Yukon Yellow Metal Exploration Ltd, a privately funded Yukon exploration company, explored the Winnie showing on **Shootamook Creek** (Yukon Minfile 105B 045) in southern Yukon with excavator trenching and sampling. The Winnie showing was excavated and sampled in three successive phases during 1997. Each phase was excavated to a deeper level in the same area and sampled. Gold mineralization occurs within a silicified shear zone cutting a small granitic intrusion, in quartz stockworks extending from the shear host granite, and in adjacent silicified graphitic schist (Fig. 38). Mineralization consists of immiscible sulphide (pyrite) blebs, arsenopyrite on fractures and minor malachite and scorodite staining within the intrusive. Limonite staining occurs within the intrusive and surrounding metasediments. The last and deepest phase of excavation returned a general increase in anomalous values of silver, copper, lead, zinc, arsenic, antimony and cadmium. Select samples from quartz stockworks within the intrusive, in the hanging wall of the shear, returned gold values up to 3.6 g/t in the first phase, 6.91 g/t in the second and 5.18 g/t in the third. Sampling showed typical nugget effect with some samples returning below detection but 33% of the 55 samples assaying >1 g/t Au. Anomalous Cu (up to 618 ppm), Pb (up to 1292 ppm), Zn (4821 ppm), As (up to 1.7%) Sb (up to 359 ppm), Ag (up to 84.7 g/t) and Cd (up to 13.9 ppm) were also obtained, with the values showing a general increase in value from deeper excavations. Chip sampling by Mike Burke of the Yukon Geology Program returned values up to 0.618 g/t Au over 1.5 metres from altered and stockworked granite in the immediate hanging wall of the shear. A chip sample by independant geologist Larry Carlyle from highly silicified, limonitically altered, thin bedded black graphitic schist with trace pyrite, also in the hanging wall of the shear, returned 1.86 g/t Au, 1.4 g/t Ag and 1.1% As over 1.2 metres.

__Figure 38.__ Excavator trenching on the Winnie showing at Shootamook Creek. Gold values were obtained from the light-coloured felsic intrusive in the centre of the photo and from graphitic schist in the lower left.



Whitehorse geologist Larry Carlyle and placer miner Max Fuerstner staked 142 **Cam** claims (Yukon Minfile 105E 001, etc.) in the Livingstone placer mining camp. Historical production from Livingstone Creek and tributaries is estimated at 70 000 crude ounces with nuggets up to 39 ounces. Carlyle conducted geochemical and ground VLF-EM surveys on the claims. Bull-quartz veins with widths up to 1 metre occupy several faults which strike 320°, parallel to the Big Salmon Fault, on the western edge of the claims and perpendicular to placer creeks. The property is underlain by Paleozoic biotite schists which contain sericite and chlorite alteration in proximity to faulting. Placer gold is reported to be concentrated near faults encountered during mining. Soil samples up to 898 ppb were collected in the program and one rock sample from a quartz veinlet returned 1.4 g/t Au. Carlyle has proposed the property has

Figure 39. *Harman Keyser, of Radius Exploration examines a trench in altered ultramafic rocks on the Brik property near Dawson.*

many similarities to the Macraes Mine in New Zealand and will be exploring the property based on this model in 1998.

Radius Exploration conducted an exploration program consisting of a grid establishment, geophysics survey and excavator trenching (Fig. 39) on the **Brik** (Yukon Minfile 116B 004) property. Previous work by Noranda on the property, which is close to the Klondike Highway 15 kilometres south of Dawson, identified soil anomalies with up to 300 ppb Au and 3000 ppm As associated with a vegetative kill zone. The property straddles the Tintina Fault and contains an outcrop of Eocene felsic volcanics similar to those hosting the Grew Creek Gold deposit. Trenching in the area of the soil anomaly exposed ultramafic rock with a stockworks of chalcedony veinlets and listwaenite alteration.

COAL AND INDUSTRIAL MINERALS

Exploration for commodities other than base metals and gold was also active in the Yukon in 1997. Coal and lime resources could supply both local demand and potential export. Coal offers an alternative local fuel source for the Yukon, which relies upon diesel fuel to supplement the decreased hydoelectric generation in the winter months. Coal resources are also of a sufficient quality to export to the Orient if a large enough reserve is proven. Lime, currently imported for the Yukon's operating mines, could be supplied from a local source, which would drastically cut transportation costs.

Figure 40. *Coal can be seen in this trench excavated by Cash Resources on the Carmacks Coal Project. Cash also conducted a successful program aimed at expanding reserves at the Division Mountain Coal Project 70 kilometres to the south.*

Cash Resources advanced the **Division Mountain Coal** (Yukon Minfile 105H 013) project with a program of excavator trenching and diamond drilling. The property is located 90 kilometres northwest of Whitehorse near Braeburn and is 18 kilometres southwest of the main power transmission line to Carmacks and Faro. Before the 1997 program began, the property contained drill-indicated, open-pittable reserves of 31.7 million tonnes of high-volitile bituminous B coal. Washability tests indicate that a product averaging 1.9% moisture, 14.6% ash, 29.8% volitile matter, 55.6% fixed carbon and 0.5% sulphur with a calorific value of 6583 kcal/kg (11 756 btu/lb) can be readily produced. Exploration on the South Zone, approximately 1.5 kilometres south of the previous reserve, included drilling 10 large-diameter holes totaling 1667 metres. The drilling outlined coal in a continuous seam up to 21 metres thick with as many as five narrower hanging wall seams, over a 2.5-kilometre strike length. The seam is projected to wrap around the nose of a north-plunging syncline 1.5 kilometres to the southeast. This area has high potential for a dramatic increase in low-strip-ratio coal reserves. Cash Resources estimates drill-indicated raw coal reserves at 54.7 million tonnes. Exploration on other areas of the property identified economic thicknesses of coal in three areas within 10 kilometres of the main area of excavation. Cash Resourcesalso explored for coal on other concessions in the Yukon. Trenching on the Carmacks concession (Fig. 40), 70 kilometres north of Division Mountain, and about 10 kilometres south of Carmacks, exposed five zones of bituminous coal with an aggregate thickness of up to 10 metres.

Figure 41. *Al Doherty of Aurum Geological Consultants in Whitehorse samples high purity limestone in a blast pit on the Braeburn Lime Project.*

A private Yukon exploration company conducted a blast trenching, sampling and reverse circulation drill program (Fig. 41) on the **Braeburn Lime** (Yukon Minfile 105E new) Project. The property is road-accessible, close to the Klondike Highway at Braeburn, which is midway between Whitehorse and Carmacks. Triassic Lewes River Group limestone from the North and South zones was tested and contains approximately 95% $CaCO_3$. The objective of the project is to produce a quality lime product for the domestic market.

GEMSTONES

While (unfortunately) not in the Yukon, a new gemstone occurrence was discovered by Yukon prospector, Ron Berdahl. Translucent to transparent, pale emerald-green and green beryl crystals, up to 2 cm long and 0.5 mm thick, was found in phlogopite schist developed along the contact zone between a Cretaceous rare-element pegmatite (Fig. 42) and

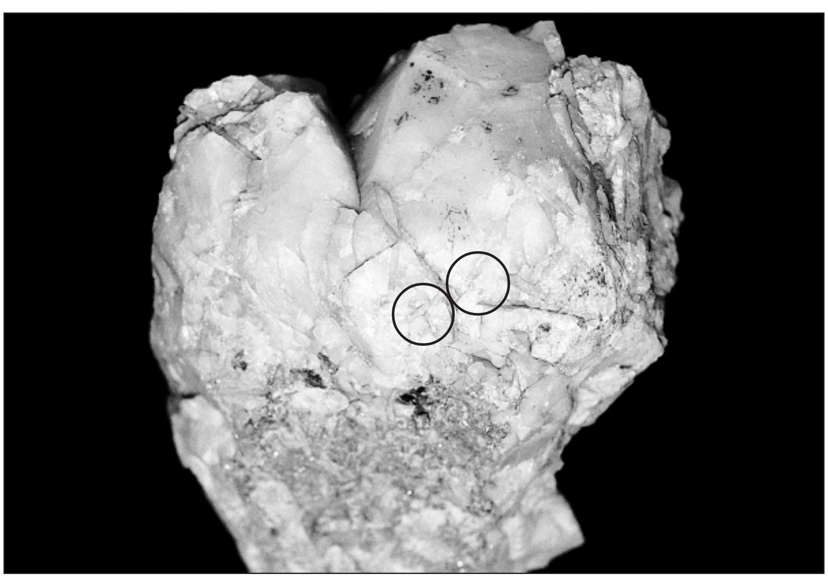


Figure 42. *Translucent to transparent, pale emerald-green and green beryl crystals can be seen in this specimen from Ron Berdahl's property in the N.W.T.*

Devonian-Mississippian carbonaceous black shales near the Yukon-N.W.T border. This locality is of extremely rare North American emerald-green beryl and needs to be evaluated for gemstone potential.

ACKNOWLEDGMENTS

This report is based on public information gathered from many sources. It includes information provided by companies through press releases, property summaries provided to the department and from property visits conducted in the 1997 field season. The cooperation of companies in providing information and their hospitality during field tours are gratefully acknowledged. Editing by Charlie Roots is appreciated.

Companies and individuals exploring in the Yukon and wishing to be included in future reports are encouraged to contact the authors.

APPENDIX 1: 1997 EXPLORATION PROJECTS

BS-Bulk Sample	F-Feasibility	M-Mining	T-Trenching
D-Development	G-Geology	PD-Percussion Drilling	U/GD-Underground Development
DD-Diamond Drilling	GC-Geochemistry	PF-Prefeasibility	
ES-Environmental Studies	GP-Geophysics	R-Reconnaissance	

PROPERTY	COMPANY	MINING DISTRICT	YUKON MINFILE (prefix is NTS map #)	WORK TYPE	COMMODITY
Alp/Nug/Rog/Old/Nut	Eagle Plains Resources Miner River Resources	Mayo	105O 04, 048, 055, 039, 044	G, GC, P	Au
Argus	Atna Resources/YGC	Watson Lake	105G 013	G, GC, DD	Pb, Zn, Ag
Arn	Expatriate Resources	Watson Lake	105G 112	G, GC, P, T, DD	Zn, Pb, Cu
Aurex	Yukon Revenue	Mayo	105M 060	G, T	Au
BigTop	15053 Yukon Inc.	Whitehorse	105C 021	G, GC, GP, T	Pb, Zn, Cu, Au
Bnob/Chzerpnough	Eagle Plains Resources Miner River Resources	Whitehorse	105F 071, 073	G, GC, P	Cu, Zn, Pb, Au, Ag
Braeburn Lime	Private	Whitehorse	(105E/5)	G, GC, PD	Lime
Brewery Ck	Viceroy Resource Corporation	Dawson	116B 160	M, PD, T, G GC	Au
Breakaway	Expatriate Resources	Watson Lake	105G 93	G, P, DD	Zn, Pb, Ag
Brik	Radius Exploration	Dawson	116B 004	G, GC, P, T	Au
Cabin Lake (C.L.)/ Caribou Creek (C.C.)	Fairfield Minerals Ltd.	Whitehorse	(105B/4) (105C/8)	G, GC, P, T, GP	Cu, Pb, Zn, Ag
Cam	Larry Carlyle	Whitehorse	105E 001	G, GC, GP	Au
Canadian Creek	Alexis/Wildrose Resources	Whitehorse	115J 036	G, GC, T	Cu, Au
Canalask	Expatriate Resources	Whitehorse	115F 045	DD, G	Ni, Cu
Carmacks Copper	Carmacks Copper Limited	Whitehorse	115I 008	ES, D	Cu, Au
Casino	Pacific Sentinel Resources	Whitehorse	115I 028	ES	Cu, Mo, Au
Clear Creek	New Millennium Mining	Dawson	115P 011	G, GC	Au
Convert	Nordac Resources	Watson Lake	(105B/5)	G, GC, P, DD	Pb, Zn, Ag
Discovery Ck	BYG Natural Res.	Whitehorse	115I 093	G, GC.DD	Au, Ag, Cu, Mo, Pb, Zn
Division	Cash Resources Ltd.	Whitehorse	115H 013	DD, T, G, ES	Coal
Drag	Eagle Plains Resources Miner River Resources	Whitehorse	105J 007	G, GC, P, T	Au
Dromedary	Blackstone Resources	Whitehorse	105L 031, 051	G, GC	Pb, Zn, Ag
Dublin Gulch	New Millennium Mining	Mayo	106D 021-29	F, ES	Au
End Zone	Nordac Resources	Watson Lake	105B 101	G, P, DD	Pb, Zn, Ag
ENG (Bar)	Cominco	Whitehorse	105C 003	G, DD	Pb, Zn, Ag
Fairchild	Newmont/Westmin	Mayo	(106/C, D, E)	G, DD	Cu, Au, Ag, Co

PROPERTY	COMPANY	MINING DISTRICT	YUKON MINFILE (prefix is NTS map #)	WORK TYPE	COMMODITY
Faro (Grum)	Anvil Range Mining Corporation	Whitehorse	105K 056	DD, D, M	Pb, Zn, Ag, Au
Finlyson Project	Expatriate	Watson Lake		G, GC, GP, DD	Cu, Zn, Pb, Au, Ag
First Base	Arcturus Resources	Watson Lake	105G 031	G, GC, P, DD	Cu, Pb, Zn
Fret/Dot etc.	Pacific Bay Minerals Ltd.	Watson Lake	(105G)	G, GC	Cu, Pb, Zn, Ag, Au
Fyre Lake	Columbia Gold Mines	Watson Lake	105G 034	G, GC, GP, DD	Cu, Co, Au
Goal/Net	Expatriate Resources	Watson Lake	(105G/7)	G, GC, P	Pb, Zn, Ag
Goddell	Omni/Arkona	Whitehorse	105D 025	DD, U/GD	Au
Hat	Rob Hamel	Whitehorse	105D 053	G, T	Cu, Au
Hess River	Cyprus Canada	Watson Lake	105O 009, etc.	G, GC, R	Au
Ice	Expatriate Resources	Watson Lake	(105G/14)	G, GP, GC, DD	Cu, Co, Au
Java	Camdan Exploration	Whitehorse	(105E/7)	G, GC, P	Cu, Au
JP/Border	KRL Resources	Watson Lake	(95D-4)	G, GP	Pb, Zn, Ag
Keno Hill	United Keno Hill Mines	Mayo	105M 001	ES	Pb, Zn, Ag
Ketza	YGC Resources	Watson Lake	105F 019	DD, G	Au
Kiwi	Teck Exploration	Whitehorse	(105J/12)	G, P	Au
Klu/Burwash	Fort Knox Resources/Inco	Whitehorse	115G 003, 084, 016	G, GP	Cu, Ni, PGE
Kudz Ze Kayah	Cominco Ltd.	Watson Lake	105G 117	ES, F, DD, G	Cu, Zn, Pb, Ag, Au
Len	Panamex Resources	Mayo	106D 020	G, GC, DD	Au
Liard/Watson	KRL Resouces	Watson Lake	(105A/2)	G, GP	Au
Lonestar/Buckland	Klondike Gold	Dawson	115O 72, 077	G, T	Au
Mamu	Oro Bravo	Whitehorse	105F 013	G, GC, GP, DD	Cu, Pb, Zn, Ag
Marg	NDU Resources	Mayo	106D 004	G, GC, DD	Cu, Pb, Zn, Ag, Au
Mars	Placer Dome	Whitehorse	105E 002	G, GC, GP	Cu, Au
Mart	Private	Whitehorse	105D 178	G, GP, T	Au
Matson Creek	Atna Resources/YGC	Dawson	115N 100	G, GP	Cu, Pb, Zn
Maui	Brett Resources	Watson Lake	(105G/11)	G, GC	Au
May Creek	Eagle Plains/Miner River	Mayo	115P 056	G, P	Au
Mel	Cominco	Watson Lake	95D 005	G, GC, DD	Pb, Zn, Ag
Minto/DEF	Minto Explorations	Whitehorse	115I 021, 022	D, ES	Cu, Au, Ag
Money	Atna/YGC	Watson Lake	105H 078	G, GP, DD	Cu, Zn, Pb, Au, Ag
Mt. Nansen	BYG Natural Resources	Whitehorse	115I 064, 065	M, T, G	Au, Ag
Oki-Doki	International Kodiak	Dawson	(116B/1)	G, GC, GP	Au
Olympic	Major General	Dawson	116B 099	G, GP	Cu, U, Co, Au, Ag
Poker Creek	Madronna Mining	Dawson	116C 019, 146	GC	Cu, Pb, Zn

PROPERTY	COMPANY	MINING DISTRICT	YUKON MINFILE (prefix is NTS map #)	WORK TYPE	COMMODITY
Power Play	Expatriate Resources	Watson Lake	(105G/12)	G, GC, P, DD	Cu, Co, Au
Primo	Klondike Gold	Watson Lake	105H 096	G, GC	Cu, Zn, Au, Ag
Prospector Mtn.	Troymin Resources	Whitehorse	115I 034, 036	G, P, T	Au, Ag
Puck	Westmin/Expatriate	Watson Lake	105G 072	G, DD	Cu, Zn, Pb, Ag, Au
RBI	Demand Gold	Watson Lake	105G 117	G, GC, DD	Cu, Zn, Pb
Rusty Springs	Eagle Plains Resourses	Dawson	116K 003	G, GC, T, PD	Ag, Cu, Zn, Pb
Sa Dena Hes	Cominco Ltd.	Watson Lake	105A 012, 013	D	Zn, Pb, Ag
Scheelite Dome	Kennecott Canada	Mayo	115P 033	G, GC, P, T, PD	Au
Screamer	Pacific Galleon	Dawson	115P 040	G, GC, P	Au
Shootamook	Yukon Yellow Metal	Watson Lake	105B 045	GC, T	Au
Simpson	Nordac Resources	Watson Lake	(105G/13)	G, GC, P, DD	Pb, Zn, Ag, Cu
Skate	Expatriate Resources	Watson Lake	105K 098	G, GC, P, DD	Pb, Zn, Ag, Cu
Skukum Creek/Raca	Omni Resources/Arkona	Whitehorse	105D 022, 023	G, GC, P, DD	Au
Starr	Pathfinder Resources	Watson Lake	(105G/5)	G, GP	Pb, Zn, Ag
Sun/Sprogge	Viceroy Resouce Corp.	Watson Lake	105H 034	G, GC, T	Au
Swift River	Birch Mountain Resources	Watson Lake	105B 027	G, GC, GP, DD	Zn, Cu, Pb
Taiga	Blackstone Resources	Dawson	116B 128	G, GC, P, DD	Ni, Mo, Zn, Au, Pt
Tally-Ho	Gary Lee/Mike Power	Whitehorse	105D 032	G, GC	Au
Touchdown etc.	Nordac Resources	Watson Lake	(105A, B)	G, GC, GP, T	Cu, Pb, Zn, Ag, Au
TY	Westmin Pacific Bay Minerals	Watson Lake	105G 083	G, GC, GP	Cu, Zn, Pb, Au, Ag
Ver/CJ	Westmin	Watson Lake	95D 011	G, GC	Au
War/Lip	Expatriate	Watson Lake	105G 070	G, GC, GP	Cu, Pb, Zn, Ag, Au
Watson	KRL Resources	Watson Lake	(105A/2)	G, DD	Pb, Zn, Ag
Wayne (McQueston)	Eagle Plains/Miner River	Mayo	105M 029	G, T, PD	Au
Wellgreen	Northern Platinum	Whitehorse	115G 024	G, U/GD	Cu, Ni, PGE
Wild/Eve	Artemis Ventures Inc.	Watson Lake	105F 020	P, T	Cu, Pb, Zn
Wolf	Atna/YGC	Watson Lake	105G 008	G, GC, DD	Pb, Zn, Ag
Wolverine	Westmin/Atna	Watson Lake	105G 072	G, GC, GP, DD	Au, Ag, Cu, Zn, Pb

APPENDIX 2: 1997 DRILLING STATISTICS

PROPERTY	COMPANY	DIAMOND DRILL METRES	DIAMOND DRILL # HOLES	RC/PERCUSSION DRILL METRES	RC/PERCUSSION DRILL # HOLES
Arm	Expatriate Resources	462	4		
Argus	Atna Resources	610	6		
Breakaway	Expatriate Resources	92	1		
Brewery Ck	Loki Gold			2914	33
Canalask	Expatriate Resources	1228	10		
Convert	Nordac Resources	993	6		
Division Mountain Coal	Cash Resources	1667	10		
Eliza Extension	BYG Resources	1560	10		
End Zone	Nordac Resources	100	2		
ENG (Bar)	Cominco	536	4		
Fairchild	Newmont	4000	33		
Faro Mine	Anvil Range Mining	2700	13		
Finlayson Regional	Cominco	1050	7		
First Base	Arcturus Resources	366	3		
Fyre Lake	Columbia Gold	13 500	44		
Goddell Gold	Omni Resources/Arkona/Trumpeter	8521	37		
Ice	Expatriate Resources	7880	87		
Ketza	YGC Resources	1217	11		
Kudz Ze Kayah	Cominco	5360	17		
Mamu	Oror Bravo	350	3		
Marg	NDU Resources	1830	7		
MEL	Cominco	361	2		
Money	Atna Resources	610	4		
Mt. Nansen	BYG Resources				
Olympic	Major General Resources	2672	11		
Power Play	Expatriate Resources	1895	6		
QB	Nordac Resources	995	8		
RBI	Pacific Bay Resources	480	2		
Ridge/Raca	Omni/Arkona/Trumpeter	2215	7		
Rusty Springs	Eagle Plains Resources Ltd.			412	8
Scheelite Dome	Kennecott Canada	1000	13		
Simpson	Nordac Resources	980	6		
Skate	Expatriate Resources	556	3		
Swift River	Birch Mountain Resources	985	9		
Taiga	Blackstone/Glenhaven	616	12		
Watson	KRL Resources	750	5		
Wayne (McQueston)	Eagles Plains Miner River			500	6
Wellgreen	Northern Platinum			60	3
Wolf	Atna Resources	2956	9		
Wolverine/Puck/Regional	Westmin Resources/Atna	15 330	53		
TOTAL		**85 489**		**3886**	

YUKON GEOLOGY PROGRAM

Yukon Geology Program

Grant Abbott
Yukon Geology Program

Abbott, Grant. 1998. Yukon geology program. *In:* Yukon Exploration & Geology 1997; Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p.41-48.

The past year was a time of uncertainty, change and opportunity for the Yukon Geology Program (Fig. 1). The Program was established as a *de facto* Yukon Geological Survey in 1996 when the Canada/Yukon Mineral Development Agreement (MDA) ended. Under the Yukon Geology Program umbrella, two offices with different administrative structures are integrated and jointly managed (Fig. 2). These include federal funding through the Exploration and Geological Services Division of Indian and Northern Affairs Canada (DIAND) and territorial and cost-shared funding through the Mineral Resources Branch of the Department of Economic Development. The Geological Survey of Canada also maintains an office with the Program and other projects receive support and funding.

The main challenges in 1997 were to cope with personnel changes, restrictions on hiring, digital product development, conversion to publishing-on-demand, and increased demands from devolution, land claims and the Yukon Protected Areas Strategy. When the MDA ended, cost-shared geoscience funding was retained at previous levels, but only on a year-to-year basis. As a result, three geologist positions have remained vacant for more than two years, and a large portion of funding was directed towards geophysical surveys and compilation projects rather than for geological mapping. Long-term support for geoscience is now more certain, and hiring began last spring and will continue in the new year. Grant Lowey is our new Placer Geologist and Ken Galambos replaces Grant Lowey as Mineral Development Geologist in charge of the Yukon Mining Incentive Program. The program suffered a big loss when our Chief Geologist, Trevor Bremner, moved on to become Acting Director of Mineral Resources, DIAND and shortly thereafter, to a position in Ottawa. In addition, Rod Hill, formerly Manager of Mineral Resources Branch, has become the devolution coordinator for the Yukon Territorial Government (YTG). Grant Abbott and Shirley Abercrombie are now acting in these key positions. Bob Holmes has moved from Senior Director of Mines and Resource Development, YTG to Director of Mineral Resources, DIAND, and Jesse Duke has taken over Bob's responsibilities in YTG. Terry Sewell, formerly Assistant Deputy Minister of Strategic Management and Industry Trade and Investment in YTG, has succeeded Mike Ivanski as Regional Director General of DIAND.

The Yukon Territorial Government and Indian and Northern Affairs Canada have entered into negotiations to devolve the responsibilities of the Northern Affairs Program. Devolution is likely, but not yet certain. If agreement is reached, transfer could take place as soon as the end of 1998, and a Yukon Geological Survey will become a reality.

The Yukon Geology Program in 1997 supported two mapping geologists, two placer geologists, one mineral deposit geologist, one resource assessment geologist, two staff geologists, and in part, one GSC regional mapper. Several other projects were also funded through contributions to the Geological Survey of Canada and to university researchers.

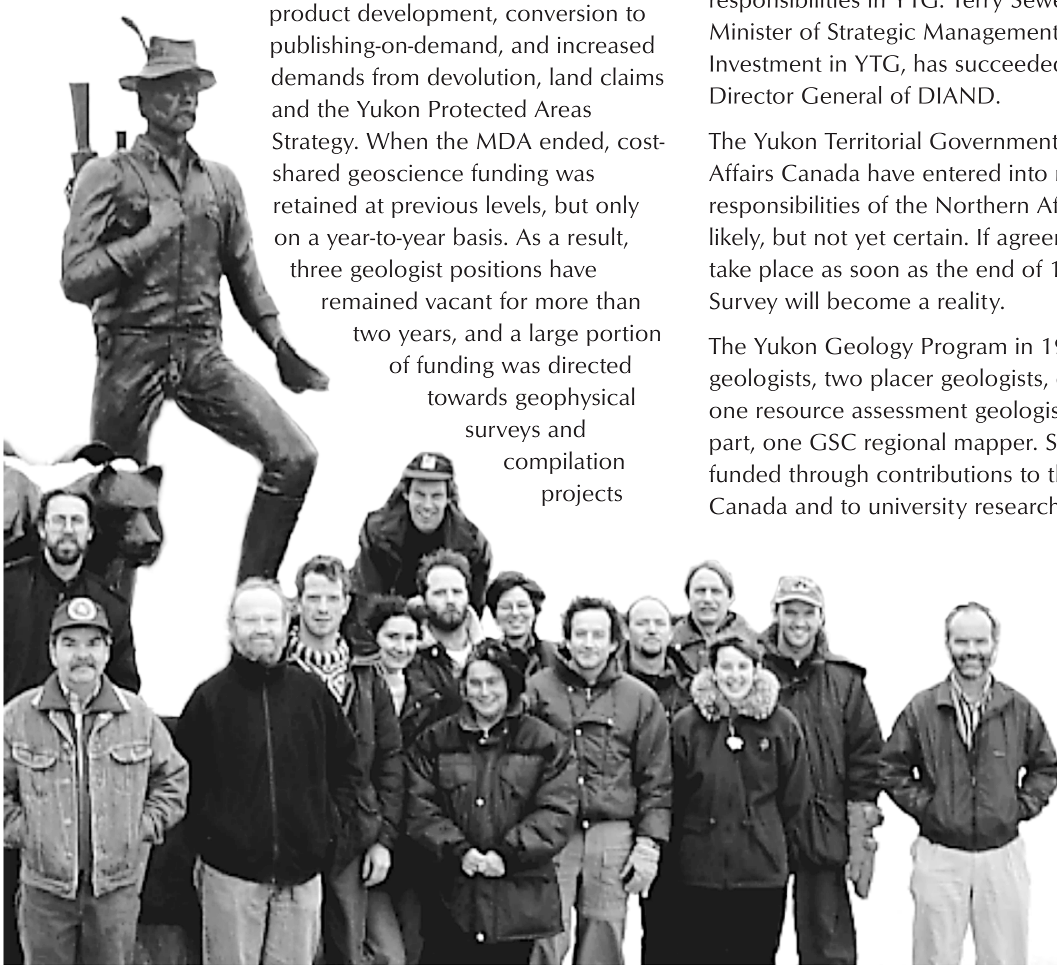


photo: N. Krocker

Figure 1.
TOP ROW, FROM LEFT: *Grant Lowey, the Prospector and his dog, Charlie Roots*
BOTTOM ROW, FROM LEFT: *Mark Nouvasad, Don Murphy, Will Van Randen, Julie Hunt, Mike Burke, Ali Wagner, Danièle Héon, Bill Lebarge, Craig Hart, Robert Deklerk, Shirley Abercrombie, Jeff Bond, Grant Abbott*

Mike Burke, our main link to the exploration industry, continued to monitor Yukon hard rock mining and mineral exploration activity, visit active properties, review reports for assessment credit, and maintain the assessment report library.

Yukon Minfile, another mainstay of the Yukon Geology Program, is maintained by Robert Deklerk. We are undertaking a major software upgrade from Foxbase to Microsoft Access v.2 and have integrated the text base data file with the searchable database. Paper copies of the text version are still available through Exploration and Geological Services Division, and the digital version will be released on CD-ROM this spring and sold by IMS Information Management Services.

Placer deposit studies were a main focus of attention from the program. Bill Lebarge maintained contact with the placer industry and participated in the Mayo Placer Research Project: an ambitious multidisciplinary investigation of the surficial geology and setting of placer deposits of the Mayo District. Other key participants under contract are Jeff Bond, Leyla Weston and Tammy Allen. Fran Hein from the University of Calgary also made significant contributions. The project is in its second and final year. A final report is expected this spring. Grant Lowey began a 1:100 000 scale compilation map of the geology of the White Channel gravel deposits in the Klondike district. Contractors S. Morison and C. Mougeot completed work on the Stewart River mapping project. Maps and an open file report will be released in the spring.

Julie Hunt, in the second year of her three-year study of volcanogenic massive sulphide (VMS) deposits, focused on the Fyre Lake, Wolverine, Ice, and Money deposits in the Finlayson Lake District. The diversity of ages and geologic settings of these deposits is demonstrated in her reports in this volume.

Craig Hart is in the second year of a three-year metallogenic study of the Dawson Range. He has not only the task of putting into their regional context the wide variety of intrusion-related precious and base-metal deposits, but is also compiling new 1:50 000 scale maps based on interpretation of geophysical surveys of the Dawson Range that were funded by the 1990-1996 Canada-Yukon Economic Development Agreement.

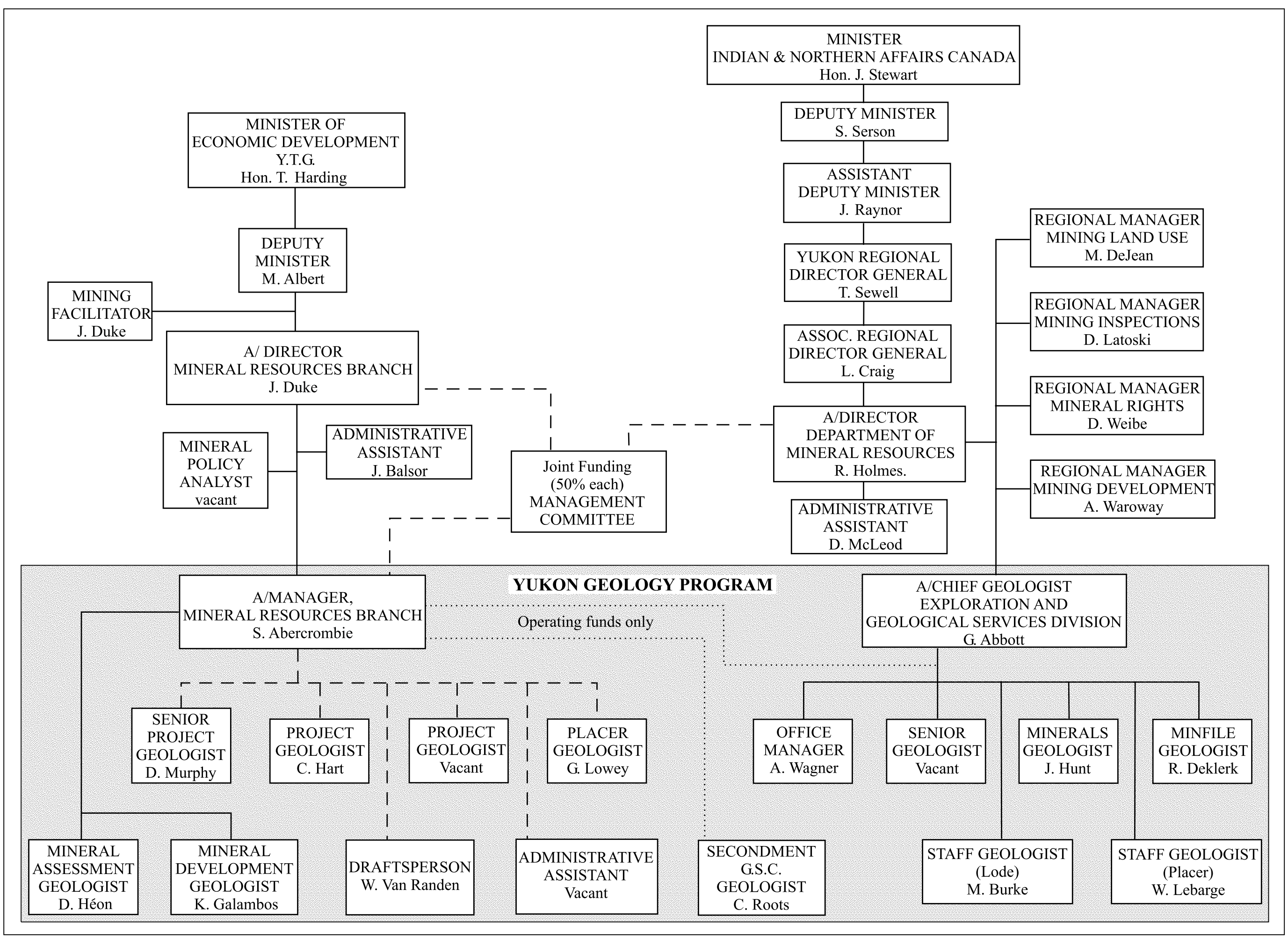
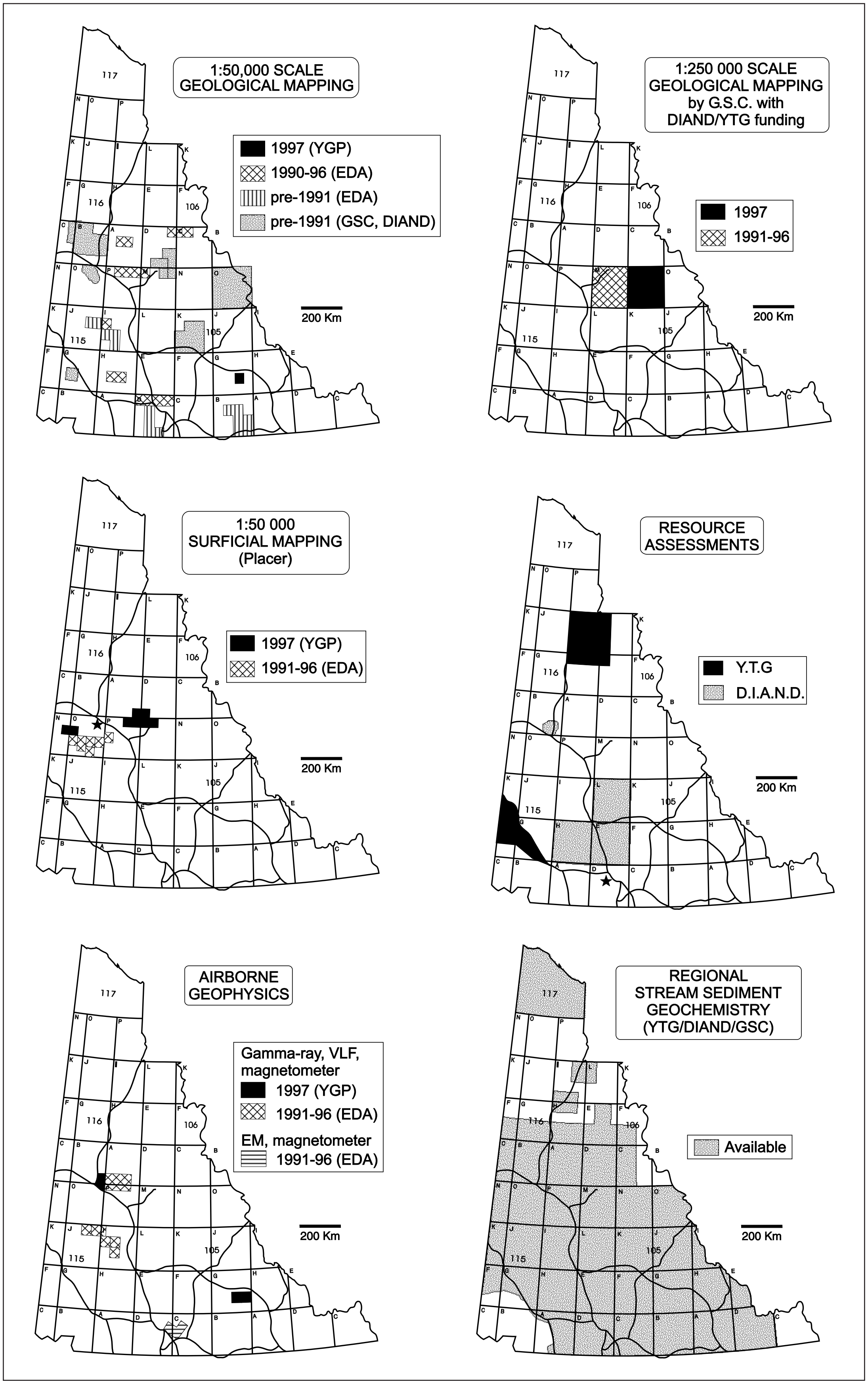


Figure 2. *Yukon Mineral Resources organizational chart*

Figure 2. Summary of available geological maps and regional geochemical and geophysical surveys in the Yukon. (Not shown are 1:250 000 scale geological maps and regional aeromagnetic maps, both of which cover most of the territory, published by the Geological Survey of Canada (GSC)).



Don Murphy completed his first 1:50 000 scale geological map in the Finlayson Lake area. His report in this volume demonstrates significant strides in understanding the stratigraphic setting of VMS deposits in this part of the Yukon-Tanana Terrane.

The Yukon Geology Program is responding to an increasing need for geological and metallogical information to assist resolution of land-use issues and conflicts. Some of the pressures have come from native land claims negotiations, and localized land use conflicts such as one within the city limits of Whitehorse, but most important is the priority of the Yukon Government to implement a Protected Areas Strategy by the year 2000. This year, Mineral Assessment Geologist, Danièle Héon, completed mineral potential studies for selected areas of the Eagle Plains and Richardson Mountains, and for the City of Whitehorse. However, the Yukon Protected Area Strategy will result in protection and withdrawal of areas in all 22 ecoregions in the Yukon. The Geology Program plans to provide efficient and cost-effective input into the selection process by undertaking a Regional Mineral Potential study for all of the Yukon in the spring of 1998.

The Yukon Geology Program supported the work of several scientists of the Geological Survey of Canada. Charlie Roots completed fieldwork in the Lansing map area and will now prepare the final report. This will be the completion of a seven-year long project to map the Mayo and Lansing map areas. This work fills a huge hole in the geological database of central Yukon. Rob Shives and Don Murphy supervised radiometric and magnetic surveys of one and three-quarters 1:50 000 scale map areas covering the Kudz Ze Kayah and Fyre Lake deposits in the Finlayson Lake area. The surveys will determine the geophysical signature of the deposits and their host rocks.

Steve Gordey is completing the compilation of a digital geological map of the Yukon. The map is expected to be released on CD-ROM in late 1998 and will be a significant step forward in our efforts to produce digital products and to manage the large amount of geological information now available in the Yukon. Alejandra Duc-Rodkin received support to produce a Glacial Limits map of the Yukon to mark the 100th anniversary of the Klondike Gold Rush in 1998. Part of this project has resulted in a significant reinterpretation of the early glacial history of Stewart River map area which will lead to a much better understanding of the placer potential in that area. The glacial limits map will be integrated with the digital bedrock compilation.

The Yukon Geology Program is converting to fully digital, on-demand publishing. All geological maps are now printed on-demand, and publications are being produced from a digital format. On-demand printing capability is expected from the Queen's Printer in the near future. This advance will greatly reduce our printing and storage costs. Within the next year, we expect to be able to sell digital files through our website.

Yukon Geology Program publications are published by Exploration and Geological Services Division (EGSD,) Yukon, Indian and Northern Affairs Canada, and are available through:

Geoscience Information and Sales
Exploration and Geological Services Division, Yukon
Indian and Northern Affairs Canada
345-300 Main Street
Whitehorse Yukon Y1A 2B5
Ph. (867) 667-3190

To learn more about the Yukon Geology Program, visit our homepage at *http://www.yukonweb.com/government/geoscience/* or contact us directly:

Grant Abbott, Acting Chief Geologist
Exploration and Geological Services Division, Yukon
Indian and Northern Affairs Canada
345-300 Main Street
Whitehorse, Yukon Y1A 2B5
Ph. (867) 667-3200 e-mail: gabbott@gov.yk.ca

Shirley Abercrombie, Acting Manager
Mineral Resources Branch
Department of Economic Development
Government of Yukon
P.O. Box 2703
Whitehorse, Yukon Y1A 2C6
Ph. (867) 667-3438 e-mail: sabercro@gov.yk.ca

APPENDIX 1: RECENT PUBLICATIONS

BULLETINS

Bulletin 6: *Geology of the McQuesten River region, northern McQuesten and Mayo map areas, Yukon Territory (115P/14-16, 105M/13-14),* by D.C. Murphy

Bulletin 7: *Geology of the Mayo map area, Yukon Territory (105M)*, by Charlie Roots

Bulletin 8: *A transect across northern Stikinia: geology of the northern Whitehorse map area, southern Yukon Territory (105D/13-16)*, by Craig J.R. Hart

Bulletin 9: *Geology of the Upper Hart River area, eastern Ogilvie Mountains, Yukon Territory (116A/10, 11)*, by Grant Abbott

GEOSCIENCE MAPS

Geoscience Map 1996-1: Geological map of Clear Creek area, western Selwyn Basin, Yukon (115P/14) by D.C. Murphy, D. Héon, and J.A. Hunt (1:50 000-scale map accompanying EGSD Bulletin 6)

Geoscience Map 1996-2: Geological map of Sprague Creek area, western Selwyn Basin, Yukon (115P/15) by D.C. Murphy and D. Héon (1:50 000-scale map accompanying EGSD Bulletin 6)

Geoscience Map 1996-3: Geological map of Seattle Creek area, western Selwyn Basin, Yukon (115P/16) by D.C. Murphy and D. Héon (1:50 000-scale map accompanying EGSD Bulletin 6)

Geoscience Map 1996-4: Geological map of Mt. Haldane area, western Selwyn Basin, Yukon (115P/16) by J.A. Hunt, D.C. Murphy, C.F. Roots and W.H. Poole (1:50 000-scale map accompanying EGSD Bulletin 6)

Geoscience Map 1996-5: Geological map of Keno Hill area, Yukon (115P/16) by D.C. Murphy and C.F. Roots (1:50 000-scale map accompanying EGSD Bulletin 6)

Geoscience Map 1997-1: Bedrock geology of Mayo map area, central Yukon (NTS 105M) by C.F. Roots (Geological Survey of Canada) (1:250 000-scale map accompanying EGSD Bulletin 7)

Geoscience Map 1997-2: Geology of map area NTS 116A/10, eastern Ogilvie Mountains, Yukon by Grant Abbott (1:50 000-scale map accompanying EGSD Bulletin 9)

Geoscience Map 1997-3: Geology of Two Beaver Lake map area (NTS 116A/11), eastern Ogilvie Mountains, Yukon by Grant Abbott (1:50 000-scale map accompanying EGSD Bulletin 9)

Geoscience Map 1997-4: Geology of Thirty-seven Mile Creek map area, southern Yukon (NTS 105D/13) by Craig J.R Hart (1:50 000-scale map accompanying EGSD Bulletin 8)

Geoscience Map 1997-5: Geology of Upper Laberge map area southern Yukon (NTS 105D/14) by Craig J.R. Hart (1:50 000-scale map accompanying EGSD Bulletin 8)

Geoscience Map 1997-6: Geology of Joe Mountain map area southern Yukon (NTS 105D/15) by Craig J.R. Hart and Julie A. Hunt (1:50 000-scale map accompanying EGSD Bulletin 8)

Geoscience Map 1997-7: Geology of Mount M'Clintock map area southern Yukon (NTS 105D/16) by Craig J.R. Hart and Julie A. Hunt (1:50 000-scale map accompanying EGSD Bulletin 8)

Geoscience Map 1997-8: Geology of Aishihik Lake map area, Yukon (NTS 115H/6) by Stephen Johnston and Jay Timmerman

Geoscience Map 1997-9: Geology of Hopkins Lake map area, Yukon (NTS 115H/7) by Stephen Johnston and Jay Timmerman

MISCELLANEOUS

Yukon Quaternary Geology Vol. 2., W. Lebarge and C. Roots, ed.

Open File 1997-3. Preliminary geological map of Grass Lakes area, Pelly Mountains, southeastern Yukon (NTS 105G/7), by D.C. Murphy.

1997 Assessment Report Index, Mike Burke ed.

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APPENDIX 2: GEOSCIENCE RESEARCH IN THE YUKON, 1997

Geochemical and Sm-Nd isotope systematics of Yukon-Tanana terrane eclogites. *Robert A. Creaser, Philippe Erdmer* and *J. Goodwin-Bell* (University of Alberta).

Geochemical and Nd isotopic constraints for the origin of the Dorsey terrane. *Robert A. Creaser* (University of Alberta) and *Tekla Harms* (Amherst College).

Nd-Sr-Pb, U-Pb and geochemical systematics of the Mississippian Simpson Range Plutonic Suite, Money Klippe, Yukon-Tanana terrane. *Robert A.Creaser, Philippe Erdmer* and *Steve Grant* (University of Alberta).

Geochemical and Nd isotope constraints for the origin of major temporal changes in miogeoclinal sedimentary rock record, Selwyn Basin. *Robert A. Creaser* and *Philippe Erdmer* (University of Alberta).

Petrogenesis of Eocene plutonic rocks, Skukum and Bennett Lake areas. *Robert A. Creaser* and *George Morris* (University of Alberta).

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U-Pb geochronology studies: Timing constraints on deformation and thermal history of the Teslin Zone. *Sharon Carr* (Carleton University).

Geotectonics of the Allochthonous Terranes of the Northern Cordillera from paleomagnetic and geobarometric studies: Yukon-Tanana Terrane. *David T.A. Symons* (University of Windsor), *William H. Blackburn* (University of Western Ontario) and *Craig J.R. Hart* (Yukon Geology Program).

The structural and metamorphic history of the St. Cyr klippe, south-central Yukon: implications for terrane associations and terrane assembly in the Northern Canadian Cordillera. *Karen M. Fallas* and *Philippe Erdmer* (University of Alberta).

Sedimentology and stratigraphy of Haggart Creek Placer Deposits in the Mayo Mining District, central Yukon Territory. *Leyla Weston* (University of Calgary).

Carmacks-aged, gold-rich polymetallic vein mineralization in the Dawson range, west-central Yukon. *Katherine Smuk, A.E Williams-Jones* and *Don Francis* (McGill University).

Xenolith studies of the lithospheric mantle beneath the Yukon. *Don Francis, Anne Pelsier* and *Shi Lang* (McGill University).

Geochemical signature of the shoshonitic Carmacks Group volcanics, Yukon. *Don Francis* (McGill University).

Geochemistry and isotopes of recent alkaline basalts in the Northern Cordillera. *Don Francis* and *Anne-Claude Abraham* (McGill University).

Geochemistry of the Sloko-Skukum volcanic event in the Northern Cordillera. *Don Francis* (McGill University).

Geology and geochronology of the Yukon-Tanana Terrane in western Yukon and eastern Alaska. *James K. Mortensen* (University of British Columbia).

Geochronology of the Yukon-Tanana Terrane in southeastern Yukon. *James K. Mortensen* (University of British Columbia) and *D.C. Murphy* (Yukon Geology Program).

Geochronology and geochemistry of intrusive rocks of the Tombstone and Tungsten plutonic suites. *James K. Mortensen, James Lang, Timothy Baker* (University of British Columbia) and *D.C. Murphy* (Yukon Geology Program).

Fluid chemistry of intrusion-related mineralization associated with the mid-Cretaceous Tombstone Plutonic Suite. *Timothy Baker, James Lang* and *James K. Mortensen* (University of British Columbia).

Geology and geochemistry of the Dublin Gulch intrusion-hosted gold deposit, central Yukon. *Terri Maloof* and *John F.H. Thompson* (University of British Columbia).

Petrology, geochemistry and physical properties of the Emerald Lake intrusion, Tombstone Plutonic Suite, east-central Yukon. *R. Duncan* and *J. Kelly Russell* (University of British Columbia).

Evolution of Cretaceous magmatism in Yukon Territory. *James K. Mortensen* (University of British Columbia), *D.C. Murphy* (Yukon Geology Program), *Robert G. Anderson* and *Steve P. Gordey* (Geological Survey of Canada-Vancouver).

Geochronology and Pb isotope geochemistry of plutonic and metaplutonic rocks associated with the Minto and Williams Creek copper porphyry(?) deposits, west-central Yukon. *James K. Mortensen* (University of British Columbia).

Age and Pb isotopic geochemistry of SEDEX and VMS base metal deposits in the Yukon-Tanana Terrane, Yukon and east-central Alaska. *James K. Mortensen* (University of British Columbia).

Age and origin of Meso- and Neoproterozoic magmatism in the Wernecke and Ogilvie Mountains, Yukon. *James K. Mortensen* (University of British Columbia), *Derek J. Thorkelson* (Simon Fraser University) and *J. Grant Abbott* (Yukon Geology Program).

U-Pb age constraints on possible southern extensions of the Yukon-Tanana Terrane east of Teslin Lake, southern Yukon and northern British Columbia. *Richard M. Friedman* and *James K. Mortensen* (University of British Columbia), *JoAnne Nelson* and *Mitch G. Mihalnyuk* (B.C. Geological Survey Branch).

Age and evolution of igneous and sedimentary rocks in and adjacent to the Tintina Trench: implications for the nature and offset history of the Tintina Fault Zone. *James K. Mortensen* (University of British Columbia).

Nature and origin of westerly derived Upper Triassic sedimentary rocks along the western margin of North America in southeastern Yukon and implications for the earliest stages of terrane accretion in the northern Cordillera. *James K. Mortensen* (University of British Columbia), *Phillipe Erdmer* (University of Alberta) and *Edward Ghent* (University of Calgary).

U-Pb geochronology of the Flex Zone, Mount Nansen area, Yukon. *Vikki Meyer* and *James K. Mortensen* (University of British Columbia).

U-Pb geochronology of mid-Paleozoic plutonic rocks in the northern Yukon. *James K. Mortensen* (University of British Columbia) and *Larry S. Lane* (Geological Survey of Canada-Calgary).

Geology and origin of the Ketza River gold deposit, east-central Yukon. *Ana Fonseca* and *James K. Mortensen* (University of British Columbia).

Structural controls on gold mineralization at the Brewery Creek gold deposit. *C. Germain* and *James K. Mortensen* (University of British Columbia).

Deformation processes along the Denali Fault System. *Joseph C. White* (University of New Brunswick).

Geochronology of Dawson Range mineral deposits. *Mike Villeneuve* (Geological Survey of Canada-Ottawa) and *Craig J.R. Hart* (Yukon Geology Program).

RECENTLY COMPLETED YUKON GEOSCIENCE THESES

Evidence for two magmas within the Eocene Sloko-Skukum volcanics. *Eric Galbraith*, Unpublished B.Sc. thesis, McGill University, Montreal, 1997.

Late Cenozoic history of McQuesten map area (115P), Yukon Territory. *Jeff D. Bond*, Unpublished M.Sc thesis, University of Alberta, 161 p. 1997.

Geochemical, radiogenic tracer isotopic and U-Pb geochronological studies of Yukon-Tanana Terrane rocks from the Money Klippe, southeastern Yukon, Canada. *Steven L. Grant*, Unpublished M.Sc thesis, University of Alberta, 177 p. 1997.

Stratigraphic framework for syngenetic mineral occurrences, Yukon-Tanana Terrane south of Finlayson Lake: A progress report

Donald C. Murphy

Yukon Geology ProgramMurphy, D.C., 1998. Stratigraphic framework for syngenetic mineral occurrences, Yukon-Tanana Terrane south of Finlayson Lake: A Progress Report. *In:* Yukon Exploration and Geology 1997, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p.51-58.

Abstract

Yukon-Tanana Terrane in Grass Lakes map area south of Finlayson Lake consists of highly deformed though regionally mappable metasedimentary and metavolcanic rocks. Four newly revised map units and various subunits have been traced throughout the area. These include unit 1, a quartz-rich metaclastic unit with felsic metavolcanic rocks at its lowest exposed level and a middle calcareous marker; unit 2, a mafic metavolcanic unit with lesser carbonaceous metasedimentary rocks; unit 3, a carbonaceous phyllite and quartzite and felsic metavolcanic unit, and unit 4, an upper unit of carbonaceous phyllite, mafic metavolcanic rocks and coarse-grained quartzofeldspathic metaclastic rocks. Units 2 and 4 have been redefined from a previous report based on new observations and a consideration of the provenance of coarse-grained quartzofeldspathic metaconglomerates now included in unit 4. In the current interpretation, the metaconglomerate-bearing strata north of and overlying the felsic meta-volcanic rocks hosting Kudz Ze Kayah are considered to unconformably overlie them.

Three of these map units are associated with mineral occurrences or deposits. Rusty, locally malachite-stained muscovite-quartz schist at Arcturus Resources' First Base claims and Expatriate Resources' Blue Line and Winger claims belong to the felsic metavolcanic part of unit 1. Columbia Gold's Fyre Lake deposit is hosted in unit 2 mafic metavolcanic rocks, possibly associated with a synvolcanic fault. Cominco's Kudz Ze Kayah deposit occurs in unit 3 felsic metavolcanic rocks. Gossans on Cominco's Cobb claims, Expatriate's Overtime and NHL claims, and Atna/Westmin's Pack claims and anomalous copper in soils at Arcturus' Bas claims are also spatially associated with this unit.

Résumé

Le terrane de Yukon-Tanana, dans la région cartographique de Grass Lakes au sud du lac Finlayson, comprend des roches métasédimentaires et métavolcaniques très déformées mais cartographiables à l'échelle régionale. Quatre unités cartographiques récemment révisées et diverses sous-unités ont été identifiées dans la région. Parmi celles-ci figurent l'unité 1, unité métaclastique riche en quartz comprenant une unité métavolcanique felsique à son niveau inférieur exposé ainsi qu'un niveau repère calcaire; l'unité 2, unité métavolcanique mafique renfermant en quantités moindres des roches métasédimentaires carbonées; l'unité 3, qui comprend des phyllades carbonés, des quartzites et des métavolcanites felsiques; et l'unité 4, unité supérieure composée de phyllades carbonés, de roches métavolcaniques mafiques et de métaconglomérats à cailloux quartzofeldspathiques. Les unités 2 et 4 ont été redéfinies relativement à un rapport publié antérieurement sur la base de nouvelles observations et eu égard à l'origine des métaconglomérats quartzofeldspathiques à grain grossier, désormais inclus dans l'unité 4. Selon l'interprétation actuelle, on considère que les strates contenant les métaconglomérats, qui reposent au nord des roches métavolcaniques felsiques encaissant le gisement de Kudz Ze Kayah et sur ces dernières, reposent en fait en discordance sur elles.

Trois de ces unités cartographiques sont associées à des occurrences ou à des gisements minéraux. Des schistes felsiques rouillés à muscovite et quartz renfermant localement de la malachite sur les claims de First Base, de la société Arcturus Resources, et sur les claims de Blue Line et Winger, de la société Expatriate Resources, appartiennent à la partie métavolcanique felsique de l'unité 1. Le gisement de Fyre Lake, de la Columbia Gold, est inclus dans les roches métavolcaniques mafiques de l'unité 2, en association possible avec une faille synvolcanique. Le gisement de Kudz Ze Kayah, de la Cominco, est situé dans les roches métavolcaniques felsiques et les chapeaux de fer de l'Unité 3, ainsi que sur les claims de Cobb, de Cominco, sur les claims d'Overtime et NHL, d'Expatriate, et sur celles de Pack d'Atna/Westmin; les concentrations pédologiques exceptionnelles de cuivre dans les claims de Bas, d'Arcturus Resources, sont spatialement associées à cette unité.

INTRODUCTION

This report presents an update on the stratigraphy of Yukon-Tanana Terrane northwest of the Tintina Fault (Fig. 1) as elucidated during one and a half field seasons of 1:50 000-scale geological mapping in Grass Lakes map area (105G/7, Fig. 2). The area was mapped at 1:250 000-scale by the Geological Survey of Canada in the 1950's (Wheeler et al. 1960), in the early 1970's (Tempelman-Kluit, 1977, 1979) and in somewhat greater detail as part of a doctoral thesis (Mortensen, 1983; Mortensen and Jilson, 1985; Mortensen, 1992a). A re-investigation of the geology of this region was considered appropriate in light of the reconnaissance nature of previous work and the high level of mineral exploration activity in Yukon-Tanana Terrane stimulated by the Cominco's 1994 discovery of the Kudz Ze Kayah massive sulphide deposit. A map and report on the northeast third of Grass Lakes map area was published in 1997 (Murphy and Timmerman, 1997a,b); this report and accompanying map (Murphy, 1997) supercedes and extends the previous work.

STRATIGRAPHY OF GRASS LAKES MAP AREA

In Grass Lakes map area, strongly foliated and lineated layered metasedimentary and metavolcanic rocks occur sporadically in a roof setting above and between bodies of Early Mississippian granitic orthogneiss and weakly foliated mid-Cretaceous granite. Murphy and Timmerman (1997a) reported a four-fold subdivision of the layered rocks in the northeastern third of the map area. This subdivision has now been extended over the entire area with some significant modification resulting from new observations and interpretations (Fig. 3).

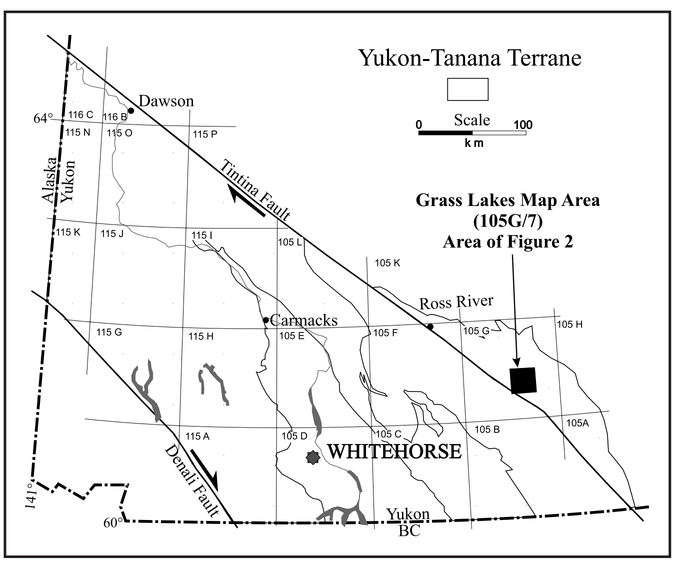


Figure 1. *Grass Lakes map area (105G/7) with respect to the distribution of Yukon-Tanana Terrane in Yukon.*

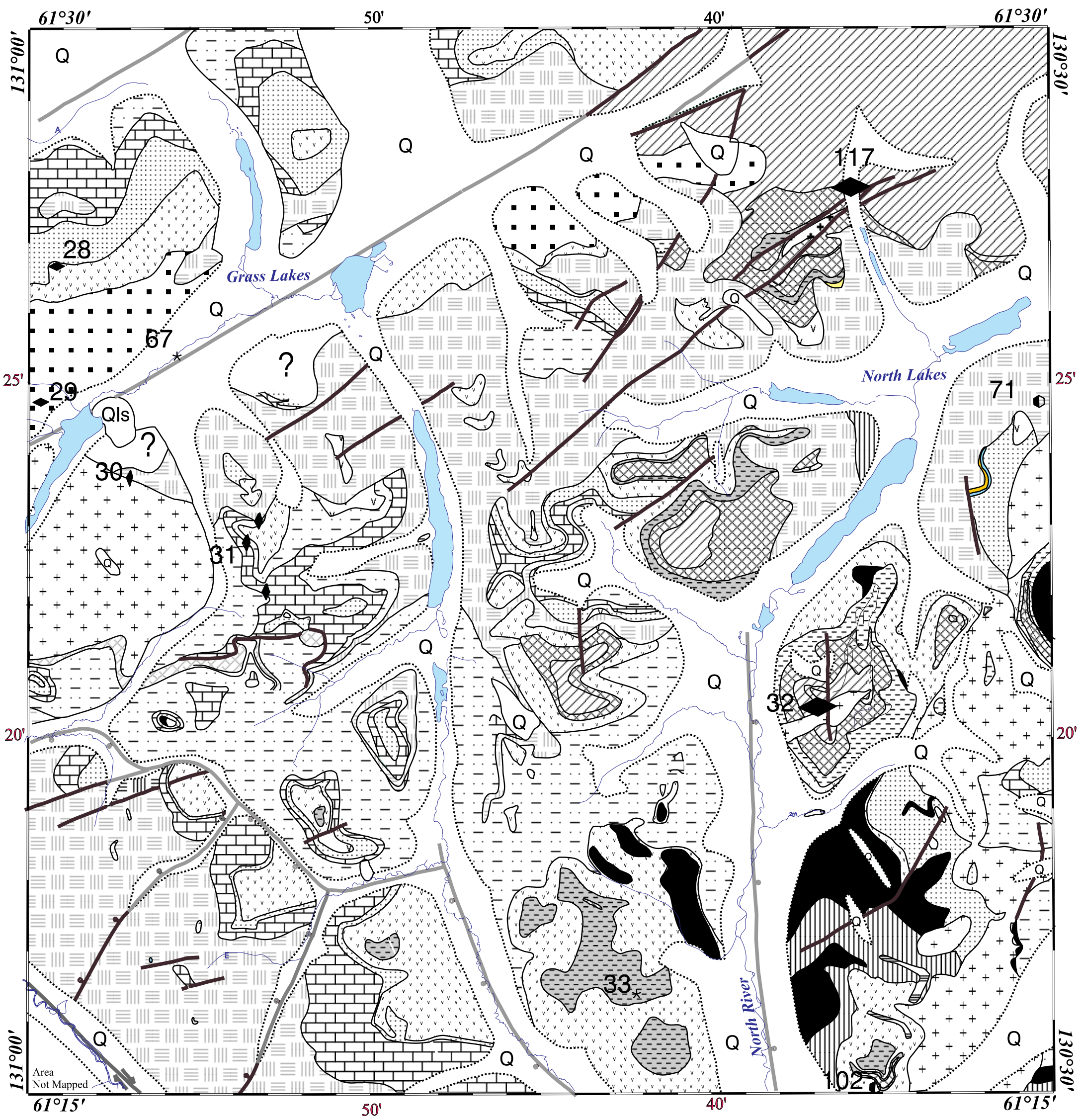
UNIT 1

The lowest unit in the Yukon-Tanana Terrane stratigraphy in this area is a quartz-rich metaclastic unit with a lower felsic metavolcanic member and a middle laterally variable calcareous member. Most of the unit is tan to brown and locally rusty-weathering, (garnet)-biotite-muscovite-quartz schist and psammite, (staurolite-chloritoid)-garnet-biotite-quartz-muscovite metapelitic schist and rare quartz-pebble conglomerate. Lesser rock types include metre-scale layers of locally calcareous biotite-feldspar-chlorite schist and siliceous carbonaceous phyllite and quartzite.

The lowest stratigraphic unit in the map area, exposed in the network of ridges west of the southernmost Grass Lake and tracking westward to the western edge of the map area, is a locally rusty and malachite-stained muscovite-quartz schist and feldspar-quartz augen schist member (unit 1f, Fig. 4). On the ridge west of the southernmost Grass Lake, the felsic schist unit is overlain by a few tens of metres of biotite-feldspar-chlorite schist (unit 1m, not differentiated in Figs. 2 or 3). This unit passes laterally westward into a fine-grained sulphide-bearing rock of indeterminate protolith. Arcturus Resources' First Base and Expatriate Resources' Blue Line and Winger claims cover rusty felsic schist of unit 1f.

Unit 1 strata above the felsic metavolcanic unit have been traced throughout much of the central, southern and northwestern part of the map area. Directly overlying the felsic metavolcanic member is about 200 m of tan, locally cliff-forming quartzose psammite and metapelite and lesser biotite-chlorite schist (unit 1qsl). This unit is overlain by a laterally variable calcareous unit that forms a prominent marker throughout much of the map area. In the fault-bound southwestern corner of the map area and the northwestern corner of the map area, the calcareous unit (unit 1cls) consists of finely foliated, grey garnet-bearing (locally cm-scale porphyroblasts) calcareous schist and metapelite, thin-bedded to massive metre-scale grey marble, lesser calcareous psammite and rare carbonaceous phyllite. Elsewhere in the map area, calcareous psammite (unit 1clp) predominates in this unit with lesser marble and locally significant amounts of calcareous biotite schist and calcsilicate. Overlying the calcareous member is a variable thickness of quartz-rich metaclastic rocks similar to those below the calcareous member but with upwardly increasing amounts of biotite-feldspar-chlorite schist (unit 1qsu). The uppermost part of unit 1qsu is locally marked by carbonaceous and siliceous phyllite.

The intense deformational overprint has generally obliterated primary features in unit 1. Psammitic (metasandstone) beds in unit 1 locally have one sharp contact and one transitional contact with adjacent metapelite beds, suggesting a graded character (Fig. 5). Such rare indications of younging direction consistently indicate that unit 1 is the oldest exposed stratigraphic unit of the terrane in Grass Lakes map area.



Layered Metamorphic Rocks

- Unit 4qf: quartzofeldspathic metaclastic rocks
- Unit 4: carbonaceous phyllite, mafic metavolcanic rocks
- Unit 3f/3r: felsic metavolcanic rocks
- Unit 3q: calcareous qz psammite
- Unit 3cp: carbonaceous phyllite
- Unit 2m: mafic metavolcanic rocks
- Unit 1qsu: upper qz-rich metaclastic rocks
- Unit 1cls, clp: calcareous marker
- Unit 1qsl (lower qz-rich metaclastic rocks) and undifferentiated unit 1
- Unit 1f: felsic metavolcanic rocks

Intrusive or Meta-Intrusive Rocks

- Unit Td: Tertiary felsic dykes
- Unit Kg: Cretaceous granite
- Unit Mg: Mississippian orthogneiss
- Unit 3qfp: quartz-feldspar porphyry
- Unit 2mum: meta-gabbro, meta-pyroxenite
- Unit 2um: meta-ultramafic rocks

Figure 2. *Bedrock geological map of Grass Lakes map area. Heavy dark and shaded lines are defined and inferred faults respectively. Numbers denote mineral occurrences as enumerated in Yukon Minfile for map area 105G: 028, Gyp; 029, Gee; 030, Pit; 031, Rob; 032, Pack; 033, Tak; 067, Lawn; 071, Myda; 088, Cookie; 102, Howdee (Rife); 117, Tag (Kudz Ze Kayah).*

The age of unit 1 is unknown. Samples of unit 1f felsic metavolcanic rocks have been collected for radiometric dating.

UNIT 2

Overlying unit 1qsu across a narrowly transitional contact zone is intermediate to mafic schist and phyllite of unit 2m. Throughout much of the map area, unit 2m consists of dark brown to black plagioclase-quartz-chlorite-biotite schist. In the network of ridges west of the North River, in the south-central part of the map area, and also in the northwestern corner of the map area, unit 2m comprises medium green to olive green biotite-porphyroblastic plagioclase-actinolite-chlorite schist and phyllite. The areas marked by biotite schist are marginal to the voluminous Grass Lakes and Houle River orthogneisses and the apparent higher grade may be due in part to proximity to the intrusions. Other rock types in unit 2m are carbonaceous phyllite and quartzite and rarely light grey coarsely crystalline marble.

The mafic mineralogy of unit 2m suggests a mafic volcanic or sedimentary rock protolith. Primary textures are generally overprinted by intense foliations although fragmental textures appear locally (Fig. 6) and bedding occurs in less highly deformed rocks in the northern part of the map area. Unit 2m rocks contain variable amounts of quartz, plagioclase, biotite, epidote, titanite or rutile suggesting that both sedimentary rock and volcanic rock protoliths are represented in Grass Lakes map area.

Preliminary assessment of trace element geochemical data from eight unit 2m samples collected in Grass Lakes map area shows that unit 2m is composed primarily of low potassium tholeiitic andesite or basaltic andesite with island arc affinity (6 samples). Two samples consistently plot as subalkaline basalts with MORB affinities. A comprehensive analysis of the geochemical characteristics of Yukon-Tanana Terrane metavolcanic rocks is currently in progress (Hunt et al. in prep.).

In the south-central and southeastern parts of the map area, unit 2m mafic schists are spatially associated with coarse-grained whitish-green leucoamphibolite (metagabbro), medium to dark green amphibolite (meta-pyroxenite) (both shown together as unit 2mum in Fig. 2) and aeromagnetically prominent dun-coloured meta-ultramafic rocks made up of talc, magnetite, serpentine, tremolite, phlogopite, and relict olivine,

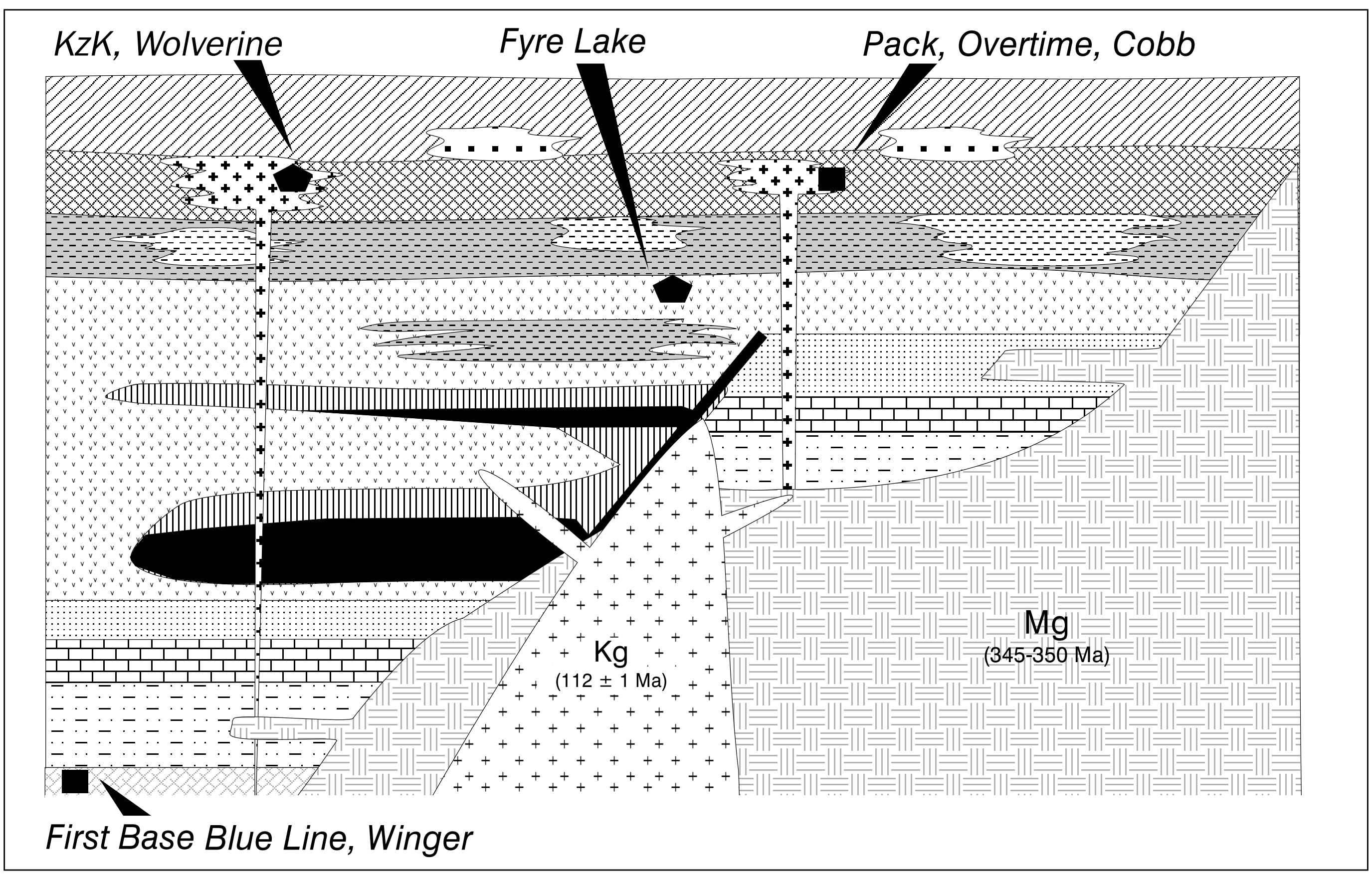


Figure 3. *Schematic illustration of stratigraphy and field relationships in Grass Lakes map area. All map units, except for the weakly foliated Cretaceous granite, are strongly foliated and lineated. Symbols are as in Figure 2, except heavy '+' pattern which is meant to represent felsic cryptodome and dyke.*

Figure 4. *View to west of rusty felsic metavolcanic rocks of unit 1f (to left) in thrust contact with stratigraphically younger rocks of unit 1qsu. Arcturus Resources' First Base claims.*

area, the combined thickness of units 2m, 2mum and 2um decreases to less than 100 m.

Tempelman-Kluit (1977, 1979) included the unit 2m mafic schists in the southeastern corner of the map area and mafic and ultramafic meta-intrusive rocks in the Anvil Allochthon, a sheet of obducted oceanic crust. Mortensen (1992a,b) also inferred the ultramafic rocks in this area to be allochthonous, correlating them with Slide Mountain Terrane. The relationships between the mafic and ultramafic meta-intrusive rocks and units 1 and 2m are, however, compatible with the interpretation that these rocks are *in situ*, possibly co-magmatic intrusions. Neither the rocks at the base of the meta-intrusive sheet nor the narrowly transitional contact between units 1qsu and 2 are more deformed than rocks elsewhere in the region, suggesting that these contacts are not faulted. Unit 2m is regionally extensive, and if its lower contact is a major fault where associated with mafic and ultramafic meta-intrusive rocks, it would have to be a thrust fault in other places; there is no evidence in support of this interpretation. Alternatively, the stratabound character of the meta-intrusive rocks for much of their extent is reminiscent of a sill. West of the North River, unit 2mum and 2um could be a single differentiated sill. East of the North River where more than one level of ultramafic rock is present, more than one sill or level of cumulate development may be represented. The characteristics of the ultramafic rocks in the southeasternmost corner of the

orthopyroxene and chromite (unit 2um). West of the North River, such mafic and ultramafic rocks occur as a stratabound sheet within unit 2m which extends eastwardly from a lateral termination in a peak west of the North River (Fig. 7) across the North River into the southeastern corner of the map area. The sheet increases in thickness from zero at its westwardly lateral termination to over 500 metres east of the North River. In the southeasternmost corner of the map area, the amount of unit 2m mafic schist between the meta-intrusive rocks and the top of unit 1 decreases to zero and, uniquely to this area, ultramafic rocks also appear at different levels in unit 1, occurring in unit 1qsu west of the Cretaceous granite and in unit 1qsl at the same structural level east of the granite (Fig. 2). Southeast of the map

Figure 5. *Psammite bed in unit 1qsu with sharp base and gradational top suggestive of upright grading.*

Figure 6. *Rounded compositionally distinct domains in biotite-chlorite schist of unit 2m suggestive of fragmental texture.*

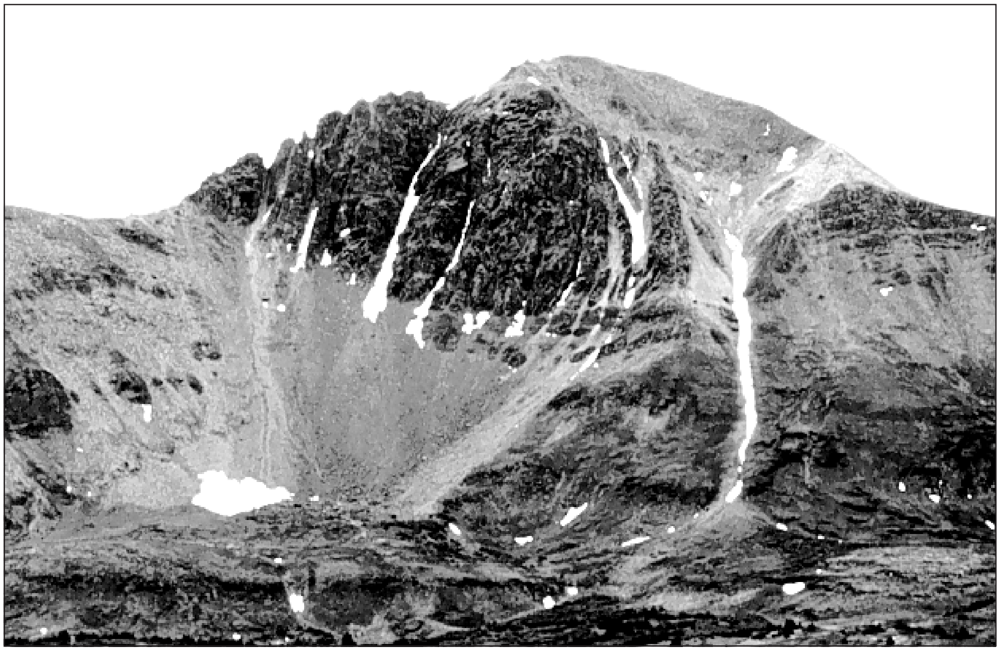


Figure 7. View to south of lateral termination of meta-ultramafic body enveloped by actinolite-chlorite schist of unit 2m. Note how deformation has wrapped the underlying unit 1 and 2 rocks around its westward termination.

map area suggest a discordant character, possibly marking the locus of transition from a sill to a feeder dyke. In this area, the base of the ultramafic sheet occurs progressively lower in unit 2 and, uniquely to this area, ultramafic rocks appear at different levels in unit 1. Furthermore, as this zone of apparent discordance is marked by the juxtaposition of different stratigraphic levels of unit 1 and a dramatic drop in the combined thickness of units 2m, 2mum and 2um, the dyke may have intruded along a syn-volcanic fault.

It should be noted that the Fyre Lake Cu-Co-Au massive sulphide deposit (Foreman et al., this volume; Hunt, this volume) occurs in the upper part of unit 2m along strike from this area of discordance, stratigraphic juxtaposition and thickness change and increase in volume of co-magmatic(?) intrusions, suggesting a possible genetic association. Synvolcanic faults, thickness changes of volcanic rocks and increases in abundance of comagmatic(?) intrusions are all considered to be pathfinders to the proximal portions of volcanic systems where volcanic-hosted massive sulphide deposits typically reside (e.g. Gibson et al. 1997).

The age of unit 2m has not been determined directly but possibly comagmatic gabbro and diorite have yielded Devono-Mississippian U-Pb ages (Mortensen, 1992a and pers. comm. 1996).

UNIT 3

Rocks overlying unit 2m are found mainly in the central network of ridges between the North River and the prominent valley hosting Big Campbell Creek and the largest of the Grass Lakes, and in the northwestern and east-central parts of the map area. Unit 3 and younger units have been removed by erosion from the western part of the map area. In the central network of ridges, mafic schist of unit 2m is succeeded by a laterally diverse unit of carbonaceous phyllite (unit 3cp), calcareous quartzose psammite (unit 3q), rare light grey marble and light-coloured, locally rusty quartz-muscovite schist and massive fine-grained siliceous rock locally with amygdules indicating a felsic volcanic heritage (unit 3f/3r). In the southern part of Grass Lakes map area and northern part of the adjacent Fire Lake map area, the lower part of this unit (up to 200 m) is primarily strongly foliated siliceous and carbonaceous phyllite with rare lenticular bodies of rusty quartz-muscovite schist and other quartzofeldspathic rock types of indeterminate heritage. To the north, the lower part of the unit includes increasing amounts of felsic metavolcanic rock, and locally, calcareous quartzose psammite and quartzite as at Atna/Westmin Resources' Pack property (Yukon Minfile 105G 032). Minor amounts of mafic schist occur locally. The thickest accumulation of felsic metavolcanic rock in the map area occurs at Cominco's Kudz Ze Kayah deposit (Schultze, 1996; Yukon Minfile 105G 117)

Figure 8. Interbedded quartz-feldspar pebble meta-conglomerate and darker carbonaceous phyllite of unit 4. Bedding is upright, dipping steeply to right.

where a few metres of carbonaceous phyllite and quartzose psammite are overlain by over 2km (structural thickness) of felsic muscovite-quartz schist, cherty amygdaloidal meta-rhyolite, variably altered quartz-feldspar augen schist (possibly a subvolcanic intrusion) and lesser carbonaceous phyllite and intermediate to mafic schist. Substantial accumulations of felsic metavolcanic rock also occur on Cominco's Cobb claims, Expatriate's Overtime claims, Arcturus Resources' Bas claims and Atna/Westmin's Pack claims; in these areas, felsic metavolcanic rocks are associated with gossans, anomalous soil geochemistry, and sulphide showings.

A preliminary assessment of trace element geochemical data suggests that unit 3 felsic metavolcanic rocks are primarily calc-alkaline rhyodacite with lesser rhyolite and have characteristics typical of volcanic arc suites.

Mortensen (1983, 1992a, and pers. comm., 1996) reports Early Mississippian U-Pb ages for felsic metavolcanic rocks of Yukon-Tanana Terrane in the Finlayson Lake area.

UNIT 4

Murphy and Timmerman (1997a,b) included in unit 4 the succession of carbonaceous phyllite, biotite-plagioclase-chlorite phyllite and schist and quartzofeldspathic psammite overlying unit 3 felsic metavolcanic rocks in the central and eastern part of the map area. Unit 4 strata occur along the tops of ridges in the ridge network between the largest of the North Lakes and the largest of the Grass Lakes, underlying parts of Arcturus' Bas claims and Cominco's Cobb claims. Unit 4 strata also occur in the hinge zone of a recumbent north-closing fold on Atna/ Westmin's Pack property (Yukon Minfile 105G 032) east of the largest of the North Lakes.

Carbonaceous phyllite, biotite-plagioclase-chlorite phyllite and schist and lenticular bodies of coarse-grained quartzofeldspathic sandstone and conglomerate north of, and physically overlying, the felsic metavolcanic rocks at Kudz Ze Kayah (Yukon Minfile 105G 117) are also currently included in unit 4 (Fig. 2). Murphy and Timmerman (1997a, b) originally considered these strata to be an inverted panel of unit 2 on the overturned limb of a syncline cored by the felsic metavolcanic rocks at Kudz Ze Kayah. The inclusion of these strata in unit 4 is based on the possibility that the conglomerates are products of the erosion of nearby coarse-grained Mississippian orthogneiss, which intrudes unit 3 felsic metavolcanic rocks. The metaconglomerate locally contains cm-sized single crystal feldspar clasts suggesting that they were fairly proximal deposits (Fig. 8). Indeed, some exposures of metaconglomerate so closely resemble Mississippian orthogneiss that they were incorrectly identified in 1996. If the metaconglomerate was derived from nearby orthogneiss, then it must be younger than unit 3 and they must mark a profound unconformity reflecting substantial uplift and erosion.

DISCUSSION

Owing to the highly strained nature of Yukon-Tanana Terrane in the Finlayson Lake district, the stratigraphic units defined herein should be considered preliminary and will likely be revised with new work. However, although preliminary and defined only in Grass Lakes map area, some speculative correlation with neighboring areas is possible. The distinctive calcareous schist and marble part of unit 1cls correlates directly with Tempelman-Kluit's (1977) unit PCsc which he has traced around large regions of the Finlayson Lake 1:250 000 map area. This unit is a regional marker that provides a starting point in the search for the overlying prospective metavolcanic stratigraphy. Unit 2 mafic schists have not been systematically traced in previous work but, given the extent to which Tempelman-Kluit (1977) traced unit 1cls, it may be relatively straightforward to locate. As previously discussed, the combination of unit 2m and ultramafic and mafic meta-intrusions may indicate local magmatic centres. Unit 3 felsic metavolcanic rocks likely correlate with felsic metavolcanic rocks at Wolverine Lake 20 km to the east in the adjoining Wolverine Lake map area based on similar U-Pb ages (Mortensen, 1992a and pers. comm., 1996) and stratigraphic position. This correlation suggests that some of the mafic meta–volcanic rocks immediately overlying the felsic metavolcanic rocks at Wolverine Lake may correlate with unit 4. However, given the uncertainty about the nature of the contact at the base of the overlying Campbell Range pillow basalt and chert sequence, any extension of this correlation to include the Campbell Range sequence should be entertained with caution.

SUMMARY

Field work during 1997 clarified the stratigraphic framework of Yukon-Tanana Terrane in a part of the Finlayson Lake district, providing firmer definition of map units and their extent. As a result, the stratigraphic position of syngenetic mineral occurrences in the area is now fairly firmly established, and in the case of Fyre Lake, some understanding of the stratigraphic setting has been gained. Finally, the new interpretation of unit 4 implies that it overlies a profound unconformity which may be a significant clue in resolving the Upper Paleozoic tectonic setting of Yukon-Tanana Terrane.

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Jay Timmerman (1996) and Jennifer Jones (1997) provided tremendous assistance during the two field seasons of mapping in Grass Lakes map area. I appreciate the discussions that I've had with Julie Hunt and her assistance in mapping the southeastern corner of the map area. I thank Lee Pigage of Expatriate Resources for sharing detailed information from the numerous Expatriate properties in the area and for discussions about the regional geology. Doug Eaton of Expatriate Resources generously permitted Lee to share his information with me. I am grateful to Paul MacRobbie and Neil O'Brien of Cominco, Ian Foreman of Columbia Gold for discussions about the regional geology and for providing access to their Trans North contract helicopters and other logistical assistance, and Charlie Roots for his careful editing of drafts of this paper. I'd also like to thank Bob Krause and Graham Davidson of Arcturus Resources for sharing information about the First Base property. Pilots John Witham, Steve Soubliere, and Chris Guichon (all of Trans North Air) provided punctual, safe and uneventful flying services.

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A note on preliminary bedrock mapping in the Fire Lake area

J.A. Hunt and D.C. Murphy
Yukon Geology Program

Hunt, J.A. and Murphy, D.C., 1998. A note on preliminary bedrock mapping in the Fire Lake area. *In:* Yukon Exploration and Geology 1997, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p.59-68.

Abstract

New geological mapping around the Fyre Lake Cu-Co-Au deposit in Yukon-Tanana Terrane, southeastern Yukon, has established the continuity of stratigraphic units from nearby Grass Lakes map area and affirmed the stratigraphic context of the deposit. The deposit is located near the top of a regionally persistent chlorite schist and phyllite unit that is spatially associated with voluminous mafic and ultramafic intrusive rocks. As in Grass Lakes map area, chloritic schist and associated mafic and ultramafic meta-intrusive rocks in the Fire Lake area overlie a regionally persistent quartz-rich metaclastic and carbonate unit and underlie a thick carbonaceous phyllite unit with lesser marble and felsic meta-volcanic rocks.

Yukon-Tanana Terrane rocks are truncated to the east by a shear zone of mylonitic Mississippian granite that lies at the base of the Money Klippe. The klippe is composed of undeformed (except in the shear zone) Mississippian granite and granodiorite of the Simpson Range Plutonic Suite and their wall rocks and roof pendants. Wall rocks and pendants include meta-sedimentary, meta-volcanic and meta-intrusive rocks. Layered wall rocks include a lower quartz-rich metaclastic and carbonate unit and a chlorite-actinolite-epidote phyllite unit with mafic breccia, ?augite porphyry, bands of green chert, and variably thick and laterally persistent accumulations of white marble. Rocks of intrusive protolith include *ca.* 361 Ma quartz porphyry, gabbro and ultramafic rock. Most contacts are observed or inferred to be intrusive or stratigraphic and are not everywhere faulted as previously mapped. With the exception of the chert and marble in the mafic phyllite, the wall rocks bear a strong resemblance to Yukon-Tanana Terrane rocks beneath the shear zone and are tentatively correlated with them. Indeed, as the wall rock sequence is intruded by granite and granodiorite of the Simpson Range Plutonic Suite, a fundamental component of Yukon-Tanana Terrane, such a correlation seems required. Such a correlation would suggest that the basal shear zone of the klippe is a minor intra-terrane structure and not a major structure or terrane boundary as previously inferred.

INTRODUCTION

Two weeks were spent mapping the geology around the Fyre Lake volcanic-hosted massive sulphide (VMS) deposit (Yukon Minfile 105G 034) in order to better characterize the structural and stratigraphic setting of the deposit (Fig. 1). The Fire Lake area, about 160 km northwest of Watson Lake, in southeastern Yukon, provides an excellent opportunity to examine the field relationships of rock units including the Anvil and Simpson allochthons of Money Klippe (Tempelman-Kluit, 1977, 1979). Rocks of Money Klippe have been considered as parts of oceanic and arc terranes that were structurally imbricated and thrust over Yukon-Tanana Terrane (Tempelman-Kluit, 1979; Mortensen, 1992a). In this report we position the Fyre Lake deposit in the context of the revised stratigraphy established by Murphy (this volume) immediately to the northwest, and present evidence which suggests that layered rocks of Money Klippe correlate directly with Yukon-Tanana Terrane. Such a correlation implies that the basal contact of Money Klippe is a minor intra-terrane structure.

PREVIOUS WORK

The Fire Lake area was first mapped by Wheeler et al., (1960) as quartz-rich schist surrounding large bodies of quartz monzonite and granodiorite and lesser mafic and ultramafic meta-igneous rocks, southwest of the headwaters of Money Creek. Tempelman-Kluit (1977, 1979) interpreted the two igneous assemblages mapped by Wheeler et al. (1960) as distinct thrust sheets which formed a structure he called the Money Klippe. He named the felsic plutonic rocks the Simpson, and the structurally lower mafic and ultramafic meta-igneous rocks the Anvil allochthons respectively. The quartz-rich schist which hosts the Fyre Lake deposit and underlies the Anvil Allochthon was included in the Nisutlin Allochthon (Tempelman-Kluit, 1977). The maps of Tempelman-Kluit (1977, 1979) also show a composite volcanic plug of Cretaceous age which intrudes all three allochthons.

Subsequent work led to revised interpretations. Mortensen (1983) suggested that the composite plug is a component of the Anvil assemblage and included the klippe of granitic rocks in the Simpson Range plutonic suite of Yukon-Tanana Terrane. He also indicated that the gabbro unit of the Anvil assemblage has a close association with the Simpson Range plutonic suite of Yukon-Tanana Terrane based on similar U-Pb zircon ages and intrusive relationships. Erdmer (1985) included the composite plug in Simpson Allochthon. Mortensen (1992b) included the composite plug in Slide Mountain Terrane and determined a *ca.* 361 Ma U-Pb zircon age. Grant (1997) affirmed Mortensen's U-Pb age determinations and considered the composite plug and gabbro units to also belong to the Simpson Range plutonic suite based on field relationships and U-Pb zircon, geochemical and other isotopic data. Grant (1997) noted both intrusive and faulted contacts between the various meta-igneous units.

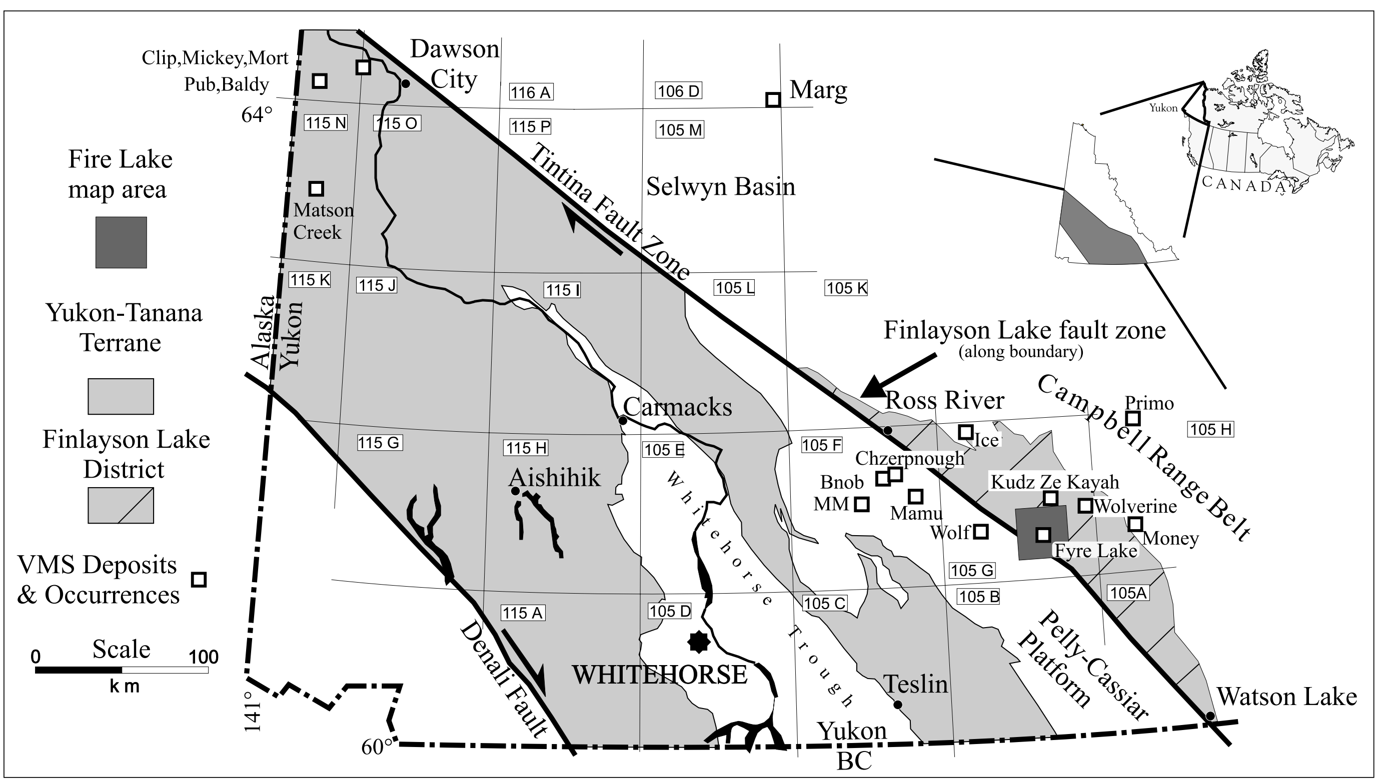


Figure 1. *Location of the Finlayson Lake district and Fire Lake map area.*

YUKON-TANANA TERRANE NORTHEAST OF FIRE LAKE

In general, layered rock units defined during mapping of Grass Lakes area (105G/7) immediately to the northwest can be traced into the area northeast of Fire Lake (Murphy, 1997; Murphy and Timmerman, 1997a,b; Murphy this volume; Fig. 2). These include unit 1, quartz-rich meta-clastic rocks, calcareous quartz psammite, marble, and minor biotite-chlorite-actinolite schist; unit 2, biotite-chlorite schist and minor meta-clastic rocks; and unit 3, consisting of siliceous carbonaceous phyllite (*3cp*) and lesser marble and felsic meta-volcanic rock (*3f*; for more detailed descriptions see Murphy, this volume).

The Fyre Lake deposit is hosted in unit 2 chlorite schist (*2m*) close to the contact with carbonaceous phyllite of unit 3 (*3cp*). Chloritic phyllite hosting the deposit overlies at least 50 m of carbonaceous phyllite indistinguishable from carbonaceous phyllite of unit *3cp* that overlies the chlorite schist. The underlying carbonaceous phyllite may either be an infold of unit *3cp* or a separate stratigraphic unit. If the latter, then its presence is evidence for local faulting that controlled sedimentation and massive sulphide deposition as proposed by Murphy (this volume).

Meta-intrusive rock units defined in the Grass Lakes area also continue into the area northeast of Fire Lake. These include unit *2um*, dun-coloured, variably serpentinized ultramafic rocks and unit *2mum*, a mixed unit of leuco-amphibolite (meta-gabbro), dark green amphibolite (meta-pyroxenite) and hornblende-biotite meta-diorite. Murphy (this volume) inferred that these units are sills intruding unit 2 fed by dykes intruding along a syn-sedimentary fault. This fault is inferred to be the northeast side of the basin in which the Fyre Lake massive sulphide deposit formed.

'MONEY KLIPPE'

Units 2 and 3 northeast of Fire Lake are truncated to the east by a moderately east-dipping, up-to-700 m-thick zone of mylonitic granitic gneiss (*Mgs*; Fig. 2). Intensely foliated and lineated, fine-grained mylonitic quartz-potassium feldspar-muscovite gneiss and schist passes transitionally upward through increasingly coarse-grained potassium feldspar porphyroclastic mylonite into undeformed coarse-grained Early Mississippian (Grant, 1997; Mortensen, pers. comm., 1997) biotite (hornblende) granite. This shear zone lies at the base of an internally faulted domain of mafic, ultramafic and felsic intrusive rocks and lesser meta-sedimentary and mafic meta-volcanic rocks which Tempelman-Kluit (1979) termed the Money Klippe. In the 'klippe', coarse-grained Mississippian granitic rocks predominate with mafic meta-volcanic, mafic and ultramafic meta-intrusive rocks, felsic intrusive rocks, quartzose metaclastic rocks and carbonate occurring in a roof setting or as pendants in the granite. The meta-sedimentary, meta-volcanic and mafic meta-plutonic rocks occurring as roof pendants, and the quartz porphyry, bear a strong resemblance in rock type and sequence to those beneath the strain zone and are thought to correlate with them.

METASEDIMENTARY AND METAVOLCANIC ROCKS

Above the strain zone in the southeast corner of the map area, the lowest layered rocks are similar to unit 1 of Yukon-Tanana Terrane, comprising tan to light grey micaceous quartzite, light grey marble interbanded with calc-silicate, intervals of dark grey carbonaceous phyllite above and below the marble and minor chloritic phyllite above the marble (L. Pigage, pers. comm., 1998 and this study). The age of these rocks is not known but they must be older than the Mississippian granite by which they are intruded. Micaceous quartzite passes upward into rocks that resemble unit 2 of the Yukon-Tanana Terrane. These are made up dominantly of green chlorite-actinolite-epidote phyllite with green chert layers 1 to 5 m thick (L. Pigage, pers. comm., 1998 and this study). Towards the top of this unit, is a variably thick, laterally persistent, thick- to thin-bedded white marble intercalated with chloritic phyllite (L. Pigage, pers. comm., 1998 and this study). In the southeast corner of the map area the top of the chlorite-actinolite-epidote phyllite is a low- to moderate-angle fault contact with Mississippian granite (L. Pigage, pers. comm., 1998 and this study).

Mafic volcanic breccia ($2m_{bx;}$ Fig. 3) and ?augite porphyry (Fig. 4), also thought to belong to unit 2, are found as unstrained pendants in quartz porphyry at the west end of the ridge 5 km northeast of the headwaters of Kona Creek (e.g. Easting 422630, Northing 6792580; Fig. 2). The pendant of breccia is about 100 m-thick and approximately 500 m across.

Green and maroon weathering breccia is made up of maroon, pale green and black, angular fragments in a dark green to locally maroon matrix (Fig. 3). The fragments range from 0.5 to 3 cm across and are variably vesicular and/or amygdaloidal mafic volcanic rocks. Locally the matrix has ?augite phenocrysts. In places the entire rock is epidotized. Locally there are blebs of jasper in the breccia. Some fragments have amygdules and fractures filled by carbonate.

Augite porphyry occurs about 300 m east of the breccia in a smaller pendant about 100 m wide. The ?augite porphyry has a medium green, fine grained groundmass with about 5% augite phenocrysts 2 to 3 mm across (Fig. 4). Locally the rock is epidotized or has minor disseminated pyrite and weathers rusty.

The age of the mafic meta-volcanic rocks is not known. However, they are intruded by Devono-Mississippian (360.5±1.9 Ma, Mortensen, 1992b; 356+3.4/-4.0 Ma, Grant, 1997) quartz porphyry (see description below). If the meta-volcanic rocks are comagmatic with the mafic and ultramafic meta-plutonic rocks then the unit is likey uppermost Devonian (see below).

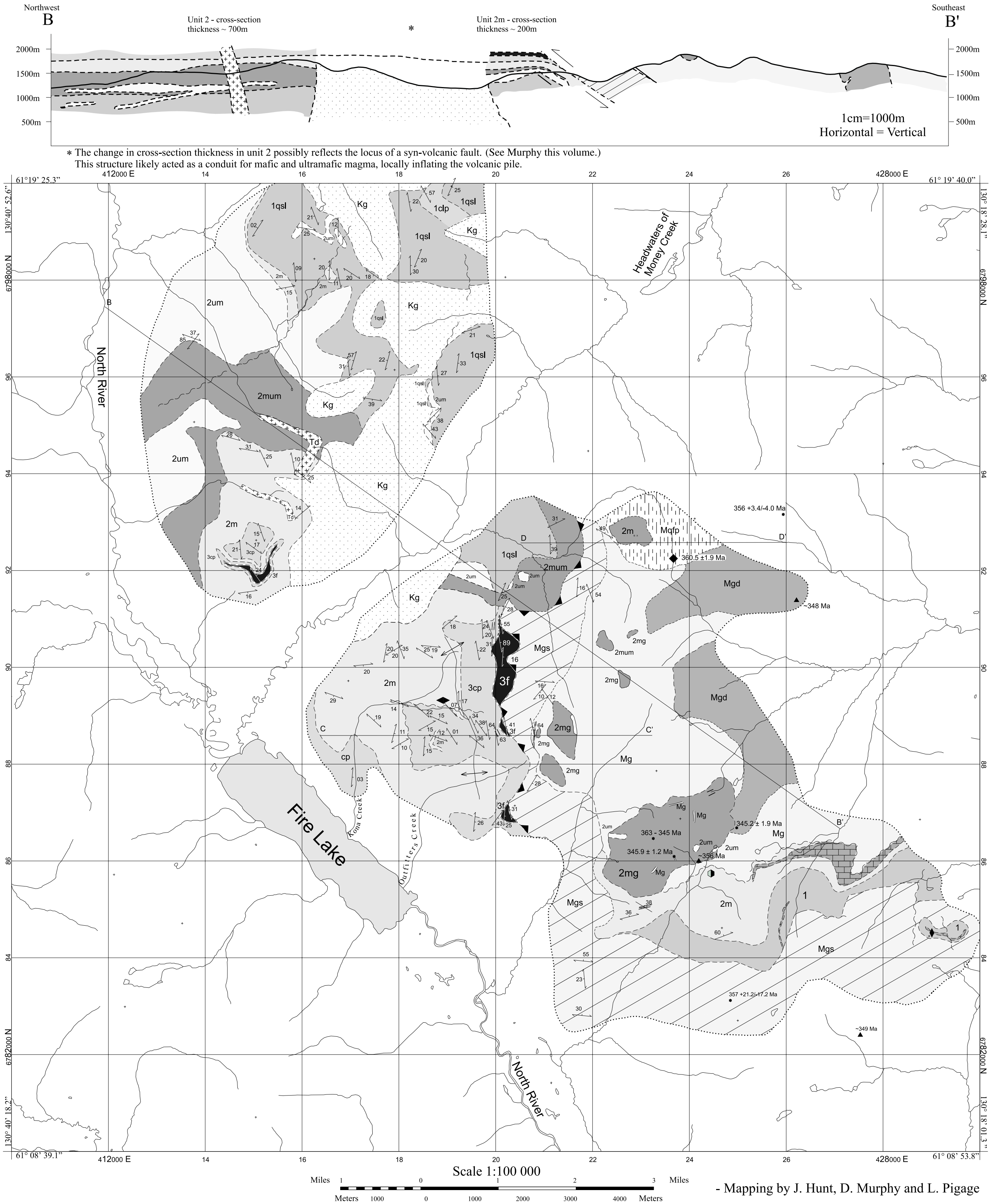


Figure 2. *Bedrock geology map of the Fire Lake area.*

Legend:

INTRUSIVE ROCKS

TERTIARY

Td — North-northeast trending undeformed, brown, clay-altered feldspar porphyry dykes and light grey aphyric felsic dykes

CRETACEOUS

Kg — Weakly foliated medium- to coarse-grained biotite-muscovite granite, generally equigranular [1]

MISSISSIPPIAN

Mgs — Medium to coarse grained granite variably strained

Mg — Medium to coarse grained granite, unstrained

Mgd — Medium grained granodiorite, unstrained

Mqfp — Quartz-feldspar porphyry, variably foliated, mineralized and oxidized

2m bx — Mafic volcanic breccia and augite porphyry

2mg — Fine to coarse grained gabbro

2mum — Biotite-actinolite-plagioclase amphibolite (meta-gabbro) and actinolite amphibolite (meta-pyroxenite)

Age unknown

2um — Massive to layered metamorphosed ultramafic rocks including dunite and pyroxenite, locally serpentinized on fractures

Ultra mafic rock

LAYERED METAMORPHIC ROCKS

Unit 3

3f — Light grey, tan to white platy quartz-muscovite schist, locally with mm-scale quartz and feldspar augen (at least in part felsic metavolcanic rocks)

3cp — Medium to dark grey carbonaceous muscovite-quartz schist or phyllite, quartzite, uncommon light grey marble

cp — Lithologically similar to 3cp, but stratigraphic position is unclear (may underlie unit 2)

Unit 2

2m — Massive calcareous actinolite-plagioclase-chlorite-biotite schist, subtly layered plagioclase-actinolite-chlorite schist, and lesser carbonaceous phyllite and quartzite

White marble

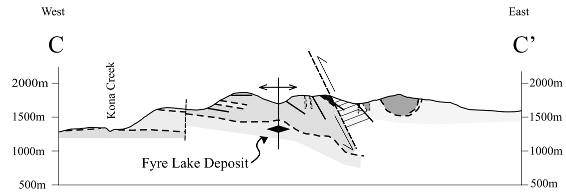
Unit 1

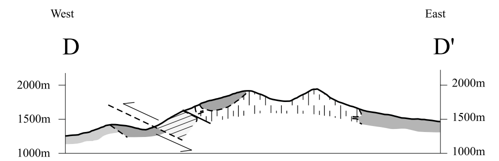
1clp — Calcareous quartz psammite, marble, calcareous chlorite-biotite schist and epidote-biotite-calcite-garnet calcsilicate schist; stratigraphically equivalent to Unit 1cls

1qsl — Lower quartzose metaclastic unit: biotite-quartz-muscovite schist and lesser biotite-muscovite quartz schist and plagioclase-quartz-chlorite-biotite schist

1 — Undifferentiated unit one with bands of calc-silicate

1 112 Ma U-Pb determinations reported from this and similar bodies elsewhere in the Pelly Mountains (Mortensen, 1992 and personal communication, 1996).





Scale 1:100 000
1cm = 1000m
Horizontal = Vertical

SYMBOLS

Geological contact (defined, approximate, assumed and/or covered)......................

Fault ....

Thrust fault, teeth on hanging wall...

Limit of outcrop...

Line of cross-section.. A A'

Age dates...
- * U- Pb age determination from Grant (1997)
- ▲ U- Pb age determination from J.K. Mortensen (personal communication, 1997)
- ◆ U- Pb age determination from Mortensen (1992b)

Foliation... 60

Anticlinal fold axis...

Survey point... +

MINERAL OCCURRENCES

Yukon Minfile		Name	Type
105G 034	◆	Fyre Lake	Cu - Co - Au
		Shutout	Base metal occurrence
	♦	Bell's Showing	Skarn

Unit descriptions modified from Murphy (this volume).

INTRUSIVE ROCKS

Mafic and ultramafic rocks (2mg, 2mum, 2um)

The suite of mafic igneous rocks in the Fire Lake area is heterogeneous, comprising dark green and white gabbro and dun-coloured ultramafic rocks (part of the Anvil Allochthon of Tempelman-Kluit, 1977, 1979). Massive, unstrained, fine- to very coarse-grained gabbro (*2mg*), mixed gabbro and ultramafic (*2mum*), and ultramafic rocks (*2um*) underlie about 15 percent of the area northeast of Fire Lake (Fig. 2).

The gabbro (*2mg*) is preserved as pendants and inclusions within granite in the southern two thirds of the map area (Fig. 5). The pendants are irregularly shaped and range from about 100 m to 1 km across. Irregular-shaped bodies of mixed gabbro and ultramafic rocks (*2mum*) occur in two main locations: in the northwest corner of the map area and in the southeast corner. Dun-brown weathering ultramafic rocks (*2um*) occur primarily in the northwest corner of the map area, in 105G/7 and have been described by Murphy (this volume).

Unit *2mg* is made up primarily of dark green to black weathering gabbro comprised of white feldspar and dark green to black pyroxene and/or amphibole (Fig. 6). Excellent exposures of very coarse- to fine-grained gabbro, preserved as an unstrained pendant in Mississippian granite, occur about 2 km east of the head of Kona Creek (UTM zone 9, Easting 421200, Northing 6789060). Locally, the contacts of the pendants have strong epidote, potassium feldspar and hematite alteration or are bleached. In places the granite is brecciated along the contacts with the gabbro. Locally the gabbro intrudes ultramafic rock. In the southeast corner of the map area unit *2mg* is in low-angle fault contact with unit *2m* chlorite schist.

Unit *2mum* is made up of gabbro (as above) and dun-brown weathering ultramafic rock as described by Murphy (this volume).

Fine- to medium-grained plagiogranite occurs as small irregular bodies in gradational contact with the gabbro, and as narrow crosscutting dykes. The plagiogranite is interpreted to be a late differentiate from the mafic magma (Mortensen, 1983). Mortensen, (pers. comm. 1997) determined a 356 ± 1Ma U-Pb age for the gabbro; a similar though less precise age was determined by Grant (1997).

Quartz Porphyry (Mqfp)

Quartz porphyry (*Mqfp*) occurs on the ridge at the northeastern edge of the map area (e.g. UTM zone 9, Easting 422330, Northing 6792550; in this area strained granite gradually changes over about 200 m to medium-grained unstrained granite which is in sharp intrusive contact with quartz porphyry). Here there are excellent exposures of essentially undeformed white- to cream-weathering porphyry, characterized by a fine-grained, cream-coloured groundmass and grey quartz phenocrysts about 2 mm in diameter (Fig. 7). Close to the contact the porphyry is crowded with quartz phenocrysts; these decrease in abundance away from the contact. The quartz porphyry is easily distinguishable from the granite and granodiorite which intrude it.

The quartz porphyry locally contains pendants of mafic volcanic breccia (*$2m_{bx}$*) and ?augite porphyry (Figs. 3, 4). The pendants vary from several hundred metres to 1 km across (Fig 2). These pendants, like those in the granite, are unstrained and are correlated with unit 2. The porphyry is cut by a white quartz vein about 1 m wide with malachite staining. A sample of the vein returned values of 2760 ppm Cu, 582 ppm Zn, 1725 ppm Pb and 29.8 ppm Ag.

U-Pb zircon age determinations from the quartz porphyry are 360.5 ±1.9 Ma (Mortensen, 1992b) and 356 +3.4/-4.0 Ma (Grant, 1997).

Figure 3. *Mafic volcanic breccia. This sample is from a pendant in quartz porphyry. Location: 105G/1; UTM zone 9, Easting 422630, Northing 6792580 (JH97-162).*

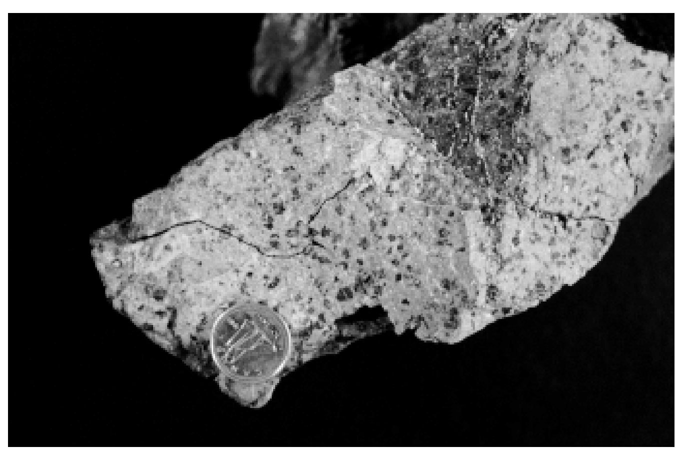


Figure 4. *Augite porphyry occurs as a pendant in quartz porphyry. Location: UTM zone 9, Easting 423690, Northing 6792530 (JH97-164).*

Figure 5. *Gabbro (unit 2 ?) intruded by lighter coloured granite of the Simpson Range plutonic suite. Location: 105G/1; UTM zone 9, Easting 423360, Northing 6787640. (JH97-108).*

Figure 6. *Coarse- to fine-grained gabbro with mafic inclusions. Location: 105G/1; UTM zone 9, Easting 422750; Northing 6789700 (JH97-48).*

Granite, Strained Granite and Granodiorite (Mg, Mgs, Mgd)

Mississippian granite and granodiorite (part of Simpson Allochthon of Tempelman-Kluit, 1977, 1979) and the Simpson Range Plutonic Suite of Yukon-Tanana Terrane of Mortensen (1983) underlie about 30 percent of the Fire Lake area, forming several large bodies east of Fire Lake, southwest of the head waters of Money Creek (Fig. 2). Plutons are irregularly shaped, 1 to 5 km wide and up to 9 km long. The intrusions are blocky jointed, locally inclusion-bearing and distinctive in their lack of deformation. Pink granite (*Mg*) occurs east of the Fyre Lake deposit and forms the largest pluton in the Fire Lake area. White to pale pink granodiorite (*Mgd*) occurs on the eastern edge of the map area and locally appears transitional with the granite. The plutons are generally massive, except in the strain zone 2.5 km east of Fire Lake where the granite can be traced from undeformed granite to fine-grained mylonitic schist (*Mgs*) across a zone 0.3 to 1.0 km thick (Fig. 2).

Granite (*Mg*) is well exposed about 4 km east of the head of Kona Creek (UTM zone 9, Easting 423750; Northing 6789950). Here there are excellent exposures of pink-weathering, coarse-grained granite, easily distinguishable from the granodiorite which is white-weathering and medium-grained (Figs. 8, 9). The granite is made up of 30 to 40% quartz, 25 to 30% potassium feldspar, 25 to 30% plagioclase, and 5 to 10% biotite and hornblende. The granite varies from coarse- to medium-grained and in places is difficult to distinguish from the granodioritic phase. It is possible that there is a continuum between the two phases as they have similar U-Pb zircon ages (Grant, 1997; J.K. Mortensen, pers. comm., 1997). However, locally the granite does intrude into the granodiorite and therefore must, in places, be slightly younger (this study; Mortensen, 1983).

Locally the granite is cut by numerous quartz veinlets and has epidote, chlorite and potassium feldspar alteration, especially close to the contact with the granodiorite. Near the contact with the granodiorite are several quartz veins about 2 cm wide with malachite, galena, pyrite, chalcopyrite, bornite and native copper. Grab samples of the vein contain up to 6750 ppm Cu, 2730 ppm Zn, 324 ppm Pb and 22.5 ppm Cd.

In addition to intruding quartz porphyry, the granite intrudes chlorite schist of unit 2 (*2m and 2mum*), ultramafic rocks (*2um*) and mafic rocks (*2mg and 2mum;* Fig. 5) some of which occur as undeformed pendants and inclusions of fine and coarse-grained gabbro, diorite and pyroxenite that vary from centimetre-sized up to 1 km across.

Granodiorite (*Mgd*) is well exposed about 4 km east of the head of Kona Creek (UTM zone 9, Easting 423800; Northing 6789850). Here there are excellent exposures of white weathering, medium-grained granodiorite easily distinguishable from the granite (Figs. 8, 9). The granodiorite is made up of 10 to 15% quartz, 50 to 70% plagioclase, 5% potassium feldspar, 10 to 15% hornblende (minor biotite) and is essentially undeformed (Fig. 9). In places the granodiorite is intruded by the granite. Locally, however, it appears to be transitional, over a distance of 1 km, with the granite especially at the southeastern edge of the map area near the Shutout property (Fig. 2).

Strained granite (*Mgs*) is well exposed in the valley northeast of the head of Kona Creek (e.g. UTM zone 9, Easting 421790, Northing 6791550). Here there is a strain zone at least 1 km wide (map view) where the granite can be traced from unstrained in the east to foliated and finally to muscovite schist in the west (see cross-section B-B', Figs. 2, 10). The strain zone is believed to be the edge of the granitic intrusion which took up strain during deformation, leaving the remainder of the pluton virtually undeformed.

Weakly deformed, *strained granite* is similar in appearance to undeformed granite but has flattened pink feldspar grains. As

Figure 7. *Quartz porphyry (composite plug) of unit 3. Location: 105G/1; UTM zone 9, Easting 422330, Northing 6792550 (JH97-160).*

the degree of strain increased quartz grains became flattened and the rock gained a distinct foliation. Closer to the edge of the intrusion the rock loses its granitic appearance and is increasingly foliated until it becomes green, well foliated muscovite schist with large blebs of white mica on the foliation planes.

The ages of the granite and granodiorite are 345.9±1.2 Ma and 345.2±1.9 respectively (Grant, 1997). Similar U-Pb age dates have been determined by J.K. Mortensen (pers. comm., 1997). Strained granite was dated by Grant (1997) and zircons returned an imprecise U-Pb date of 357+21.1/-17.2 Ma; the imprecise nature of this date probably reflects modification of the U-Pb systematics during deformation.

CRETACEOUS GRANITE

Medium-grained, weakly foliated biotite-muscovite granite (*Kg*) also underlies a part of the area northeast of Fire Lake. This is the southern end of a large Cretaceous stock that underlies much of the southeastern corner of Grass Lakes map area (Fig. 2).

DISCUSSION

The Fyre Lake massive sulphide deposit is hosted in unit *2m* mafic meta-volcanic rocks in an area where there are subtle indications of sub-basin development and syn-volcanic faulting and intrusion. Unit 2 in this area is spatially associated with mafic and ultramafic meta-plutonic rocks with sill-like characteristics (Murphy, this volume). In southern Grass Lakes map area, the meta-plutonic bodies are stratabound within unit *2m* and increase in thickness toward the east from zero to more than 500 m along strike to the north from the Fyre Lake deposit. Further across strike to the east, the total thickness of unit *2m* and the sill-like meta-plutonic rocks decreases to less than 100 m, coincident with the occurrence of ultramafic rocks in unit 1 and an anomalous juxtaposition of different stratigraphic levels of unit 1 (see Murphy, this volume). Taken together, these observations suggest the presence of a syn-magmatic fault which controlled the intrusion of the mafic and ultramafic bodies and the thickness of meta-volcanic rocks, and possibly acted as a conduit for mineralizing hydrothermal solutions. The occurrence of an additional unit of carbonaceous phyllite beneath unit 2 chlorite schist near the Fyre Lake deposit suggests that the fault may have bounded a local sub-basin.

Unlike previous workers, our impression is that **all** the rocks of Money Klippe, including the layered metasedimentary and mafic metavolcanic rocks and the quartz porphyry should be correlated with Yukon-Tanana Terrane. This conclusion is based primarily on the strong resemblance in rock type and sequence

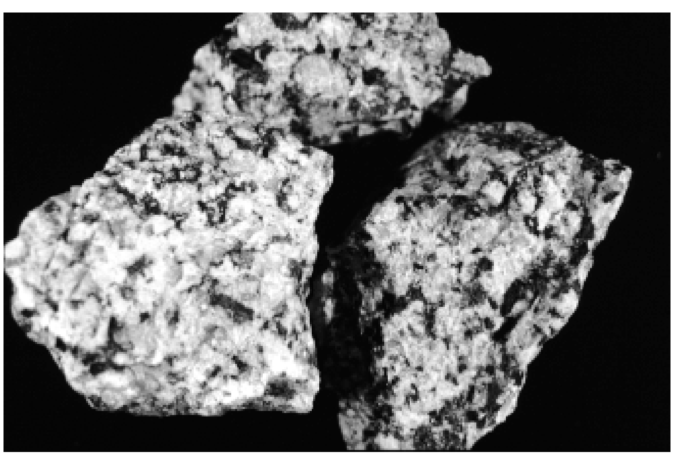


Figure 8. *Granite of the Simpson Range plutonic suite. Location:105G/1; UTM zone 9, Easting 423750; Northing 6789950 (JH97-40).*

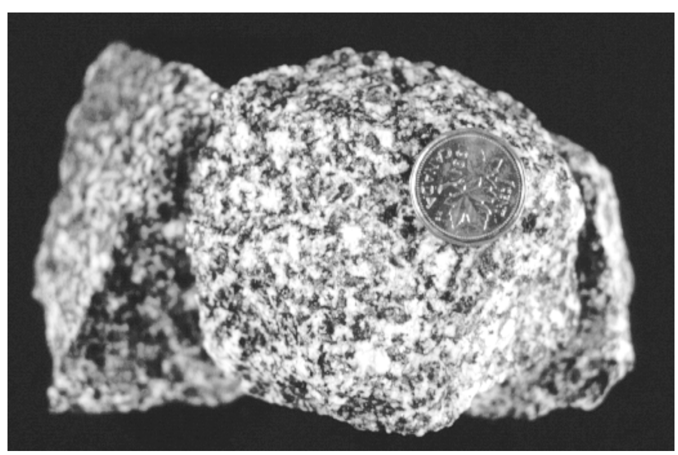


Figure 9. *Granodiorite of the Simpson Range plutonic suite. Location: 105G/1; UTM zone 9, Easting 423800; Northing 6789850 (JH97-44).*

of the layered rocks with Yukon-Tanana Terrane stratigraphy beneath the klippe, the common association of mafic meta-volcanic rocks with mafic and ultramafic meta-plutonic rock, and the similarity in U-Pb ages between the quartz porphyry and felsic meta-volcanic rocks of Yukon-Tanana Terrane. In addition, this correlation is almost required by the observed intrusive relationships between all the rock units and granite of the Simpson Range plutonic suite — which is already considered by Mortensen (1983, 1992a) to be a fundamental part of Yukon-Tanana Terrane.

That being said, we acknowledge some significant differences between the layered rock of the klippe and the Yukon-Tanana Terrane stratigraphy beneath the shear zone. Firstly, chlorite schist in the klippe is intercalated with significant amounts of green chert and white marble, neither of which have yet been observed in unit *2m* beneath the klippe. Secondly, although there are subtle indications of porphyritic textures in the highly deformed unit *2m* beneath the klippe, unequivocal ?augite meta-porphyries haven't been observed in Yukon-Tanana Terrane beneath the klippe. Although we acknowledge these differences, the first-order similarity of the rocks within the klippe with Yukon-Tanana Terrane is apparent.

If the rocks within the klippe correlate with Yukon-Tanana Terrane as proposed, then the shear zone at the base of the klippe need not be a major structure. Previous workers have included the rocks of Money Klippe with the Anvil and Simpson allochthons (Tempelman-Kluit, 1977, 1979) or Slide Mountain terrane (Mortensen, 1992a,b). These previous correlations imply that the shear zone at the base of the klippe is a terrane boundary possibly accommodating orogen-scale displacements. In contrast, our interpretation is far more conservative. Although we cannot yet directly determine a displacement across this structure as mylonitic Mississippian granite is juxtaposed against units 2 and 3 along a footwall ramp, the nearby occurrence of roof pendants of unit 2 in the granite implies that the stratigraphic separation cannot be very large.

Our impression of the internal structure of the klippe also differs from that of previous workers. Tempelman-Kluit (1979) and Erdmer (1985) inferred that all contacts in the klippe are structural and documented low-angle faults. Although low-angle faults do occur locally, most contacts have intrusive characteristics. The prominent low-angle faults documented by previous workers are likely splays off the basal shear zone; the occurrence of unit 2 metavolcanic and meta-plutonic rocks and Mississippian granite both above and below the faults suggests small displacement.

The proposed correlation of rocks of Money Klippe with Yukon-Tanana Terrane increases their prospectivity for VMS deposits. If the mafic schist unit within the klippe is indeed unit *2m* of Yukon-Tanana Terrane, then it is prospective for Fyre Lake-type deposits and indeed is locally characterized by massive pyrite lenses and anomalous cobalt soil geochemistry as at Expatriate Resources' Shutout claims. If the quartz porphyry is coeval with unit 3, then it has potential to host Kudz Ze Kayah- and Wolverine Lake-type VMS deposits.

SUMMARY

New geological mapping around the Fyre Lake Cu-Co-Au deposit has established the stratigraphic position of the deposit within Yukon-Tanana Terrane stratigraphy defined in neighbouring Grass Lakes map area (Murphy, 1997, this volume). In addition, examination of the rocks and contact relationships within Money Klippe has shown that rocks of the klippe previously correlated with Slide Mountain Terrane (Anvil assemblage) likely correlate with Yukon-Tanana Terrane.

The correlation of rocks of Money Klippe with Yukon-Tanana Terrane has implications for mineral exploration. The new

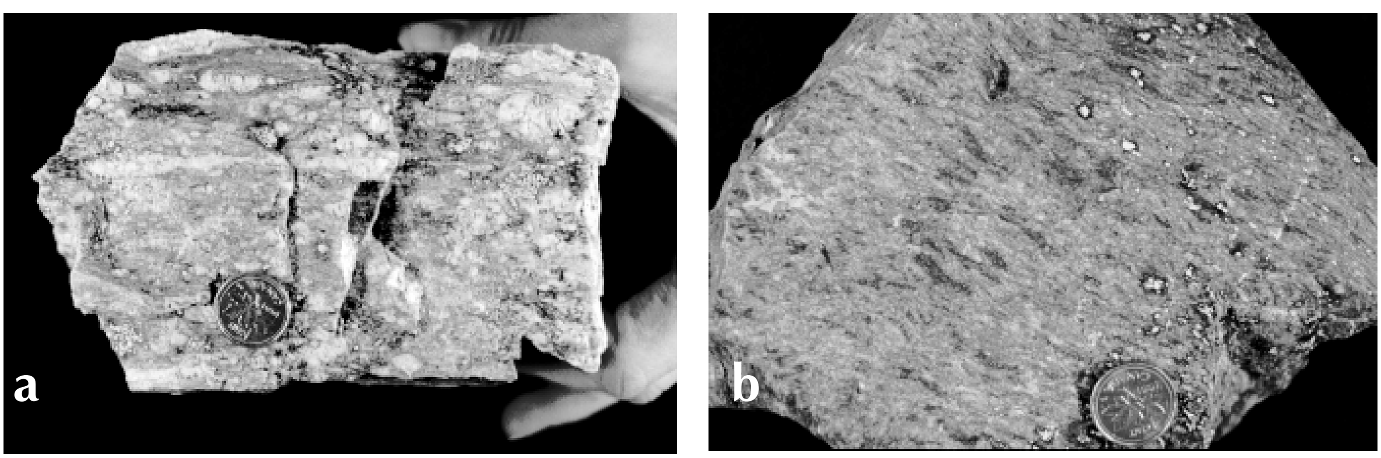


Figure 10. *Strain variations in granite (*Mgs*) of the Simpson Range plutonic suite. Sample 10b has undergone greater strain than sample 10a. Location: 105G/1; UTM zone 9, Easting 421790, Northing 6791550 (JH97-89).*

mapping shows that the Fyre Lake deposit occurs within mafic schists of unit *2m* near the fault-controlled margin of a syn-volcanic basin. The proposed correlation implies that the mafic meta-volcanic unit of the klippe is the same unit that hosts the Fyre Lake deposit and is therefore prospective for deposits of that type. As coarse-grained quartz-rich porphyritic rocks are associated with VMS mineralization at Kudz Ze Kayah and Wolverine Lake, the area around the Money Klippe quartz porphyry should be considered prospective for that type of deposit.

ACKNOWLEDGMENTS

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Stratigraphic succession and U-Pb geochronology from the Teslin suture zone, south-central Yukon

Douglas H. Oliver[1] and James K. Mortensen[2]

[1] Department of Geological Sciences, Southern Methodist University
Dallas, TX, USA 75275, e-mail: oliver@mail.smu.edu
[2] Department of Earth and Ocean Sciences, University of British Columbia
Vancouver, BC, Canada V6C 1Z4, e-mail: jmortens@eos.ubc.ca

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ABSTRACT

A lithologic succession is recognized in tectonites of the eastern Teslin suture zone in south-central Yukon. Metagraywacke and quartzite, marble, mafic metavolcanics, and interbedded metagraywacke and argillite outcrop on both limbs of an upright northwest-trending syncline at Little Salmon Lake. A body of equigranular granodiorite intrudes the basal stratigraphic units. The granodiorite and its host sediments were penetratively deformed during top-to-the-SW shearing and greenschist facies metamorphism. The granodiorite gives a Devono-Mississippian U-Pb zircon age (353 +1.3/-1.4 Ma) which is interpreted as the minimum age of crystallization. This provides a minimum depositional age for these suture zone protoliths. Based on the sedimentary succession and the age constraints, the eastern suture zone protoliths show a clear genetic link to other pericratonic terranes in the northern Cordillera.

RÉSUMÉ

Une succession lithologique a été identifiée dans les tectonites de la partie orientale de la suture de Teslin, dans le centre-sud du Yukon. À Little Salmon Lake, des métagrauwackes et des quartzites, des marbres, des métavolcanites mafiques ainsi que des métagrauwackes et des argilites interstratifiées affleurent sur les deux flancs d'un synclinal debout de direction nord-ouest. Un massif de granodiorite équigranulaire pénètre les unités stratigraphiques de base. La granodiorite et les sédiments encaissants ont été déformés de manière pénétrative au cours d'épisodes de cisaillement allant du sommet vers le sud-ouest et de métamorphisme du faciès des schistes verts. La datation à l'U-Pb de zircons de la granodiorite a fourni un âge dévono-mississippien (353 +1.3/-1.4 Ma), que l'on interprète comme l'âge minimum de cristallisation. Cette datation fournit également un âge minimal de dépôt de ces protolithes de la partie orientale de la suture de Teslin.

INTRODUCTION

The Teslin suture zone is a belt of complexly deformed tectonites that outcrop across south-central Yukon (Fig. 1). Despite an abundance of new structural, geochemical and thermochronometric data, the origin and tectonic significance of the Teslin suture zone remains controversial (e.g., Hansen, 1989, 1992; Stevens and Erdmer, 1996; Creaser et al., 1997). In part, this is a function of the polyphase deformational history of this crustal feature. Different study areas often record dissimilar tectonic events, cooling histories, and/or resided at different crustal levels at the time of deformation. However, data sets that would allow for the testing of the various tectonic models — specifically, constraints on the age and source of the protoliths, and the timing and duration of deformation — are only beginning to be developed.

Geologic investigations at Little Salmon Lake have focused on: 1) the nature and sequence of deformation events along this segment of the Teslin suture zone, 2) the thermochronometric history of this area, and 3) P-T conditions at the time of deformation. However, an effort was also made to constrain the age and origin of the protoliths through identification of conodont microfossils from relatively undeformed carbonate units and zircon separation from an orthogneiss body. Although penetrative deformation precluded fossil preservation, U-Pb zircon methods dated the metaplutonic body thus providing a minimum age of deposition for the host rocks. In addition, a lithologic succession is recognized in the eastern part of the study area. The U-Pb crystallization age and the lithologic succession allow new correlations between the study area and other lithologic assemblages in southern Yukon.

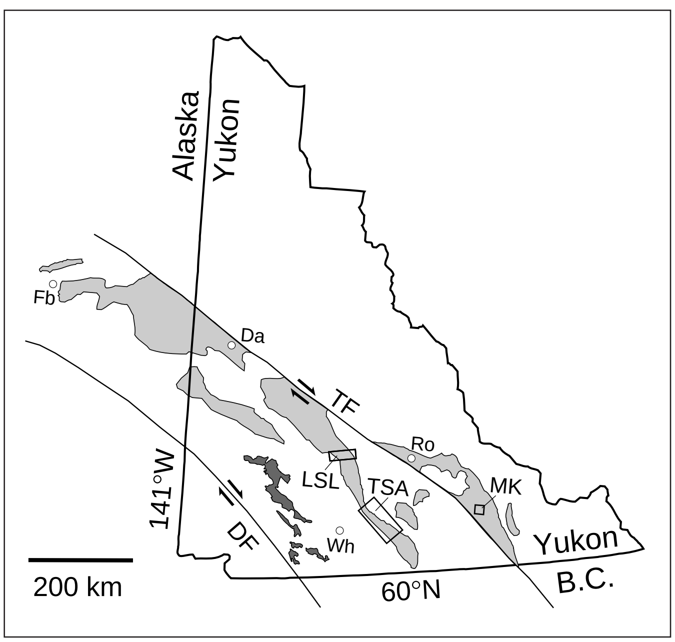

Figure 1. Distribution of rocks broadly correlative with those of the Yukon-Tanana Terrane and Teslin suture zone in light gray. Nisling terrane and equivalent rocks in dark gray. LSL - Little Salmon Lake study area, TSA - Teslin study area of Stevens et al. (1996), MK - Money Klippe, Wh - Whitehorse, Da - Dawson City, Ro - Ross River, Fb - Fairbanks, TF - Tintina Fault, DF - Denali Fault.

REGIONAL GEOLOGY

The Teslin suture zone is a prong of the Yukon-Tanana terrane which extends across southeastern Yukon. The suture zone marks a fundamental crustal discontinuity that separates rocks of autochthonous North America from the accreted terranes to the west (Tempelman-Kluit, 1979). Tectonites within the suture zone are defined by a pervasive, penetrative ductile fabric with the sedimentary, volcaniclastic and igneous protoliths commonly metamorphosed to greenschist or amphibolite facies (Hansen, 1989; Stevens and Erdmer, 1996).

Little Salmon Lake is located 170 km north-northeast of Whitehorse and 65 km west of Faro. Access is provided by the Robert Campbell Highway which transects the area of interest. Good exposures on both the north and south shores of Little Salmon Lake and in road-cuts allow for a nearly continuous transect across the Teslin suture zone before it enters the lowlands to the northwest.

The Teslin suture zone at Little Salmon Lake is 25 to 30 km wide and is bounded on the east and west by the d'Abaddie and Big Salmon faults, respectively (Campbell, 1967). Lithologies of North American affinity occur northeast of the d'Abaddie Fault (Fig. 2). The suture zone tectonites commonly display both a mylonitic foliation and an elongation lineation (Oliver, 1996). Foliation strikes N40W with both southwest and northeast dips. A series of 5 to 20 km wavelength folds are the most conspicuous structural feature at Little Salmon Lake. These NW-trending folds — close to tight, steeply inclined to upright, and gently plunging — increase in amplitude to the northeast. Axial planar cleavage is infrequently observed except within the core of the eastern syncline. The orientation of the steeply-dipping cleavage is compatible with development during broad-scale folding.

In addition to a mylonitic foliation, most Little Salmon Lake tectonites also display a mineral elongation lineation consisting of sheared mica or rodded quartz. Lineation trends are dominantly either parallel or perpendicular to strike and form several spatially-distinct domains. Kinematic analysis through microshear-sense indicators and quartz c -axis analysis reveals a complex structural history (Oliver and Goodge, 1996). From oldest to youngest, the deformation events include: 1. Top-to-the-SW and top-to-the-NE dip-slip shear within the structurally low tectonites, 2. Partial overprinting of the dip-slip fabrics during top-to-the-NW shearing in the structurally high tectonites, and 3. Folding of the tectonite assemblage after the cessation of penetrative deformation (Oliver, 1996).

Graphitic phyllites east of the d'Abaddie fault contain dip-slip lineations that are parallel to those in the adjacent suture zone tectonites. However, the graphitic phyllites differ in protolith, are of a lower metamorphic grade and lack kinematic indicators. The relationship of these tectonites to those of the suture zone and the relative timing of fabric development is unconstrained.

STRATIGRAPHIC SECTION

Siliciclastic sediments constitute the primary protoliths at Little Salmon Lake with lesser amounts of pelites, marls/limestones, volcaniclastics, mafic flows, and intermediate intrusives. Attempts to establish a stratigraphy in the western part of the suture zone were unsuccessful. Although the lithologic successions are not chaotic, neither are they systematic and a high degree a compositional heterogeneity characterizes many outcrops. The absence of distinctive, wide-ranging markers is an impediment to stratigraphic correlation and the pronounced mylonitic foliation obscures lithologic contacts, either depositional or tectonic.

In contrast, field investigations in the eastern third of the Little Salmon Lake study area indicate that a sedimentary succession is preserved within the eastern syncline. Tectonites in this area display strong L-S fabrics and record dominantly top-to-the-SW dip-slip shear giving way to top-to-the-NW shear in the core of the syncline. The protoliths have been metamorphosed to the greenschist facies.

A metagraywacke and quartzite unit is exposed at the lowest structural/stratigraphic level (Fig. 3). The metagraywackes are composed primarily of quartz, muscovite, plagioclase, chlorite and biotite and are weakly graphitic. Thin interbeds include relatively clean quartzite, chloritic phyllite and minor stretched-pebble conglomerate. The units show a pronounced mylonitic foliation and primary bedding is not observed. Quartz within the metagraywacke and quartzite are commonly sheared into ribbons that remain unannealed.

A ~10 m thick layer of fine-grained sugary white quartzite is exposed on the south shore of Little Salmon Lake (SS-27). This unit contains up to 10% disseminate pyrite and is extensively stained with jarosite and possibly scorodite. Because of the pervasive ductile shearing, the primary relationship of this unit to the surrounding metagraywacke and quartzite remains equivocal although it could be syngenetic and exhalative.

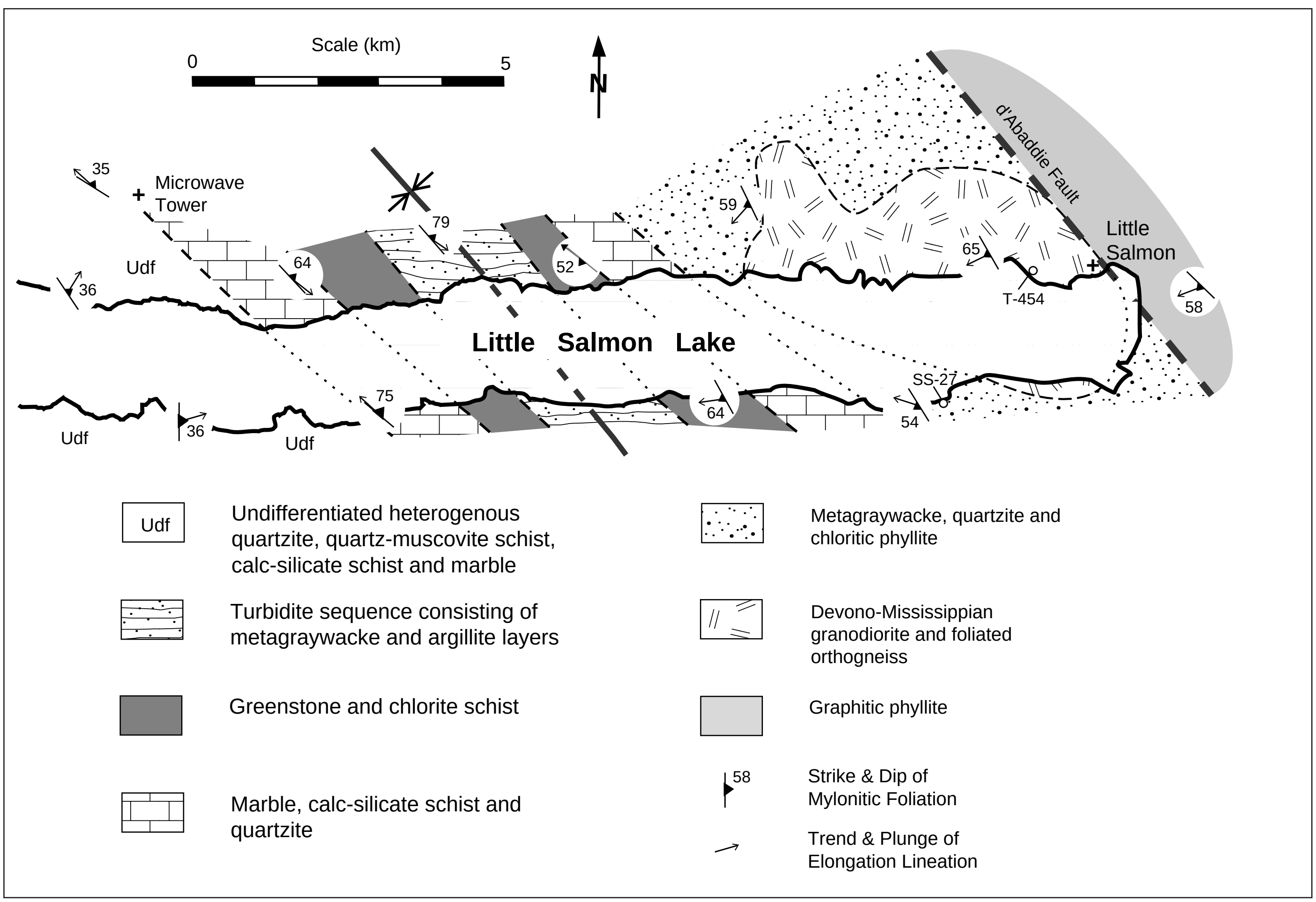

Figure 2. *Geology of the eastern Little Salmon Lake study area.*

However, geochemical analyses revealed only background amounts of Au, Ag and As.

The base of the metagraywacke/quartzite unit is not exposed although it has a thickness of at least 1.5 km. It appears to fine upward into chloritic phyllite and may have a gradational contact with the overlying unit.

Marble and calc-silicate schist form a distinctive unit on both limbs of the eastern syncline. The marbles are strongly recrystallized and occasionally contain disseminated dolomite rhombs. Epidote, clinozoisite and minor titanite are commonly observed in both the calc-silicate schists and in quartzite layers within the marbles. The marbles are intensely contorted with fold axes parallel to the eastern syncline. The marble and calc-silicate schist unit has a thickness of approximately 500 m.

Greenstone and intercalated chlorite schist overlie the marble and calc-silicate schist although the contact is covered. The greenstones are often massive and lack both foliation and lineations. The greenstone and chlorite schist appears to have been derived from mafic volcanics although no primary textures are preserved. They have an approximate thickness of 500 m.

Metagraywacke and argillite form the core of the eastern syncline. This metagraywacke is similar in composition to that seen in the metagraywacke/quartzite unit but differs by its lack of a well-developed tectonite fabric. Bedding relations in the upper metagraywacke unit consist of grits fining upward into graphitic argillite followed by an abrupt contact with the next overlying grit layer. The grit/argillite pairs range in thickness from 0.5 to 4 m and resemble upright turbidite sequences. An axial planar cleavage is well-developed in the argillite layers, particularly in the core of the syncline. Although the top of the upper metagraywacke is not exposed, the unit is estimated to have a minimum thickness of about 1.5 km.

Orthogneiss outcrops immediately west of the d'Abaddie fault and is the only deformed plutonic body at Little Salmon Lake. Massive, medium-grained equigranular granodiorite is exposed at sample station T-454 and consists of plagioclase, quartz and chlorite after amphibole with minor biotite. The intrusive becomes increasingly mylonitized away from the undeformed core. In most outcrops the orthogneiss displays a pronounced foliation including discrete bands of ultramylonite. Quartz grains within the orthogneiss are sheared into ribbons and the feldspar porphyroblasts are comminuted with σ-tails. The orthogneiss is surrounded by the metagraywacke/quartzite unit on the south, west and north. Because the metagraywacke has a bulk mineralogy similar to the orthogneiss, they are often indistinguishable after deformation and the contact relationship between them remains obscure. The limits of the orthogneiss are poorly constrained although it has a minimum surface area of ~8 km^2.

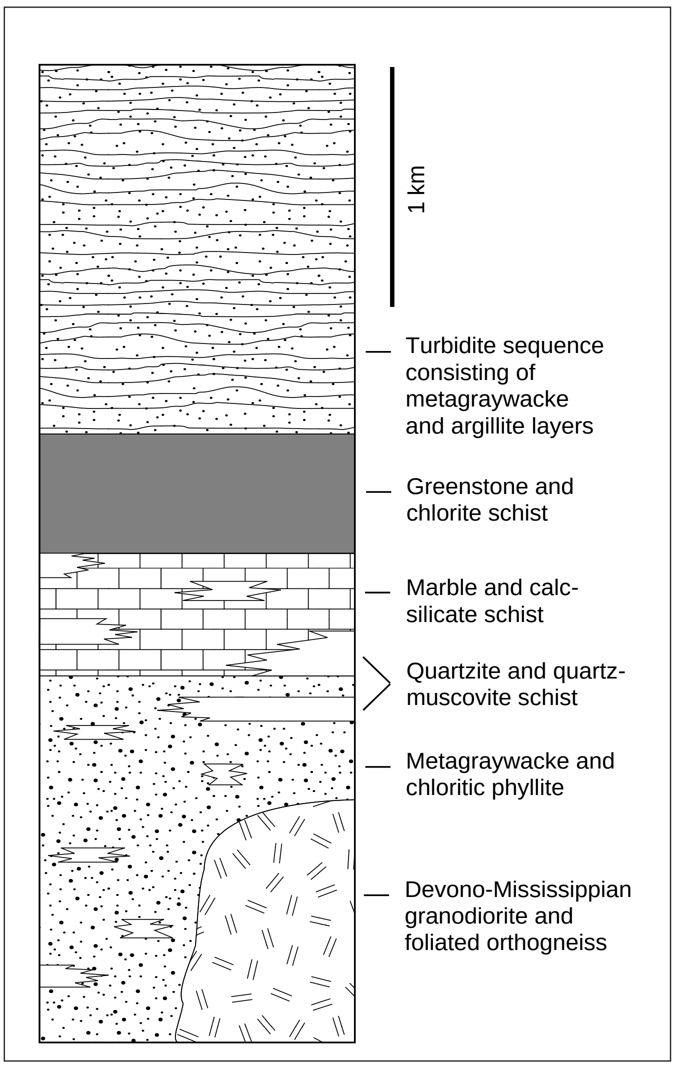

Figure 3. *Stratigraphy of the eastern Teslin suture zone at Little Salmon Lake.*

U-Pb RESULTS

A sample from the undeformed core of the orthogneiss body was chosen for U-Pb zircon dating. Sample T-454 was collected on the north side of the Robert Campbell Highway and consists of unfoliated granodiorite. Care was taken to exclude the mafic xenoliths that are locally contained within the pluton. The analytical results are shown in a conventional U-Pb concordia plot (Fig. 4).

Three fractions of zircon from sample T-454 were analyzed (Table 1). All the fractions are discordant but a regression line through the three analyses (MSWD = 0.3) gives lower and upper intercept ages of 353 +1.3/-1.4 Ma and 3.12 ±0.35 Ga, respectively. The data array indicates the presence of a small inherited zircon component in all the fractions. The lower intercept age is interpreted as the minimum crystallization age of the granodiorite.

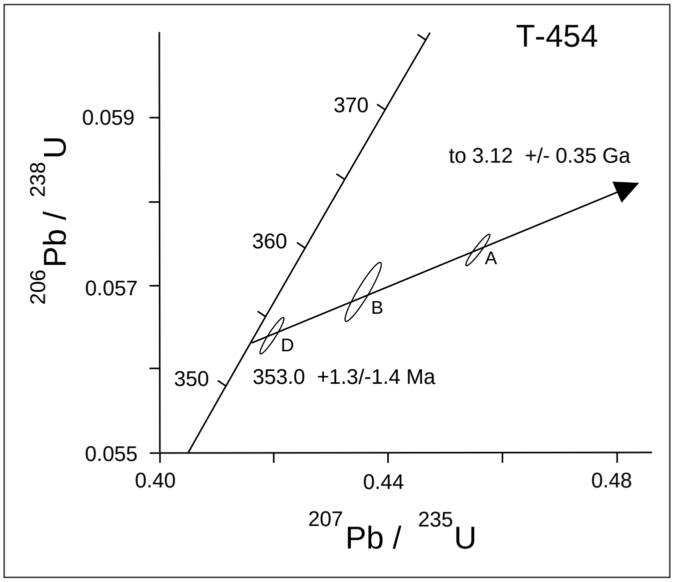

Figure 4. *U-Pb concordia diagram for granodiorite sample.*

DISCUSSION

U-Pb zircon dating at Little Salmon Lake establishes that at least the basal portion of the sedimentary succession in the eastern study area is pre-Mississippian. The distinctive sedimentary succession — coupled with Devono-Mississippian magmatism — allows for possible correlations with other lithotectonic terranes in the northern Cordillera.

Intermediate composition plutonic bodies with Devono-Mississippian crystallization ages have previously been reported from within the Teslin suture zone (Stevens et al., 1993). Analyses of three bodies of quartz-diorite orthogneiss in the Teslin map area yielded U-Pb zircon crystallization ages ranging from 341 to 351 Ma. Because of the intrusive relationship between the orthogneiss and the siliceous schists of the Nisutlin assemblage, Stevens et al. (1996) argue the Nisutlin assemblage was a coherent lithotectonic unit by Mississippian time. Consequently, the Nisutlin assemblage could not be the product of Permian to Early Jurassic subduction/accretion as has been suggested (e.g., Tempelman-Kluit, 1979; Hansen, 1989). Because ε_{Nd} values of the sedimentary protoliths in the Teslin map area indicate two sources of sediment supply — one of continental affinity and a second from a more primitive source-Creaser et al. (1997) conclude that the Nisutlin assemblage represents the outermost margin of ancestral North America.

However, plutons yielding comparable crystallization ages are found in a number of lithotectonic terranes. Hornblende-bearing Devono-Mississippian plutons are found in the eastern Alaska Range (Nokleberg and Aleinikoff, 1985), north of the Tintina fault in the Finlayson Lake area (Mortensen and Jilson, 1985; Grant et al., 1996), and the in Tracy Arm assemblage in the Coast Ranges (Karl et al., 1996). Devono-Mississippian plutons with peraluminous compositions are reported from the orthogneiss assemblage of the Yukon-Tanana Terrane of east-central Alaska (Dusel-Bacon and Aleinikoff, 1985; Aleinikoff et al., 1986), the Nisling terrane (Mortensen, 1992; Johnston et al., 1996), and the Cassiar terrane in the Laberge-Quiet Lake area east of the d'Abaddie fault (Hansen et al., 1989).

Similarly, the primitive to evolved ε_{Nd} signature of the Nisutlin sediments has also been reported from quartz-rich schists of the Nisling terrane (Jackson et al., 1991), the Tracy Arm and related assemblages of the Coast Ranges (Samson et al., 1991), and the "lower unit" strata beneath the Money klippe north of the Tintina Fault (Grant et al., 1996). Consequently, neither the Devono-Mississippian plutons nor the ε_{Nd} signature of the sedimentary host rocks allow for an unambiguous correlation between the suture zone tectonites and other pericratonic terranes in the northern Cordillera.

The lithologic succession observed at Little Salmon Lake offers an alternative means of identifying prospective correlative lithotectonic units. A similar stratigraphy is observed in the Finlayson Lake area (Mortensen and Jilson, 1985; Hunt, 1997). There the "lower unit" consists of pre-Late Devonian micaceous

Description[1]	Wt (mg)	U (ppm)	Pb[2] (ppm)	$^{206}Pb/^{204}Pb$ (meas.)[3]	total common Pb (pg)	% ^{208}Pb[2]	$^{206}Pb/^{238}U$[4] ($\pm$% 1σ)	$^{207}Pb/^{235}U$[4] ($\pm$% 1σ)	$^{207}Pb/^{206}Pb$[4] ($\pm$% 1σ)	$^{206}Pb/^{238}U$ age (Ma, $\pm$%2σ)	$^{207}Pb/^{206}Pb$ age (Ma, $\pm$%2σ)
Sample T-454, undeformed granodiorite (62°11.99'N; 134°26.79'W)											
A: N2, >134	0.255	319	18.6	10090	29	10.3	0.05741(0.17)	0.4558(0.23)	0.05758(0.10)	359.9(1.2)	513.8(4.3)
B: N2, >134	0.180	247	14.2	2314	69	10.1	0.05692(0.31)	0.4357(0.36)	0.05552(0.13)	356.8(2.1)	433.2(6.0)
D: N2, 104-134	0.118	254	14.4	9454	11	9.8	0.05639(0.19)	0.4197(0.25)	0.05398(0.10)	353.6(1.3)	370.3(4.7)

Analyses done at the Geochronology Laboratory, University of British Columbia, methods as described in Mortensen et al., 1995
[1] N2 = non-magnetic at one degree side slope on Frantz isodynamic magnetic separator, grain size given in microns
[2] radiogenic Pb; corrected for blank, initial common Pb, and spike
[3] corrected for spike and fractionation
[4] corrected for blank Pb and U, and common Pb

Table 1. *U-Pb analytical data.*

quartzite, marble, limy argillite and greenstone, and carbonaceous quartzose rocks. Devono-Mississippian augen gneiss also occurs at the base of the section. Similarly, descriptions of the Aishihik metamorphic suite from the Nisling terrane indicate that quartzofeldspathic mica schist is overlain by metabasite, marble and carbonaceous quartzite (Johnston et al., 1996). However, the metabasite largely lies under the primary marble unit. Two-mica granite orthogneiss contained within the Aishihik metamorphic suite also gives an Early Mississippian U-Pb crystallization age. Finally, quartzose schists with metaigneous rocks and marble are recognized in the Coast Range (Wheeler and McFeely, 1991).

Because of the Teslin suture zone's location, the Nisling terrane and ancestral North America are considered the most likely potential source terranes for the tectonites of the eastern study area. Although it remains ambiguous which provides the best match, the similarities between the eastern tectonites and other terranes with North American affinities is an important constraint in the evolution of the Teslin suture zone. The processes that tectonized these pericratonic fragments and resulted in their distribution are inherently linked to the larger issues of terrane distribution and tectonic history in the northern Cordillera.

However, it is emphasized that these results should not be extrapolated across the entire suture zone at Little Salmon Lake. Tectonites in the western part of the study area differ from those to the east in protolith, shear sense and cooling history (Oliver and Hansen, 1997). Although age constraints for these western tectonites are lacking, lithologic associations suggest a diverse source of sediments and multiple depositional environments. Given its heterogeneous nature, it is possible that the Teslin suture zone juxtaposes constituents with spatially and temporally distinct tectonic histories.

ACKNOWLEDGMENTS

This paper summarizes results that form part of a Ph.D. dissertation (Oliver, 1996). Oliver was supported by National Science Foundation grant EAR-9103531 to Vicki L. Hansen. We thank the staff of the UBC Geochronology Laboratory for assistance in producing the analytical data.

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Biotite chemistry of the Casino porphyry Cu-Mo-Au occurrence, Dawson Range, Yukon

David Selby and Bruce E. Nesbitt

Department of Earth and Atmospheric Sciences, University of Alberta,
Edmonton, Albert, Canada T6G 2E3 e-mail: dselby@maildrop.srv.ualberta.ca

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ABSTRACT

Biotites from hydrothermal alteration zones of the Casino porphyry Cu-Mo-Au deposit have a chemical composition that is distinct from biotites of the unaltered Dawson Range Batholith and Casino Plutonic Suite. Biotites from potassic, phyllic, and propylitic alteration zones contain distinctly higher XMg (XMg = Mg/(Mg+Fe)) values than biotites from the unaltered country rocks. The XMg values are positively correlated with Ti, F, Cl, Si, and negatively correlated with Al, Fe, Mn, Ba contents. The XF/XOH (X = mole fraction) values are positively correlated with XMg/XFe values and describe a positive linear trend from propylitic, to potassic, to phyllic zones. The distinct XMg, Ti, F, Cl, Al, Fe, Mn, and XF/XOH and XMg/XFe compositions of biotites from alteration zones may prove to be useful in understanding the evolution of fluid chemistry, and the identification of alteration zones in porphyry copper systems in the Dawson Range.

RÉSUMÉ

Les biotites des zones d'altération hydrothermale du gisement de Cu-Mo-Au du porphyre de Casino ont des compositions chimiques distinctes de celles des biotites du batholite non altéré du chaînon Dawson et de la suite plutonique de Casino. Les biotites des zones d'altération potassique, phylliteuse et propylitique se caractérisent par des valeurs nettement plus élevées du rapport XMg (XMg = Mg/(Mg+Fe)) que les biotites des roches encaissantes non altérées. Les valeurs de XMg présentent une corrélation positive avec les teneurs en Ti, F, Cl et Si et une corrélation négative avec les teneurs en Al, Fe, Mn et Ba. Les valeurs de XF/XOH (X = fraction molaire) présentent en outre une corrélation positive avec les valeurs de XMg/XFe et une tendance linéaire positive caractérisant respectivement les zones propylitique, potassique et phylliteuse. Les valeurs particulières des teneurs et rapports XMg, Ti, F, Cl, Al, Fe, Mn, XF/XOH et XMg/XFe des biotites des zones d'altération s'avéreront peut-être utiles à la compréhension de l'évolution de la chimie des fluides et à l'identification des zones d'altération dans les systèmes de cuivre porphyrique du chaînon Dawson.

INTRODUCTION

There are numerous porphyry copper-molybdenum±gold occurrences in the Dawson Range, central Yukon. The largest occurrence is the Casino mineralization with a geological resource of 675 million tonnes of 0.25% Cu, 0.48 g/t Au and 0.024% Mo (Bower et al., 1995; Yukon Minfile 115J 028). Documentation of the geology and alteration at many of the porphyry deposits in the Yukon is largely based on research in academic programs (e.g. Casino: Godwin, 1976; Mt. Nansen: Sawyer and Dickinson, 1976, Cash: Sinclair et al., 1981), while regional geology is derived from reconnaissance mapping by Tempelman-Kluit (1974, 1984), Payne et al. (1987) and Carlson (1987).

This paper presents results from a study of biotite chemistry from the Casino deposit, the Dawson Range Batholith and the Casino Plutonic Suite. This study shows that biotite compositions may prove useful in identifying alteration zones of porphyry systems. Criteria to differentiate biotite from altered and from unaltered rocks are proposed.

GEOLOGY

The Casino porphyry Cu-Mo-Au mineralization occurs in the Dawson Range, which is part of the Yukon-Tanana Terrane of the central Yukon. In the Casino area the Yukon-Tanana Terrane is represented by the Devono-Mississippian Wolverine Creek Metamorphic Suite (Johnston, 1995; Fig. 1). This suite is divided into two units, meta-igneous rocks and metasedimentary rocks (Payne et al., 1987). The metasedimentary unit is dominated by quartz-feldspar-mica schist and gneiss, quartzite and micaeous quartzite. The meta-igneous unit is comprised of hornblende amphibolite, biotite-hornblende-feldspar gneiss and orthogneiss. The Wolverine Creek Metamorphic Suite was intruded by the Dawson Range Batholith and Casino Plutonic Suite during mid-Cretaceous time (Payne et al., 1987). The Dawson Range Batholith (104.0±5.0 Ma U-Pb zircon date by J.K. Mortensen pers. comm., 1997) is dominated by hornblende>biotite and biotite>hornblende-bearing granodiorite. Field relationships indicate that the Dawson Range Batholith was intruded by the Casino Plutonic Suite although the date is contemporaneous (104.2±0.5 Ma; J.K. Mortensen, pers. comm., 1997). Casino Plutonic Suite contains fine- to medium-grained, locally porphyritic, leucocratic granodiorite, quartz monzonite and aplite phases.

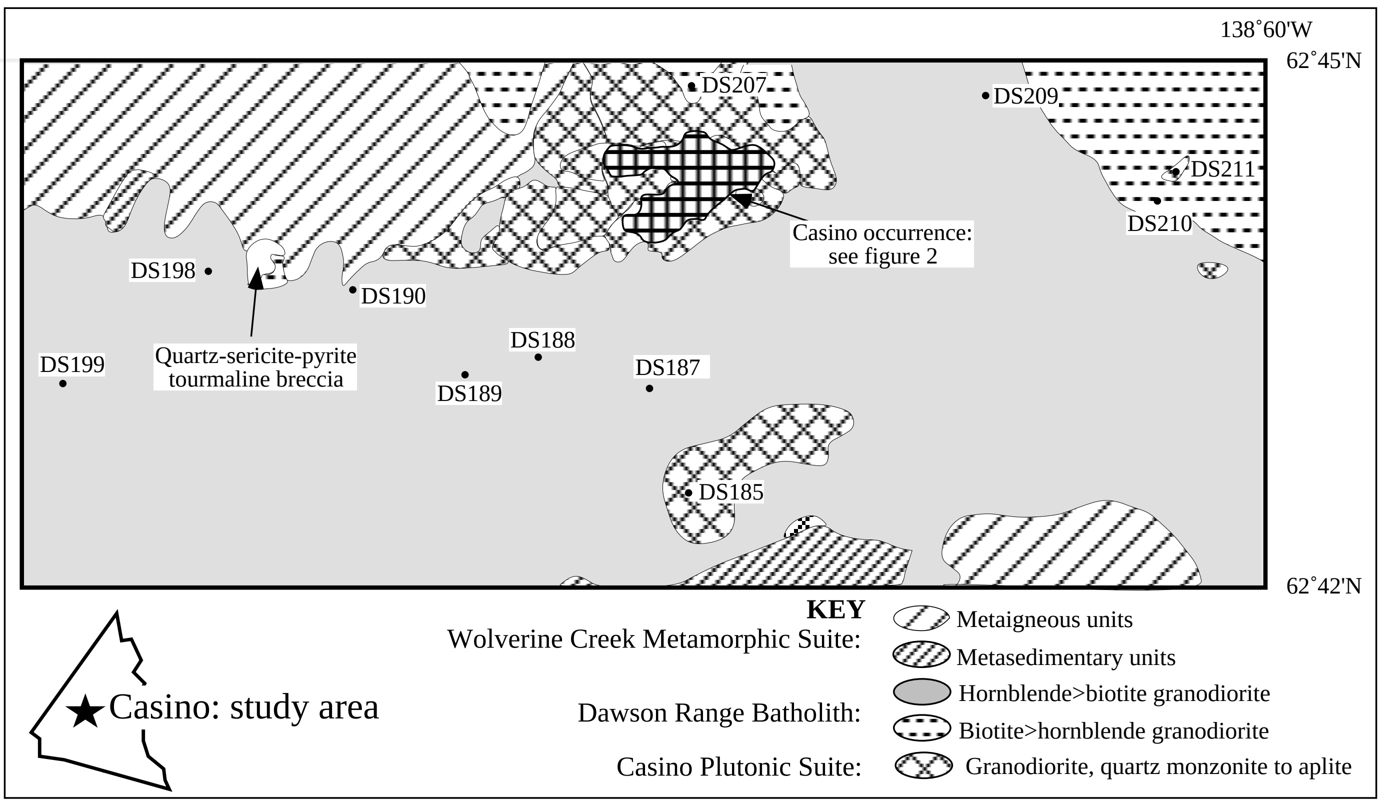

Figure 1. *Geology of the Casino area (modified after Payne et al., 1987 and Johnston, 1997). Bold cross-hatched area is the limit of mineralization and alteration surrounding the Casino occurrence (Fig. 2). Dots indicate the location of rocks from which biotite was extracted.*

The copper-molybdenum-gold mineralization of the Casino porphyry occurrence is genetically related to the Patton Porphyry, a small (500 by 700 m) late Cretaceous (72.4±0.5 Ma U-Pb zircon date by J.K. Mortensen, pers. comm., 1997) porphyritic plagioclase-biotite dacite. Mineralization and hydrothermal alteration at the Casino occurrence are hosted by the Patton Porphyry and surrounding country rock, which is dominantly the Dawson Range Batholith. Ore mineralization consists of chalcopyrite, molybdenite and gold, with minor bornite and tetrahedrite, and supergene minerals of native copper, chalcanthite, malachite, brochantite (Bower et al., 1995). Mineralization occurs in veins, disseminations, irregular patches, boxworks, and as coatings on pyrite grains (Bower et al., 1995). Hydrothermal alteration of the Casino occurrence is centered upon a potassic-altered breccia pipe, which is bordered by strongly developed, fracture-controlled phyllic alteration. A weakly formed propylitic assemblage lies at the northern edge of the Casino occurrence (Bower et al., 1995). The potassic alteration assemblage typically comprises K-feldspar, biotite, magnetite, and quartz. Quartz, pyrite, sericite, and tourmaline characterize the phyllic alteration assemblage. The propylitic alteration assemblage consists of epidote, chlorite, and minor calcite. Probably genetically related to mineralization and alteration at Casino is a small (200 by 500 m) breccia pipe located 4 km west of the Casino occurrence (Fig. 1). The breccia pipe is strongly altered to quartz-sericite, and contains tourmaline and pyrite, an assemblage that is typical of the phyllic alteration zone of the Casino occurrence.

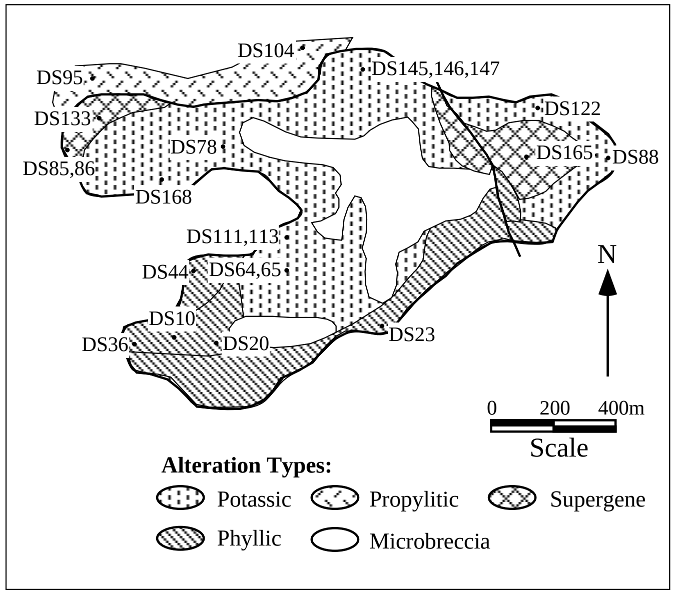

Figure 2. *Geology and alteration of the Casino occurrence (modified after Bower et al., 1995) and the location of rock samples for biotite chemistry determinations.*

BIOTITE CLASSIFICATION

Biotites of this study are classified as either magmatic, or secondary origin. The term magmatic denotes biotites that crystallized from a magma. Magmatic biotites are further divided into unaltered and hydrothermal biotites. The term 'unaltered' is used for biotites from unaltered rock types, and 'hydrothermal' is used for biotites present in hydrothermal alteration assemblages (e.g. potassic, phyllic and propylitic). Secondary biotites are those that formed from a hydrothermal fluid, and their distinguishing characteristics are described below. Samples collected from the potassic zone of the Patton Porphyry contain both hydrothermal and secondary biotites, while the potassic zone of the Dawson Range Batholith contains only secondary biotites. Only hydrothermal biotite is observed in the phyllic- and propylitic-altered Dawson Range Batholith, and the phyllic-altered Patton Porphyry.

PETROGRAPHY

Unaltered biotites of the Dawson Range Batholith and Casino Plutonic typically occur as euhedral to subhedral phenocrysts and microphenocrysts, and as subhedral to anhedral flakes. Some unaltered biotites exhibit frayed and ragged grain edges. Hydrothermal biotites of the Patton Porphyry are commonly euhedral phenocrysts, while those of the Dawson Range Batholith are ragged, splintery, frayed, kinked, and partially chloritized. Altered rock types of the Casino Plutonic suite contain highly chloritized biotites that were not suitable for analysis. Secondary biotites are a major constituent of the potassic alteration assemblage. Texturally, secondary biotites are distinct from unaltered and hydrothermal biotites, being small (typically 10 to 100 μm), occurring as aggregate clusters, which exhibit a random orientation of grains, with shapes that may define pseudomorphs after hornblende and biotite.

ANALYTICAL PROCEDURES

Biotites from thin section slides were analyzed to determine Mg, Fe, Ti, Al, Mn, Si, Ba, F, and Cl contents. Figures 1 and 2 show the location of samples analyzed. A suite of natural standards were used for calibration, biotite was used for F, Si, Al, and Fe; kaersuititic amphibole for Mg, and Ti; tugtupite for Cl; sanidine for Ba, and willemite for Mn. Analyses were conducted using a beam width of 3 μm and current of 15kv (accelerating potential), and a probe current measured on the faraday cup at 15 nA. The counting time used for each element analysis was 20 seconds. Matrix effects were corrected using ZAF based on 22 oxygens. The full procedure is described in Selby (In prep.). A microprobe analysis in this study is defined as the arithmetic mean of five spot analyses of a biotite.

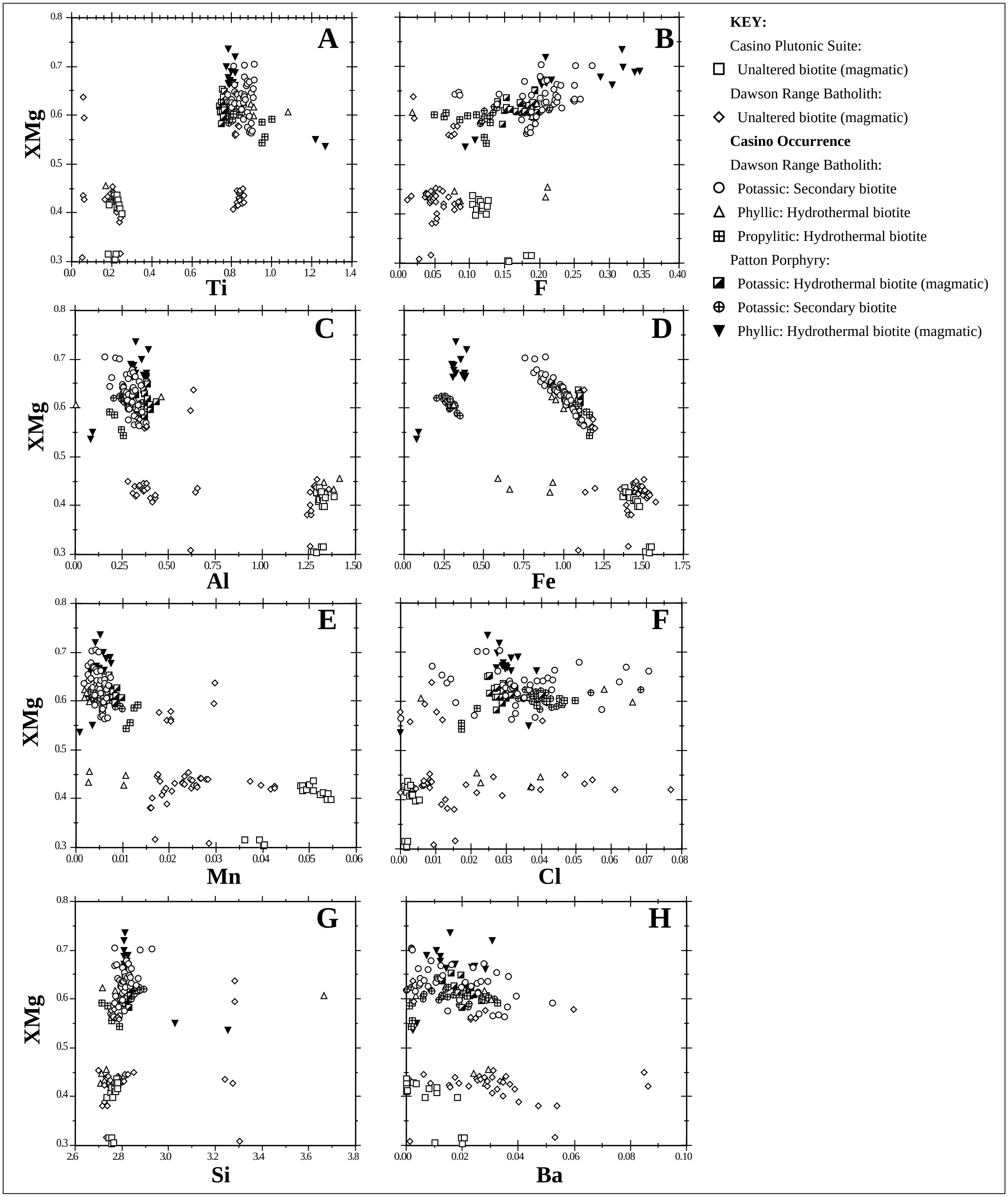

Figure 3. *Chemical compositions of biotites from alteration zones of the Casino porphyry mineralization, the Dawson Range Batholith and the Casino Plutonic Suite. The composition of the biotites are plotted as XMg vs. Ti, F, Al, Mn, Ba, Si, and Cl. The XMg value is defined as Mg/(Mg+Fe) on a cation basis, and Ti, F, Al, Fe, Mn, Ba, Si, Cl contents are in an atomic basis, calculated using 22 oxygens/formula units.*

BIOTITE COMPOSITIONS

The compositions of biotite types are shown in Figures 3A-H, plotting XMg (defined as Mg/(Mg+Fe) in moles) against Ti, F, Si, Cl, Ba, Mn, Al, and Fe contents. For all these elements except Fe, the concentrations are calculated from oxide values determined from electron microprobe analyses. The biotite data from the Casino area show that the XMg value is the most significant factor in the chemical distinction between unaltered, hydrothermal and secondary biotites. Biotites (hydrothermal and secondary) present in the alteration zones of the Casino occurrence have higher XMg values than unaltered biotites. Unaltered biotites from the Dawson Range Batholith and Casino Plutonic Suite are fairly homogeneous with respect to XMg value, except for the unaltered biotites in samples DS198 and DS207. Sample DS198 is proximal to the breccia pipe west of the Casino occurrence (Fig. 1), and contains minor epidote, chlorite and sericite. Sample DS207 is located north of the northern limit of the Casino occurrence (Fig. 1), and contains minor chlorite. The biotites from these samples have XMg values similar to biotites from the propylitic alteration zone.

The XMg values are positively correlated with Ti, F, Cl, Si, and negatively correlated with Al, Mn, Fe, and Ba contents (Figs. 3A-H). With respect to Ti, F, Cl, Al, Fe, and Mn contents, biotites of the Dawson Range Batholith from the zone of hydrothermal

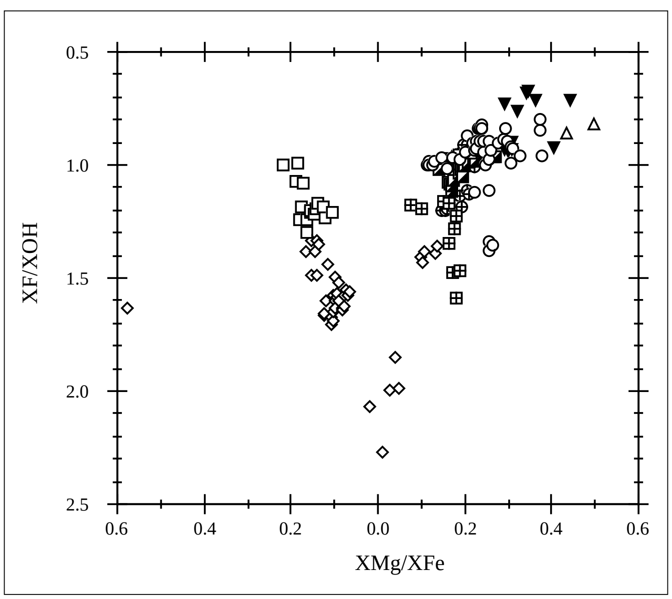

Figure 4. *A plot of XMg/XFe vs. XF/XOH of biotites from alteration zones of the Casino porphyry mineralization, the Dawson Range Batholith and the Casino Plutonic Suite. Symbols are the same as in Figure 3.*

alteration of the Casino occurrence have significantly different compositions relative to unaltered biotites (Fig. 3A-F). The Si content of unaltered and hydrothermal biotites from all alteration zones is essentially the same, with secondary and hydrothermal biotites from the potassic and phyllic zones having slightly higher Si values (Fig. 3G). The Ba content of secondary and hydrothermal biotites is slightly lower than unaltered biotites of the Dawson Range Batholith (Fig. 3H). The Fe contents of hydrothermal biotites of the potassic zone from the Patton Porphyry and Dawson Range Batholith are similar (Fig. 3D); however, secondary biotites of the Patton porphyry have distinctly lower Fe contents. Hydrothermal biotites from the phyllic alteration zone of the Patton Porphyry have slightly higher Fe values than secondary biotites from the same rock type (Fig. 3D).

The compositions of biotites from the phyllic zone from the Dawson Range Batholith and Patton Porphyry are variable (Figs. 3A-H), although the hydrothermal biotite from the potassic zone of the Patton Porphyry shows more homogeneous chemistry. The Ti, F, Al, Mn, and Fe content of hydrothermal biotite from the propylitic zone is diagnostically distinct from that of unaltered biotites and biotites of the potassic and phyllic zones (Fig. 3A-E).

The Ti and Al contents of unaltered biotites of the Dawson Range Batholith describe two distinct biotite populations (Fig. 3A and C). The population with higher Ti contents contain lower Al contents, but have similar XMg values to the population with lower Ti and higher Al contents. Those with higher Ti and lower Al contents correlate with the Ti and Al contents of biotites from all alteration zones. Because there no increase in the XMg value between the populations suggests that the Ti and Al contents reflect those incorporated at the time of crystallizing.

Figure 4 shows a distinction between the XMg/XFe and XF/XOH values of unaltered biotites, and those of all the altered samples. Secondary and hydrothermal biotites have XMg/XFe and XF/XOH values that increase progressively from unaltered, to propylitic, to potassic, to phyllic alteration types (Fig. 4). The XMg/XFe and XF/XOH values for secondary and hydrothermal biotites from the potassic and phyllic alteration zones define a linear trend (Fig. 4), indicating that a systematic F and Mg enrichment is occurring simultaneously during potassic, phyllic and propylitic alteration. Biotites from the unaltered Dawson Range Batholith that reveal Mg or F enrichment similar to biotites from the propylitic alteration zone, are found in samples DS207 and DS198. These data suggest that hydrothermal fluids, which were probably related to mineralization and alteration of the Casino occurrence, have altered the chemistry of biotites in rock types proximal to the occurrence.

SUMMARY

The XMg value is a useful criterion for the distinction between unaltered biotites and biotites. Further, trends in XMg vs. Ti, F, Fe, Al, Mn, Si, Ba and Cl contents discriminate between unaltered biotites and biotites from alteration zones. Unaltered biotites are further distinguished from biotites from alteration zones based on XMg/XFe and XF/XOH values, which describe an increasing enrichment in Mg and F from unaltered, to propylitic, to potassic, to phyllic zones. The composition of biotites from the propylitic zone show distinct chemistries from those of the potassic and phyllic zones. The composition of biotites from samples DS198 and DS207 from outside the alteration zone of the Casino occurrence indicate the interaction of hydrothermal fluids to alter the primary chemistry. Therefore biotite chemistry could be used to understand the fluid chemistry in porphyry copper systems. Further, biotite chemistry may be a useful technique to detect the presence of ancient hydrothermal fluids which may have led to porphyry copper mineralization.

ACKNOWLEDGMENTS

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The Pattison Creek pluton – a mineralized Casino Intrusion made bigger with gamma rays

Craig J.R. Hart[1] and David Selby[2]

[1]Yukon Geology Program, Box 2703, Whitehorse, Yukon, Y1A 2C6, e-mail: craig.hart@gov.yk.ca
[2]Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Alberta, T6G 2E3

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Abstract

Results from an airborne gamma ray and magnetics survey in the Dawson Range in west-central Yukon indicate that the Pattison Creek pluton may be larger than currently mapped. Ground follow-up indicates that the pluton is approximately three times larger than originally shown. This pluton is a member of the Casino Intrusions – a unit identified as being genetically associated with copper-molybdenum mineralization and as such is considered a good exploration target. Examination of the pluton indicates that it is a highly fractionated, epizonal stock composed primarily of granite and alkali feldspar granite with later phases of peraluminous muscovite-bearing alaskite and aplite. Microthermometric and isotopic data indicate that mineralizing hydrothermal fluids are of low salinity, and depleted in deuterium and $\delta^{18}O$ relative to values typical of magmatic waters. The gamma-ray survey shows it to have among the highest U and Th values in the survey area (> 3.0 and 15 ppm respectively).

Résumé

Les résultats fournis par un levé gamma et magnétique aéroporté réalisé dans le chaînon Dawson dans le centre-ouest du Yukon révèlent que le pluton de Pattison Creek est plus étendu que ne l'indiquent les cartes actuelles. Le suivi de terrain révèle en effet que le pluton est environ trois fois plus volumineux qu'on ne l'avait indiqué jusqu'ici. Ce pluton fait partie des intrusions de Casino - unité considérée comme étant génétiquement associée à des minéralisations de cuivre-molybdène et constituant donc une cible d'exploration propice. L'examen du pluton révèle qu'il s'agit d'un stock épizonal très fractionné composé essentiellement de granite et de monzonite quartzique accompagnés de phases tardives d'alaskite et d'aplite à muscovite. Le levé gamma indique en outre que le pluton présente certaines des plus hautes teneurs en U et en Th de la région prospectée (>3,0 et 15 ppm respectivement).

INTRODUCTION

Regional-scale, airborne gamma-ray and magnetics surveys provide a quantifiable indication of rock types and alteration. This type of survey is particularly useful in unglaciated regions with deep weathering where the surface material (colluvium) is the same as the underlying bedrock. Such a survey was recently conducted in the Dawson Range (Fig. 1) with the ultimate goals of: 1) improving the existing geological maps of the region (e.g. Johnston and Shives 1995) and 2) providing data with which exploration efforts could be focused. The largest mineral deposit in the region is the Casino copper-molybdenum-gold porphyry (675 million tonnes of 0.25% Cu, 0.02% Mo, 0.48 g/t Au).

The Pattison Creek pluton (62°02'N; 138°38'W, not the same as the Pattison pluton of Lynch and Pride (1983)) is a small felsic intrusion located approximately 27 km south of the Casino deposit and 130 km west-northwest of Carmacks in the western Dawson Range. The pluton is one of several which together comprise the Casino Intrusions – a suite of leucocratic quartz monzonite to granodiorite stocks identified by Payne et al. (1987) as the intrusive unit most closely associated with the Casino Cu-Au-Mo porphyry deposit. Several small occurrences of this unit were mapped in the central Dawson Range of west-central Yukon (Payne et al., 1987). The Pattison Creek pluton was identified by Payne et al. as being geologically and chemically similar to the Casino deposit. As such, the Pattison Creek pluton is a prospective target for Casino-style mineralization and indeed is known to host an occurrence of copper and molybdenum.

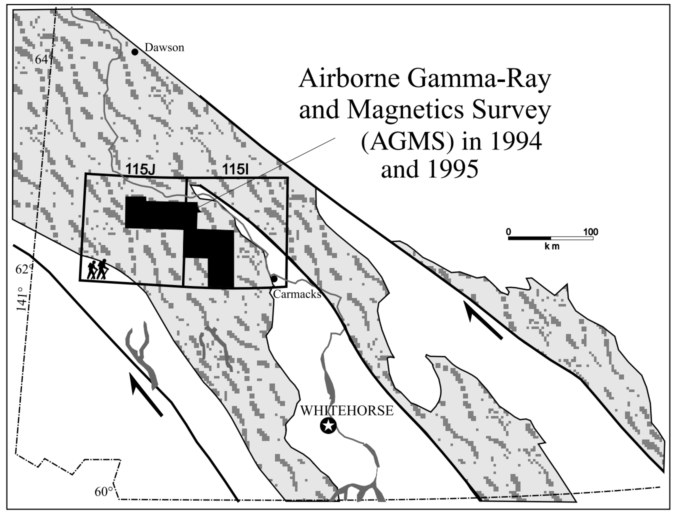

***Figure 1**. Location of the airborne geophysical survey in the Dawson Range of west-central Yukon. The survey area is entirely within the Yukon-Tanana Terrane (patterned).*

Results from an airborne gamma-ray and magnetic survey of the Dawson Range indicated a discrepancy between the geophysical response and the currently mapped distribution of the Pattison Creek pluton. The geophysical anomalies suggest that the Pattison Creek pluton may be larger than mapped. If so, a greater area is prospective for the occurrence of Casino-style mineralization.

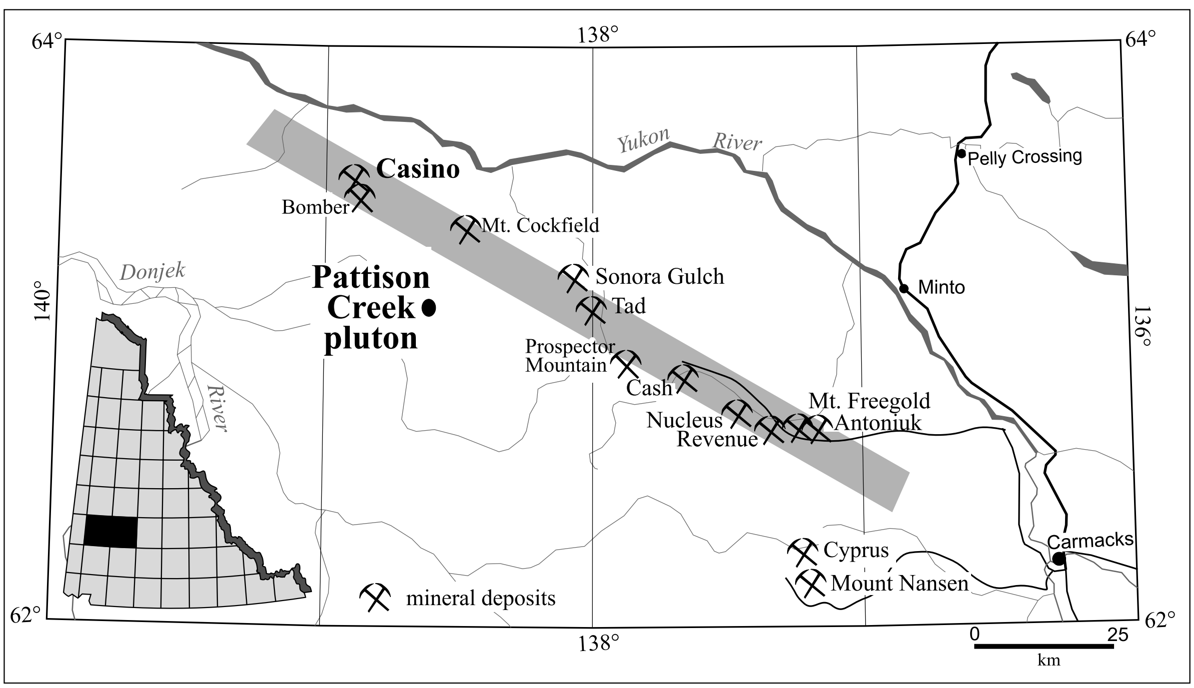

***Figure 2.** Location of the Pattison Creek pluton with relation to the Dawson Range mineral belt (shaded). The significant mineral deposits of the region are also shown.*

Ground follow-up, combined with detailed examination of the gamma-ray signature results in a new map of the Pattison Creek pluton. The new map indicates that the areal extent of the Pattison Creek pluton at least triples. This paper reports on new observations made during brief field visits in 1996 and 1997.

LOCATION

The airborne geophysical survey covered the equivalent area of six 1:50 000 map areas that comprise the mineral deposit-rich regions of the Dawson Range in west-central Yukon (Fig. 1). The surveys (Geological Survey of Canada 1994, 1995) consisted of approximately 9000 line-kilometres of helicopter-borne gamma-ray and magnetics. Flight lines were flown north and south and were spaced 500 m apart

The Pattison Creek pluton was covered by the westernmost survey (Geological Survey of Canada 1994a). The pluton is located near the headwaters of Pattison Creek in the central Dawson Range in southeastern NTS map sheet 115J/10. The property is accessible by helicopter from Carmacks, approximately 130 km west-northwest of Carmacks (Fig. 2). Alternatively, the Casino airstrip, located 27 km north of Pattison Creek, can be used as a staging area.

GEOLOGICAL SETTING

The Pattison Creek pluton is within the western portion of the Yukon-Tanana Terrane. It intrudes the contact between the Yukon-Tanana Terrane metamorphic rocks and the mid-Cretaceous hornblende-biotite granodiorite of the Dawson Range Batholith. The metamorphic rocks are dominated by Nasina assemblage black, carbonaceous quartzite, tan-coloured quartzite, and amphibolite with lesser felsic orthogneiss. The Dawson Range batholith is composed of coarse-grained biotite-hornblende granodiorite.

The Pattison Creek pluton is one of a series of plutons in the Casino Intrusive suite which also include small bodies at Casino and Idaho Creek. Mapping by Payne et al. (1987) showed the pluton as a north-trending elliptical body with maximum dimensions of 4 x 2 km and a surface area of 4.5 km^2.

PATTISON CREEK PLUTON

The Pattison Creek pluton it is generally light weathering and recessive with few outcrops (Fig. 3). The roof of the pluton is exposed in two places suggesting a flat-topped pluton with an exposed cupola. The sharp eastern contact may be truncated by a north-trending normal fault.

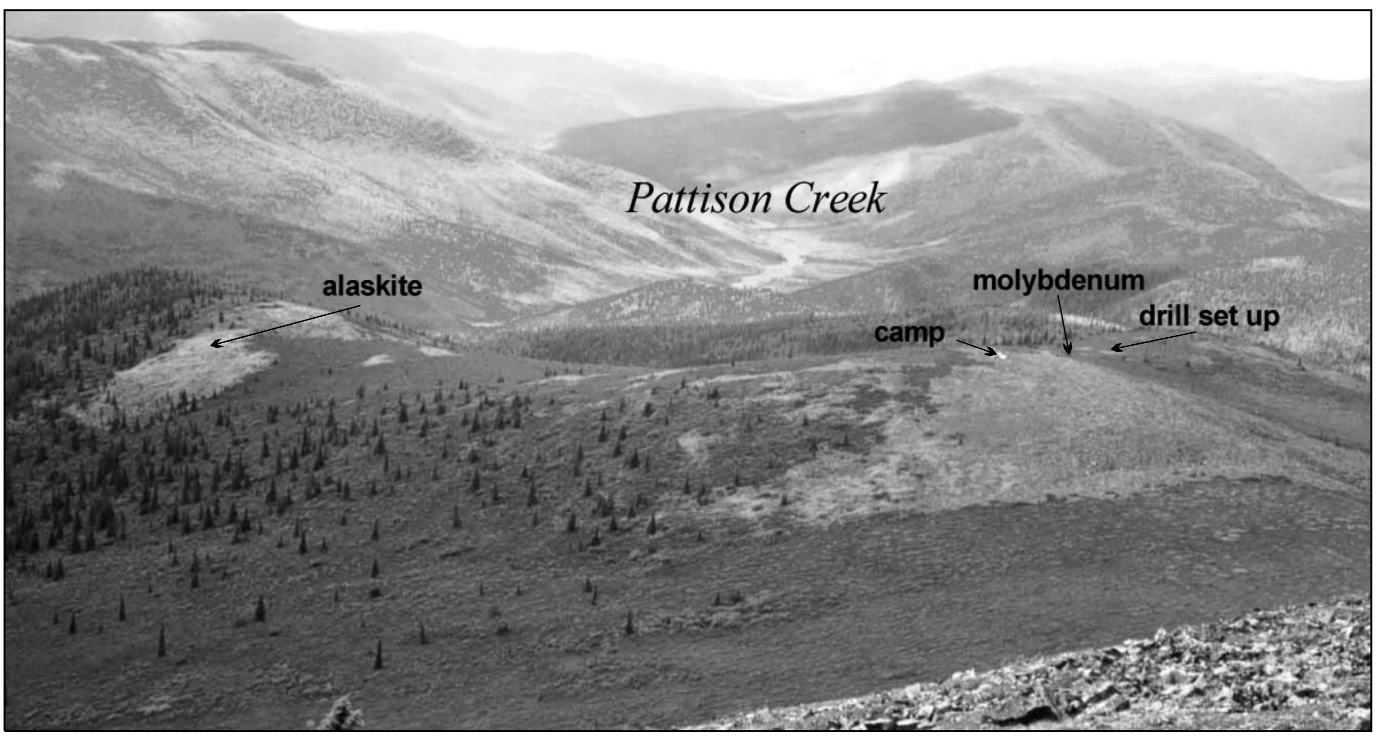

Figure 3. *Looking southwest down Pattison Creek. The Pattison Creek pluton is the recessive weathering ridges in the foreground. The background rocks are predominantly Yukon-Tanana Terrane metamorphic rocks.*

The Pattison Creek pluton is lithologically and texturally diverse. It is variably composed of granite, quartz monzonite, and alaskite with associated aplite.

The dominant phase is light grey, weathering porphyritic granite with a sucrossic matrix (80%) composed of approximately equal amounts of fine- to medium-grained intergrown quartz and alkali feldspar with subordinate (5%) but important biotite (Fig. 4a). Euhedral phenocrysts of plagioclase (8%, up to 6 mm), quartz (5%, up to 8 mm), biotite (2%, up to 4 mm), hornblende (0.5%, up to 4 mm) and rare muscovite were observed. In weakly altered samples, ragged biotite is locally pseudomorphed by muscovite and opaque oxides.

The alaskitic phase is subordinate and composed of white to buff weathering, equigranular, medium- to coarse-grained granite alaskite with approximately 30% quartz, 25% plagioclase, and 35% late alkali feldspar and no biotite (Fig. 4b). This unit has rusty weathering cavities that likely result from the oxidation of sulphide minerals. Some phases contain up to 10% primary muscovite. Secondary, finer-grained muscovite appears to be locally replacing alkali feldspar. This phase is shows evidence of high temperature phyllic alteration (muscovite, pyrite) locally.

The alaskitic phase has an associated aplite phase which is composed of equigranular, sucrossic and fine-grained, intergrown and graphic textured quartz, alkali feldspar and plagioclase with some coarser-grained quartz phenocrysts (Fig. 4c). Muscovite is typically coarser grained and comprises up to 15% of the rock. The alaskite also forms a few late sills which cut the other phase.

All phases contain small miarolitic cavities up to 2 mm in diameter. Zircon was observed locally in thin section. Late quartz-alkali feldspar pegmatite dykes also cut the pluton.

A northerly-trending series of 2-5 m wide, fine-grained andesitic to dacitic dykes are common in the country rocks surrounding the Pattison Creek pluton (Unit 15b of Payne et al., 1987). Locally they are sparsely porphyritic with phenocrysts of plagioclase and hornblende. The pluton is cut by at least one of these dykes, thus confirming a younger relative age.

GAMMA RAYS

An investigation of results from the airborne gamma-ray and magnetics survey from the Dawson Range indicates that the region underlain by the Pattison Creek pluton is high in K, Th and U, and low and flat in magnetics (Fig. 5). These are the expected responses from an evolved and fractionated, quartz-rich magmatic rock. Furthermore, the Th/K ratio is very high and the U/K and U/Th ratios are low. However, the region defined by these variables is not coincident with the currently mapped pattern. As a result, the area was mapped at 1:25 000 scale, despite the paucity of outcrop. New mapping indicates that the pluton is exposed over an area of 16-18 km^2 (Fig. 6).

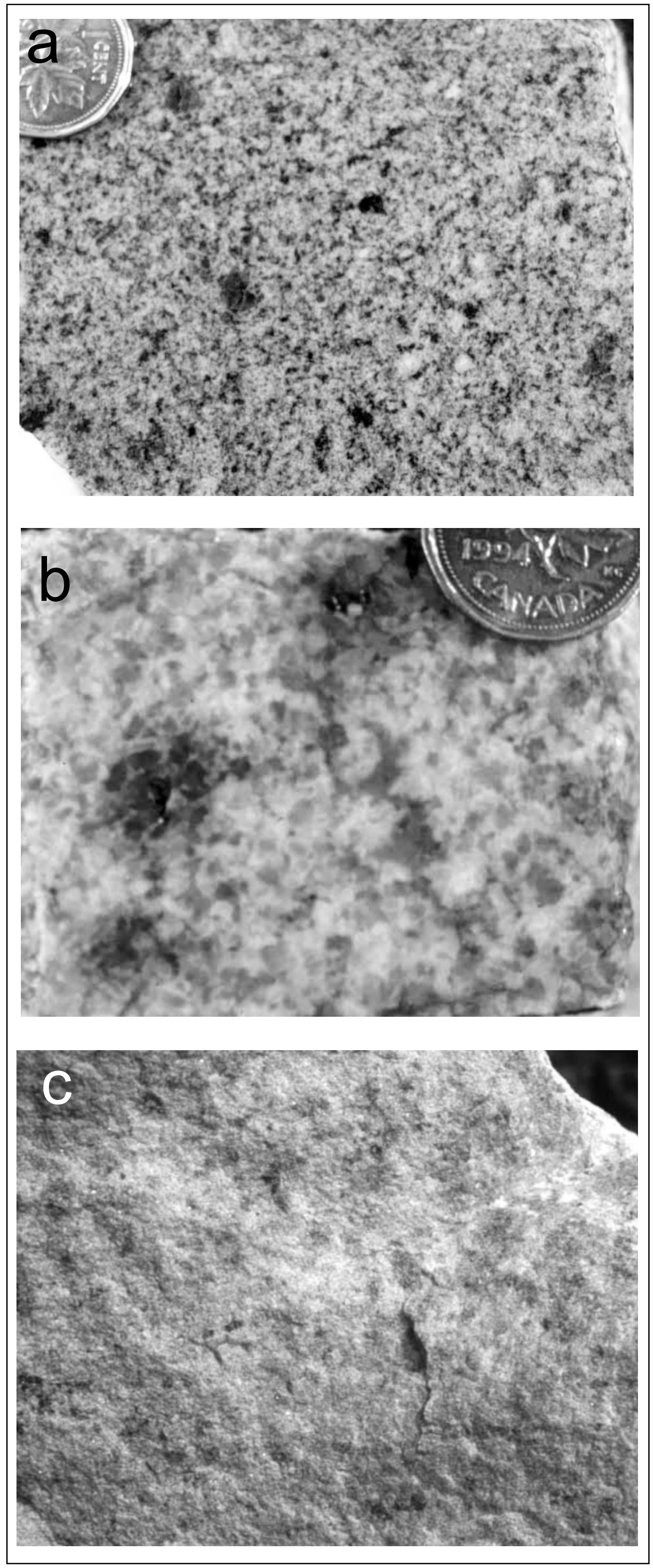

Figure 4. *a) photo of granite phase; b) photo of alaskite phase. The dark spots are oxidized sulphide minerals; c) photo of aplite phase.*

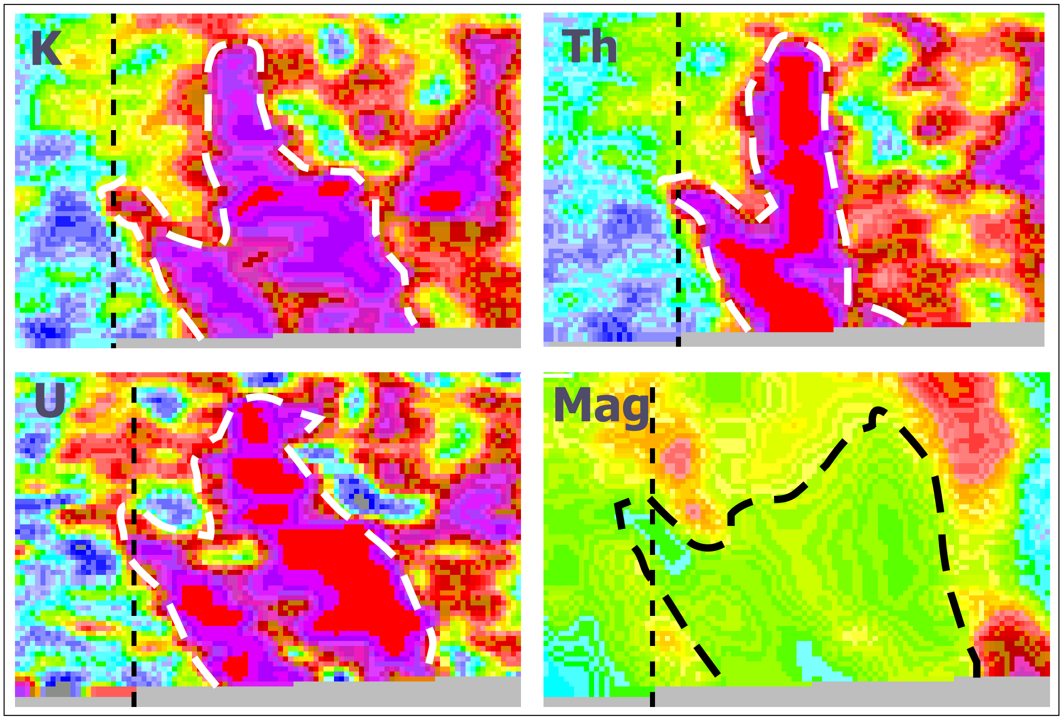

Figure 5. Detail from Geological Survey of Canada (1994a) airborne geophysical survey of the Pattison Creek area indicates regions (defined by dashed line) of high K (>2.0%), high Th (>12 ppm), high U (>1.8 ppm) and low magnetics (<-49 gammas). These anomalous patterns are not coincident with the map pattern of the Pattison Creek pluton. The vertical dashed line on all the figures is 138°40′W longitude.

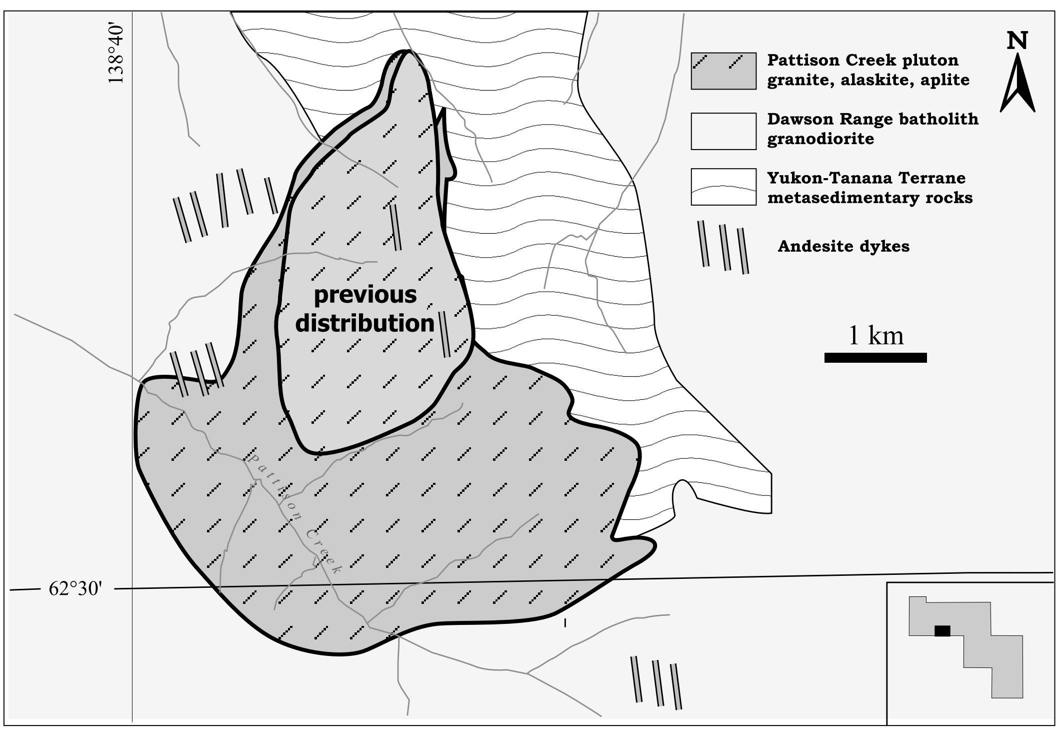

Figure 6. General outline and geology map of the Pattison Creek pluton showing the enlarged area based upon field mapping guided by the radiometric survey results. The new map reflects an extent based on ground follow-up of the geophysical results. Inset map shows location within AGMS survey area in west central Yukon (see Fig. 1).

GEOCHEMISTRY

Preliminary geochemical analyses of samples from the Pattison Creek pluton support their identity as granite, perhaps best referred to as alkali feldspar granite (Fig. 7a). Plots on Shand's chemical index support the mineralogical data (muscovite-bearing, no hornblende) which indicate a classification of peraluminous (Fig. 7b). SiO_2 values range from 73-78% and K_2O values vary between 3 and 5.5%. The elevated U and Th values are supported by the geochemical analyses with values between 6 and 20, and 9 and 25 ppm, respectively (Fig. 8). These values have higher U contents than averages for the upper crust or low Ca granites, but are lower than values from the Surprise Lake batholith near Atlin, B.C. — a pluton that is recognized as being uraniferous (Ballantyne and Littlejohn, 1982).

MINERALIZATION

The Pattison Creek pluton hosts an occurrence of molybdenum and chalcopyrite. The PATT mineral occurrence (Yukon Minfile 115J 087) was discovered and staked in 1974 by Amoco Canada Petroleum Company who followed up copper and molybdenum silt anomalies with a soil survey and mapping. Minor molybdenite and chalcopyrite was discovered in narrow quartz veins cutting quartz monzonite and alaskite. An IP survey was undertaken the following year. In 1976, four holes totalling 565 m were drilled from three set-ups to test Mo-in-soil anomalies and weak IP responses. All holes encountered molybdenite mineralization with lesser chalcopyrite, and pyrite blebs in quartz veins. Minor amounts of disseminated molybdenum was also discovered in aplitic phases. Copper graded 0.01% throughout but molybdenum values varied between holes with grades of up to 0.059% MoS_2 over 52 m (DDH PATT-1) and 0.037% MoS_2 over 160 m (DDH PATT-3). Alteration has been discovered so far weak phyllic and limited argillic.

Porphyry copper deposits are typically associated with a gamma-ray response that includes elevated K and a low Th/K ratio. This is typically in response to potassic alteration in the core of porphyry system. Despite the high potassium values, the Pattison Creek pluton does not show a low Th/K region. Instead it contains the highest ratios on the entire map sheet with values between 8 and 9.5, including the location of the known molybdenum occurrence (Fig. 9). This largely reflects the highly fractionated nature of the magma which results in Th-enrichment.

FLUID CHEMISTRY

Stable isotope and fluid techniques have been used to investigate the chemistry of the hydrothermal fluids associated with molybdenum and chalcopyrite mineralization. Analyses were performed at the University of Alberta in the Earth and

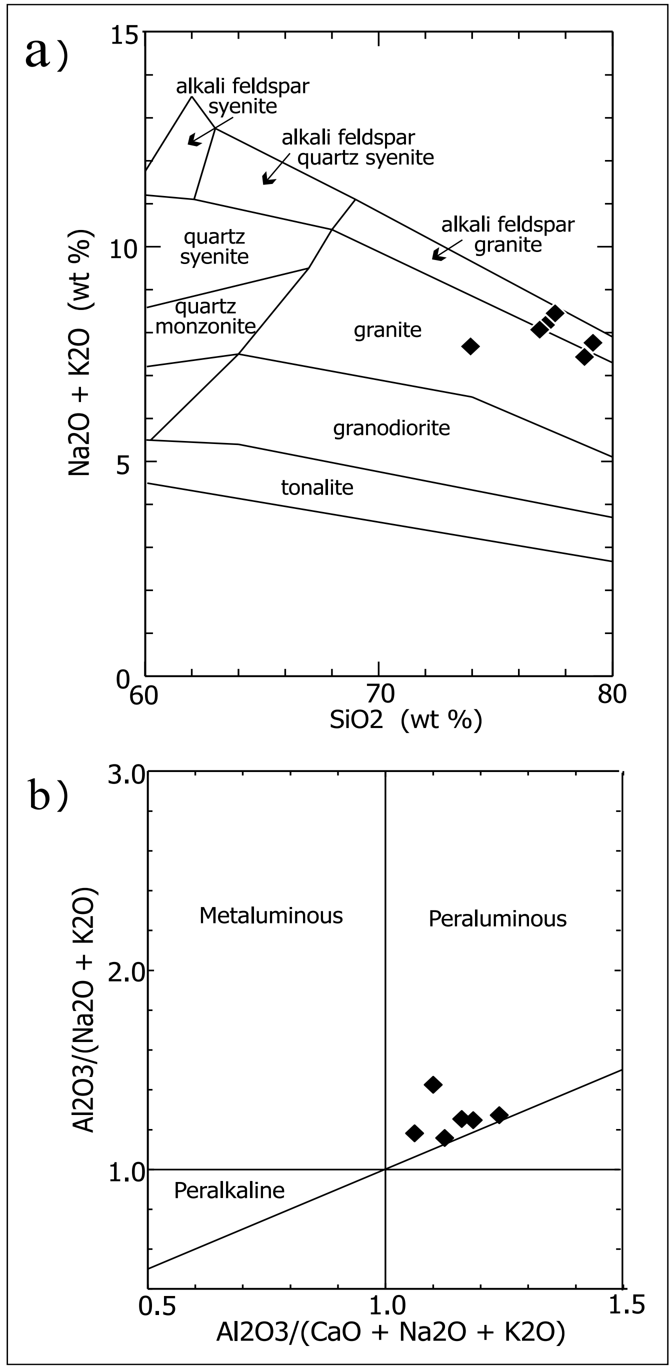

Figure 7. a) *Total alkali – silica plot which shows that rocks from the Pattison Creek pluton lie in the true granite or alkali feldspar granite fields (as defined by Middlemost, 1985).* **b)** *Shand's index shows samples to plot in the peraluminous field as expected due to the presence of muscovite. Geochemical data are presented as anhydrous and were obtained by standard x-ray methods from XRAL Laboratories. Dataset is expected to be published in an upcoming Bulletin.*

Atmospheric Sciences Stable Isotope and Fluid Inclusion Facility. Data presented below are from quartz vein samples from DDH PATT-3. The analytical precision for stable isotope analyses (1σ) are ±0.2‰ for oxygen and ±5‰ for hydrogen, and for mircothermometric measurements are ±0.2°C for freezing and ±2°C for heating.

Quartz veins consist of molybdenite, with minor chalcopyrite and pyrite mineralization. Silicification, sericite, and chlorite comprise the alteration assemblage bordering the quartz veins. Optical observations of quartz fluid inclusion chips at room temperature identified only one fluid inclusion type which is small (up to 10 µm), two phase, liquid-rich inclusions. Microthermometric analysis were conducted on four quartz veins. Final ice melting (T_{fm}) temperatures are between -0.1° to -2.9°C, with a mean value of -1.79±0.69°C (n = 67). Using the expressions of Bodnar and Vityk (1995) T_{fm} values indicate salinities between 0.18 and 4.8 wt.% NaCl eq. The fluid inclusions homogenize by vapor bubble disappearance at temperatures between 187° and 340°C, with a mean value of 240.5±30.97°C (n =67).

Oxygen and hydrogen isotope ratios determined from the same quartz veins yield $\delta^{18}O$ values between 5.5 and 6.4 ‰ (SMOW), with a mean value of 6.1±0.41 ‰ (n = 4). Waters from fluid inclusions yield δD values between -147 and -168 ‰ (SMOW), with a mean value of -155.5±8.96 ‰ (n = 4).

Microthermometric and isotopic data indicate hydrothermal fluids are of low salinity, and depleted in deuterium and $\delta^{18}O$ relative to values generally accepted as magmatic waters (Talyor and Sheppard, 1986). The fluid chemistry characteristics from the Pattison Creek molybdenum occurrence are more similar to fluids encountered in epithermal vein systems (e.g. Freegold Mtn., McInnes et al., 1988; Mt. Nansen, K. Smuk, pers. comm.), and are dissimilar to fluids from Dawson Range porphyry systems (e.g. Casino, Mt. Nansen, Cash; Selby, unpub. data).

GEOCHRONOLOGY

The age of the Pattison Creek pluton is uncertain. Payne et al. (1987) mapped the Casino Intrusions as being mid-Cretaceous in age, largely on the basis of numerous *circa* 100 Ma K-Ar age dates from similar rocks at the Casino deposit (Godwin, 1975a). Godwin (1975a,b) thought that the quartz monzonite phases at Casino were a phase of the mid-Cretaceous Klotassin (Dawson Range) batholith and largely co-genetic with mineralization. Subsequently, the Casino intrusions were included in the Prospector Mountain plutonic suite by Johnston (1995) who assigned them a Late Cretaceous age on the basis of *circa* 70 Ma age dates from the Prospector Mountain and Mount Pitts areas. It is most probable that the Pattison Creek pluton is mid-Cretaceous in age but Ar-Ar geochronology is currently underway.

DISCUSSION/CONCLUSIONS

Evaluation of airborne gamma-ray and magnetics survey information indicates that the Pattison Creek pluton is likely larger than previously mapped. Its greater extent is confirmed by revision mapping which indicates new boundaries of the pluton. The textural and lithological diversity of the pluton, in

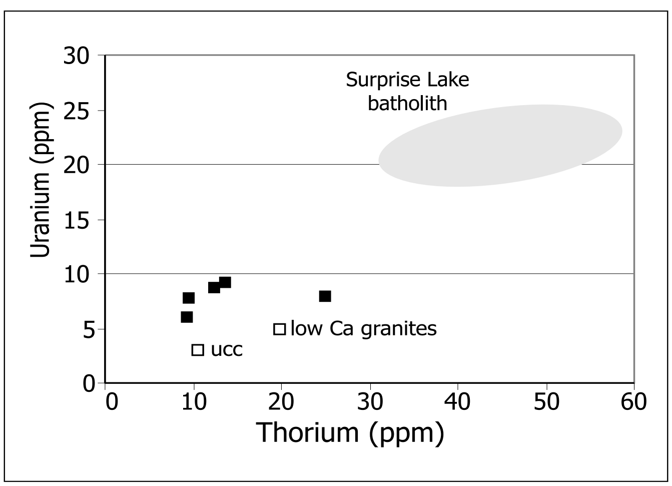

Figure 8. *U vs. Th plot for samples from the Pattison Creek pluton. Range of Surprise Lake batholith values from Ballantyne and Littlejohn (1982); ucc=upper continental crust average from Taylor and McLennan (1985); low-Ca granite values from Turekian and Wedepohl (1961).*

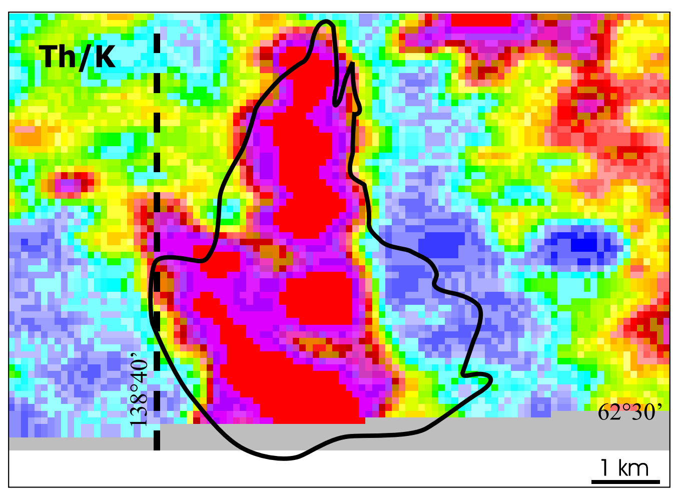

Figure 9. *Detail from Geological Survey of Canada (1994a) of the Pattison Creek area showing region of elevated Th/K ratio with new outline of the Pattison Creek pluton and the location of molybdenum mineralization. The southeast corner of the pluton has a low value due to well exposed Yukon-Tanana Terrane metamorphic rocks on a west-facing slope.*

combination with small miarolitic cavities, indicates probable intrusion at a relatively high level in the crust. The presence of muscovite, aplite and alaskite, in combination with high K, Th and U values determined from the airborne survey, indicate that the Pattison Creek pluton is highly fractionated. This is confirmed by preliminary lithogeochemistry that confirms its classification as a peraluminous alkali feldspar granite. Plutons in southwest Alaska with similar geochemistry (e.g. Donlin Creek) are associated with gold mineralization (Bundtzen and Miller, 1997). It is unlikely that the Pattison Creek pluton has been evaluated in that context.

Molybdenum mineralization may result from evolved fluids associated with the magmas, but the stable isotopes suggest a more dilute fluid influenced by meteoric waters. Age dating studies are currently underway to determine the age and affiliation of the pluton.

Airborne gamma-ray and magnetics surveys allow a new level of geological understanding in regions of poor outcrop exposure. Survey results from the Dawson Range and have proven themselves to be useful in this regard (this study and Johnston and Shives, 1993), but in all cases require ground follow-up.

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

by J.A. Hunt
Yukon Geology Program

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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.

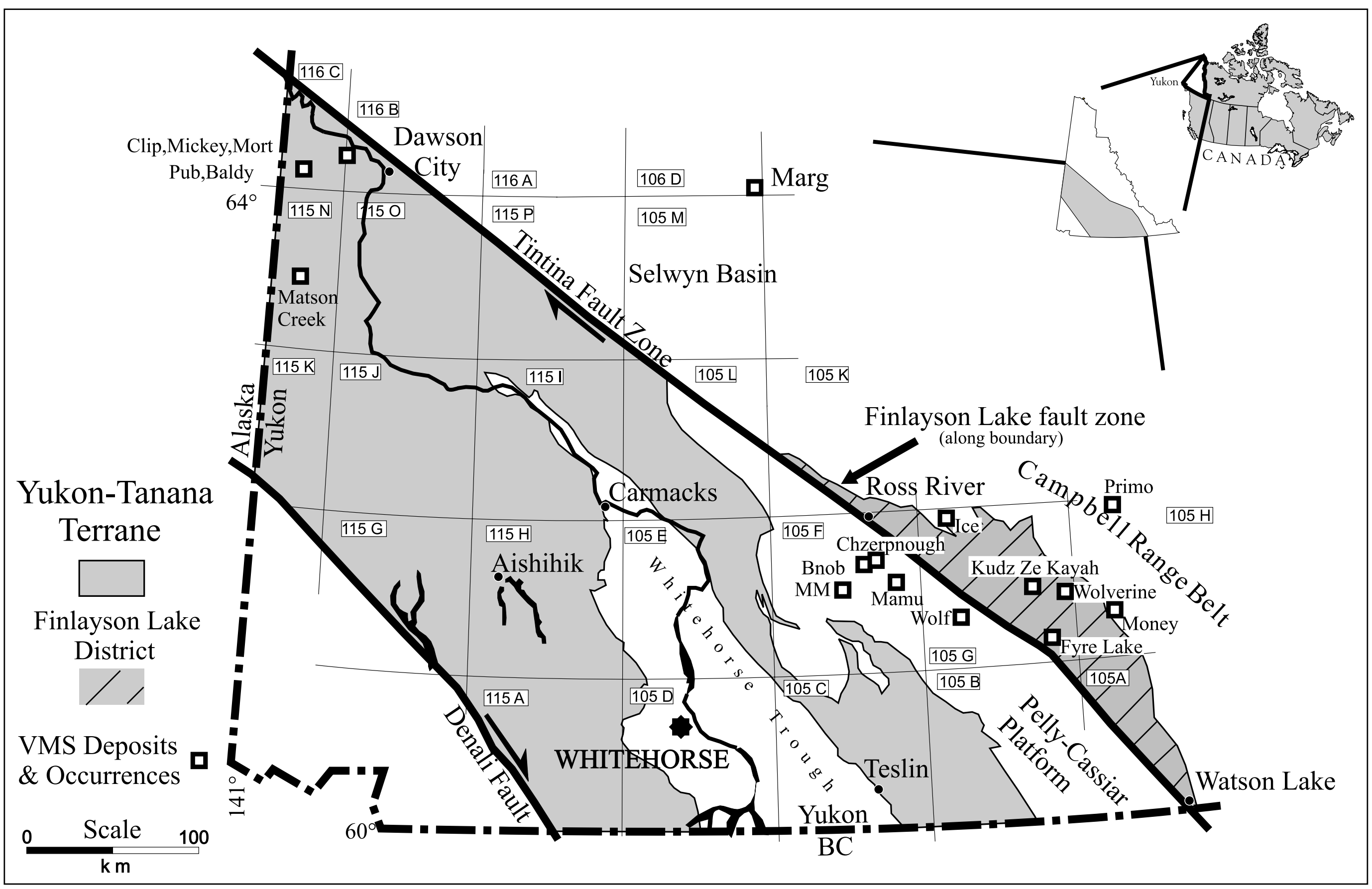

Figure 1. Location of VMS deposits in the Finlayson Lake district.

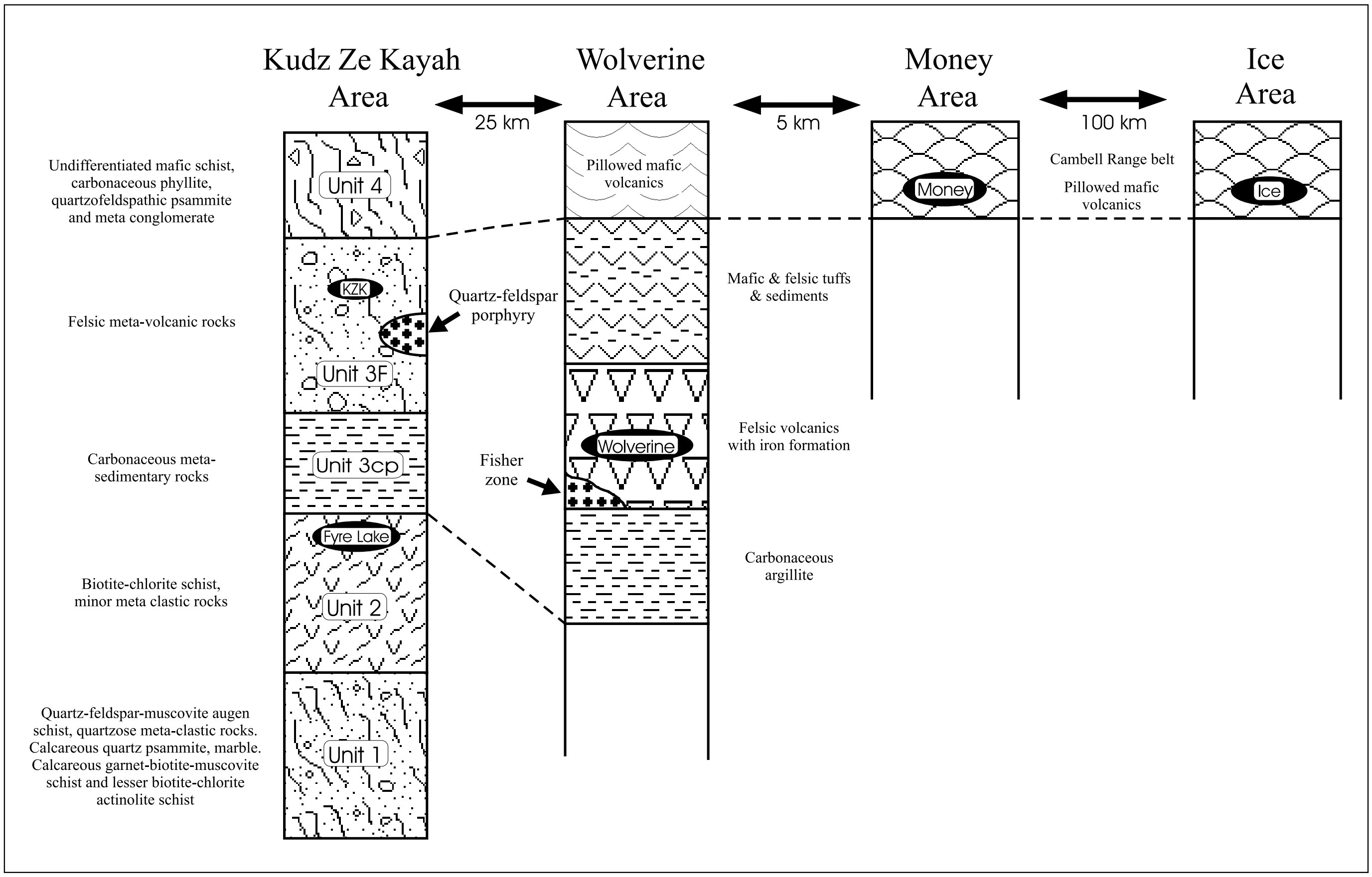

Figure 2. *Schematic stratigraphic sections for the Finlayson Lake district. Unit descriptions for the Kudz Ze Kayah (KZK) area are from Murphy (this volume).*

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

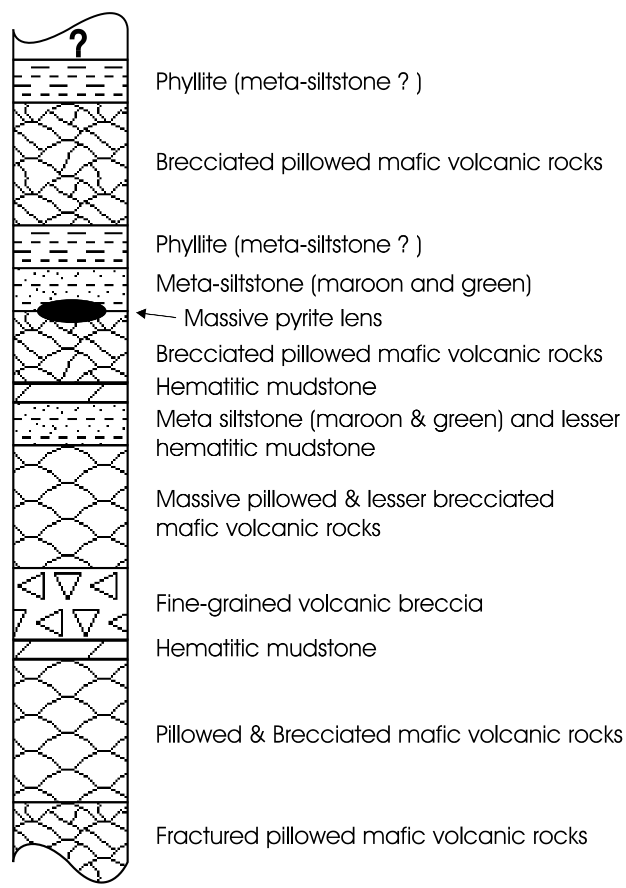

Figure 6. *Schematic stratigraphy, Money claims. Not to scale.*

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 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.

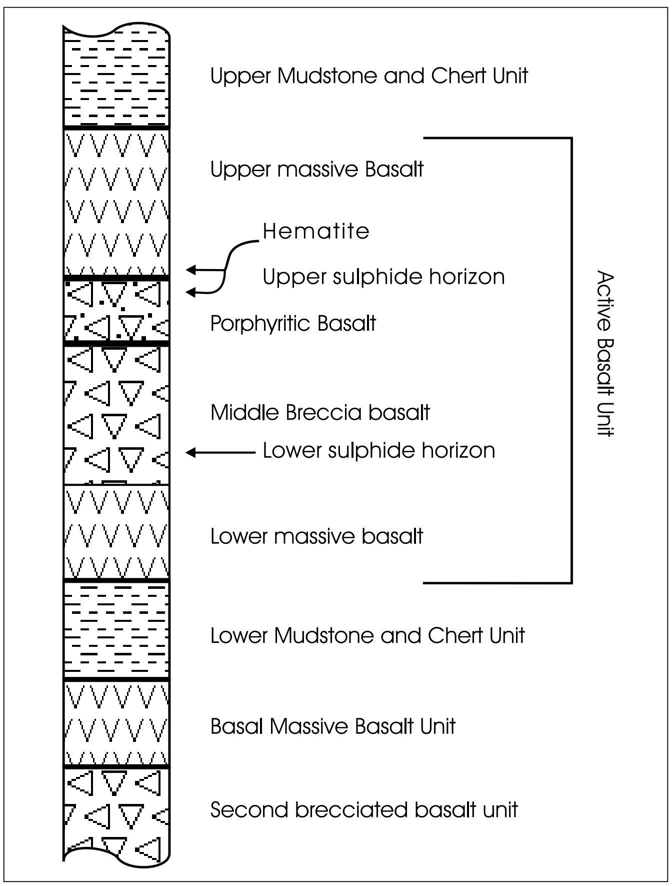

Figure 7. *Simplified stratigraphic section for the Ice deposit. Not to scale. Modified from Pigage (1997).*

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

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,

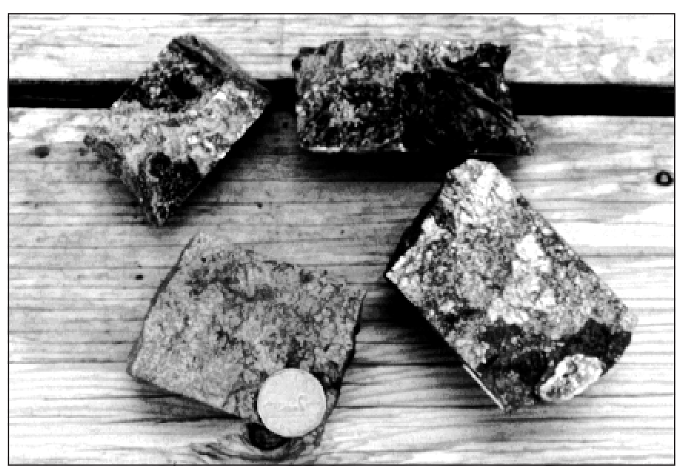

Figure 9. *Stringer sulphide mineralization from the Ice deposit.*

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.

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